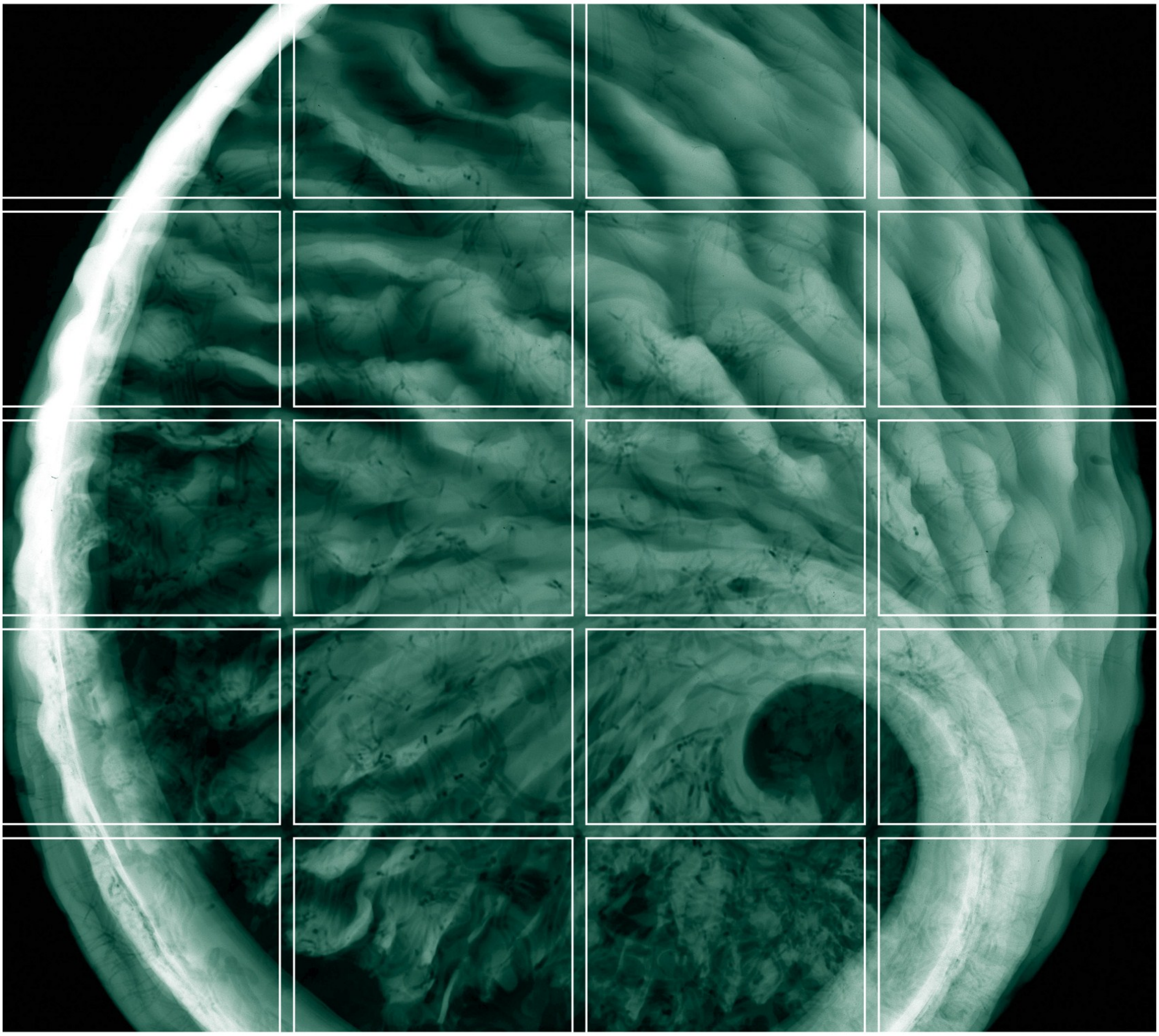

NRE No.1 Colliery Project Application (09_0013)

Environmental Assessment
Volume VI—Annexes S to V

Gujarat NRE Coking Coal Pty Ltd

February 2013

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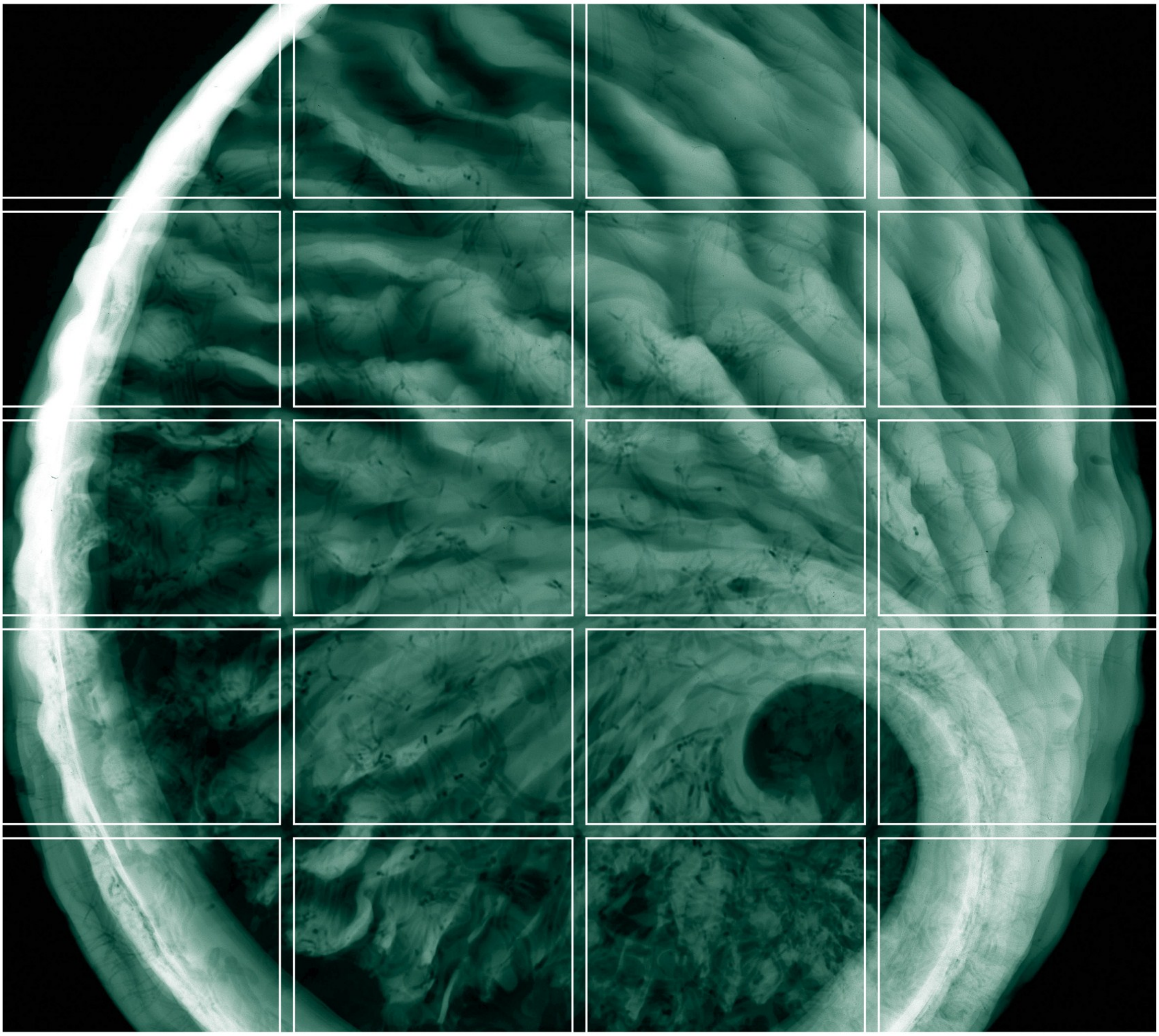
Annex S

Terrestrial Flora And Fauna Assessment



NRE No.1 Colliery Stage 2

Terrestrial Flora and Fauna Assessment

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NRE No.1 Colliery Stage 2

Terrestrial Flora and Fauna Assessment

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February 2013

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Date:	*8 February 2013*
Prepared by:	*Naomi Buchhorn*
Position	*Project Manager*
Signed:	Buchhorn
Date:	*8 February 2013*
Approved by:	*Steve O'Connor*
Position:	*Technical Director*
Signed:	S. O'Connor
Date:	*8 February 2013*

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FINAL REPORT

Gujarat NRE Coking Coal Limited

NRE No.1 Colliery Stage 2

Terrestrial Flora and Fauna Assessment

February 2013

0079383_Post Adeq_Ecology

Environmental Resources Management Australia
Building C, 33 Saunders Street
Pyrmont, NSW 2009
Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800
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GLOSSARY OF TERMS

angle of draw	The angle between the vertical and the line joining the edge of the mining void with the limit of vertical subsidence, usually taken as 20millimetres.
anthropogenic	Associated with human activities and development.
aquifer	A permeable body of rock or regolith that both stores and transmits groundwater.
arboreal	Adapted for living in and/or moving around in trees.
base flow	The flow of water entering stream channels not attributable to direct runoff from rainfall and usually from groundwater or related sources.
bioregion	Region where the boundaries are primarily determined by (or reflect) similarities in geology, climate and vegetation.
cleared land	Where the native over-storey has been cleared, there is no native mid-storey and less than 50% of the groundcover vegetation is native species or greater than 90% of the groundcover (dead or alive) is cleared.
clearing	Clearing of native vegetation is defined in the *Native Vegetation Act 2003* as any one or more of the following: cutting down, felling, thinning, logging or removal; killing, destroying, poisoning, ringbarking, uprooting or burning.
community	The recognisable association of species that regularly occur together in similar environments.
consequences (subsidence)	Changes to terrestrial ecological features as a result of subsidence impacts (this may include stream flow alterations, groundwater losses, rock falls, damage to flora, fauna and their habitat) (DoP 2008).
critical habitat	Habitat declared to be critical in relation to that species or ecological community under the *Threatened Species Conservation Act 1995* or the *Environment Protection and Biodiversity Conservation Act 1999*.
depth of cover	The depth of the roof of the coal seam from the ground measured in metres.
driveage	A horizontal or inclined underground roadway that provides vehicular access to coal reserves. The road way will be used to access a new mining area within the lease.
ecological community	An assemblage of native species that inhabits a particular area.
ephemeral stream	Stream that may or may not have a well-defined channel, generally with unpredictable flow, only during and immediately after rain.
endangered	A species, population or ecological community that is likely to become extinct or is in immediate danger of extinction.
endangered ecological community	Ecological community specified as endangered under Part 3 of Schedule 1 of the *Threatened Species Conservation Act 1995* or under the *Environment Protection and Biodiversity Conservation Act 1999*.
endangered population	Population identified as endangered under Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995*.
endangered species	Species identified in Part 1 of Schedule 1 of the *Threatened Species Conservation Act 1995* or under the *Environment Protection and Biodiversity Conservation Act 1999*.
endemic	Restricted to a particular area having originated there.
exfoliating sandstone	Sandstone that has separated from the main body of rock into small sheets on the surface, as part of the natural weathering process. These sheets are often used as a shelter by reptiles.
exotic species	A non-indigenous species.
floristics	Species composition of a plant community.
first order stream	Stream that does not have any other stream feeding into it.

first workings	Involves the development of 'headings' or 'roadways', using continuous miners with integrated roof and rib bolting rigs, to provide access to the coal resource. First workings leave the coal pillars intact and the overlying strata fully supported resulting in 'zero' subsidence.
gate roads (maingates)	An underground access roadway connecting the longwall working face with the main roadways.
goaf	The mined out area in an underground mine into which the immediate roof strata breaks.
groundcover	Structural layer closest to the ground containing grasses, forbs, ferns, sub-shrubs, and sedges.
groundwater	Water that occurs beneath the surface of the ground that has filtered down to zone where the earth or rocks are fully saturated.
groundwater dependent ecosystem	Ecosystems which have their species composition and their natural ecological processes determind by groundwater.
habitat	An area or areas occupied or periodically occupied by a species, population or ecological community and includes any biotic or abiotic component necessary to sustain survival and reproduction.
headwater swamp	Headwater swamps are freshwater wetlands situated in areas high in the catchment near catchment divides, located in areas of shallow, impervious substrate formed by either sandstone or clay horizons. Headwater swamps are likely to have perched watertables within the sediments that are independent of the water table in the Hawkesbury sandstone, dependent upon rainfall and surface runoff.
hibernation	To spend winter in close quarters in a dormant condition.
hollow-bearing tree	Tree where the base, trunk or limbs contain hollows, holes or cavities that have formed as a result of decay, injury or other damage.
indigenous	Native to, or originating in, a particular region or country.
intermittent stream	Stream with a well-defined channel that carries water for at least part of the year, but ceases to flow occasionally or seasonally because bed seepage and evapotranspiration exceed the available water supply.
iron oxidizing bacteria	Bacteria that derive energy by converting iron in the ferrous form to the ferric form, which then combines with oxygen to produce iron oxide, often appearing as a rusty red or organge 'fluffy' clumps or stains in the stream. Reaction is dependent on oxygen presence and is more likely to be found where oxygen-poor groundwater is reaching the surface of the stream.
key threatening process	Threatening process identified as such in Schedule 3 of the *Threatened Species Conservation Act 1995* or under the *Environment Protection and Biodiversity Conservation Act 1999*.
life cycle	The series or stages of reproduction, growth, development, ageing and death of an organism.
local population	The population that exists in the study area as well as any individuals occurring in the adjoining areas known or likely to utilise habitats in the study area.
longwall mining	A high capacity underground mining method that utilises a mechanical shearer to cut the coal. The loosened coal falls onto a conveyor for removal from the mine to the surface. As the coal is cut away (a 'shear') both the longwall machine (known as the 'shearer') and the hydraulic roof supports advance forward along the panel, ready for the next shear.
longwall panel	A large contiguous block of coal, typically suitable for longwall extraction.

native groundcover or understorey	Is where at least 50% of the perennial vegetation cover in the groundcover strata or understorey is made up of native species and not less than 10% of the area is covered with vegetation (dead or alive).
upland swamp	Upland swamps are vegetated freshwater wetlands occurring in shallow basins located in low hills, plateaus of mountains.
native or indigenous	Species that existed in NSW before European settlement.
negligible	Small and unimportant, such as to be not worth considering.
non-volant	An animal not capable of active flight (includes gliders).
offset (biodiversity)	One or more appropriate actions put in place in an appropriate location to counterbalance or offset an impact on biodiversity values.
Perched watertable	Saturated soil horizon with a free water surface generally above the normal water table.
perennial stream	Stream with a well-defined channel that flows continuously all year during a year of normal rainfall with the aquatic bed located below the water table for most of the year.
population	A group of animals or plants of the same species, potentially capable of interbreeding and sharing the same habitat in a particular area at a particular time.
regeneration	Where native vegetation is allowed to return naturally to an area generally by removing existing impacts such as grazing or slashing.
regrowth vegetation	Defined in the *Native Vegetation Act 2003* as any native vegetation that has regrown since 1 January 1990 (or 1 January 1983 Western Division). Excluding regrowth after illegal clearing or natural events such as bushfire, floods and drought.
remnant vegetation	Any native vegetation that is not regrowth.
revegetation	Use of methods such as planting of tubestock and direct seeding to return native vegetation to an area.
riffle	A section of a stream with shallow, fast-flowing water with a distinctly disturbed surface and usually with a gravle or pebble base.
riparian	Associated with drainage lines.
risk of extinction	The likelihood that the local population will become extinct either in the short term or long term as a result of direct or indirect impacts on the viability of that population.
risk management zone	An identified area containing significant natural features as defined by DoP (2008), delineated from the outside extremity of the surface feature, either by a 40° angle from the vertical down to the coal seam which is proposed to be extracted, or by a surface lateral distance of 400 m, whichever is the greater.
run-of-mine	Raw coal as mined that has not undergone any screening, crushing or washing.
second order stream	Stream formed where two first order streams come together.
second workings	Extraction of coal by pillar extraction methods.
Special Areas	Areas surrounding SCA's dams which are subject to additional management measures to protect the quality of drinking water. These areas are declared under the *Sydney Water Catchment Management Act 1998* for their value in protecting the quality of the raw water used to provide drinking water to greater Sydney and for their ecological integrity.

Special significance status	Special significance status is based on an assessment of a natural feature that determines the feature to be so special that it warrants a level of consideration (and possibly protection) well beyond that accorded to others of its kind. It may be based on a rigorous assessment of scientific importance, archaeological and cultural importance, uniqueness, meeting a statutory threshold or some other identifiable value or combination of values (PAC 2009).
strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points, as a result of underground coal mining.
stratum (singular)	An arbitrary horizontal layer of plants within a vegetation community used to describe the vegetation community structure.
strata (plural)	
subsidence	The totality of subsidence effects and impacts and their associated environmental consequences.
subsidence effects	The deformation of the ground mass surrounding a mine due to the mining activity, including both vertical and horizontal displacement, tilt, strain and curvature (DoP 2008).
subsidence impacts	The physical changes to the ground and its surface caused by subsidence effects. These impacts are principally tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence but also include subsidence depressions or troughs.
subsidence impact zone	The surface area that is likely to be affected by the proposed underground mining.
termitaria	Nest chambers built by termites a.k.a. termite mounds.
third order stream	Stream that forms where two second order streams come together.
threatened species	A plant or animal identified in the *Threatened Species Conservation Act 1995* or *Environment Protection and Biodiversity Conservation Act 1999* as extinct, critically endangered, endangered, or vulnerable. This term may be extended to encompass threatened species, populations or ecological communities.
threatening process	A process that threatens, or may threaten the survival, abundance or evolutionary development of species, populations or ecological communities.
tilt	Change in slope of the surface landform as a result of underground mining.
understorey	Collective term for vegetation which grows below the canopy of a forest or woodland.
upsidence	Relative upward movement, or uplift, created by the horizontal compression and buckling behaviour of the rock strata in the vicinity of the valley floor.
valley closure	A phenomenon whereby one or both sides of a valley move horizontally towards the valley centreline, due to changed stress conditions beneath the valley and its confining land masses.
valley infill swamp	Valley infill swamps form on the floor of incised second or third order stream valleys on sediment deposited possibly as a result of channel blockage such as a log jam (DoP 2008). Valley infill swamps are likely to have direct connection to regional water table and may receive water from multiple sources including rainfall, streamflow and groundwater seepage (PAC 2010).
vertical subsidence	Vertical downward movements of the ground surface caused by underground coal mining.
viable	The capacity to successfully complete each stage of the life cycle under normal conditions.
volant	An animal capable of active flight (does not include gliders).

vulnerable	A species, population or ecological community that is likely to become extinct or is in immediate danger of extinction.
Wonga East	The eastern area of proposed Stage 2 workings.
Wonga Mains	Main driveage through the Wongawilli seam.
Wonga West	The western area of proposed Stage 2 workings.
zero subsidence	Defined by DRE as vertical downward movement of the ground surface that is less than or equal to 20mm.

ABBREVIATIONS

A1, A2, A3, A4	Area 1, Area 2, Area 3, Area 4
BoM	Australian Government Bureau of Meteorology
BSO	Bulli Seam Operation
BCUS	Bellambi Creek Upland Swamp
CCUS	Cataract Creek Upland Swamp
CEMP	construction environment management plan
CL	Coal Lease
CMA	Catchment Management Authority
CRUS	Cataract River Upland Swamp
DEC	Department of Environment and Conservation (NSW)
DECC	Department of Environment and Climate Change (NSW) including the Parks and Wildlife Division, Cultural Heritage Division and Environment Protection and Regulation Division (Formerly DEC)
DECCW	Department of Environment, Climate Change and Water (NSW) (Formerly DECC)
DEWHA	Department of Environment, Water Heritage and Arts (Commonwealth)
DMR	Department of Mineral Resources
DNR	Department of Natural Resources (NSW)
DoP	Department of Planning (NSW)
DP&I	Department of Planning and Infrastructure (NSW)
DPI	Department of Primary Industries
DRE	NSW Department of Trade and Investment, Division of Resources and Energy
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth)
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EP&A Act	*Environmental Planning and Assessment Act, 1979*
EP&A Regulation	Environmental Planning and Assessment Regulation, 2000
EPA	Environment Protection Authority (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act, 1999*
EPI	Environmental Planning Instrument
ERM	Environmental Resources Management Australia Pty Ltd
ESD	Ecologically Sustainable Development
FMEA	Failure Mode and Risk and Effect Analysis
GDE	Groundwater Dependent Ecosystems
GIS	geographic information system
ha	hectares
km	kilometres
LCUS	Lizard Creek Upland Swamp
LCT1	Lizard Creek Tributary 1

LEP	Local Environmental Plan
LGA	Local Government Area
m	metres
ML	Mining Lease
mm	millimetres
mm/m	millimetres per metre
MOP	Mine Operations Plan
MSB	Mine Subsidence Board
Mt	Million tonnes
Mtpa	Million tonnes per annum
NPWS	National Parks and Wildlife Service
NRE	Gujarat NRE Minerals Pty Ltd
NSW	New South Wales
NV Act	*Native Vegetation Act, 2003*
OEH	Office of Environment and Heritage (formerly DECCW)
PAC	NSW Planning Assessment Commission
PWP	Preliminary Works Project
RMZ	Risk Management Zone
ROM	Run of Mine (raw coal prior to washing).
ROTAP	Rare or Threatened Australian Plant
SCA	Sydney Catchment Authority
SCI	Southern Coalfields Inquiry
SEPP	State Environmental Planning Policy
SMP	Subsidence Management Plan
sp./spp.	species singular / plural
subsp./subspp.	sub-species singular / plural
Tpa	Tonnes per annum
TSC Act	*Threatened Species Conservation Act, 1995*
WC	Wallandoola Creek
WCUS	Wallandoola Creek Upland Swamp
%	percent
° C	degree Celsius

EXECUTIVE SUMMARY

Gujarat NRE Coking Coal Limited (NRE) is seeking approval for continuation, consolidation and expansion of underground coal mining at its NRE No1 Colliery located at Russel Vale, NSW (the Project). Environmental Resources Management Australia Pty Limited (ERM) was commissioned by NRE to conduct a terrestrial flora and fauna assessment of the Study Area above the proposed mining areas. This report will accompany a formal Environmental Assessment Report (EAR) for the Project application in accordance with relevant State and Commonwealth Legislation.

The flora and fauna assessment included a desktop survey and field investigations. Desktop research included analysis of relevant literature, databases and existing vegetation mapping for the Study Area. Field investigations assessed the distribution and condition of habitat for threatened species, populations and ecological communities within the Study Area, and surveyed for threatened flora and fauna during eight site visits between 2006 and 2011.

The field investigations recorded Shale Sandstone Transition Forest Endangered Ecological Community (EEC) which is listed on both the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and Coastal Upland Swamp EEC, which is listed under the TSC Act. Eleven (11) threatened flora species are known or considered likely to occur in the Study Area; including seven considered vulnerable to subsidence. Twenty (20) threatened fauna species are known or considered likely to occur in the Study Area; including 13 considered vulnerable to subsidence. Species known or likely to occur within the Study Area, and considered vulnerable to the impacts of subsidence were subject to an Assessment of Significance.

All threatened species and ecological communities with the potential to occur in the Study Area were considered for their vulnerability to subsidence. Those species which were identified to have a moderate to high likelihood of occurrence, and which are also susceptible to subsidence, were assessed under the TSC Act and EPBC Act.

The assessments concluded that the Project was likely to have a significant impact on habitat for local populations of the Red-crowned Toadlet and Giant Burrowing Frog specifically in the tributaries of Lizard Creek in the Wonga West area.

The Project will have an adverse effect on potential breeding habitat for the Heath Frog in 1st order streams associated with upland swamps. If a population is present within the affected areas, the Project would accordingly have an effect on the life cycle of this species such that the local population may be placed at risk of extinction.

The assessment for the Large-eared Pied Bat and other cave-dependent bats including the Large-footed Myotis and Eastern Bentwing-bat concluded that there is a negligible to low risk that the Project could modify, destroy, remove or isolate or decrease the availability or quality of breeding habitat associated with the cliffs and/or steep slope habitat in the Study Area.

Another species that occurs in upland swamps that was recorded in the Wonga West and Wonga East is the Prickly Bush-pea (*Pultenaea aristata*). Prickly Bush-pea has been recorded in 15 of the 84 upland swamps in the area. The majority of these records were in the Wonga West area to the west of Shaft No 5. Of the 65ha of confirmed upland swamp habitat in the Study Area, approximately 23ha is at a greater than negligible risk of negative environmental consequences. The changes to hydrology in these areas have been generally reported to be 'potential and minor'. Given that this species is associated with drier vegetation on the fringes of the upland swamps, it is unlikely that the habitat for this species will be modified. Terrestrial habitat for this species will be not removed and is unlikely to be modified by the proposed subsidence. Further discussion of the assessment outcome for this species is provided in *Section 24.5.4*.

The upland swamps are representative of the Coastal Upland Swamp EEC as listed under the TSC Act. Approximately 265ha of Coastal Upland Swamp are present in Wonga East and Wonga West domains of the Study Area. The Project will not directly clear any areas of the EEC. However, the proposed longwall mining may result in subsidence and alter hydrological processes affecting the swamps, in particular headwater swamps, as the mine plan has been revised to avoid the more sensitive valley infill upland swamps along Lizard Creek and Wallandoola Creek in Wonga West.

The Project has a risk of negative environmental consequences for approximately 29 of the 84 upland swamps, including 15 upland swamps of special significance, being approximately 60ha or 23% of that ecological community in the Study Area.

The risk assessment has identified that nine of the 15 swamps of special significance have potential to be subjected to subsidence impacts including:

- five swamps (CCUS4, CCUS10, CRUS1, LCUS8 and WCUS11) with a low likelihood of negative environmental consequences, NRE may wish to consider changes to longwall layouts to reduce potential impacts on these swamps;
- two swamps (WCUS4 (headwater swamp) and WCUS7) with a moderate likelihood of negative environmental consequences, NRE should consider changes to longwall layouts to reduce the risk of impacts on these swamps; and
- two swamps (CCUS1 and CCUS5) with a significant likelihood of negative environmental consequences, NRE should consider implementation of habitat avoidance, minimisation and mitigation measures to reduce impacts on these swamps.

By definition of the PAC (2009, 2010) and OEH (2012) these upland swamps of special significance have a higher relative importance for conservation of habitat beyond that afforded to other areas of coastal upland swamp EEC.

The alteration of habitat following subsidence due to longwall mining is listed as a key threatening process (KTP) under the TSC Act. The alteration or modification of habitat was considered likely to occur for the majority of species assessed as a result of the Project and for these species this is considered the operation of a KTP.

NRE has provided an undertaking that the mining operations would be modified as required through adaptive management measures informed through monitoring of actual subsidence impacts to reduce the risk of negative consequences. An adaptive management plan will be developed to use the monitoring program to detect subsidence impacts and thereby determine the need for adjustment to the mining operations so that the subsidence predictions are not exceeded and subsidence impacts creating significant negative environmental consequences do not occur in upland swamps. Recommendations provided by Biosis (2012a) in their assessment of upland swamps will be considered in development of the adaptive management plan and future mining plans.

With adoption of the recommendations of Biosis (2012a), implementation of the adaptive management plan, and the commitment to not create a risk of negative environmental consequences, the extent of upland swamps in the locality may not be significantly affected.

1 INTRODUCTION

This chapter provides a description of the project, defines the Study Area and presents the legal framework within which it must be assessed.

1.1 PROJECT DESCRIPTION

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Gujarat NRE Coking Coal Limited (NRE) to assess the terrestrial flora and fauna within the Project Application Area (PAA) for the proposed consolidation, continuation and expansion of existing operations at the NRE No1 Colliery at Russell Vale, NSW (the Project). The assessment will accompany the Environmental Assessment Report (EAR) under Part 3A of the *Environmental Planning and Assessment Act, 1979* (EP&A Act) for the Project.

The assessment has been prepared to address the Director General's Requirements for the Project and the Guidelines for Threatened Species Assessment under Part 3A (2005) prepared by the Department of Environment and Conservation (DEC) and Department of Primary Industries (DPI). The assessment also addresses comments received by the Office of Environment and Heritage (OEH) at the adequacy phase of the assessment.

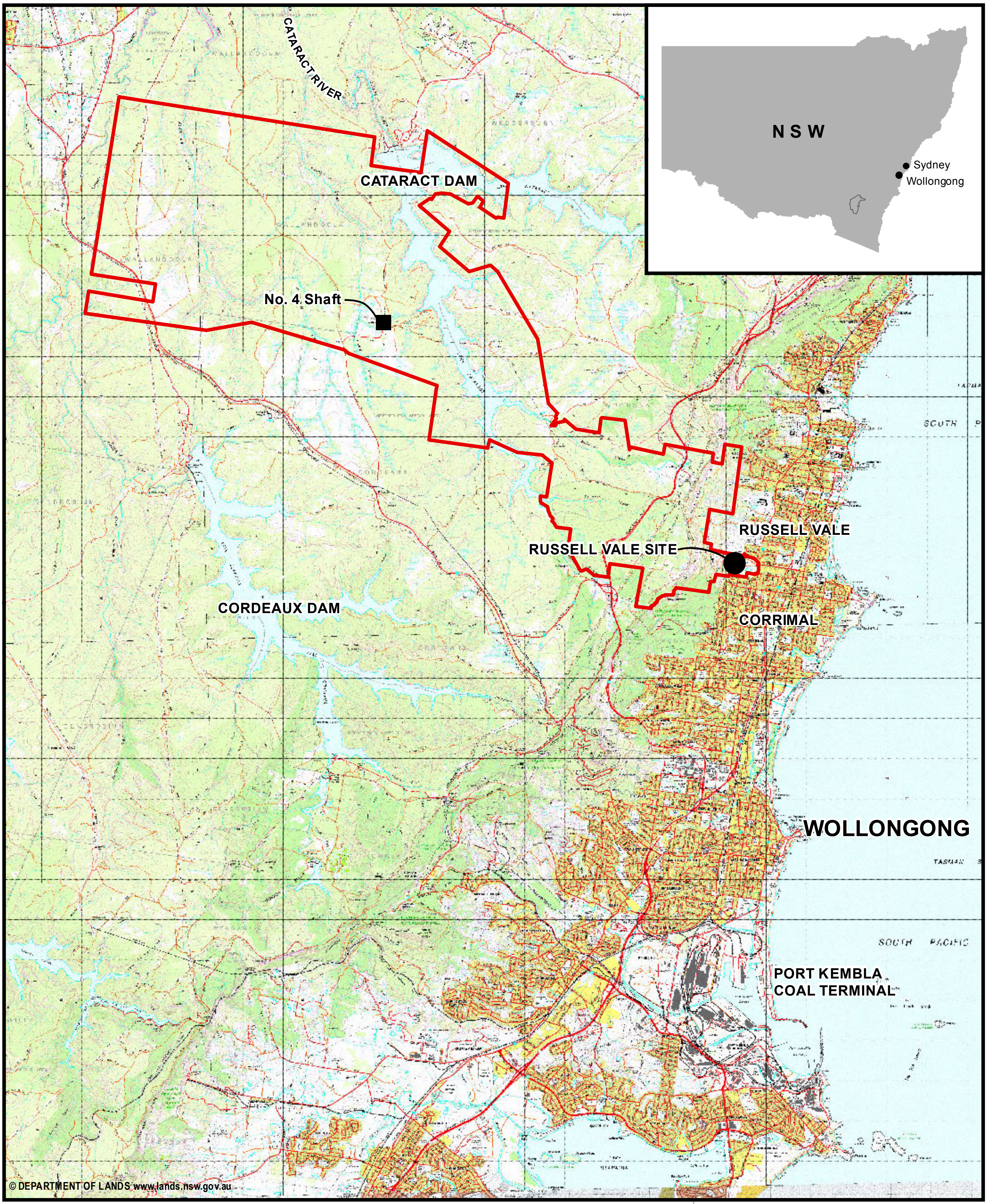
1.2 PROJECT APPLICATION AREA

The Project Application Area (PAA) is approximately eight kilometres (km) north of Wollongong and 70km south of Sydney (see *Figure 1.1*), within the Local Government Areas (LGAs) of Wollongong and Wollondilly in the Illawarra region of NSW. The PAA comprises Consolidated Coal Lease (CCL) 745, Mining Purposes Lease (MPL) 271 and Mining Lease (ML) 1575.

Native bushland and/or the waters of Cataract Dam cover the majority of the PAA. A large part of the PAA is designated as a Schedule 1 Restricted Access Area (Metropolitan Special Area) under the *Sydney Water Catchment Management Act 1998* (SWCM Act) and Sydney Water Catchment Regulation 2008. This area is managed by the Sydney Catchment Authority (SCA) in accordance with the Special Areas Strategic Plan of Management 2007, to protect water quality and provide high quality raw water in reservoirs, by protecting ecological integrity and the natural and cultural values of the area.

The PAA contains two distinct proposed mining domains known as Wonga East and Wonga West (see *Figure 1.2*). Wonga East contains two areas for longwall mining, known as Area 1 and Area 2, while Wonga West contains two areas for longwall mining, known as Area 3 and Area 4 (see *Figure 1.2*).

NRE has surface leases at Russell Vale on the coast and six other surface sites on the Woronora plateau: No. 4 Shaft (for men, materials and ventilation), Mining Purposes Lease (MPL) 271 and four ventilation shaft sites (No. 1, 2, 3 and 5 Shafts)) (see *Figure 1.2*). Other surface infrastructure includes a Telstra fibre optic cable, electrical transmission lines, the Southern Freeway (Mount Ousley Road), unsealed fire trails (Fire Road No 8 and Fire Road No 7) and Picton Road.



Legend

Project Application Area

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G001_R1.mxd

Date: 27/11/2012 Drawing size: A4

Drawn by: GC Reviewed by: MB

Scale: Refer to Scale Bar

N

0 1 2 3km

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Figure 1.1

Locality Map

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

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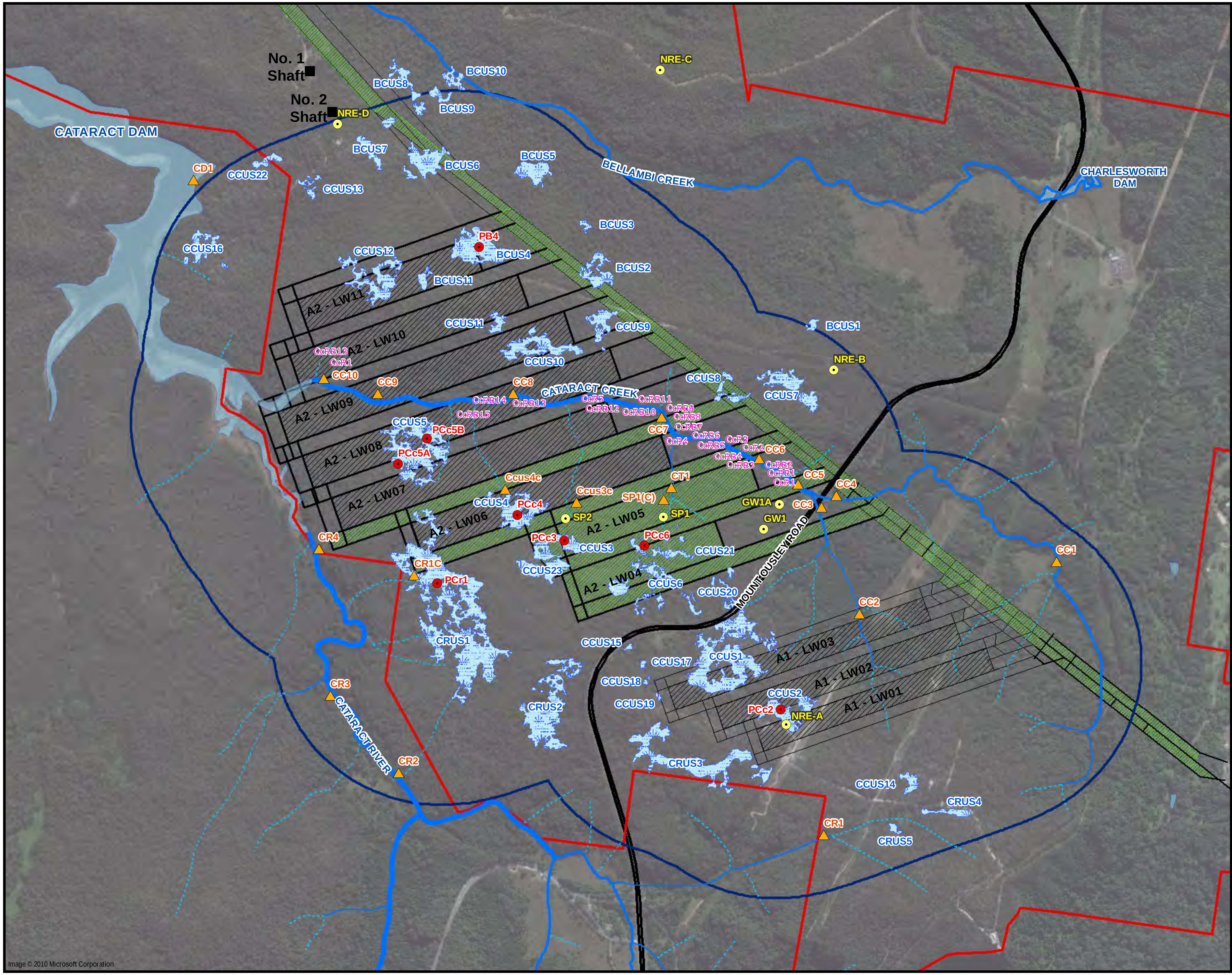

Legend

- Project Application Area
- Study Area
- Subject to Separate Application (MP 10_0046_MOD 1)
- Upland Swamps (Biosis 2012)
- Cataract Dam
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order and AboveStream
- Major Road
- Shaft Locations
- CC4 Stream Monitoring Sites (GeoTerra 2012)
- Swamp Piezometers (GeoTerra 2012)
- Basement Piezometers (GeoTerra 2012)

Figure 2.1

Wonga East Surface Water Features

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery Ecological Assessment

Drawing No: 0079383s_ECA_G004_R3.mxd

Date: 13/11/2012 Drawing size: A3

Drawn by: SQW Reviewed by: NB

Scale: Refer to Scale Bar

N 0 150 300 450m

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

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1.3 *DEFINITION OF STUDY AREA*

The Study Area is defined as the proposed mining footprints in Wonga East and Wonga West with an additional surrounding surface perimeter of 600 metres (m) covering approximately 2,623 hecatares (ha). The Study Area was determined as the area in which impact of mining in the proposed Wonga West and Wonga East areas may occur using the recommendations for risk management zones as established by the Southern Coalfield Inquiry (Department of Planning (DoP) 2008).

The original Study Area was larger than the defined area in this report, because the original mine layout plans covered significantly greater area than the final proposed layout. As ecological values of the Study Area were realised during the assessment, NRE mine planners as part of the iterative process altered the mine layout to avoid significant environmental values. As a result, much of the original survey work for this assessment occurred in areas that are now outside of the Study Area.

1.4 *COMPLIANCE WITH RELEVANT DIRECTOR-GENERAL'S REQUIREMENTS*

The assessment was designed to meet the assessment requirements provided by the Director-General of the DoP (now the Department of Planning and Infrastructure (DP&I)) and issues raised by relevant Government authorities with regard to terrestrial biodiversity, threatened species and their habitats as summarised in *Table 1.1*.

Table 1.1 Compliance with Relevant Director-General's Requirements

Requirement - Description	Relevant section in this report
Department of Planning Director-General's Requirements Key Issues - Biodiversity:	
• accurate estimates of vegetation clearing and other impacts;	*Chapter 5*
• detailed assessment of the potential impacts of the project on any terrestrial and aquatic threatened species, populations, ecological communities or their habitats.;	*Chapter 5*
• a detailed description of the measures that would be implemented to maintain or improve the biodiversity values of the surrounding region in the medium to long term	*Chapter 6*
Department of Planning Director-General's Requirements Policies, Guidelines and Plans – Biodiversity:	
• Draft Threatened Biodiversity Survey Assessment Guidelines (DEC 2004);	*Chapter 3*
• State Environmental Planning Policy No. 44 – Koala Habitat Protection	*Section 4.5.4*
• Draft Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979 (DEC & DPI 2005).	*Chapter 3*
Department of Environment, Climate Change and Water (DECCW) Environmental Key Issues - Biodiversity:	
• targeted survey for all identified species must be undertaken within the project area, concentrating on those areas of high sensitivity and medium sensitivity;	*Chapters 3 and 4*
• detailed assessment of the potential impacts of the project on any terrestrial and aquatic threatened species, populations, ecological communities or their habitats;	*Chapter 5*
• accurate predictions of the proposed vegetation clearing;	*Chapters 4 and 5*
• document the actions that will be taken to avoid or minimise impacts or compensate for unavoidable impacts of the project on threatened species. This should include an assessment of effectiveness and	*Chapter 6*

Requirement - Description	Relevant section in this report
reliability of the measures and any residual impacts after these measures are implemented; and • opportunities should be explored to restore habitat for specific threatened species and endangered ecological communities listed within the study area.	*Chapters 5 and 6*
DECCW Environmental Guidance Material - Attachment B: • Draft Guidelines for Threatened Species Assessment (DEC & DPI 2005); • Draft Threatened Biodiversity Survey Assessment Guidelines for Developments and Activities (DEC 2004); • DECC Principles for the use of Biodiversity offsets in NSW; • Any appropriate Recovery Plans for threatened species; • The Native Vegetation of the Woronora O'Hares and Metropolitan catchments – NSW National Parks and Wildlife Service (2003); • NSW Government's Southern Coalfield Underground Coal Mining Inquiry Report (2007);	This material is applicable to many components of the project and has been addressed throughout the document
Department of Environment and Climate Change (DECC 2007a) Environmental Indicative List of Flora and Fauna at Risk from Subsidence Impacts - Attachment C: • assess all species listed as having regional significance and legal conservation status which could be at risk of subsidence impacts; and • check all relevant listings for Threatened Species are covered in the assessment, including any new listings.	*Chapter 2* *Chapter 5*

This report has been prepared with consideration of the draft Guidelines for Threatened Species Assessment prepared by DEC and DPI in 2005. In keeping with the guidelines, this ecological assessment report provides the following:

- an evaluation of the impacts of the Project in *Chapter 5* including consideration of the potential effects of the proposal on threatened species, populations or ecological communities; and
- a discussion of measures to avoid impacts and where it is not possible to avoid impacts, identifies measures to mitigate impacts including proposed offset strategies in *Chapter 6*.

1.5 PROPOSED MINING OPERATIONS

NRE seeks approval to continue its underground coal mining operations at NRE No. 1 Colliery and to increase coal production to a maximum of three million tonnes per annum (3Mtpa) over a period of up to 18 years.

NRE proposes to undertake mining in the Bulli, Balgownie and Wongawilli seams as follows:

- Bulli seam - first workings in the 'Bulli West' area;
- Balgownie seam - limited to first workings only, beneath overlying Bulli seam workings; and
- Wongawilli seam - longwall mining in Wonga East and Wonga West.

First workings in the Balgownie and Bulli seams are fully supported and will not result in subsidence and consequent surface impacts.

The action being assessed is the longwall mining of the Wongawilli seam in Wonga East and Wonga West domains (see *Figure 1.2*). The proposed underground road driveage between the two mining areas will be fully supported and is not expected to result in any surface impacts, and is therefore not included in the Study Area.

1.6 PURPOSE OF THIS REPORT

The purpose of this report is to detail the terrestrial ecological assessment of the Study Area to address the Director Generals Requirements (DGRs) issued on 20th March, 2009, the comments of the agencies received at adequacy review in 2011, and to meet the following objectives:

- identify and describe the conservation significance of ecological communities, flora, fauna and wildlife habitat within the Study Area;
- assess the type and degree of mining-induced impacts on terrestrial ecological communities known to, or considered likely to occur in the Study Area;
- assess the type and degree of consequences of mining induced impacts to ecological communities, flora and fauna of conservation significance in the Study Area, as a result of subsidence effects;
- identify measures to avoid impacts and consequences of mining induced effects to terrestrial ecological values;
- identify mitigation measures to ameliorate the impacts and consequences of mining-induced subsidence effects on terrestrial ecological values; and
- provide a benchmark against which future changes to habitats and biota can be compared.

1.7 LEGISLATION

1.7.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires approval of the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities for actions that may have a significant impact on matters of National Environmental Significance (NES). The EPBC Act also requires Commonwealth approval for certain actions on Commonwealth land. Matters of national environmental significance under the Act include the following:

- World Heritage properties;
- National Heritage places;
- Great Barrier Reef marine park;
- Ramsar wetlands of international importance;
- threatened species or ecological communities listed in the EPBC Act;
- migratory species listed in the EPBC Act;
- Commonwealth marine environment; and
- nuclear actions.

Any proposed action that is expected to have an impact on matters of NES must be referred to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities for assessment under the EPBC Act, or assessed under the accredited State approval process.

A stand-alone report that assesses Matters of NES is provided in *Annex T* of the Environmental Assessment Report (ERM 2013a). The findings of that report are summarised in *Section 5.6* of this report.

1.7.2 *Environmental Planning and Assessment Act 1979*

Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) detailed the approval process for major infrastructure and other significant 'projects'. The Project is a Major Project according to State Environmental Planning Policy (Major Projects) 2005 (SEPP MP) and is assessed under the provisions of Part 3A of the EP&A Act, with the Minster for Planning and Infrastructure as the Consent Authority for the Project application.

Part 3A of the EP&A Act was repealed in September 2011. However, Schedule 6A of the EP&A Act outlined the transitional arrangements for projects formally identified as Part 3A projects prior to the repeal. In keeping with these arrangements and through consultation with the DP&I, the Project continues to be assessed under Part 3A of the Act.

Under Section 75R of the EP&A Act, environmental planning instruments other than State Environmental Planning Policies do not apply to a 'Major Project'. However, in accordance with Section 75J, the Minister, when assessing the project, may take into account the provisions of any environmental planning instrument (EPI). In this regard, the Minister is not bound by environmental planning instruments other than SEPPs but is obliged to consider such instruments.

Section 5A of the EP&A Act lists seven factors that must be taken into account in the determination of the significance of potential impacts of a proposed development on 'threatened species, populations or ecological communities (or their habitats) listed under the TSC Act. The 'seven part test' is used to determine whether a proposed development is 'likely' to impose 'a significant effect' on threatened biota.

There is no requirement for the consent authority to consider Section 5A of the EP&A Act when determining a Project application under Part 3A of the Act. Notwithstanding this, seven part tests pursuant to Section 5A of the EP&A are utilised to determine if the Project will have a significant impact on threatened species, populations and communities.

1.7.3 *Threatened Species Conservation Act 1995*

Projects determined by a statutory authority of the NSW State Government are required to be assessed in accordance with the EP&A Act, as amended by the *Threatened Species Conservation Act 1995* (TSC Act). The TSC Act lists threatened species, populations and ecological communities under Schedules 1 and 2 of the Act, that are priorities for conservation within NSW.

A number of threatened species and endangered ecological communities have been identified as occurring or suitable habitat has been identified in the PAA. The potential impacts on threatened species have been considered in accordance with the requirements of the TSC Act and the EP&A Act.

Schedule 3 of the TSC Act lists Key Threatening Processes for species, populations and ecological communities within NSW. Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process under the TSC Act.

1.7.4 Native Vegetation Act 2003

The *Native Vegetation Act 2003* (NV Act 2003) aims to provide flexibility and incentives to manage native vegetation, end broad scale clearing (unless it improves or maintains environmental outcomes) and encourage healthy and productive landscapes. Under the NV Act authorisation is required to clear native vegetation under Section 12 of the NV Act.

In accordance with Section 75U of the EP&A Act, authorisation to clear native vegetation under Section 12 of the NV Act is not required for projects approved under Part 3A of the EP&A Act.

1.7.5 State Environmental Planning Policy No 44 – Koala Habitat Protection

State Environmental Planning Policy 44 (SEPP 44) - Koala Habitat Protection aims to '*encourage the proper conservation and management of areas of natural vegetation that provide habitat for Koalas, to ensure permanent free-living populations over their present range and to reverse the current trend of population decline*'. Wollongong and Wollondilly LGAs are listed in Schedule 1 as areas where Koalas are known to occur and accordingly where the provisions of SEPP 44 apply.

Under SEPP 44 *potential* koala habitat is defined as vegetation that incorporates a minimum of 15 percent of tree species in the '*upper or lower strata of the tree component*' listed in Schedule 2 of SEPP 44. *Core* koala habitat is defined as '*an area of land with a resident population of Koalas, evidenced by attributes such as breeding females…and recent sightings of and historical records of a Koala population*'.

An assessment of whether the Study Area supports *potential* or *core* Koala habitat is provided *in Section 4.5.4.*

2 EXISTING ENVIRONMENT

This chapter provides a description of the existing natural features of the environment within the PAA and the Study Area.

2.1 GEOLOGY, SOILS AND LANDFORM

2.1.1 Landform and Topography

The PAA extends from the coastal slopes near Russell Vale across the Illawarra Escarpment and the Woronora Plateau (See *Figure 1.1*). The land above the proposed mining area ranges in elevation from 260m to 400m above the Australian Height Datum (AHD). The area contains north-western sloping drainage depressions and dells, uplands swamps, plateau surfaces, narrow to gently undulating crests and ridges, and rugged steep slopes and sandstone gorges incised by the deep valleys of the Cataract River and its tributaries (Hazelton and Tille 1990). The PAA is typical of lands flanking the Illawarra Escarpment in the Wollongong region (Land Information Centre 2000).

2.1.2 Geology

The PAA is located within the Southern Coalfield of the Sydney-Bowen geological basin. The strata include a gently folded succession of sandstones, shales, claystones and coal, of Permian to Triassic age (Geological Survey NSW 1966). The north-westerly plunging South Bulli Syncline is the dominant geological structure at NRE No. 1 Colliery. West of the escarpment, the Permian deposits are overlain by the Triassic Narrabeen Group, comprising sandstone, siltstone, claystone, shale and tuffaceous claystone.

Further west, extending across the majority of the PAA, these deposits are overlain by Hawkesbury Sandstone, characterised by quartz sandstone with some shale. There are some relatively small areas where the Hawkesbury Sandstone is overlain by the Liverpool sub group (Geological Survey NSW 1966). East of the Illawarra Escarpment, the geology of the PAA comprises Permian age Illawarra Coal Measures, underlain by units of the Shoalhaven Group.

In the Southern Coalfield, the economic coal seams occur within the Illawarra Coal Measures. The three commonly mined coal seams of these measures, in descending stratigraphical order, are the Bulli seam, Balgownie seam and then the Wongawilli seam.

The Bulli seam has been extensively mined for more than 120 years within CCL 745. The thinning of the seam to the north west represents the general trend. The immediate roof may be carbonaceous shale, a mudstone-shale or a laminite. The immediate floor is comprised of coaly shale, grading down to shale, to siltstone, to laminite, to sandstone. This sandstone layer averages about nine metres thick and forms the roof of the underlying Balgownie seam.

The Balgownie seam was mined by longwall in the 1970's and more recently by first workings in 2002 to 2003. The roof is invariably cross-bedded sandstone, and the floor is formed by a carbonaceous mudstone grading down to mudstone and to siltstone.

Two minor seams, the Cape Horn seam and the Hargrave seam, lie between the Balgownie and Wongawilli seams, but are too thin and too high in ash to be of economic significance.

The top of the Wongawilli seam is 22 to 25m below the Balgownie seam and is typically nine to 11m thick. The Wongawilli seam consists of interbedded bands of (occasionally) kaolinitic brown mudstone or carbonaceous shale (with occasional thin pyrite or siderite lenses) and coal layers. Only the lower section of the seam is considered of economic value due to deterioration from thickening and increasing numbers of stone bands in the working section progressing northward in the Coalfield.

The Wongawilli seam has been mined by longwall methods at other collieries in the Southern Coalfield; and has been mined most recently in Wonga East mining domain in Area 2 Longwall panel 4 (A2 LW4) in accordance with a subsidence management plan approved by Department of Trade and Investment Division of Resources and Energy (DRE) on 26 March 2012

2.1.3 *Soil Landscapes*

The Russell Vale site is on the Illawarra Escarpment soil landscape, while the majority of the PAA occurs west of the escarpment on the Maddens Plains and Lucas Heights soil landscapes on the plateau with the Hawkesbury soil landscape located in the lower, downstream incised valleys. Warragamba soil landscape dominates Cataract Creek.

The Maddens Plains soil landscape is characterised by moderately to gently undulating rises on plateau surfaces with widespread upland swamps/wetlands. Local relief ranges from one metre up to 10m with valley slope gradients of 1-10%. The dominant landform elements are broad, usually waterlogged drainage depressions with scattered rock outcrop (Hazelton and Tille 1990). The Maddens Plains landscape is present within the Study Area associated with the channels of Wallandoola and Lizard Creeks.

The Lucas Heights soil landscape is characterised by gently undulating plateau surfaces and ridges 200 to 1000m wide; with level to gently inclined slope gradients of <10%. Local relief is less than 30m and rock outcrops are absent (Hazelton and Tille 1990). The Lucas Heights landscape borders the Maddens Plains soil landscape around Shaft 4 and Shaft 5, between the Wonga East and Wonga West mining domains, and to the west of Area 3 panels in Wonga West.

The Hawksesbury soil landscape is characterised by rolling to very steep hills; with local relief of 100 to 200m, and slope gradients of 20 to 70%. Crests and ridges are convex and narrow and <100m wide. Slopes are moderately inclined to precipitous. Valleys are narrow (20-100m) and incised. Rock outcrop is common and occurs as horizontal benches and broken scarps up to 10m high. Rock outcrops and surface boulders and cobbles up to 50% of the ground surface (Hazelton and Tille 1990). The Hawkesbury landscape is present within the steeper, incised sections of Lizard and reaches of Wallandoola Creek downstream of the Study Area; and dominates Wonga East mining domain.

A small area of the Gymea soil landscape occurs along the north-eastern edge of Cataract Dam. The Bundeena soil landscape is present along Bellambi Creek.

Warragamba soil landscape occurs on the slopes and ridges of the Woronora Plateau including the sourthern region of Lake Cordeaux and upper reaches of Lake Avon and Lake Nepean (Hazelton and Tille 1990). Moderate to very steep slopes, sloping narrow ridges, narrow sandstone and colluvial benches with abundant sandstone boulders dominate (Hazelton and Tille 1990). Dominant vegetation is tall open wet sclerophyll forest and rainforest. Cataract Creek and the Area 1 panels occur within this landscape unit.

Within the PAA the soils are developed from Hawkesbury Sandstone and are typically infertile and acidic with a high erosion hazard (DoP 2008). Mass movement and rock fall hazards are characteristic of the Illawarra Escarpment, Warragamba and Hawkesbury landscapes. Soil types within the PAA include podzolic soils (yellow, red, lateritic and greyed podzolic soils), lithosols, yellow soloths, yellow earths, brown earths, earthy sands, siliceous sands and leached sands (Hazelton and Tille 1990). Acid peats are present in swamps and areas of poor drainage (Hazelton and Tille 1990). Lateritic podzolic soils can also be present within the Lucas Heights profile, which would be a source of dissolved iron into stream waters.

2.2 *WATER RESOURCES*

The following description of water resources in the PAA is based upon specialist studies for the Project undertaken by GeoTerra for surface water (GeoTerra 2012a), groundwater (GeoTerra 2012b) and the upland swamp assessment undertaken by Biosis (2012a).

2.2.1 *Streams*

The PAA is located within the Nepean River catchment, on land that forms part of the SCA Special Areas for Sydney's water supply. Watercourses of third order and above (according to the Strahler classification scheme) over the proposed underground mining areas include Cataract Creek, Bellambi Creek, Lizard Creek, Wallandoola Creek, Lizard Creek Tributary 1, Lizard Creek Tributary 2 and Cataract River as shown on *Figure 2.1* and *Figure 2.2*.

Cataract, Bellambi, Lizard and Wallandoola Creeks have been undermined in the past, within and/or upstream of the PAA. GeoTerra (2012a) has documented observations of the condition of the streams over the previously mined areas.

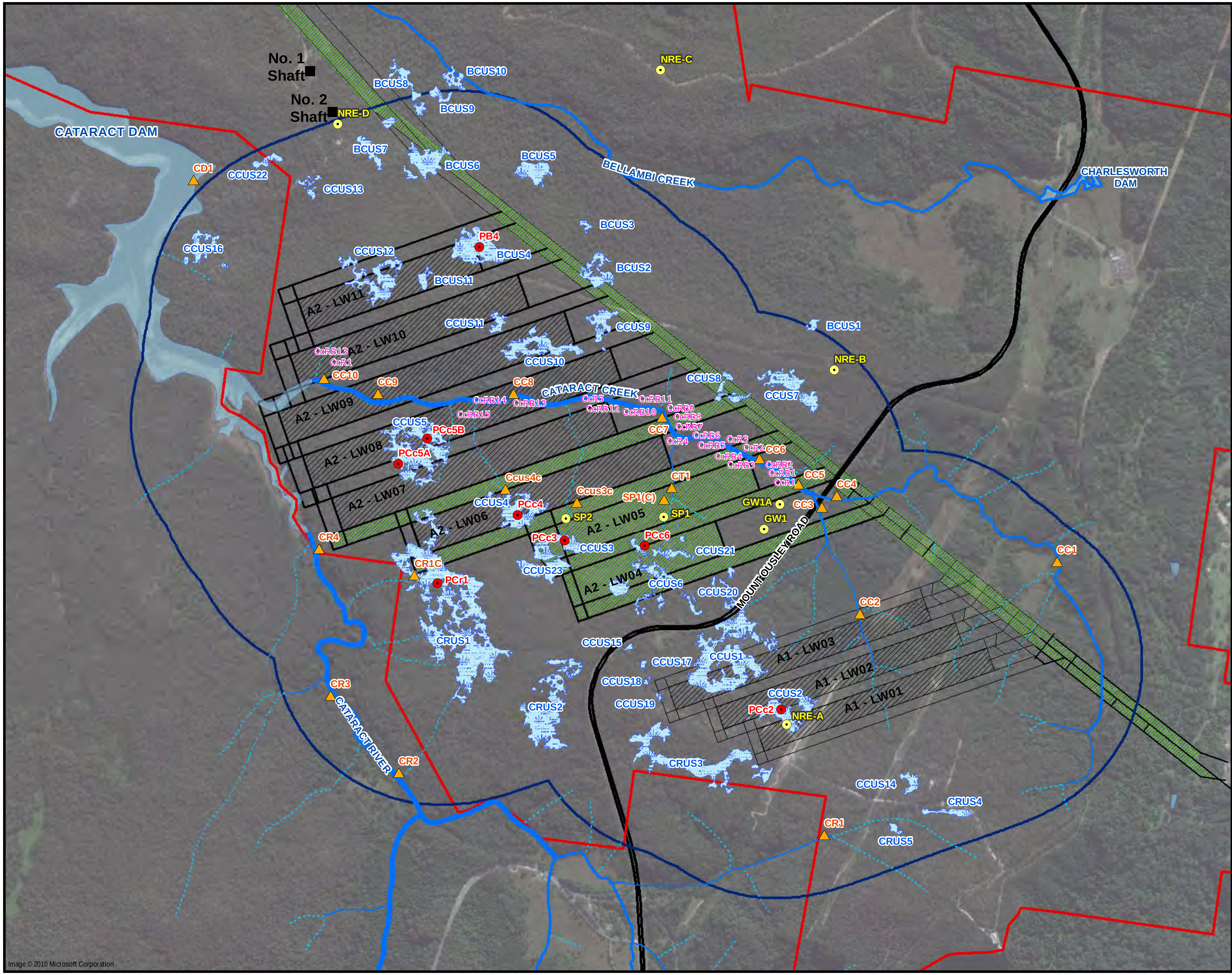
In Wonga East, Cataract Creek and Bellambi Creek flow predominantly in a westerly direction under Mount Ousley Road, discharging into the upper reaches of Cataract Reservoir (see *Figure 2.1*).

East of the Illawarra Escarpment, streams drain from the Russell Vale site into Bellambi Gully, through urban areas of Russell Vale and Bellambi into the South Pacific Ocean at Bellambi Beach.

Stream headwaters in the PAA are characterised by extensive upland swamps leading into broad, shallow streams with poorly defined channels and a low bed gradient. Further downstream bed gradients generally increase, elongated pools are present and creeks flow over exposed sandstone bed rock and rock shelves. Deeply incised sandstone valleys flank the creeks in Wonga West, particularly along the lower reaches of Lizard and Wallandoola Creek.

In Wonga West, Wallandoola Creek and Lizard Creek have a generally northerly alignment and discharge into the Cataract River downstream of Cataract Dam and upstream of Broughton's Pass Weir (see *Figure 2.2*).

The following description of the streams is based upon the surface water assessment for the proposal prepared by GeoTerra (2012a). The stream monitoring sites described by GeoTerra (2012a) (eg LC1, CC1) have been used as reference points to describe changes in the stream morphologies. These sites are shown on *Figures 2.1* and *2.2*.



Legend
- Project Application Area
- Study Area
- Subject to Separate Application (MP 10_0046_MOD 1)
- Upland Swamps (Biosis 2012)
- Cataract Dam
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order and AboveStream
- Major Road
- Shaft Locations
- CC4 Stream Monitoring Sites (GeoTerra 2012)
- Swamp Piezometers (GeoTerra 2012)
- Basement Piezometers (GeoTerra 2012)

Figure 2.1
Wonga East Surface Water Features

Client: Gujarat NRE Coking Coal Limited
Project: NRE No.1 Colliery Ecological Assessment

Drawing No: 0079383s_ECA_G004_R3.mxd
Date: 13/11/2012 Drawing size: A3
Drawn by: SQW Reviewed by: NB
Scale: Refer to Scale Bar

N 0 150 300 450m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

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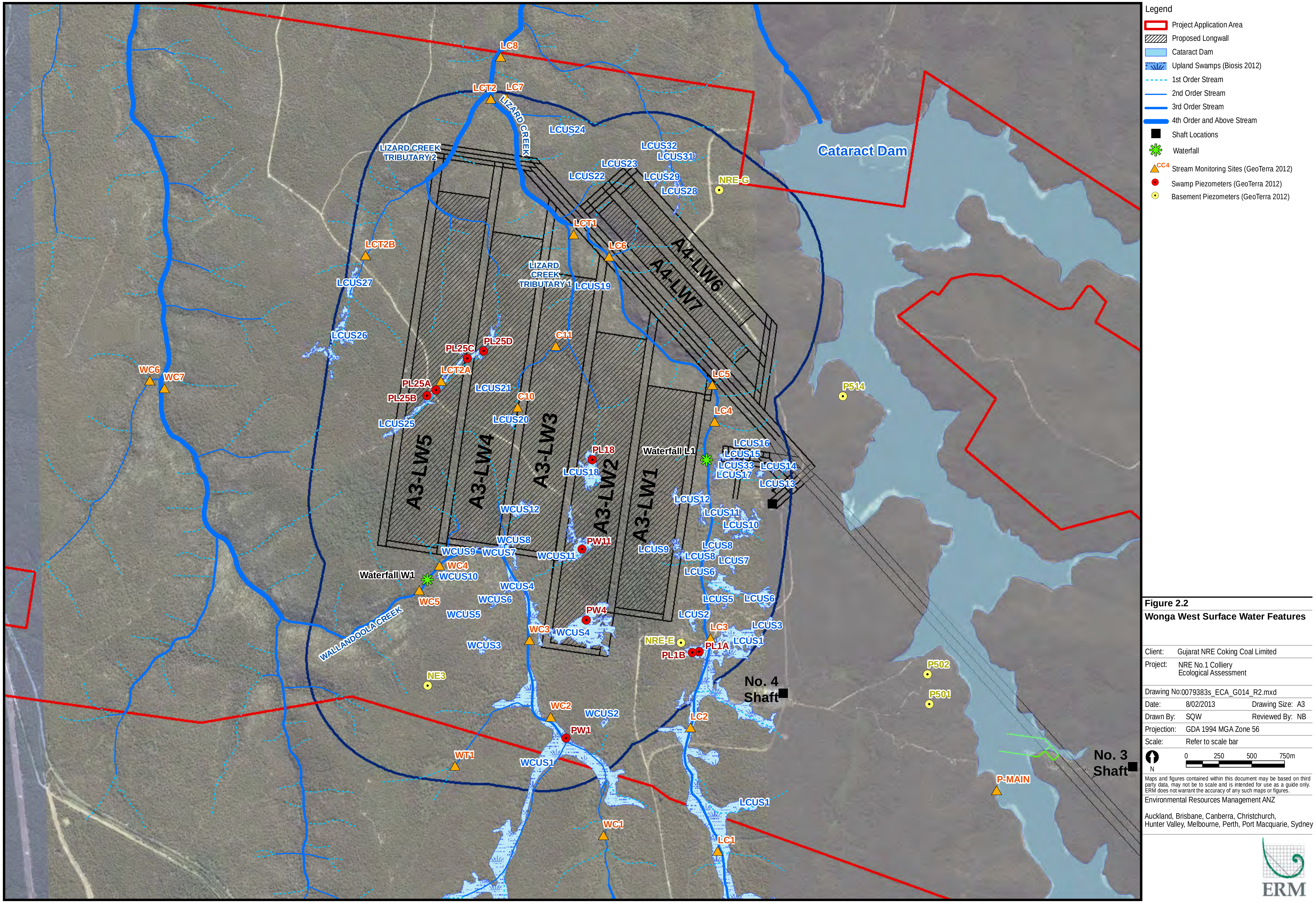


Figure 2.2

Wonga West Surface Water Features

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery Ecological Assessment		
Drawing No:	0079383s_ECA_G014_R2.mxd		
Date:	8/02/2013	Drawing Size:	A3
Drawn By:	SQW	Reviewed By:	NB
Projection:	GDA 1994 MGA Zone 56		
Scale:	Refer to scale bar		

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch,
Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

Cataract Creek

The headwater tributaries of Cataract Creek have eroded through the Hawkesbury Sandstone and, in the deeper eroded areas, through to the Bald Hill Claystone and the underlying Bulgo Sandstone. The main channel of Cataract Creek has eroded sequentially into the Newport and Garie Formations and Bald Hill Claystone with the Bald Hill Claystone and Bulgo Sandstone being exposed in the lower reach of the creek upstream of the reservoir (GeoTerra 2012a).

The creek is relatively steep, particularly in the two steeply sloping headwater valleys over Area 1 between monitoring sites CC1 to CC2, and CC3 to CC4 (see). Downstream of Mount Ousley Road (between CC5 and CC9) there are a series of long elongated pools that are constrained by low (<0.5m high) shallow rock bars, which predominate in the upper to mid-section, along with occasional, gravel sized riffle sections that also predominate in the upper to mid-section of the study reach. Significant reaches of sandy based substrate dominate between CC7 and CC9, which has developed in an eroded, interspersed shale and sandstone sequence compared to the Hawkesbury Sandstone.

A limited number of rock bar constrained pools are present between CC7 and CC9, although two moderate sized, deep pools (<1-2m) have developed at significant bends at rock bars CcRB13 and CcRB14. No waterfalls or highly stepped zones are present in Cataract Creek.

The stream bed and banks of the plateau streams are well vegetated, and do not show significant erosion or bank instability. From the edge of the escarpment to downstream of Mount Ousley Road, heavily vegetated rainforest is developed which transgresses into heavily wooded forest between Mount Ousley Road and the Cataract Dam.

Given that the Cataract River is not to be undermined and it is predicted that is will not be impacted by the mine, no detailed assessment of geomorphology of the reach between the waters of Cataract Dam and the freeway has been undertaken (GeoTerra 2012a).

Wallandoola Creek

Wallandoola Creek flows in a northerly, then westerly direction within Wonga West Area 3 (see). The creek has previously been undermined by longwall mining in the Bulli seam in both the BHP Cordeaux and NRE leases. While Wallandoola Creek channel does not overlie the proposed Wongawilli seam panels, it is contained within the 20mm subsidence envelope to the south of panels A3 LW3 and A3 LW4 (subsidence envelope predicted by Seedsman 2012).

Within the Wonga West 20mm subsidence zone, the main channel of Wallandoola Creek is a Schedule 2, 3rd order stream (GeoTerra, 2012a) with ephemeral 1st and intermittent 2nd order tributaries, becoming increasingly incised into Hawkesbury Sandstone as it drains downstream. Wallandoola Creek becomes a 4th order stream approximately 1.7km downstream of the proposed workings (see *Figure 2.2*).

The stream gradient generally increases with distance downstream in the Wonga West (Area 3). In the Wonga West area, Wallandoola Creek is characterised by a long linear pool and rock bar at WC1 and downstream a valley infill swamp, which overlies the BHP Cordeaux longwall subsidence area, upstream of the PAA boundary.

Downstream of WC3 (see), Wallandoola Creek reverts back to an approximately 110m long valley infill swamp, then transposes into an approximately 300m long linear pool followed by a restricted channel flowing over exposed sandstone, at the downstream end of which is a pool with a distinct iron hydroxide orange colouring. The coloured pool terminates at a rock bar with a less than 3m high shallow 'step' and a 'clear' approximately 1.7km long pool situated immediately upstream of the less than five metre drop into a plunge pool at WC4.

Waterfall W1 has two major 'steps' of 11m and 16m, for a total drop of approximately 30m over a 1.1km stream reach. Downstream of the waterfalls, and outside of the 20mm subsidence zone, the stream gradient flattens out to a series of extended pools constrained by rock bars.

The waterfall is affected by cracking in the sandstone, as the stream has not been observed to flow over the falls during 'dry' periods (GeoTerra 2012a). The sandstone streambed located approximately 100m upstream of Waterfall W1 is situated over the western edge of the old Bulli Seam workings subsidence area, and it is assessed that the stream bed cracks are due to mine subsidence. Downstream of the waterfall, the plunge pool containing Site WC5 maintains a consistent pool, with a distinctly orange 'ferruginous' colour.

Wallandoola Creek joins the Cataract River approximately eight kilometres (or 11km along the stream reach) north west of the Study Area edge, downstream of the Cataract Dam wall. Its headwaters are located south of the PAA. The creek is not regulated by any dams or weirs within the Study Area.

Lizard Creek

Lizard Creek flows in a north to north westerly direction between the proposed Wonga West Area 3 and Area 4 mining domains (see), joining the Cataract River approximately six kilometres (or seven along the stream reach) to the north of the Study Area edge, downstream of the Cataract Dam wall. Lizard Creek is not regulated by any dams or weirs.

Lizard Creek has previously been undermined by longwall mining in the Bulli seam in both the BHP Cordeaux and NRE leases. While the main channel of Lizard Creek does not overlie the proposed Wongawilli panels in Wonga West, it is contained within the 20mm subsidence envelope as predicted by Seedsman (2012).

Upstream of it's confluence with Lizard Creek Tributary 1, the main channel of Lizard Creek is a Schedule 2, 3rd order stream (GeoTerra, 2012a) with ephemeral 1st to intermittent 2nd order tributaries. This section is characterised by a series of valley infill upland swamps and pools. The pool levels are supported behind exposed sandstone rock bars, often with less than a 0.5m drop between pools which range up to approximately 500m long (GeoTerra 2012a).

The stream bed can be dry for a stream reach of approximately 750m between the downstream termination of valley fill swamp LCUS4 and the approximately 200m long, orange discoloured permanent pool upstream of Waterfall L1.

Lizard Creek becomes increasingly incised into Hawkesbury Sandstone as it drains downstream of Waterfall L1. The Waterfall is approximately 26m high. It is not observably affected by previous subsidence related cracking, however significant underflow / throughflow is observed to exit the face of the waterfall through bedding planes and joints (GeoTerra 2012a).

Downstream of the waterfall, the stream flows through a sequence of elongated pools, rock bars, boulder fields and rock shelves to LC4 and onto LC5. The creek has been observed to dry out after extended low rainfall periods between LC5 and LC6 over approximately 1.3km of stream reach in an area of sequential pools, rock bars, boulder fields and sandy sediment based pools. Permanent stream flow and pool depth is re-instated at LC6, where the water is highly orange iron hydroxide affected. Between LC6 and downstream of LC7, the stream gradient flattens out where permanent elongated pools held behind rock bars are prevalent. Downstream of Lizard Creek Tributary 2 (LC7), Lizard Creek is a 4th order stream (see *Figure 2.2*).

The northern boundary of the Gujarat lease is located at LC8, which is located in a permanent elongated pool held back by a sandstone rock shelf. From the lease boundary, the creek gradient steepens, with a series of pools held behind rock bars and elongated sandstone shelves, ending in a 20m high step / waterfall zone. Downstream of the waterfall, Lizard Creek subsequently flows into Cataract Creek.

Two 3rd order tributaries flow into Lizard Creek over Area 3. Tributary LCT1 has its headwaters over proposed Longwall A3 LW2 and A3 LW3, with the 3rd order reach overlying the northern end of A3 LW3, downstream of monitoring point C11. Swamp LCUS18 is located in its headwaters.

All of the 1st, 2nd and 3rd order components of Tributary LCT1 have previously been subsided by the Bulli Seam longwalls, with stream bed cracking, sub-surface transfer of stream flow and ferruginous seeps present in the channel. During extended dry periods, the 3rd order reach of LCT1 is dry.

The headwater of LCT2 originate in upland swamp LCUS25, which overlies the proposed Area 3 longwalls A3 LW4 and A3 LW5, as well as swamp LCUS26, which lies to the west of the proposed longwalls. The 1st and 2nd order tributaries flow over Area 3 Longwalls A3 LW4 and A3 LW5, joining as a 3rd order stream in the northwest corner of the proposed A3 LW5, which then becomes 4th order over the proposed first workings.

Tributary LCT2A and swamp LCUS25 have been undermined by first workings in the Bulli Seam, although the downstream end of LCUS25 has also been partially undermined by Longwall 310. Tributary LCT2B and swamp LCUS26 have not been undermined.

The 3rd and 4th order reach of Tributary LCT2 generally contains flowing or ponded water and does not have significant ferruginous precipitates, although it tends to be ponded during extended dry periods.

Wallandoola Creek and Lizard Creek vary along their reach from 'losing streams' in the southern headwaters, where the shallow groundwater system is recharged from stream flow seeping vertically down from the base of the creek, to 'gaining streams' in the middle and northern portions of the PAA where the creeks are incised into Hawkesbury Sandstone (GeoTerra 2012a).

Variable seepage from the Hawkesbury Sandstone enters the creeks downstream of the waterfalls and can maintain a low volume stream baseflow, depending on the interaction between rainfall runoff / recharge and groundwater level applying at any one time (GeoTerra 2012a).

2.2.2 *Groundwater*

The groundwater quality throughout the Study Area is variable. In general, sandstone and shales of the Woronora Plateau do not provide good aquifers for utilisation of groundwater resources. Past sampling indicates that shallow groundwater in association with upland swamps is relatively fresh and acidic. The V Mains area specifically only support a shallow groundwater resource within the unconsolidated swamp sediments, but is likely to be perched and not hydraulically connected to the deeper groundwater resources within the bedrock aquifer (ERM 2009).

Groundwater flow rates are higher in the moderate to high permeability shallow unconsolidated aquifer systems than low permeability deeper consolidated rocks like the Hawkesbury Sandstone. The groundwater system can provide a base flow component to stream flow and can help maintain upland swamps. Groundwater seeps at relatively low rates into the receiving streams through fractures, bedding planes and joints primarily in sandstone, as well as on top of shale/sandstone interbeds. Groundwater also supports groundwater dependent ecosystems including upland headwater and valley infill swamps (Biosis 2012a, GeoTerra 2012b).

The following five hydrogeological domains have been identified in the Study Area:

- the hydraulically disconnected (perched), ephemeral weathered Hawkesbury Sandstone soil and upland swamps;

- the deeper Hawkesbury Sandstone, which is hydraulically separated from the underlying Bulgo Sandstone at Wonga West, although not at Wonga East, both before and after subsidence, by the Bald Hill Claystone. This is one of the main aquifers in the Study Area;

- the Narrabeen Group sedimentary lithologies, the lower portions of which have already been locally fractured and depressurised above the existing workings, and will be fractured and depressurised over the proposed workings up to the upper Bulgo Sandstone. The Narrabeen Group lithologies have significantly lower yielding aquifers compared to the Hawkesbury Sandstone;

- the Illawarra Coal Measures, which contains the Bulli, Balgownie and Wongawilli seam aquifers, which have also been fractured and depressurised by the existing workings and will be locally fractured and depressurised by the proposed workings. They have limited groundwater storage and transmission potential, while the interburden sandstones, siltstones, conglomerates and shales/mudstones have very low permeabilities. The Bulli, Balgownie and Wongawilli seam aquifers would be recharged by vertical infiltration from overlying lithologies, and there is no direct connection between the seams and the surface creeks. However the Newport and Garie Formations along with the underlying Bald Hill Claystone and the upper Bulgo Sandstone outcrop within the base of the headwater valleys within the Wonga East area, and would be directly recharged by stream flow leakage from Cataract Creek and Bellambi Creek; and

- the sedimentary sequence of aquifers and aquitards underneath the Wongawilli seam (GeoTerra 2012b).

The Bald Hill Claystone hydraulically separates the Hawkesbury Sandstone and Quaternary units from the underlying Bulgo Sandstone and deeper lithologies, except where it has been eroded away in the mid valley of Cataract Creek at Wonga East (GeoTerra 2012b).

Monitoring observations a NRE No1 indicate that the groundwater quality within the regional groundwater system has not been adversely affected by past mining activities (GeoTerra 2102b).

2.2.3 *Upland Swamps*

Upland swamps are vegetated freshwater wetlands occurring in shallow basins located in low hills, plateaus of mountains. Upland swamps are significant biodiversity features that provide habitat for a high diversity of plant and animal species, many of which are threatened or endemic (DECC 2007a). Upland swamps regulate the quality and quantity of surface-water discharge by releasing moisture over extended (often dry) periods. This water availability means that many species are dependent upon upland swamps and their associated perennial streams for some or all of their lifecycle.

The Southern Coalfield Inquiry (SCI) made a distinction between headwater swamps or valley infill swamps based on location in the landscape and susceptibility to subsidence (DoP 2008). In some swamps, in particular larger swamps, it may be difficult to distinguish between where they are headwater or valley infill swamps.

Headwater swamps are situated in areas high in the catchment near catchment divides, located in areas of shallow, impervious substrate formed by either sandstone or clay horizons (DoP 2008). Headwater swamps are likely to have perched watertables within the sediments that are independent of the water table in the Hawkesbury sandstone, dependent upon rainfall and surface runoff. Groundwater seepage from these swamps contributes to downstream baseflows (PAC 2010).

Valley infill swamps are less common on the Woronora Plateau than headwater swamps. Valley infill swamps form on the floor of incised 2nd or 3rd order stream valleys on sediment deposited possibly as a result of channel blockage such as a log jam (DoP 2008). Valley infill swamps are likely to have direct connection to regional water table and may receive water from multiple sources including rainfall, streamflow and groundwater seepage (PAC 2010).

Upland swamps support wetland vegetation communities primarily sedges and wet heaths. On the Woronora Plateau, upland swamps support a mosaic of Sedgeland-Heath Complex, Tea-tree Thicket and Banksia Thicket (NPWS 2003) in response to soil moisture and fertility. Of these communities, Tea-tree Thicket is dependent upon permanently wet habitat while the others are more tolerant of decreased moisture levels (OEH 2012). The presence of Tea-tree Thickets is an indicator that a swamp is likely to support a more complex vegetation structure.

Upland swamps have been mapped, described and assessed by Biosis (2012a) (provided as *Annex Q* to the EA). A description of each upland swamp is provided in Appendix 1 of *Annex Q*. The following provides a brief summary of the upland swamps in each mining area. Further consideration of ecological values and habitat value of the upland swamps and is provided in later sections of this report and in detail in Biosis (2012a).

Wonga East

Thirty-nine (39) upland swamps were recorded within Wonga East Study Area of which 13 overlie proposed longwall panels (see *Figure 2.1*). All of the swamps within Wonga East are classed as headwater swamps.

Upland swamps in Wonga East range in size from 0.04ha to 9.84ha, with an average of 1.26ha. Within the Wonga East Study Area the total area of upland swamps is 49.06ha (Biosis 2012a).

The majority (34 of the 39) of the upland swamps in Wonga East support Banksia Thicket, with twenty (20) upland swamps supporting only this vegetation sub-community. Ten (10) upland swamps support Tea-tree Thicket. Six (6) upland swamps support a complete range of upland swamp vegetation sub-communities.

Wonga East Area 1 panels underlie two upland headwater swamps (identified as CCUS1 and CCUS2) high in the Cataract Creek catchment. CCUS1 is one of the larger swamps (4.8ha) in the Wonga East area supporting a diversity of vegetation communities. A third upland swamp (CRUS3) occurs in the Cataract River catchment, to the south of the abutment pillar of panel A1 LW2, and will not be undermined.

Eleven upland headwater swamps overly the proposed Wonga East Area 2 panels. All of these swamps have been undermined by Bulli seam first workings (Bulli bord and pillar) and in some instances longwall mining of the Balgownie Seam.

The large headwater swamp CRUS1 (9.84ha) in the Cataract River catchment partly overlies the initial part of Longwall A2 LW6. Nine upland headwater swamps occur in the Cataract Creek catchment in Wonga East Area 2 (see). CCUS6 overlies Longwall A2 LW4; CCUS3 and CCUS23 overlie Longwall A2 LW5; CCUS4 overlies Longwall A2 LW6; CCUS5 overlies Longwall A2 LW7 and A2 LW8; CCUS10 overlies Longwall A2 LW9; CCUS11 overlies Longwall A2 LW10; and CCUS12 overlies Longwall A2 LW11.

Two upland headwater swamp (BCUS11 and BCUS4) occur in the Bellambi Creek catchment and overlie the end of Longwall A2 LW11.

Wonga West

Forty-five (45) upland swamps were recorded within Wonga West (see *Figure 2.2*). Swamps within Wonga West and immediate environs, range in size from 0.06ha to the large LCUS1 complex covering 129.89ha, with an average size of 4.79ha. Within the Wonga West Study Area, the total area of upland swamps is 72.13ha (note that the boundaries of LCUS1 extend beyond the Study Area).

Wonga West contains both headwater and valley infill swamps. Four upland swamps (LCUS1, LCUS6, LCUS8 and WCUS4) contain both headwater and valley infill swamp types however, as these swamps are functioning as one larger swamp they have been named as such.

Upland swamps in Wonga West are diverse in the vegetation sub-communities they support. Restioid Heath sub-community of the Sedgeland-Heath Complex was the most abundant vegetation community in the upland swamps, with twenty-seven (27) upland swamp supporting this community of which thirteen (13) supporting only this community. Twenty-six (26) upland swamps support Banksia Thicket, with twelve (12) upland swamps supporting only this vegetation sub-community. Thirteen (13) upland swamps support Tea-tree Thicket. Six (6) upland swamps support all of the upland swamp vegetation sub-communities.

Twelve upland swamps overlie the proposed longwalls in Area 3. In the Wallandoola Creek catchment, upland swamps over the longwall panels include WCUS4, WCUS11, WCUS12 and WCUS8. Upland swamp WCUS7 partially overlies the gateroad and/or abutment pillars of A3 LW3 and A3 LW4. In the Lizard Creek catchment, upland swamps over the workings include LCUS9, LCUS18, LCUS20, LCUS21 and LCUS25. Part of LCUS12 overlies Longwall A3 LW1 while a large part of the same swamp complex occurs to the east of the proposed gateroad. Similarly part of LCUS8 complex occurs over the proposed gateroad to Longwall A3 LW1 while the large part of the swamp extends over Lizard Creek.

LCUS13, LCUS14, LCUS15 and LCUS33 all overlie the mainroad access to the proposed Balgownie seam first workings.

Area 4 is located to the north of Lizard Creek and comprises Longwalls A4 LW6 and A4 LW7. These panels are each 155m wide with 65m pillars located at least one kilometre from the Cataract Dam wall and positioned to avoid subsiding or cracking Lizard Creek, as well as to avoid generating a hydraulic connection via subsidence cracking between the 20mm subsidence zone and Cataract Reservoir.

There are no upland swamps mapped over the longwall panels in Area 4 however LCUS28 overlies the gateroad to Longwall A4 LW6.

2.3 BIOGEOGRAPHY

The proposed longwall mining areas of Wonga East and Wonga West underlie the Metropolitan Special Area (MSA) managed by the SCA. The 'Special Areas' are managed for the dual purposes of water supply protection and maintenance of ecological condition (SCA 2007). Over 26 significant plant species, 30 threatened animal species and 10 endemic fish species have been identified in the Special Areas (DECC 2007a).

The Study Area forms part of the Great Eastern Ranges initiative (formerly the Alps to Atherton Conservation Corridor) (DECC 2007b).

Comprehensive vegetation mapping of the Woronora O'Hares and Metropolitan Catchments was produced by NSW National Parks and Wildlife Service (NPWS 2003) and covers the Study Area. The mapping indicates that the PAA is predominantly dry sclerophyllous woodlands on exposed sandstone plateau with extensive upland swamps within shallow drainage basins. Within the gullies and gorges, tall moist forests predominate with some temperate rainforest also occurring in the deeper gullies in Wonga East. Large areas are unfragmented and are therefore important both locally and regionally for both flora and fauna.

Native vegetation has previously been cleared at areas of existing infrastructure, including at the Russell Vale site, the primary personnel and equipment shaft (Shaft 4), other ventilation shafts and along access tracks.

2.4 *FEATURES OF SPECIAL SIGNIFICANCE*

The SCI identified that the Southern Coalfields underlie a landscape containing highly significant ecological features that are sensitive to subsidence impacts resultant of longwall mining (DoP 2008). The sensitive landscape features include streams, swamps, rocky habitats, endangered ecological communities (EECs) and threatened species.

Highly significant natural features are classified as features of 'special significance' in the NSW Planning Assessment Commission (PAC) review reports for the Bulli Seam Operations (BSO) (PAC 2010). Special significance status is based on assessment of a natural feature that determines *the feature to be so special that it warrants a level of consideration (and possibly protection) well beyond that accorded to others of its kind*. It may be based on a rigorous assessment of scientific importance, archaeological and cultural importance, 'uniqueness', meeting a statutory threshold or some other identifiable value or combination of values (PAC 2009).

This section discusses the vulnerability of ecological features to the impacts of subsidence as identified by DECC (2007a) in their submission to the Southern Coalfield Inquiry (SCI); the outcomes of the Metropolitan Colliery PAC review (PAC 2009) and BSO PAC (2010); and in the draft Upland Swamp Environmental Assessment Guidelines released by the Office of Environment and Heritage (OEH 2012). These guidelines have been prepared to provide guidance for the underground mining industry operating in the southern coalfields.

2.4.1 *Streams*

The SCI identified that streams of the Southern Coalfields are considered a high priority for protection if they have some or all of the following characteristics:

- perennial or intermittent/ephemeral streams with pools;
- a diverse array of in-stream habitats that provide feeding, breeding or drought refuge;
- and/or they support threatened species, iconic species or a high diversity of species (DECC 2007a).

The parameters that contribute to whether a stream is of special significance as outlined in the Bulli Seam Operations PAC (2010) include size or scale of the stream, hydrological values to the catchment and water use, ecological values, environmental qualities or naturalness, visual amenity and community values.

The Study Area is known to contain intermittent and perennial streams and channel pools that are expected to provide habitat for a diverse array of species, particularly in dry periods. The Bulli Seam Operations PAC (2010) identifies Wallandolla Creek as a stream of special significance status. An assessment of stream values has been undertaken for the Project and is presented in Chapter 16 of the Environmental Assessment Report and in GeoTerra (2012a).

The assessment identified that Cataract Creek is a stream of special significance because: it is characterised by permanent flow; a diversity of habitats; is known to support threatened fish species; provides habitat for the threatened Adams Emerald Dragonfly (Cardno Ecology Lab 2012); has headwater upland swamps in its catchment and these swamps provide habitat for threatened species; and water supply values.

Cataract River is a stream of special significance for naturalness, hydrological values to the catchment and water supply, ecological values, visual amenity and community values.

Lizard Creek has previously not been considered a stream of special significance in the Bulli PAC (2010) given diminished naturalness values attributed to the effects of previous mining (dry in affected reaches after extended lack of rainfall, highly ferruginous). Notwithstanding this, the PAC considered Lizard Creek a significant stream because of scale, hydrological value and the environmental quality of its physical form and largely pristine setting worthy of protection from negligible impacts (PAC 2010). Since that time, upland swamps within the creek and its tributaries have been identified as an endangered ecological community. Monitoring of the creek by Cardno Ecology Lab (2012a) indicates that while the AUSRIVAS 'health' of aquatic macroinvertebrates varied seasonally so did the control sites however, the SIGNAL2 scores indicated that the creek is more polluted than control sites.

The reach of Lizard Creek within the Study Area has been assessed as not of special significance on the basis that its naturalness has been diminished by the effects of previous mining. Notwithstanding this assessment, it does warrant protection and will not be undermined by the proposed longwall mining.

The 3rd order tributaries of Lizard Creek have been assessed as warranting special significance for LCT2 however LCT1 has also been adversely affected by previous mining and has been assessed by GeoTerra (2012a) as not warranting consideration as special significance on the basis of diminished naturalness values.

The Bulli PAC (2010) on the basis of a qualitative assessment identified Wallandoola Creek as a stream of 'special significance' status. GeoTerra (2012a) identify that for the a length of Wallandoola Creek within the Study Area, or more specifically within the 20mm subsidence zone, the 'naturalness' values of the creek are also diminished due to the effects of previous mining.

The waterfalls on Lizard Creek and Wallandoola Creek have been assessed as features of special significance both as part of the stream system (GeoTerra 2012a) and as cliff feature (SCT 2012).

Subsidence due to longwall mining can impact on stream flows, pools and in-stream habitats by causing cracking in the regolith (DoP 2008). Surface cracking can have the following consequences for aquatic environmental values:

- loss of or redirection of surface flows;
- loss of aquatic or in-stream habitats;
- loss of longitudinal connectivity;
- changes to water quality, in particular ferruginous springs and/or development of iron bacterial mats;
- reduced diversity of in-stream habitat; and
- altered hydrochemistry of aquatic habitat.

2.4.2 *Upland Swamps*

Upland swamps are habitats of high conservation value and are recognized as a habitat of high priority for conservation in the Sydney region (DECC 2007d). Four contiguous networks of intact upland swamps are considered to be of particular conservation significance (DECC 2007a) including the Wallandoola Creek swamp cluster that is mapped as extending across the majority of the Study Area.

Both the Metropolitan (PAC 2009) and BSO PAC reports (PAC 2010) provided guidelines for determination of special significance of swamps and for assessment of the potential impacts from subsidence. With the listing of the Endangered Ecological Community Coastal Upland Swamp in the Sydney Basin Bioregion all upland swamps meet the criteria for special significance. In light of this, and to provide a best practice guide for assessment and management of upland swamps, OEH have developed draft assessment guidelines for the underground mining industry operating in the southern coalfields (OEH 2012).

OEH (2012) guideline defines a swamp being of special significance by consideration of whether it meets three of the following five criteria:

- statutory thresholds, indicated by the presence of threatened ecological communities or threatened species; or
- swamp size greater than 7.4ha being in the top 10% of swamps in the region;
- unusual complexity or biodiversity supported by a full range of habitats associated with a mosaic of hydrological characteristics from drier fringing areas to permanently wet areas. Where vegetation mapping has been undertaken complexity is indicated by the presence of Banksia Thicket, Tea-tree Thicket and Sedgeland-Heath Complex. Where mapping of NPWS (2003) is relied upon, the presence of Tea-tree Thicket is an indicator of unusual complexity; or
- closely proximate habitat being a swamp occurring in one of the four key clusters of swamps (as defined by the PACs); or

- importance for scientific research being those swamps in Dharawal upland swamp scientific research area plus paired reference sites.

An assessment of the special significance of the upland swamps in the Study Area was undertaken by Biosis (2012a) in accordance with the procedures outlined in the OEH (2012) guidelines and is included in the EA Report as *Annex Q*.

All of the upland swamps within the Study Area meet criterion for statutory thresholds (Coastal Upland Swamp EEC), and criterion of closely proximate habitat (all are part of the Wallandoola Creek cluster).

The Study Area supports 84 upland swamp clusters. Biosis (2012) identified that seven (7) of the 39 uplands swamp in Wonga East are considered to be of 'special significance' according to criteria set out in OEH (2012) (see *Table 2.1*)

In addition to meeting the statutory and closely proximate habitat criteria, CRUS1 is considered to be of 'special significance' based on size, while CCUS1, CCUS4, CCUS5, CCUS10, CRUS2 and CRUS3 are considered to be of 'special significance' due to the complexity of vegetation sub-communities within these swamps, as all support Banksia Thicket, Tea-tree Thicket and Sedgeland-Heath Complex.

Of the seven swamps of special significance, five have potential to be subject to subsidence (CCUS1, CCUS4, CCUS5, CCUS10 and CRUS1).

Eight (8) of the 45 uplands swamp in Wonga West are considered to be of 'special significance' according to criteria set out in OEH (2012) (see *Table 2.2*).

In addition to meeting the statutory, closely proximate habitat criteria all of the swamps of special significance in Wonga West are considered to be of 'special significance' due to the complexity of vegetation sub-communities within these swamps, as all support Banksia Thicket, Tea-tree Thicket and Sedgeland-Heath Complex. In addition to meeting three of the five criteria three of the upland swamps meet a fourth criterion based on size being LCUS1 (129.9ha), WCUS1 (36.16ha) and WCUS4 (11.08ha).

Of the eight swamps of special significance, four have potential to be subject to subsidence (LCUS8, WCUS4, WCUS7 and WCUS11).

Table 2.1 Upland Swamps of Special Significance in Wonga East

Swamp Name	Special Significance Criteria					
	Statutory	**Size (ha)**	**Complexity**	**Closely Proximate Habitat**	**Scientific**	**Reason**
CCUS1	Coastal Upland Swamps EEC	4.81	Yes (MU42, MU43, MU44b, MU44c)	All part of the Wallandoola Swamp Cluster	No	Statutory, complexity, closely proximate habitat
CCUS10		1.63	Yes (MU42, MU43, MU44c)			Statutory, complexity, closely proximate habitat
CCUS4		1.77	Yes (MU42, MU43, MU44c)			Statutory, complexity, closely proximate habitat
CCUS5		3.45	Yes (MU42, MU43, MU44a)			Statutory, complexity, closely proximate habitat
CRUS1		9.84	No (MU42, MU43)			Statutory, complexity, closely proximate habitat
CRUS2		3.12	Yes (MU42, MU43, MU44c)			Statutory, complexity, closely proximate habitat
CRUS3		3.42	Yes (MU42, MU43, MU44a, MU44b, MU44c)			Statutory, complexity, closely proximate habitat

Source: Biosis (2012a)
Vegetation communities are: MU42 = Upland Swamp Banksia Thicket; MU43 = Upland Swamp Tea-tree Thicket; MU44a = Sedgeland-Heath Complex (Sedgeland); MU44b = Sedgeland-Heath Complex (Restioid Heath) and MU44c = Sedgeland-Heath Complex (Cyperoid Heath).

Table 2.2 Upland Swamps of Special Significance in Wonga West

Swamp Name	Special Significance Criteria					
	Statutory	**Size (ha)**	**Complexity**	**Closely Proximate Habitat**	**Scientific**	**Reason**
LCUS1	Coastal Upland Swamps EEC	129.9	Yes (MU42, MU43, MU44b)	All part of the Wallandoola Swamp Cluster	No	Statutory, complexity, size, closely proximate habitat
LCUS27		1.04	Yes (MU42, MU43, MU44b)			Statutory, complexity, closely proximate habitat
LCUS6		3.74	Yes (MU42, MU43, MU44a, MU44b, MU44c)			Statutory, complexity, closely proximate habitat
LCUS8		2.09	Yes (MU42, MU43, MU44a, MU44b)			Statutory, complexity, closely proximate habitat
WCUS1		36.16	Yes (MU42, MU43, MU44c)			Statutory, size, complexity, closely proximate habitat
WCUS11		2.79	Yes (MU42, MU43, MU44b)			Statutory, complexity, closely proximate habitat
WCUS4		11.08	Yes (MU43, MU44a, MU44b, MU44c)			Statutory, size, closely proximate habitat
WCUS7		1.97	Yes (MU42, MU43, MU44c)			Statutory, complexity, closely proximate habitat

Source: Biosis (2012a)

Vegetation communities are: MU42 = Upland Swamp Banksia Thicket; MU43 = Upland Swamp Tea-tree Thicket; MU44a = Sedgeland-Heath Complex (Sedgeland); MU44b = Sedgeland-Heath Complex (Restioid Heath) and MU44c = Sedgeland-Heath Complex (Cyperoid Heath).

SCI identified that they are unaware of any significant impacts on headwater swamps caused by mining subsidence with most known impacted swamps being valley infill swamps (DoP 2008). More recently, the BSO PAC identified that a headwater swamp in Dendrobium Area 2 has been identified as potentially adversely affected (PAC 2010). SCI identified that the physical subsidence impacts for valley infill swamps were tensile cracking and movement of joint and bedding planes; and buckling and localized upsidence in the stream bed below the swamp. The primary consequence for valley infill swamps is:

- draining of swamps leading to:
  - drying and potential erosion and scouring of dry swamp;
  - loss of standing pools within the swamp;
  - vulnerability to fire damage;
  - change to swamp vegetation communities; and
  - adverse water quality impacts eg iron bacterial matting;
- loss of stream base flow (DoP 2008).

Secondary consequences for valley infill swamps include:

- loss of terrestrial and aquatic habitats and associated fauna, including threatened species dependent on swamp ecosystems; and
- loss of water purification and flow regulation function for downstream ecosystems.

The SCI Panel upon review of available information at that time concluded that *undermining of valley infill swamps has or will cause drainage, water table drop and consequent degradation of swamp water quality and associated vegetation* (DoP 2008).

Headwater swamps are susceptible to tensile cracking and movement of joint and bedding planes in the rock below the swamp. The primary consequences are potential drop in the perched water table leading to draining of the swamp. The potential impacts on headwater swamps are likely to be similar in character but less extensive and significant than for valley infill swamps (DoP 2008). Secondary consequences are the same as for valley infill swamps (DoP 2008).

A risk assessment for the upland swamps of 'special significance' was undertaken in accordance with the OEH (2012) guidelines, and is provided in *Annex O* and summarised in *Chapter 22* of the EAR.

2.4.3 *Rocky Habitats*

Rocky habitats that occur along valley sides and cliffs are vulnerable to subsidence impacts, particularly where they occur directly above a mined area and resulting goaf. Consequences of subsidence impacts for rocky habitats are primarily associated with overhang collapse, rock falls and surface cracking (DoP 2008). Plant and animal species dependent upon rocky environments during some part of their lifecycle are most likely to be impacted by subsidence due to longwall mining. Threatened species such as the Broad-headed Snake (*Hoplocephalus bungaroides*) and cave roosting bats are of primary ecological concern in these areas (DECC 2007a).

An assessment of mining impacts on cliffs and steep slopes was undertaken by SCT Operations (2012) and is provided in Annex V of the EA. The assessment included an inspection of cliff formations and steep slopes within both Wonga East and Wonga West that were mapped from LIDAR data by Mine Subsidence Engineering Consultants (MSEC).

In Wonga East cliff formations along Cataract Creek are typically less than a few metres high, but up to five metres high for about 30m above A2 LW8 and five to 10m high for about 50m above A2 LW10 (SCT 2012). Several cliff formations higher than 10m are located along Rocky Creek, tributary of Cataract River in the south of the Study Area.

Wonga West is located entirely within Hawkesbury Sandstone strata dominated by gently sloping area with areas of steep slopes and tiers of smaller cliff formations along the channels of Lizard Creek and Wallandolla Creek downstream of the waterfalls, and along LCT1 (SCT 2012). A 300m long section of continuous cliff formation greater than 10m high is located on the northern side of Lizard Creek (SCT 2012). Along LCT1 there are numerous steep slopes and smaller sandstone cliff formations that typically extend laterally for more than 20m. A previously undermined 10 to 15m high cliff formation of about 100m length is located immediately to the north of A3 LW3 (SCT 2012).

The PAC reports (2009, 2010) defined cliffs of special significance status as those that are longer than 200m, higher than 40m, and higher than 5m that constitute waterfalls.

SCT (2012) identified three features in the Study Area that are of special significance:

- waterfall on Lizard Creek;
- waterfall on Wallandoola Creek; and
- a 300m long cliff line on the northern side of Lizard Creek (SCT 2012).

All of the features of special significance occur in the Wonga West area. In addition to these the line of cliff formations above Longwall A4 LW6, that is semi-continuous over the panels and extends for approximately 700m to the north west of the panel, is considered border line special significance depending on how the length of cliff is defined. Although there is approximately 300m or so of the cliff line directly above the panel, the cliff line is discontinuous and isolated rock falls are not considered likely to be of high significance (SCT 2012).

The Illawarra Escarpment is recognised as a feature of special significance. However, the mine plan was modified early in the planning process to provide the required risk management zone buffer to the escarpment.

2.4.4 *Endangered Ecological Communities*

EECs listed under the TSC Act and/or the EPBC Act are considered priority habitats for conservation within NSW due their species composition, extent and distribution in the landscape. Subsidence impacts due to longwall mining are likely to be less severe in terrestrial EECs than those impacts associated with swamps and streams (DECC 2007a).

Five EECs are known to occur in the Southern Coalfields. Two of the communities are identified in the key threatening process determination as likely to be impacted by subsidence due to longwall mining and other associated mining activities (DECC 2008):

- O'Hares Creek Shale Forest; and
- Shale/Sandstone Transition Forest.

The third community is the recently listed Coastal Upland Swamps in the Sydney Basin bioregion EEC. The determination for this EEC identifies subsidence as a key threatening process. In identifying that, the upland swamps in the Study Area are representative of this EEC, it was assessed that the upland swamps are not consistent with EPBC Act listed *Temperate Highland Peat Swamps on Sandstone* EEC, because they do not meet three key criteria including altitudinal range, distribution and soils (Biosis 2012a; see Section 1.2.3 of *Annex Q*). Although the upland swamps of the Woronora Plateau are not identified as part of this EEC, the Commonwealth Threatened Species Scientific Committee is currently reviewing the listing in this respect (DECCW 2011).

2.4.5 *Threatened Species*

Threatened species are those species listed on the TSC Act and/or EPBC Act. Adverse consequences of subsidence for threatened species are most severe for species reliant upon habitats vulnerable to the impacts of subsidence (DECC 2007a). Specifically these habitats include streams, swamps and rocky habitats (DECC 2007a). The DECC submission to the SCI outlines threatened and rare species that are vulnerable to the impacts of subsidence, which should be considered when undertaking Environmental Assessments in the Southern Coalfields (DECC 2007a). These species are listed in *Table* 2.3 and *Table 2.4*, and represent threatened flora and fauna that were targeted in this terrestrial ecological assessment of the Study Area. (Note that the tables also include species which are not listed as threatened but are considered to be of high interest to the community according to DECC (2007a)).

The superseded DECCW upland swamp guidelines identified swamp specialists that are unable to withstand loss of individuals from a population within the Catchment Management Authority (DECCW 2011). The fauna species of national, state and regional significance are identified in *Table 2.3*. Swamp specialist and threatened flora species on the Woronora Plateau include *Pultenaea aristata* (national significance), *Acacia baueri* (state significance) and *Darwinia grandiflora* (regional significance) (DECCW 2011).

The regional conservation priority of species in the Special Areas of the Woronora Plateau has been included in *Table 2.3* based upon findings of a joint terrestrial vertebrate fauna survey by DECC and the SCA (DECC 2007d).

Table 2.3 Fauna Species within Southern Coalfields Vulnerable to Subsidence

Common Name	Scientific Name	TSC Act Status[4]	EPBC Act Status[4]	Regional Conservation Priority[2]	Swamp Specialist and Significance Level[3]	Vulnerability to Subsidence[1] and Habitat		
						Upland swamp	Creeks or rivers	Cliffs, rock benches or overhangs
Beautiful Firetail	*Stagonopleura bella*	-	-	Moderately High	NA – regional significance	**Yes**	No	No
Black Bittern	*Ixobrychus flavicollis* #	V	-	High	-	No	**Yes**	No
Broad-headed Snake	*Hoplocephalus bungaroides* #	E	V	High	-	No	No	**Yes**
Brush-tailed Rock Wallaby*	*Petrogale penicillata*	E	V	Highest	-	No	No	**Yes**
Eastern Bentwing-bat**	*Miniopterus schreibersii oceanensis* #	V	-	Lower	-	No	No	**Yes**
Eastern Bristlebird*	*Dasyornis brachypterus*	E	E	Highest	No – national significance	**Yes**	No	No
Eastern Pygmy Possum	*Cercartetus nanus* #	V	-	Moderate	Yes – regional significance	**Yes**	No	No
Giant Burrowing Frog	*Heleioporus australiacus* #	V	V	Moderate	Yes – national significance	**Yes**	**Yes**	No
Giant Dragonfly[4]	*Petalura gigantea*	E		-	No – state significance	**Yes**[5]	**-**	-
Green and Golden Bell Frog*	*Litoria aurea* #	E	V	Highest	Yes – national significance	No	**Yes**	No
Ground Parrot*	*Pezoporus wallicus wallicus*	V	-	Highest	No – state significance	**Yes**	No	No
Heath Frog or Littlejohn's Tree Frog	*Litoria littlejohni* #	V	V	High	Yes – national significance	**Yes**	**Yes**	No
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	V	High	-	No	No	**Yes**
Large-footed Myotis	*Myotis macropus* #	V	-	High	-	No	**Yes**	No
Little Tern	*Sterna albifrons* #	E	-	-	-	No	**Yes**	No
Long-nosed Potoroo *	*Potorous tridactylus*	V	V	Highest	Yes – national significance	**Yes**	No	No
Platypus***	*Ornithorhynchus anatinus*	-	-	Lower	-	No	**Yes**	No
Red-crowned Toadlet	*Pseudophryne australis* #	V	-	Moderate	Yes – regional significance	**Yes**	**Yes**	**Yes**

Common Name	Scientific Name	TSC Act Status[4]	EPBC Act Status[4]	Regional Conservation Priority[2]	Swamp Specialist and Significance Level[3]	Vulnerability to Subsidence[1] and Habitat		
						Upland swamp	Creeks or rivers	Cliffs, rock benches or overhangs
Rosenberg's Goanna	*Varanus rosenbergi* #	V	-	Moderate	Yes – regional significance	**Yes**	No	No
Southern Emu-wren	*Stipiturus malachurus*	-	-	Moderate	NA – regional significance	**Yes**	No	No
Stuttering Barred Frog	*Mixophyes balbus*	V	V	Highest	-	No	**Yes**	No
Tawny-crowned Honeyeater	*Phylidonyris melanops*	-	-	Moderate	NA – regional significance	**Yes**	No	No
Turquoise Parrot	*Neophema pulchella*	V	-	Moderately High	Yes – regional significance	**Yes**	No	No

1 Vulnerability to Subsidence from DECC (2007a, 2008)
2. Regional conservation priority of species in the Woronora, O'Hares Creek and Metropolitan Special Areas based upon DECC (2007d)
3. Ability to withstand loss within the Hawkesbury Nepean Catchment (HNC) and associated threshold of special significance on the Woronora Plateau from DECCW 2011. Swamps supporting species of national and state significance are of special significance.
4. Status: V- vulnerable; E – endangered
5. Not identified by DECC (2007a)
6. * May be locally extinct (DECC 2007a), ** maternity sites a very high priority, *** of high interest to the community (DECC 2007a), # recorded within 10km of the Study Area

Table 2.4 Flora Species within Southern Coalfields Vulnerable to Subsidence

Common name	Scientific name	TSC Act status[2]	EPBC Act status[2]	ROTAP status[3]	Vulnerability to Subsidence[1]		
					Habitat in upland swamps	Habitat in creeks or rivers	Habitat on cliffs, rock benches or overhangs
	Acacia baueri subsp. *aspera* #	V	-	2RC-	No	No	**Yes**
Christmas Bells	*Blandfordia cunninghamii*	-	-	3RCi	**Yes**	No	**Yes**
Lizard Orchid	*Burnettia cuneata*	-	-	3RC-	**Yes**	No	No
	Darwinia grandiflora	-	-	2RCi	**Yes**	No	No

Common name	Scientific name	TSC Act status[2]	EPBC Act status[2]	ROTAP status[3]	Vulnerability to Subsidence[1]		
					Habitat in upland swamps	**Habitat in creeks or rivers**	**Habitat on cliffs, rock benches or overhangs**
	Epacris coriacea	-	-	3RC-	No	No	**Yes**
	Epacris purpurascens var. *purpurascens* #	V	-	2KC-	**Yes**	**Yes**	No
Yellow-topped Mallee-ash	*Eucalyptus luehmanniana*	-	-	2RCa	No	No	**Yes**
Creeping Raspwort	*Gonocarpus salsoloides*	-	-	3RCa	**Yes**	No	No
Fern-leaf Grevillea	*Grevillea longifolia*	-	-	2RC-	No	**Yes**	**Yes**
Small-flower Grevillea	*Grevillea parviflora* subsp. *parviflora*	V	V	-	**Yes**	No	No
Wedge-Leaf Hibbertia	*Hibbertia hermanniifolia*	-	-	3RCa	No	No	**yes**
Shiny-leaf Guinea Flower	*Hibbertia nitida*	-	-	2RC-	No	**Yes**	No
Woronora Beard-heath	*Leucopogon exalasius*	V	V	2VC-	No	**Yes**	No
Native Cranberry	*Lissanthe sapida*	-	-	3RCa	No	No	**Yes**
River Mat-Rush	*Lomandra fluviatilis*	-	-	3RCa	No	**Yes**	No
Yellow Loosestrife	*Lysimachia vulgaris* var. *davurica*	E	-	-	**Yes**	**Yes**	No
Deane's Paperbark	*Melaleuca deanei*	V	V	3RC-	**Yes**	No	No
	Monotoca ledifolia	-	-	3RCa	No	**Yes**	**Yes**
Needle Geebung[5]	*Persoonia acerosa*	V	V		Fringing habitat	No	No
Brown Pomaderris	*Pomaderris brunnea* #	V	V	2VC-	No	**Yes**	No
Prickly Bush-pea	*Pultenaea aristata* #	V	V	2V	**Yes**	No	No

1. Vulnerability to Subsidence from DECC (2007a, 2008)
2. Status: V- vulnerable; E – endangered;
3. RoTAP status: 2 = geographic range in Australia less than 100km, 3 = geographic range in Australia is less than 1000km, R =- rare, V = vulnerable, C = conserved, a = 1000 plants or more known to occur within a conservation reserve, i = less than 1000 plants known to occur in a conservation reserve, - = reserve population size not accurately known
4. # - previously recorded within 10km of the Study Area.
5. Identified as susceptible to subsidence impacts in the determination of 'Alteration of habitat following subsidence due to longwall mining as a key threatening process'.

3 METHODS

This chapter describes the methodology of the flora and fauna assessment including desktop research and a number of field investigations.

3.1 DESKTOP RESEARCH

Desktop research was undertaken to ascertain environmental condition and to collect records of threatened species, ecological communities and existing vegetation mapping within the Study Area, as described in the following pages.

3.1.1 Literature Review

Two Planning Assessment Commision (PAC) reports were reviewed and additional literature from previous studies was undertaken, as described here.

Planning Assessment Commission Reports

The Metropolitan Coal Project PAC Report (Metropolitan PAC) (PAC 2009) provided feedback on a number of issues relevant to the Project. It is noted that there was significant concern regarding the importance of upland swamps in the Metropolitan Study Area, their classification and the detail to which the impacts on swamps was assessed. The PAC also raised concerns relating to the assessment of threatened species and triggering of legislation including the TSC Act and EPBC Act. Of specific concern was the occurrence and potential for impacts to the Eastern Ground Parrot. Other issues of concern included the identification and assessment of cliffs, overhangs and other habitat important to threatened species.

The Bulli Seam Operations PAC Report (Bulli PAC) identifies that the critical areas of concern include upland swamps, and threatened species. There was significant concern regarding the level and distribution of survey effort. Of particular concern was the level of survey effort directed toward swamps dependent species including frogs and Eastern Ground Parrot. Additional concerns raised included the adequacy of sampling effort in identifying targeted threatened species. There were concerns from the panel that there was insufficient survey effort to adequately assess the impacts of the proposed mining on ecology of the Bulli area.

In order to avoid encountering similar issues with the PAC, the following steps were undertaken:

- ERM has identified in this report that the Study Area has altered as the mine plans have changed over time, which explains why some of the survey effort was conducted outside of the current Study Area;
- the survey team endeavoured to distribute the survey effort randomly and as evenly across the Study Area as was feasible under the topographic conditions;
- engagement of two specialist herpetology subcontractors to provide informed specialist consideration of threatened frogs and reptiles in the Study Area;

- stratification of survey areas allocated proportionately greater amount of survey effort to upland swamps than terrestrial ecosystems;

- consideration of each swamp and streams values (in terms of biodiversity, hydrology and social values) was considered to determine special significance in consultation with specialists in particular GeoTerra;

- survey effort was weighted toward those species which are of high conservation value which are considered most at risk from the impacts of subsidence, particularly swamp dependent species and amphibians;

- targeted survey for Eastern Ground Parrot in suitable habitat, including call broadcasting;

- identification of ecologically significant swamp areas in Wallandoola Creek and Lizard Creek was flagged early in the iterative mine planning process;

- ecologically significant swamps and creeks were used to define boundaries of longwall panels, as a means of impact avoidance;

- assessment of all threatened species and ecological communities which have a moderate to high or high likelihood of occurrence in the Study Area, and which are considered vulnerable to subsidence was undertaken under the TSC Act and EPBC Act; and

- identification of the area in which cliffs and overhangs are most likely to occur in the Study Area.

Previous Studies

A review of previous Flora and Fauna Assessments and Environmental Assessments within the Southern Coalfields was undertaken. Literature from field surveys within the NRE No1 Colliery, V Mains, T and W Mains, Metropolitan Colliery and Wongawilli Colliery were reviewed.

The literature review provided an understanding of the existing environment within the Study Area, and provided a context of the Study Area within the regional landscape. A summary of the documents is provided below.

ERM (2009): ERM prepared a Flora and Fauna Assessment for the V-Mains development, which is located immediately adjacent to the southern boundary of the proposed Wonga West longwall development. The V-Mains Flora and Fauna Assessment recorded nine species and one ecological community listed as threatened under the TSC Act. A revision of the document suggests that one of those species (Marbled Frogmouth (*Podargus ocellatus*)) is likely to have been a misidentified specimen of Tawny Frogmouth (*Podargus strigoides*). *Table 3.1* lists the threatened species and ecological communities recorded within the Application Area of the V-Mains development, which are expected to occur within the Study Area of the Project.

Table 3.1 Threatened Species and EECs Recorded by ERM (2009)

Species / community name	TSC Act Status	EPBC Act Status
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	EEC	EEC
Gang-gang Cockatoo *Callocephalon fimbriatum*	V	-
Eastern Pygmy Possum *Cercartetus nanus*	-	V
Brown Treecreeper *Climacteris picumnis victoriae*	V	-
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	V	-
Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*	V	-
Eastern Freetail-bat *Mormopterus norfolkensis*	V	-
Powerful Owl *Ninox strenua*	V	-
Greater Broad-nosed Bat *Scoteanax rueppellii*	V	-

1. Source: ERM (2009)
2. V = vulnerable, E = endangered, EEC = endangered ecological community

Western Research Institute (2009): The Metropolitan Colliery was subject to a Flora and Fauna Assessment as part of their 2009 Environmental Assessment. Bangalay Botanical Surveys conducted a botanical assessment of the proposed Metropolitan Colliery expansion between 2006 and 2008. Four threatened flora species were recorded: Prickly Bush-pea (*Pultenaea aristata*), Bynoe's Wattle (*Acacia bynoeana*) and Thick-leaf Star-hair (*Astrotricha crassifolia*) and Deane's Paperbark (*Melaleuca deanei*). Some specimens collected may have been *Leucopogon exolasius* and *Epacris purpurascens* var. *purpurascens* although identification was not confirmed.

Zoological surveys were conducted by Biosphere Environmental Consultants and Western Research Institute. Thirteen threatened fauna species were recorded during the surveys being Giant Burrowing Frog (*Heleioporus australiacus*), Red-crowned Toadlet (*Pseudophryne australis*), Broad-headed Snake, Black-necked Stork (*Ephippiorhynchus asiaticus*), Square-tailed Kite (*Lophoictinia isura*), Grey Falcon (*Falco hypoleucos*) (suspected by ERM to be a misidentified Grey Goshawk (*Accipiter novaehollandiae*)), Turquoise Parrot (*Neophema pulchella*), Eastern Ground Parrot (*Pezoporus wallicus wallicus*), Eastern Pygmy-possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*), Grey-headed Flying Fox (*Pteropus poliocephalus*), Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Large-footed Myotis (*Myotis macropus* syn. *M. adversus*).

Biosis (2008): Biosis prepared a Flora and Fauna Assessment to accompany a Subsidence Management Plan (SMP) application for several proposed longwalls and the Pillar Extraction Area at NRE Wongawilli Colliery, to the south of the current Study Area. No threatened ecological communities were recorded in the Study Area. One threatened plant species, Prickly Bush-pea was recorded in large numbers within and adjacent to the Study Area and habitat was identified for a further eight threatened plant species. Nine threatened or migratory animal species were recorded in the Study Area. The assessments of significance undertaken by Biosis (2008) concluded that the proposal was likely to have a significant impact on local populations of Heath Frog (*Litoria littlejohni*), Giant Burrowing Frog (*Heleioporous australiacus*) and the Red-crowned Toadlet (*Pseudophryne australis*).

DECC and SCA (2007c and 2007d): DECC and SCA in a joint undertaking have conducted baseline fauna surveys of terrestrial fauna between 2002 and 2005 of the Greater Southern Sydney region in particular Sydney's drinking water catchments. Areas surveyed included Warragamba Special Area; and of greatest interest for this assessment, the Woronora, O'Hares Creek and Metropolitan Special Areas. The results of the field investigations informed habitat and distribution mapping of species; identification of a subset of species of conservation concern for detailed conservation assessment and development of management actions; creation of a prioritised list of terrestrial vertebrate for conservation actions; assessment of fauna habitats to identify the most important and the prevalence of these habitats. Volume 2 (DECC 2007c) and Volume 4 (DECC 2007d) of this project were specifically reviewed.

It is noted that within the Woronora, O'Hares Creek and Metropolitan Special Areas:

- the Long-nosed Potoroo (*Potorous tridactylus*) is extremely rare in the area and the highest priority fauna species, as this area is thought to be the last area where it exists in the Greater Sydney region;

- there are eight species of highest conservation priority that are probably locally extinct including the Ground Parrot (*Pezoporus wallicus wallicus*), Eastern Bristlebird (*Dasyornis brachypterus*), Parma Wallaby (*Macropus parma*), Brush Stone-curlew (*Burhinus grallarius*), Southern Brown Bandicoot (*Isoodon obesulus obesulus*), Brush-tailed Rock-wallaby (*Petrogale pencillata*), Stuttering Frog (*Mixophyes balbus*) and Green and Golden Bell Frog (*Litoria aurea*);

- there are three priority fauna habitats: upland swamps; grassy box woodlands; alluvial forest and woodlands with upland swamps having highest priority (DECC 2007d); and

- protects a critical proportion of the known habitat in the Greater Sydney region for Litteljohn's Tree Frog or Heath Frog (*Litoria littlejohni*), Broad-headed Snake (*Hoplocephalus bungaroides*), Koala (*Phascolarctos cinereus*), Beautiful Wren (*Stagonopleura bella*), Southern Emu-wren (*Stipiturus malachurus*), Tawny-crowned Honeyeater (*Phylidonyris melanops*), Rosenberg's Goanna (*Varanus rosenbergi*), Giant Burrowing Frog (*Heleioporus australiacus*), Red-crowned Toadlet (*Pseudophyrne australis*) and Eastern Pygmy-possum (*Cercartetus nanus*).

Data within these two reports has informed assessments of likelihood of species presence, status of population, extent of habitat and conservation significance on a regional scale.

Environmental Resources Management Pty Ltd (2006)**:** ERM undertook a desktop assessment and field surveys within the current PAA in April 2006. Shale Sandstone Transition Forest (an Endangered Ecological Community under the TSC Act was recorded in the north-east and the western portion of the site. Fauna species observed included Wombats (*Vombatus ursinus*), Red-bellied Black Snake (*Pseudechis porphyriacus*), skinks (*Egernia* sp.), macropods and a variety of native birds. Follow up surveys in June and August 2006, confirmed the presence of the threatened Powerful Owl (*Ninox strenua*) and Gang-gang Cockatoo (*Calocephalon fimbriatum*) within the site.

Kevin Mills and Associates Pty Ltd (2005)*:* Kevin Mills and Associates assessed the impact of mine subsidence (up to 200mm) on flora and fauna within the No.4 Shaft, within the current Study Area. One ROTAP species, Shining Guinea Flower (*Hibbertia* *nitida*), was recorded. No threatened fauna species were recorded during the assessment, although they were considered likely to be present within the survey area.

Kevin Mills and Associates (2005) concluded that the predicted subsidence from the proposed underground mining was unlikely to have a significant impact on flora and fauna.

Umwelt Pty Ltd (2004)*:* Umwelt assessed the ecological impacts of predicted mine subsidence for the T and W Mains, north of the current Study Area. No threatened flora or fauna species were recorded during the assessment, although the assessment area was considered to provide suitable habitat for a range of threatened species. The proposal was not expected to lead to significant impacts on diversity of the recorded flora within the assessment area. Similarly, while minor impacts to foraging resources and hydrology may occur, these were not expected to be significant or to impact on the survival of fauna species.

Kevin Mills and Associates Pty Ltd (1995)*:* Kevin Mills and Associates undertook a flora and fauna assessment of a number of survey lines within the NRE No.1 Colliery mine lease area. Four Rare or Threatened Australia Plants (RoTAPs) were recorded: Shining Guinea Flower, Prickly Bush-pea, *Darwinina grandiflora* and Hairy Geebung (*Persoonia hirsuta*). Both Shining Guinea Flower and Prickly Bush-pea are considered vulnerable to the impacts of subsidence (DECC 2007a).

3.1.2 Database Searches

Search of the DECCW Wildlife Atlas database was conducted to obtain records of threatened flora and fauna within 10km of the Study Area. The EPBC Protected Matters Search Tool managed by DSEWPC was searched to identify the likely presence of nationally listed threatened or migratory species or threatened ecological communities and their habitats occurring within 10km of the PAA. All flora and fauna database records were analysed to determine the likelihood that threatened flora and fauna could occur within habitats of the PAA.

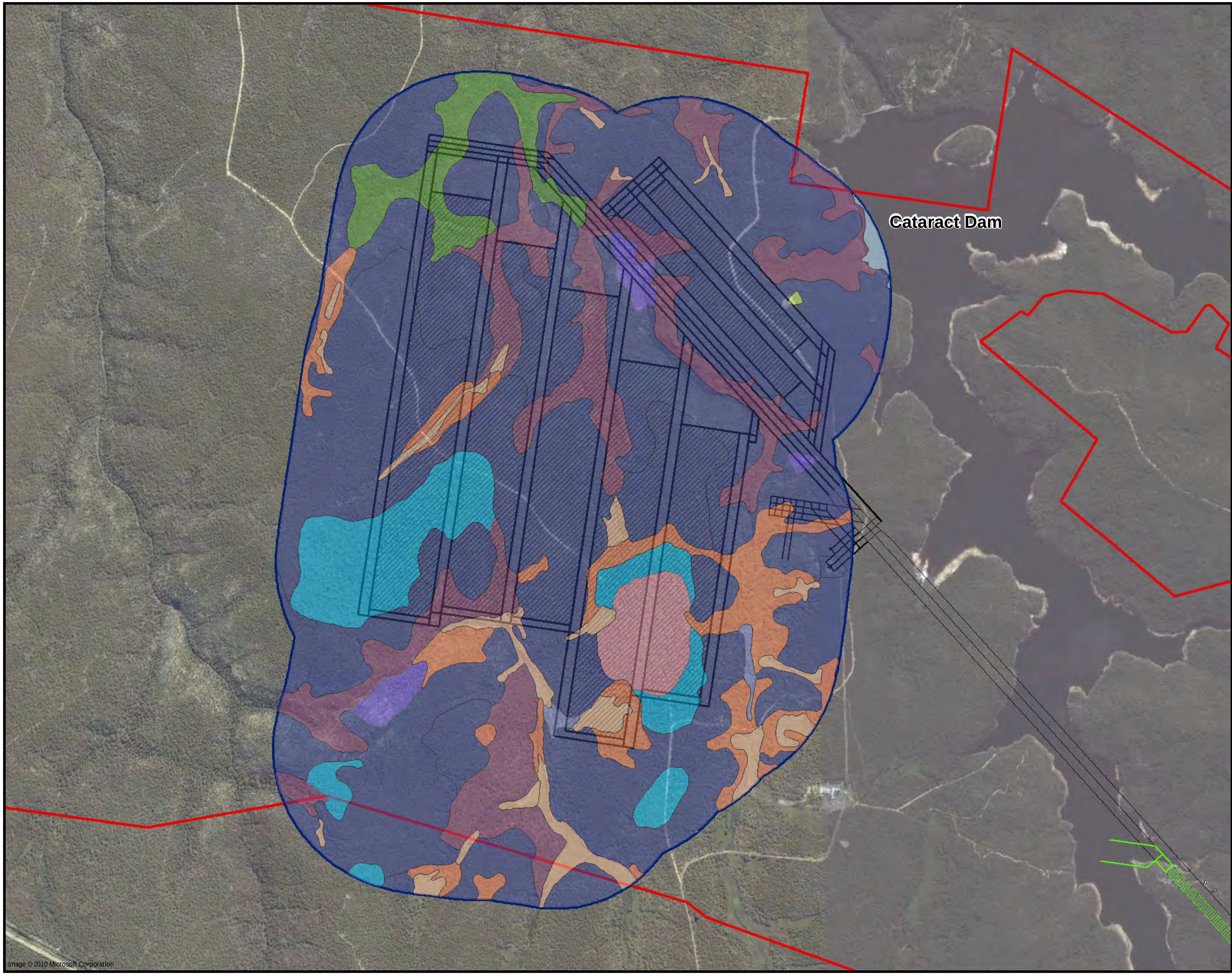
3.1.3 Existing Vegetation Mapping

Existing vegetation mapping of the Study Area was sourced from the National Parks and Wildlife Service (NPWS) publication *Native Vegetation of the Woronora, O'Hares Creek and Metropolitan Catchments* (NPWS 2003). The mapping identifies that the Study Area contains approximately 19 vegetation units as classified by NPWS (2003) as shown in *Figure 3.1* and *Figure 3.2*.

Two EECs listed under the TSC Act are mapped as occurring within the Study Area:

- Shale Sandstone Transition Forest in the Sydney Basin Bioregion (represented by Transitional Shale Stringybark Forest and Transitional Shale Open Blue Gum Forest); and

- Coastal Upland Swamp in the Sydney Basin Bioregion (represented by Upland Swamps: Banksia Thicket, Upland Swamps: Tea-tree Thicket and Upland Swamps: Sedgeland-Heath Complex).



Legend

- Project Application Area
- Study Area
- Proposed Longwalls

Vegetation Communities

- Cleared
- Exposed Sandstone Scribbly Gum Woodland
- Rock Plate Heath-Mallee
- Sandstone Gully Peppermint Forest
- Transitional Shale Open Blue Gum Forest
- Transitional Shale Stringybark Forest
- Upland Swamps: Banksia Thicket
- Upland Swamps: Fringing Eucalypt Woodland
- Upland Swamps: Sedgeland-Heath Complex
- Water
- Western Sandstone Gully Forest

Figure 3.1

Vegetation Mapping Of Wonga West Study Area (NPWS 2003)

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery
Ecological Assessment

Drawing No: 0079383s_ECA_G017_R1.mxd

Date: 12/09/2012 Drawing size: A3

Drawn by: SQW Reviewed by: MB

Scale: Refer to Scale Bar

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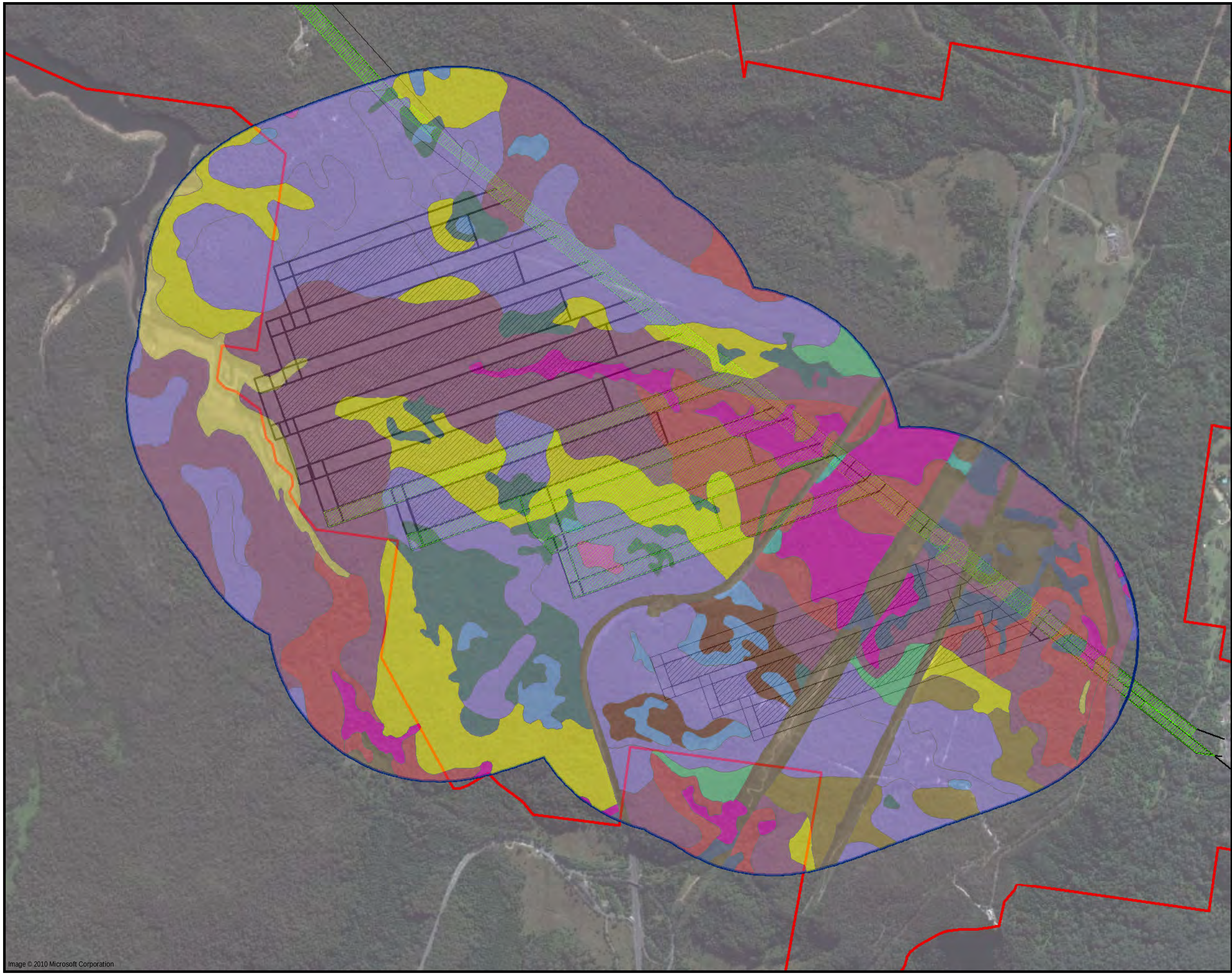

Legend

- Project Application Area
- Study Area
- Proposed Longwalls
- Approved Workings (MP10_0046)
- Cleared
- Coachwood Warm Temperate Rainforest
- Escarpment Blackbutt Forest
- Escarpment Edge Silvertop Ash Forest
- Exposed Sandstone Scribbly Gum Woodland
- Moist Blue Gum-Blackbutt Forest
- Moist Coastal White Box Forest
- Regenerating Vegetation
- Rock Plate Heath-Mallee
- Sandstone Gully Peppermint Forest
- Tall Open Blackbutt Forest
- Tall Open Peppermint-Blue Gum Forest
- Transitional Shale Open Blue Gum Forest
- Transitional Shale Stringybark Forest
- Upland Swamps: Banksia Thicket
- Upland Swamps: Fringing Eucalypt Woodland
- Upland Swamps: Sedgeland-Heath Complex
- Water
- Weeds and Exotics
- Western Sandstone Gully Forest

Figure 3.2

Vegetation Mapping Of Wonga East Study Area (NPWS 2003)

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery
Ecological Assessment

Drawing No: 0079383s_ECA_G002_R1.mxd

Date: 12/09/2012 Drawing size: A3

Drawn by: SQW Reviewed by: MB

Scale: Refer to Scale Bar

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3.2 *FLORA AND FAUNA SURVEYS*

This section describes the methodology employed for the field investigations of the Study Area.

3.2.1 *Stratification Units*

For the purposes of field survey planning the Study Area was delineated into eight stratification units for both Wonga East and West in accordance with the *Threatened Biodiversity Survey and Assessment: Guidelines for Development Activities* (Department of Environment and Conservation (DEC) 2004).

The NPWS (2003) vegetation dataset was analysed to calculate the proportionate area of each vegetation community within the Study Area, and the conservation significance of each community was assessed according to the TSC Act, EPBC Act, and the Southern Coalfield Inquiry (DECC 2007a, DoP 2008).

Survey sites were allocated to the stratification units according to the proportionate area that they covered within the Study Area and their sensitivity to impacts from subsidence due to longwall mining following DECC (2007a) and DoP (2008). For example, upland swamps are considered more susceptible to negative impacts of subsidence than terrestrial woodland ecosystems (DECC 2007a, DoP 2008), so more survey effort per unit area was targeted in those communities than in sclerophyllous forests. *Table 3.2* shows the allocation of stratification units within the Study Area.

Table 3.2 Stratification Units

Stratification unit	Vegetation communities occurring in unit (NPWS 2003)	Area (ha)
Exposed sandstone woodland	Exposed Sandstone Scribbly Gum Woodland	1316.5
Moist forest	Coachwood Warm Temperate Rainforest	46.5
	Moist Blue Gum-Blackbutt Forest	89.7
	Moist Coastal White Box Forest	0.5
Rocky habitats	Rock Plate Heath-Mallee	21.0
Shale sandstone transition forest	Transitional Shale Open Blue Gum Forest	35.8
	Transitional Shale Stringybark Forest	114.0
Tall gully forest	Escarpment Blackbutt Forest	0.0
	Escarpment Edge Silvertop Ash Forest	19.5
	Sandstone Gully Peppermint Forest	337.4
	Tall Open Blackbutt Forest	230.5
	Tall Open Peppermint-Blue Gum Forest	10.1
	Western Sandstone Gully Forest	53.4
Upland Swamp	Upland Swamp – Banksia Thicket	54.5
	Upland Swamp – Fringing Eucalypt Woodland	120.0
	Upland Swamp – Sedgeland-Heath Complex	77.8
Waterways	Dams, streams, and creeks	25.1
Disturbed land	Regenerating vegetation	17.1
	Cleared land	50.1
	Weeds and exotics	1.4

1. Data based on NPWS (2003) clipped to the Study Area using a GIS.
2. Note that the areas provided for upland swamp vegetation communities is based on NPWS 2003 mapping not the targeted mapping undertaken by Biosis (2012a).

It should be noted that as a result of changes to the mine plan some of these communities that were initially factored into survey design were no longer within the Study Area.

3.2.2 *Flora Surveys*

Floristic Assessments

Floristic composition in the Wonga West and Wonga East sites was assessed at 46 sites within the Study Area using standardised 400m^2 (20m x 20m) quadrats. Quadrat locations were randomly selected within the vegetation communities and stratification units identified in the desktop analysis. The locations of flora quadrat surveys are shown in and . Floristic composition was compared to that undertaken by NPWS (2003) to validate the accuracy of the vegetation mapping within the Study Area.

Surveys were undertaken by four ecologists between 2nd and 6th February 2009. Additional surveys were undertaken by two ecologists between 5th and 9th September 2011 targeting areas mapped by NPWS (2003) as Upland Swamp.

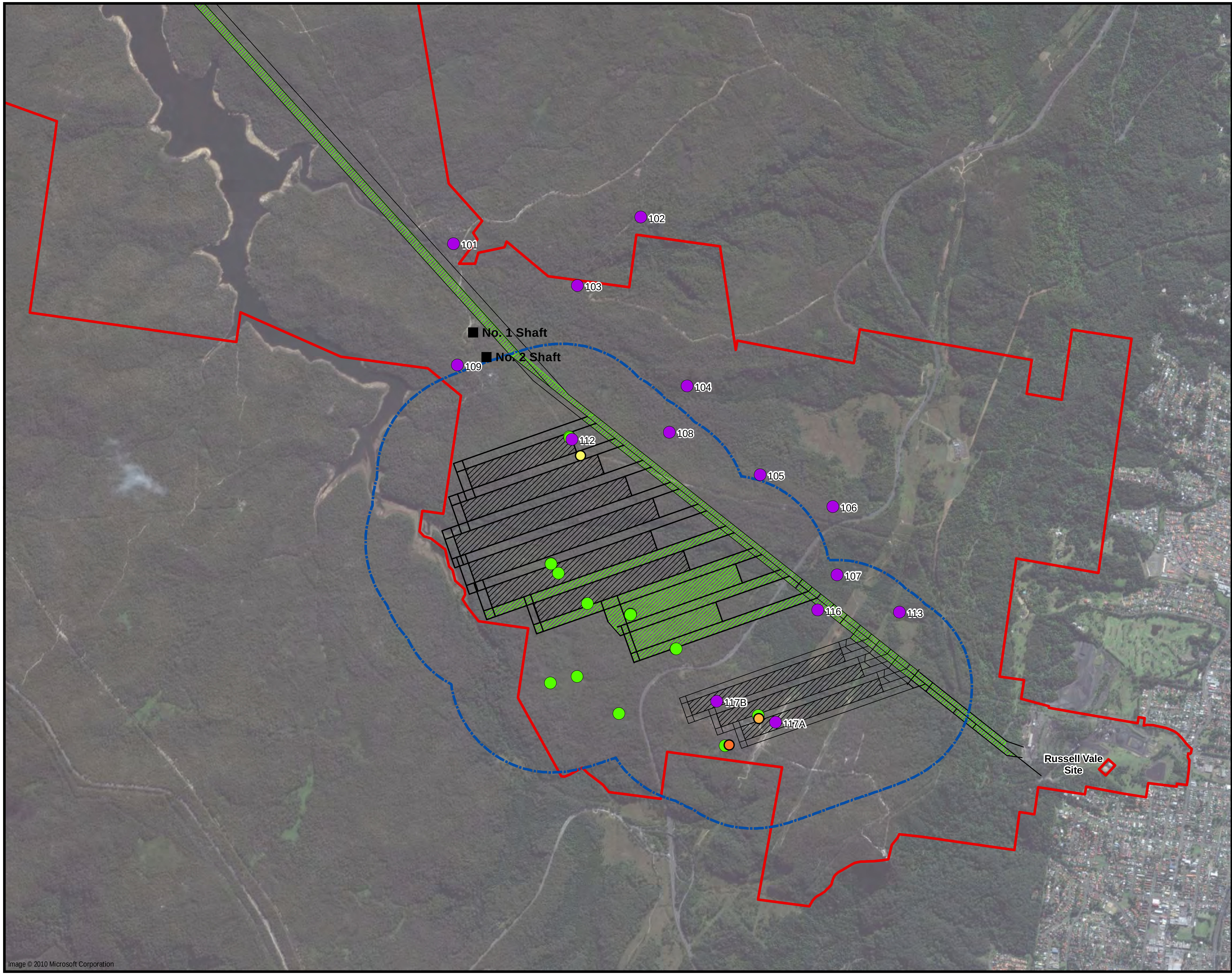
All plants recorded within each quadrat were identified to species level and to subspecies level where possible. Plants that were not able to be identified in the field were collected and dried for identification or forwarded to the Royal Botanic Gardens Sydney, for specialist identification by herbarium staff. Random meander searches were undertaken in the areas surrounding each quadrat for between 10 and 15 minutes at each location to enhance the likelihood of detecting threatened species within the quadrats and adjacent areas.

Structural formation of the vegetation community was assessed by visually estimating the height and percentage cover of each stratum (canopy, midstorey and groundstorey) within the quadrat. Dominant species of each stratum were recorded and any fruiting or flowering of species was recorded. Species were then given a cover/abundance scale rating based on the area of the quadrat covered by each plant species recorded, to determine the structural formation of each vegetation community according to the classifications in *Table 3.3*.

Table 3.3 Cover Abundance Scale Used In Floristic Assessments

Scale Rating	Percentage Cover*
1	< 5% and uncommon
2	< 5% and common
3	6 – 20%
4	21 – 50 %
5	51 – 75%
6	76 – 100%

* percentage cover is the proportion of area covered by that plant species within the 400m^2 quadrat.



Legend

- Project Application Area
- Study Area
- Proposed Longwalls
- Approved Workings (MP10_0046)
- Shaft Locations
- Floristic Quadrat Sites Oct 09
- Floristic Quadrat Sites Sept 11

Threatened Flora Search Oct 09

- Swamp5
- Swamp6
- Swamp7

Figure 3.3

Wonga East Floristic Quadrat and Threatened Flora Search Locations

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery Ecological Assessment

Drawing No: 0079383s_ECA_G008_R3.mxd

Date: 18/09/2012 Drawing size: A3

Drawn by: SQW Reviewed by: NB

Scale: Refer to Scale Bar

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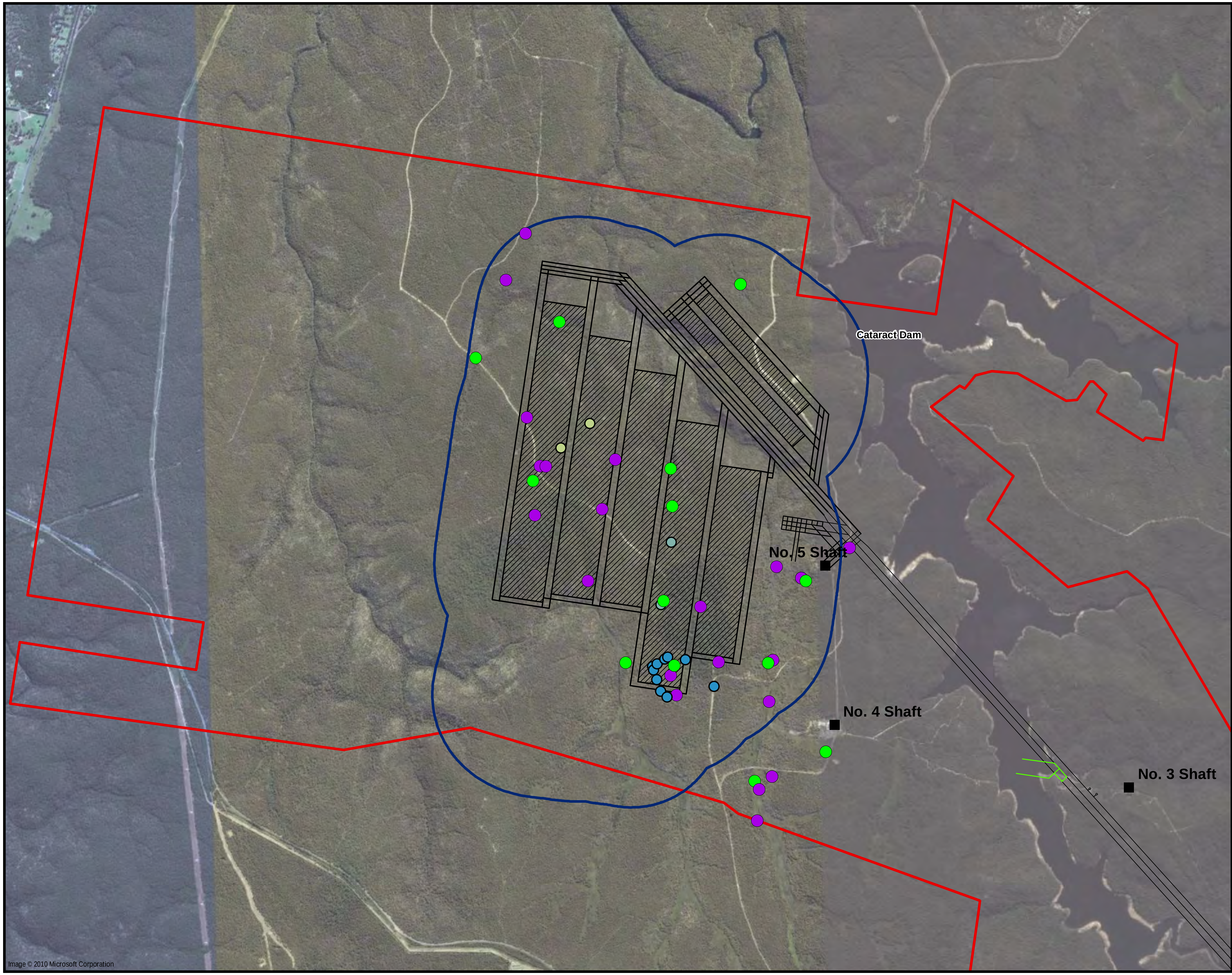

Legend

- Project Application Area
- Study Area
- Proposed Longwall
- Shaft Locations
- Floristic Quadrat Sites Feb 09
- Floristic Quadrant Sites Sept 11

Threatened Flora Search Oct 09

- Swamp1
- Swamp2
- Swamp3

Figure 3.4

Wonga West Floristic Quadrat and Threatened Flora Search Locations

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G015_R1.mxd

Date: 30/11/2012 Drawing size: A3

Drawn by: SQW Reviewed by: MB

Scale: Refer to Scale Bar

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Vegetation Mapping

The data collected during the floristic assessments was cross-referenced with the existing vegetation mapping for the Study Area (NPWS 2003). Where there were inconsistencies, the vegetation mapping was updated to provide an accurate assessment of the composition of vegetation communities within the Study Area.

Some locations within the Study Area were determined to be unsafe for access due to the remoteness and density of the vegetation. The distribution of vegetation communities within these areas was assessed using the NPWS (2003) mapping, aerial photograph interpretation and comparative observations made in the field where possible.

Targeted Flora Searches

Targeted flora searches were undertaken for threatened and rare flora identified in the DECC (2007) report as "species that would be impacted if subsidence had an adverse impact on their habitats". *Table 3.4* shows the threatened and rare flora species targeted during the searches. Searches were concentrated in upland swamps within the Study Area. Species previously recorded in the Southern Coalfields that are dependent upon creeks and/or rivers are assumed to occur within suitable habitats within the Study Area and will have been assessed for impacts through application of the precautionary principle, in *Section 5.3*.

Targeted flora surveys were undertaken by two ecologists on 7 and 8 October 2009. The location of survey sites is shown in *Figure 1.1 and Figure 1.2.*

Table 3.4 Flora Species Targeted During Field Surveys

Sensitive Flora Species	Habitat		
	Upland Swamps	Creeks or Rivers	Cliffs, Rock Benches or Overhangs
Christmas Bells *Blandfordia cunninghamii*	yes	no	yes
Lizard Orchid *Burnettia cuneata*	yes	no	no
Darwinia grandiflora	yes	no	no
Epacris purpurascens var. *purpurascens*	yes	yes	no
Creeping Raspwort *Gonocarpus salsoloides*	yes	no	no
Small-Flower Grevillea *Grevillea parviflora* subsp. *parviflora*	yes	no	no
Yellow Loosestrife *Lysimachia vulgaris* var. *davurica*	yes	yes	no
Deane's Melaleuca *Melaleuca deanei*	yes	no	no
Prickly Bush Pea *Pultenaea aristata*	yes	no	no

1. Sensitive Flora Species from DECC 2007a; and
2. See *Table 2.3* for Conservation Status.

Table 3.5 shows the person hours spent in each area searching for the target species. Searches were conducted as walked straight line transects across the search area, with two personnel walking approximately three metres apart. A compass and GPS unit were used to plot each transect. Plants that were not able to be identified in the field were collected and dried for identification or forwarded to the Royal Botanic Gardens Sydney, for specialist identification by herbarium staff.

Table 3.5 Person Hours Committed to Targeted Flora Searches

Site	Person Hours
Site 1, Area 3, Wonga West	6
Site 2, Area 3, Wonga West	1.5
Site 3, Area 3, Wonga West	2
Site 4, Area 3, Wonga West	2
Site 5, Area 1, Wonga East	1.3
Site 6, Area 1, Wonga East	2
Site 7, Area 1, Wonga East	4.3
Total hours	**19.1**

3.2.3 Upland Swamp Vegetation Mapping

Biosis were engaged to undertake detailed mapping, assessment of significance of upland swamps and assessment of the potential impacts of longwall mining to identify those swamps of special significance considered at risk of negative environmental consequences. Biosis built upon and refined the NPWS (2003) mapping of the Study Area and previous investigations undertaken by ERM. Biosis's assessment is included in full in *Annex Q* of the EA (ERM 2013a). *Figure 1* and *Figure 2* in *Annex A* show the vegetation distribution of all of the upland swamps as mapped by Biosis (2012).

The methodology was based upon the steps identified in the PAC reports (2009, 2010) and the draft upland swamp environmental impact assessment guidelines (OEH 2012).

Mapping of Upland Swamps

Upland swamps were mapped through:

- using Light Detection and Ranging (LiDAR) data to define areas of 'potential wetland polygons' requiring further investigation (see Section 2.1.1 of *Annex Q* for detailed description of this methodology);

- ground truthing of these areas in the field by a team of botanists to determine whether 'potential' wetland polygons were upland swamps, to define swamp boundaries using a GPS, and map swamp sub-communities; and

- use of a Geographic Information System (GIS) to spatially represent vegetation community data and upland swamp boundaries.

The upland swamps were named based on the catchment they were positioned within. Where possible, swamps were further classified into 'headwater' and 'valley infill' swamps based upon position in the landform and an analysis of slope and flow accumulation modelling (see Section 2.1.3 of *Annex Q*). For some of the upland swamp systems in Wonga West the distinction between areas that are defined as valley infill and/or headwater swamps was problematic and these swamps were considered to form one functional unit for the purposes of mapping. However, given the differences in type and degree of impacts they were considered separately where appropriate.

Analysis of Upland Swamps

LiDAR data and GIS spatially analyst tools were used to produce layers and to categorise the terrain and water flow (not stream flow) through individual swamp vegetation communities. The steps used to create this data are outlined in detail in Section 2.2 of Biosis (2012a).

Seedsman's (2012) predicted effects of modelled 'upper bound scenario' mining subsidence were analysed using GIS to produce a predictive surface levels following vertical subsidence and to show changes in water movement relative to the pre-mining flow accumulation models.

Comparison to Regional Vegetation Mapping

The Native Vegetation of the Woronora, O'Hares and Sydney Metropolitan Catchments (NPWS 2003) mapped four vegetation communities associated with upland swamps in the Woronora Plateau:

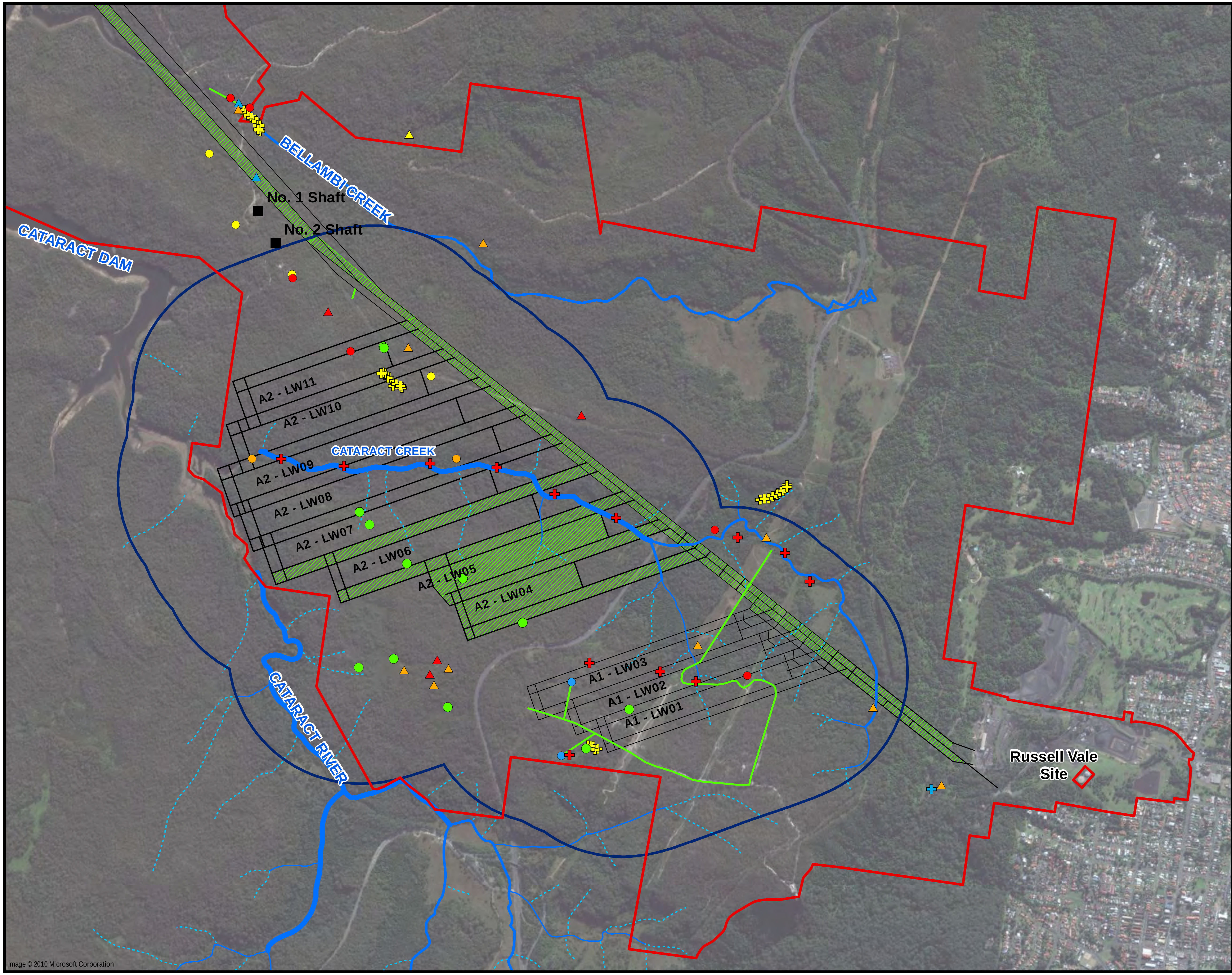
- Upland Swamps: Banksia Thicket (MU 42);
- Upland Swamps: Tea-tree Thicket (MU43);
- Upland Swamps: Sedgeland Heath Complex (MU44) a mosaic of three sub-communities including Sedgeland (MU44(a)), Restioid Heath (MU44(b)), Cyperoid Heath (MU44(c)); and
- Upland Swamps: Fringing Eucalypt Forest (MU 45).

Upland swamp mapping undertaken for this Project by Biosis (2012) was compared with mapping of upland swamps by NPWS (2003) restricted to those communities that define the Coastal Upland Swamp EEC being MU42, MU43 and MU44.

3.2.4 *Fauna Survey*

Fauna surveys were undertaken in 2009, summer of 2010 and spring of 2009. The following section describes the survey methodology.

Survey locations are shown in *Figure 3.5* and *Figure 3.6*.



Legend

- Project Application Area
- Study Area
- Proposed Longwalls
- Approved Workings (MP10_0046)
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order and Above Stream
- Spotlight Routes
- Shaft Locations
- Anabat Locations
- Bird Area Search
- Bird Point Counts
- Call Broadcasting
- Frog Habitat Survey
- Hair Funnels
- Diurnal Frog Call-playback
- Diurnal Herpetofauna Search
- Habitat Assessment
- Habitat Assessment
- Nocturnal Frog Call-playback
- Frog Habitat Survey Sites Sept 11

Figure 3.5

Fauna Survey Locations Within The Wonga East Study Area

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment		
Drawing No:	0079383s_ECA_G009_R3.mxd		
Date:	27/11/2012	Drawing size:	A3
Drawn by:	SQW	Reviewed by:	MB
Scale:	Refer to Scale Bar		

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0 200 400 600m

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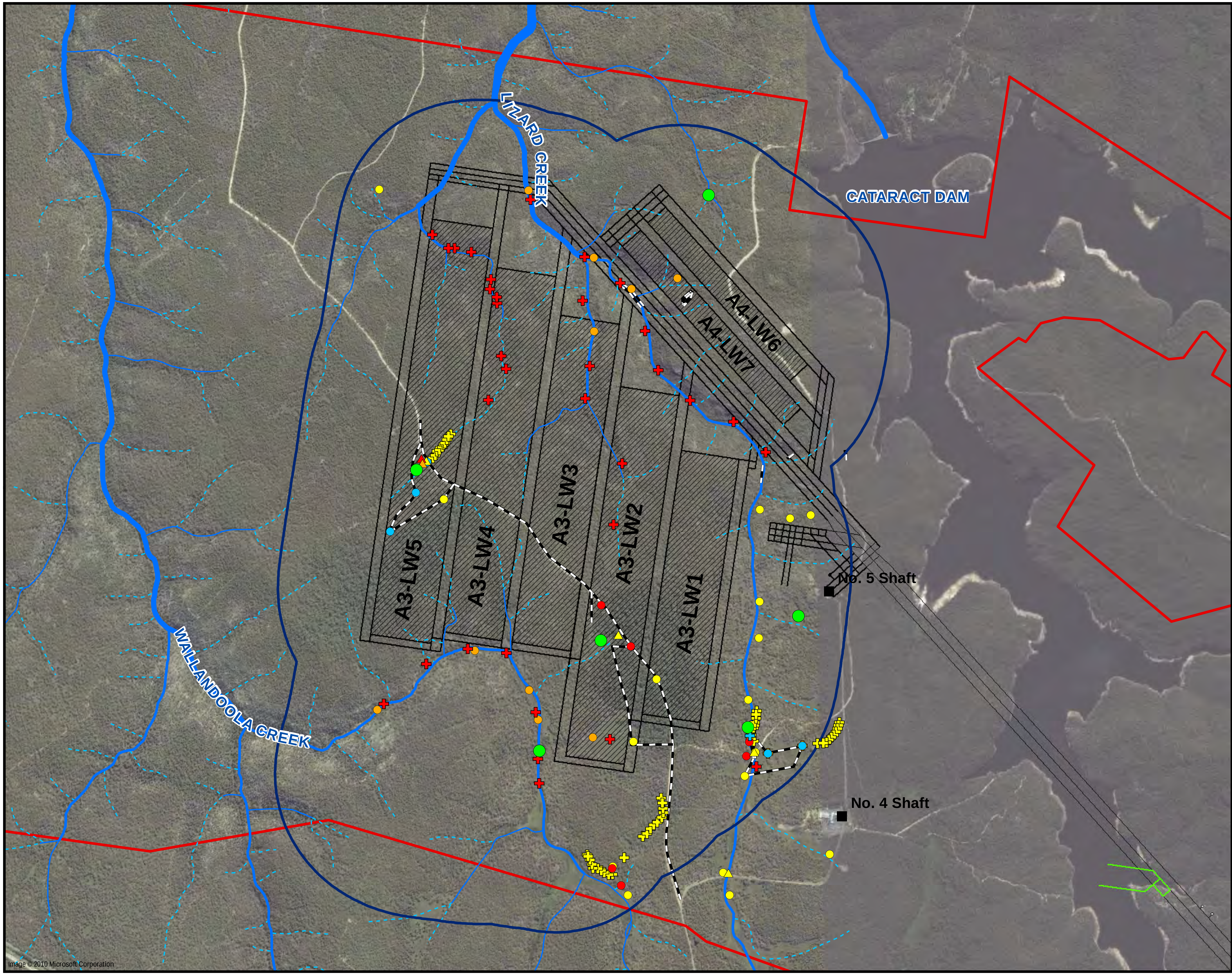
ERM



Legend

- Project Application Area
- Study Area
- Proposed Longwall
- Cataract Dam
- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order stream
- 5th order stream
- Spotlighting Routes
- Anabat Locations
- Bird Area Search
- Bird Point Counts
- Call Broadcasting
- Frog Habitat Survey
- Hair Funnels
- Spotlighting
- Diurnal Frog Call-playback
- Habitat Assessment
- Nocturnal Frog Call-playback
- Nocturnal Upland Swamp Search
- Frog Habitat Survey Sites Sept 11

Figure 3.6

Fauna Survey Locations Within The Wonga West Study Area

Client: Gujarat NRE Coking Coal Pty Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G018_R1.mxd

Date: 30/11/2012 Drawing size: A3

Drawn by: KB Reviewed by: MB

Scale: Refer to Scale Bar

N 0 250 500 750m

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Frog and Reptile Surveys

Targeted herpetofauna surveys were undertaken in 2009 by Biosis Research Pty Ltd (Biosis) and Eco Logical Australia Pty Ltd (Eco Logical) as sub-consultancies, with follow up surveys by ERM. The sub-consultant reports, including survey locations, are provided in *Annex B*.

The surveys targeted threatened frog and reptile species likely to occur within the Study Area that are susceptible to the impacts of subsidence according to DECC (2007a), and a letter from DECCW provided with the DGRs. Frog and reptile species targeted during the surveys are shown in *Table* 3.6.

Table 3.6 Frog and Reptile Species Targeted in Herpetological Surveys

Targeted Species		TSC Act	EPBC Act
Frogs			
Giant Burrowing Frog	*Heleioporus australiacus* #	V	V
Green and Golden Bell Frog*	*Litoria aurea* #	E	V
Heath Frog	*Litoria littlejohni* #	V	V
Red-crowned Toadlet	*Pseudophryne australis* #	V	-
Stuttering Barred Frog	*Mixophyes balbus***	E	V
Reptiles			
Broad-headed Snake	*Hoplocephalus bungaroides* #	E	V
Rosenberg's Goanna	*Varanus rosenbergi* #	V	-
Eastern Three-lined Skink	*Acritoscincus duperreyi***	-	-

1. Source: DECC 2007a
2. * May be locally extinct, ** not targeted in Biosis surveys, ^regionally significant, # previously recorded within 10km of the Study Area
3. V- vulnerable; E – endangered

Call broadcasting for target frog species was undertaken within upland swamps and dams/wetlands considered suitable for the target species. Call broadcast was undertaken during both daytime and nocturnal periods. A 10W amplifier was used to broadcast calls for three minutes, followed by three minutes of listening for responses.

Nocturnal searches for frogs and habitat of target frog species were undertaken in upland swamps and dams/wetlands considered suitable for target species. Habitat searches consisted of an initial five minute listening period followed by active survey of an area (at least 40m x 40m) by searching ground litter, turning logs and rocks and examining low shrubs. Creeks were searched with an initial five minute listening period followed by two person hours of active spotlight searching of 200m of the watercourse.

Due to rainfall, an opportunistic spotlight of two and a half kilometres of wet fire trail was undertaken for ten minutes. Opportunistic spotlighting was also carried out in potential habitat of Broad-headed Snake within the Study Area. All spotlighting was undertaken by two zoologists, using a head torch and handheld 50W spotlight. Any animals encountered during the surveys were identified by direct observation or by their calls. Any captured animals were identified to species and then released at the site of capture.

Eco Logical and ERM undertook targeted daylight habitat assessment for each of the focus threatened fauna species on 28th and 29th September and 6th and 7th October 2009. No single survey period was opportune for detecting all of the subject threatened species. One of the ecologists (Ross Wellington) had over thirty years' herpetological experience with the target species.

The surveys investigated the creek lines of Wallandoola Creek, Lizard Creek and Cataract Creek to the full extent to which each is underlain by the proposed workings. Location of survey routes is shown in *Figure 3.5* and *Figure 3.6*. Traverses included searching for amphibian larvae, detection of calling individuals and searches beneath suitable cover that was considered as having potential for use as shelter.

Ridgelines and rock outcrops were traversed and searched to identify any high quality benched areas with exfoliating sheets of sandstone suitable for use as shelter habitat by the Broad-headed Snake. The timing of the survey for detecting Broad-headed Snake within wintering habitat is not considered optimal. Ridgeline assessment also included examining suitable ledges and overhangs that are sometimes utilised by the Rosenberg's Goanna. The Study Area was also searched for any substantial sized termitaria that are often used as nesting chambers by the Rosenberg's Goanna.

ERM conducted a follow-up survey on 11th January 2010 to assess the habitat condition of a lateral creek draining into Lizard Creek in Area 3. Two ecologists traversed the creek to the full extent to which it is underlain by the proposed workings, as shown in *Figure 3.6*. All pools and ponds encountered were visually surveyed for tadpoles, which were then identified to species level, where possible. Notes and photographs of the condition and extent of habitat within the swamp and creek were recorded to inform an assessment of habitat condition for threatened frog species likely to occur within the creek.

ERM conducted an additional follow-up survey between 5th and 9th September 2011 to assess the habitat value of areas mapped by NPWS (2003) as Upland Swamp for four threatened frog species. Target species were the Giant Burrowing Frog, Green and Golden Bell Frog, Red-crowned Toadlet and Heath Frog.

In addition to these surveys, Biosis have undertaken monitoring in Wonga East as part of the Biodiversity Management Plan monitoring for Longwall A2 LW4 and A2 LW5. These field inspections have identified breeding habitat for Heath Frog, Giant Burrowing Frog and Stuttering Barred Frog in Wonga East. Biosis have ranked the quality of breeding habitat for these three species. This has been combined with diurnal searches for frogs along the 1st and 2nd order streams associated with upland swamps CRUS1, CRUS2 and CCUS3 (N. Garvey Biosis, pers comm).

Bird Surveys

Bird community composition was assessed using standardised two-hectare survey quadrats at 25 locations within the Wonga West and East domains between 23rd and 27th March 2009. Survey quadrats were actively searched for a minimum of 20 minutes, with surveys continuing for up to 40minutes in areas in which bird activity at the time of survey was high. The location of bird survey quadrats is shown in *Figure 3.5* and *Figure 3.6*.

Point count bird surveys were undertaken at 12 locations by one ecologist for 15 minutes at each site between 28th and 29th September, and 6th and 7th October 2009. The presence of all species heard and seen from each point was recorded, abundance was not recorded. These additional surveys were undertaken while traversing the site during herpetological surveys. The location of point counts is shown in *Figure 3.5* and *Figure 3.6.*

Targeted searches for threatened and significant species were undertaken in habitat considered suitable for each target species. The target species were: Beautiful Firetail (*Stagonopleura bella*), Ground Parrot, Eastern Bristlebird (*Dasyornis brachypterus*) and Southern Emu-wren (*Stipiturus malachurus*). Habitats searched included rocky outcrops, creek lines and upland swamps likely to be susceptible to the impacts of subsidence due to the proposed action. These searches were generally undertaken when suitable habitat was encountered when traversing the site for other activities. All ecologists within the Study Area while undertaking other activities noted opportunistic bird observations.

Mammals

Hair funnels, spotlighting, call broadcasting, scat and track identification and ultrasonic call detection methods were used to census for mammal species within the Study Area.

170 hair funnels were deployed in eight transects of 10 paired funnels, and one transect of five paired funnels across the Study Area. Transects were distributed within habitat susceptible to the impacts of subsidence including uplands swamps, and in woodland and forest habitats. Hair funnels were deployed for twelve nights each between 25th March and 7th April 2009. A total of 2040hair funnel nights were sampled. *Figure 3.5* and *Figure 3.6* show the hair funnel transects locations within the Study Area.

Within each paired transect, 10 funnels were baited with an oats, peanut butter and honey mix, and ten were baited with sardines. One group contained only ten funnels in which five funnels were baited with each mix. Along each transect funnels were deployed at distances between 25m and 50m apart, depending upon the suitability of the terrain. Funnels were placed in areas that increased their likelihood of detection by small mammals.

Anabat units were deployed at 12 locations between 23rd and 27th March 2009. At each location units were deployed overnight for two nights. Anabat locations are shown in *Figure 3.5* and *3.6.* Units were positioned in and adjacent to flyways, including vehicle tracks, riparian areas, freshwater pools, cliffs, upland swamp and rainforest understorey. Riparian areas and freshwater pools were specifically targeted to detect the occurrence of Large-footed Myotis (*Myotis adversus*). All Anabat files were analysed by microbat specialist Glenn Hoye (Fly by Night Bat Surveys).

Targeted bat roost searches were undertaken for Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), Large-eared Pied Bat (*Chalinolobus dwyeri*), and to record any additional species that may utilise caves and artificial roosts. Targeted searches were conducted between 2nd and 6th February, and 23rd and 27th March 2009 for approximately ten hours, while traversing the site. Surveyed artificial structures predominantly occur within the Wonga East area and include disused ventilation shafts, power supply housings, maintenance sheds and road culverts.

Flying-foxes were surveyed by spotlighting in conjunction with other nocturnal surveys between 23rd and 27th March 2009.

Habitat searches were undertaken for indications of mammals occurring within the Study Area, including collection and identification of scats, searches for tracks, scratches and feeding scars on trees, and recording latrine sites, burrows and other traces where encountered.

Scats that were not able to be identified in the field were forwarded to specialist Barbara Triggs for analysis. Habitat for threatened species susceptible to subsidence was targeted, specifically rock outcrops, rocky creeklines, upland swamps and EECs. A total of approximately 25 hours search effort was invested by four ecologists over the course of field surveys between 2nd and 6th February and 23rd and 27th March 2009.

Nocturnal Surveys

Spotlighting and call broadcasting was undertaken on four nights between 23rd and 27th March 2009 by two ecologists traversing the Study Area on foot, each using a 50W narrow-beam spotlight powered by a 12V battery. In all cases, the species targeted included the Yellow-bellied Glider, owls, bat species, reptiles and frogs. Spotlighting was undertaken through untracked vegetation and along vehicle tracks, recording all species encountered. Spotlight routes are shown in *Figure 3.5* and *3.6.*

Nocturnal call broadcasting was used to survey for Ground Parrot, Eastern Bristlebird, Powerful Owl and Sugar Glider (*Petaurus breviceps*) in Wonga West, as this area was deemed to contain potential habitat for the target species. In each case, call broadcasting was undertaken by two ecologists using a 10W handheld amplifier. An initial listening period of ten minutes was undertaken, including spotlighting for fauna in the vicinity. The call of the target species was then broadcast for up to five minutes, after which 10 minutes of listening and spotlighting was undertaken. All responses were recorded.

The details of the call broadcasts are shown in *Table 3.7.* Call broadcast locations are shown in *Figure 3.5 and 3.6.*

Table 3.7 Call broadcast events

Date	Time	Species	Vegetation community *	Location	Response
23/3/09	19.30	Ground Parrot	Upland Swamp - Sedgeland Heath Complex	S1	-
	20.00	Ground Parrot	Upland Swamp - Sedgeland Heath Complex	S2	-
	21.00	Powerful Owl	Transitional Shale Open Blue Gum Forest	S5	-
24/3/09	17.45	Eastern Bristlebird	Upland Swamp - Sedgeland Heath Complex	S5	-
	20.35	Sugar Glider	Exposed Sandstone Scribbly Gum Woodland	S7	Yes
	20.50	Powerful Owl	Exposed Sandstone Scribbly Gum Woodland	S8	Yes
	21.15	Sugar Glider	Exposed Sandstone Scribbly Gum Woodland	S8	Yes

Date	Time	Species	Vegetation community *	Location	Response
26/3/09	18.10	Eastern Bristlebird	Upland Swamp - Sedgeland Heath Complex	020	-
	18.40	Eastern Bristlebird	Upland Swamp - Sedgeland Heath Complex	021	-
	19.45	Ground Parrot	Upland Swamp - Sedgeland Heath Complex	021	-
	20.30	Ground Parrot	Upland Swamp - Sedgeland Heath Complex	020	-

1. * Habitat as mapped by NPWS (2003).

3.3 *SUMMARY OF SURVEY EFFORT*

Table 3.8 shows the level of survey effort per stratification unit for each of the quantitative assessments including flora and fauna surveys.

Table 3.8 Survey Effort per Stratification Unit

Stratification unit	Floristics (no. of quadrats)	Threatened flora search (person hours)	Bird area (2ha) searches	Bird point counts	Anabat surveys (Anabat nights)	Hair Funnels (no. funnel nights)
Exposed sandstone woodland	5		6		4	480
Moist forest	5			1	4	240
Rocky habitats	1			2	4	
Shale sandstone transition forest (EEC)	4		2		4	240
Tall gully forest	5		2	4		240
Upland Swamp	24	19.1	15	4	2	840
Waterways					4	
Disturbed land	2			1	2	
Total	**46**	**19.1**	**25**	**12**	**24**	**2040**

1 Note that survey effort in Upland Swamps does not include effort undertaken by Biosis (2012a).

2 Does not include survey effort of speacilaist herpitologists.

4 RESULTS

This chapter describes the results of the field investigations of the Study Area.

4.1 DATABASE SEARCH RESULTS

The DECCW Wildlife Atlas returned records of 14 threatened flora species, one endangered flora population and 48 threatened fauna species that have previously been recorded within 10km of the Study Area. The locations of these records are shown in *Figure 4.1* and *Figure 4.2*.

A summary of the DECCW output is provided in *Annex C.*

The EPBC Act Protected Matters Search Tool predicted that four Threatened Ecological Communities, 65 threatened species and 52 migratory species listed under the EPBC Act "*have the potential to occur, or rely on habitat that may potentially occur, within 10km of the Study Area*". The results of the Protected Matters Search Tool are provided in the stand-alone assessment of Matters of National Environmental Significance for the project (ERM 2013b) and summarised in *Chapter 5*.

4.2 WEATHER CONDITIONS

Weather observations for the dates of field survey were retrieved from the Bellambi weather station operated by the Bureau of Meteorology (BOM), as shown in *Table 4.1*. Weather conditions at Bellambi are considered to be milder than those experienced on the Woronora Plateau due to the maritime climate. In general the weather conditions were suitable for undertaking flora and fauna surveys. However, conditions in 2009 were considered to be drier than optimal for detecting a high diversity of frog species in any season, and October 2009 was considered hotter than optimal for detecting Broad-headed Snake under exfoliating sandstone.

Table 4.1 Weather Observations During Field Surveys

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	Wind Direction (9am)	Maximum Wind Speed (km/h)
2/2/2009	20.7	26.4	0	NE	52
3/2/2009	19.9	24.6	0	SE	48
4/2/2009	21	26.3	0	SSE	24
5/2/2009	20.3	26.8	0	NNE	43
6/2/2009	20.7	27.7	0	SE	31
23/3/2009	18.4	24.1	1.6	NNE	57
24/3/2009	18.7	23.5	1	NE	52
25/3/2009	19.3	24	0	NW	33
26/3/2009	19.7	23.3	3.2	SSW	50
27/3/2009	17.7	20.2	3.8	S	46
28/9/2009	10.4	20.9	0	SW	70
29/9/2009	10.1	19.3	0.2	SSW	24
6/10/2009	12.2	17.5	13.2	SW	41
7/10/2009	8.5	17.5	5	SSW	63
8/10/2009	9.6	15.8	3	S	87
1/11/2010	20.8	25.2	0	NE	54
5/9/2011	14.0	18.8	0	E	37

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	Wind Direction (9am)	Maximum Wind Speed (km/h)
6/9/2011	16.0	20.2	0	NNE	69
7/9/2011	10.8	17.9	1.8	SW	48
8/9/2011	12.0	16.9	0.2	S	30
9/9/2011	11.6	13.0	4.2	WSW	44

1. Source: BOM website accessed via http://www.bom.gov.au/weather/nsw/nsw-coastal-stations-map.shtml

4.3 *FLORA*

Flora species recorded in the floristic assessments of the Study Area are listed in *Annex D*. Two rare plant species listed on the Rare or Threatened Australian Plants (RoTAP) list (Briggs and Leigh 1995) were recorded: *Darwinia grandiflora* and *Monotoca ledifolia*. The threatened Prickly Bush-pea (*Pultenaea aristata*) was recorded in Wonga East by ERM and Biosis and in Wonga West by Biosis. *Pultenaea aristata* is listed as vulnerable under the TSC Act, vulnerable under the EPBC Act, and on the RoTAP list.

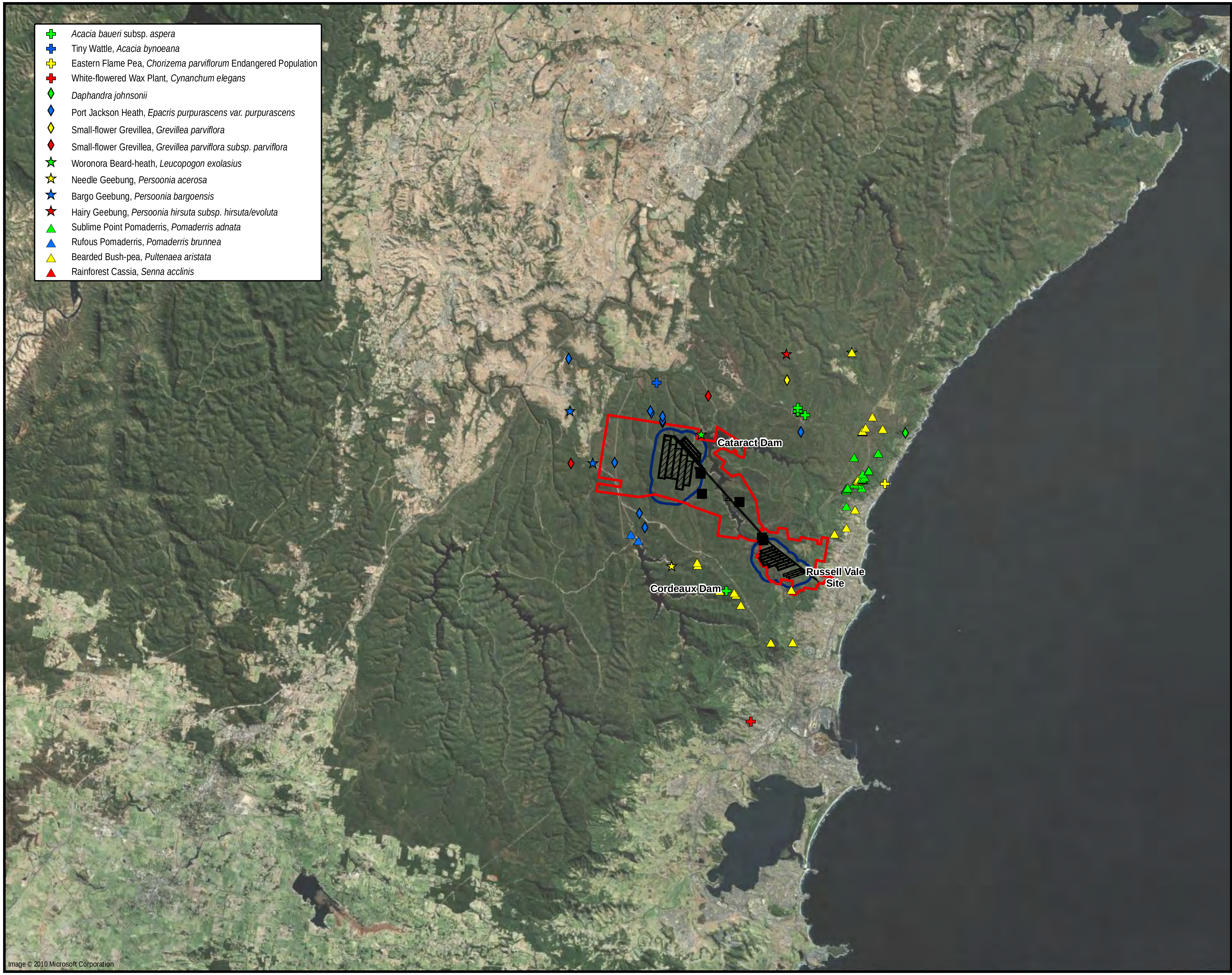
The location of rare and threatened flora species records is shown in *Figure 4.3* and *Figure* 4.4.

One introduced species was recorded although it should be noted that a comprehensive inventory of introduced species in disturbed areas was not collected.

4.3.1 *Floristics*

Condition of floristic survey sites was found to be very good, with little evidence of disturbance throughout the majority of the quadrats. There was evidence of clearing of vegetation along fire roads and vehicle tracks, historic mine survey lines and around existing mine infrastructure. The condition of vegetation in the Wonga East area was generally more degraded than Wonga West due to greater disturbance as a result of construction and maintenance of two large transmission lines, small gravel quarries, trespassing by vehicles, motorbikes and other associated disturbances in Wonga East.

A full list of plant species recorded during the floristic assessment is provided in *Annex D* for each waypoint and community surveyed.



Legend

- Project Application Area
- Study Area
- Proposed Longwall
- Mine Layout
- Shaft Locations

Source:
DECCW Wildlife Data Unit

Notes:
The data has been projected at a scale of 1:250,000 in accordance with DECCW data specifications.

Figure 4.1

Threatened Flora Previously Recorded Within 10km Of Study Area

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G012_R1.mxd

Date: 29/11/2012 Drawing size: A3

Drawn by: NS Reviewed by: NB

Scale: Refer to Scale Bar

N 0 2,500 5,000 7,500m

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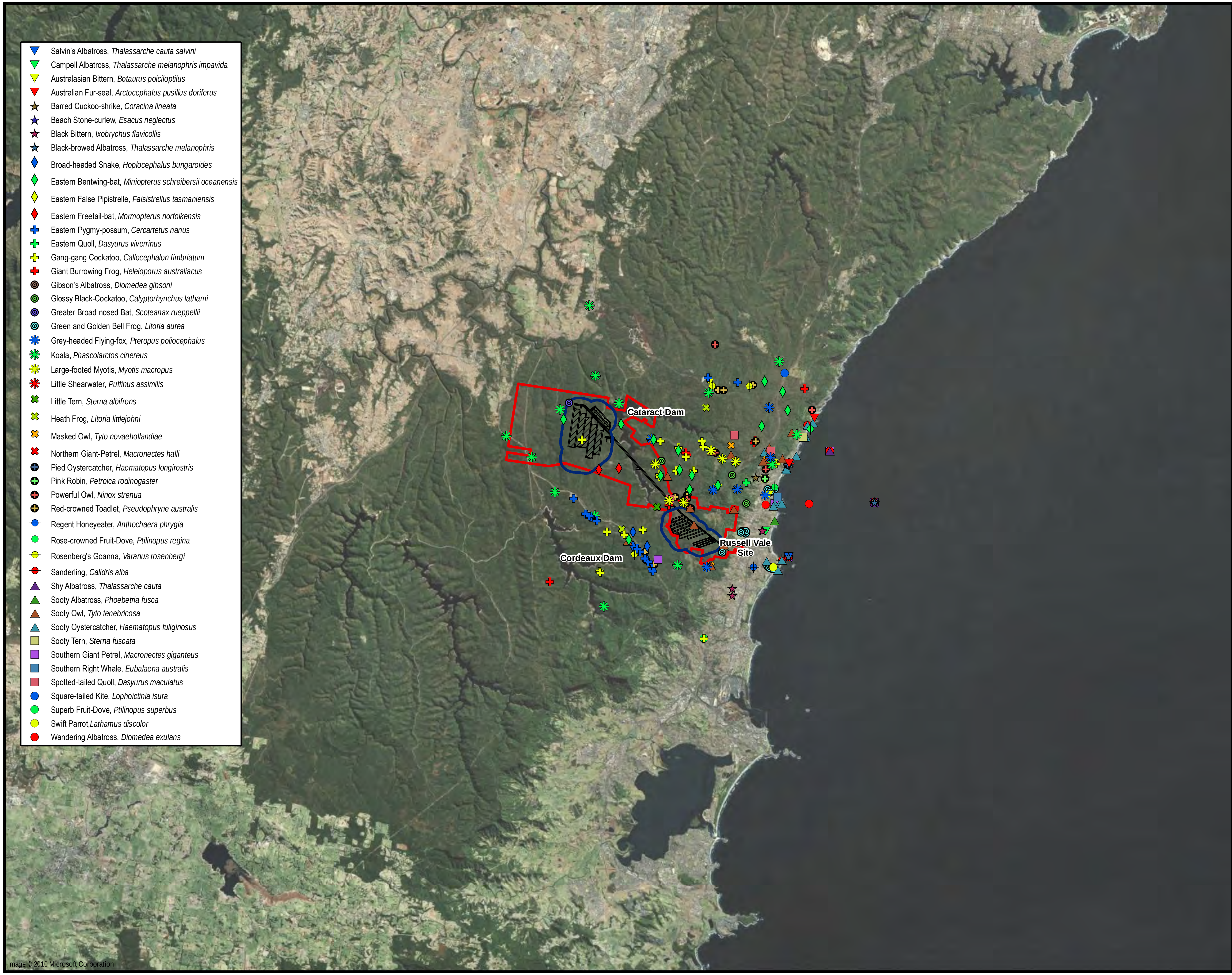

Legend
- Project Application Area
- Study Area
- Proposed Longwall
- Mine Layout
- Shaft Locations

Source:
DECCW Wildlife Data Unit

Notes:
The data has been projected at a scale of 1:250,000 in accordance with DECCW data specifications.

Figure 4.2
Threatened Fauna Previously Recorded Within 10km Of Study Area

Client: Gujarat NRE Coking Coal Limited
Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G011_R1.mxd
Date: 29/11/2012 Drawing size: A3
Drawn by: NS Reviewed by: MB
Scale: Refer to Scale Bar

N 0 2,500 5,000 7,500m

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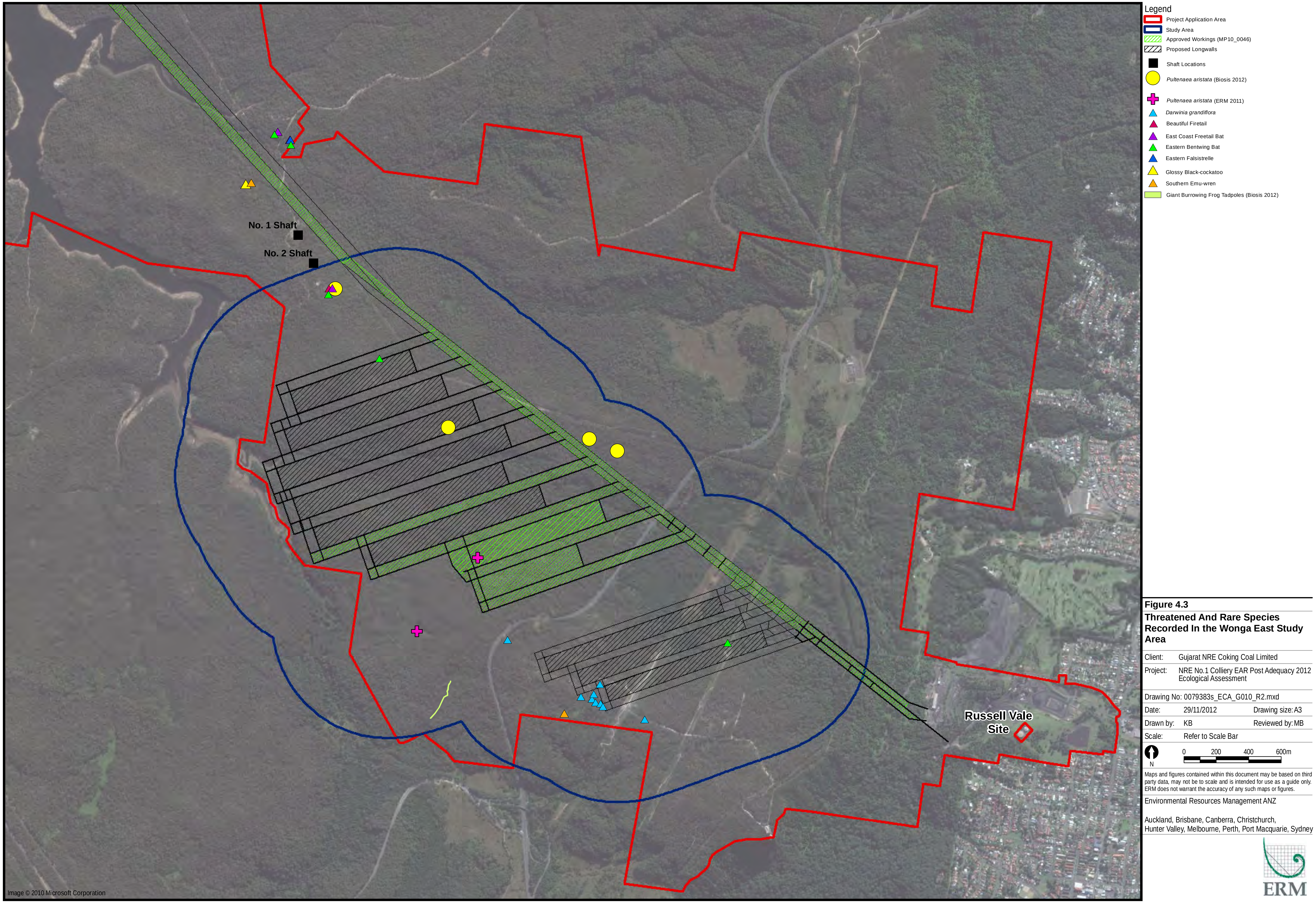

Figure 4.3

Threatened And Rare Species Recorded In the Wonga East Study Area

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G010_R2.mxd

Date: 29/11/2012 Drawing size: A3

Drawn by: KB Reviewed by: MB

Scale: Refer to Scale Bar

N

0 200 400 600m

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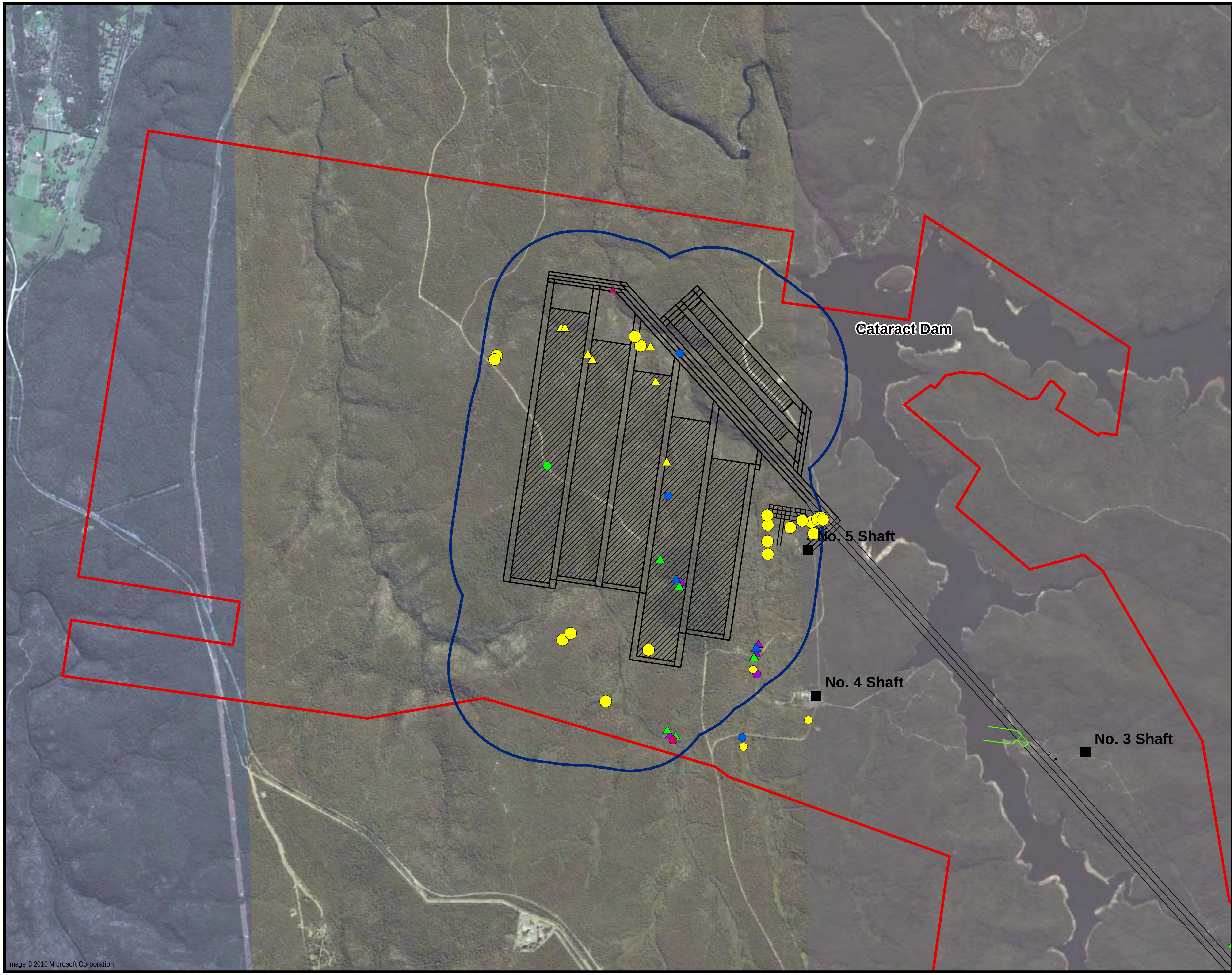
Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM



Legend

- Project Application Area
- Study Area
- Proposed Longwall
- Shaft Locations
- *Pultenaea aristata* (Biosis 2012)
- *Monotoca ledifolia*
- Beautiful Firetail
- East Coast Freetail Bat
- Eastern Bentwing Bat
- Eastern Falsistrelle
- Giant Burrowing Frog
- Greater Broad-nosed Bat
- Powerful Owl
- Red-crowned Toadlet
- Southern Emu-wren

Figure 4.4

Threatened And Rare Species Recorded In the Wonga West Study Area

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G016_R0.mxd

Date: 07/12/2010 Drawing size: A3

Drawn by: NS Reviewed by: MB

Scale: Refer to Scale Bar

N

0 300 600 900m

Environmental Resources Management ANZ

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ERM

4.3.2 *Vegetation Mapping*

Vegetation communities identified as occurring within the Study Area from field surveys and interrogation of NPWS (2003) vegetation datasets are shown on *Figure 3.1* and *3.2*. The original vegetation mapping (NPWS 2003) was determined to be accurate within the Study Area at all locations surveyed during the initial surveys.

Upland swamp surveys conducted by Biosis (2012a) provided detailed field verified mapping of the upland swamps that supersedes the mapping of the Upland Swamp communities by NPWS (2003). Biosis provides commentary on differences between the field verified mapping and that of NPWS (2003) in their report tabled as *Annex Q* for the Project.

Annex A includes the vegetation mapping produced by Biosis (2012).

4.3.3 *Vegetation Community Descriptions*

The following descriptions of vegetation communities in the Study Area is based on NPWS (2003) and field investigations by ERM and Biosis (2012a).

Transitional Shale Open Blue Gum Forest

This community (MU 19 NPWS 2003) represents a tall stand of Open Blue Gum Forest found on the low shale caps between Lizard Creek and Wallandoola Creek in Wonga West (see *Figure 3.2*). This community is part of the Shale Sandstone Transition Forest EEC listed on both the TSC Act and EPBC Act.

This tall stand of vegetation consisted of Sydney Blue Gum *(Eucalyptus saligna)* and Bangalay *(Eucalyptus botryoides)* with an understorey composition dominated by *Acacia irrorata*. The community was in a state of regeneration after fire approximately five years earlier, as indicated by densely regenerating *A. irrorata*, scattered charred logs and some epicormic budding of *E. saligna* and *E. botryoides* in the area. The condition of the canopy within the EEC was observed to be intact and in good condition.

Transitional Shale Stringybark Forest

Transitional Shale Stringybark Forest (MU 23 NPWS 2003) was dominated by White Stringybark (*Eucalyptus globoidea*), Thin-leaved Stringybark (*Eucalyptus eugenioides*) and Grey Gum (*Eucalyptus punctata*). The understorey is shrubby and contains a mix of Banksias, Tea-trees, and Geebungs. Groundcover species include Spiny-headed Mat-rush (*Lomandra longifolia*), Cane Wire-grass (*Aristida ramosa*), Bordered Panic (*Entolasia marginata*) and Upright Panic (*Entolasia stricta*) (NPWS 2003). The community was observed to occur to the west of Lizard Creek, around the Transitional Shale Tall Open Blue Gum Forest, and in separate stands to the south and west, within Wonga West (see *Figure 3.2*).

This community forms part of the Transitional Shale Sandstone Forest and Woodland Complex EEC listed under the TSC Act and EPBC Act. The community was observed to be in good condition.

Exposed Sandstone Scribbly Gum Woodland

Exposed Sandstone Scribbly Gum Woodland (MU 29 NPWS 2003) was the most spatially dominant community across the Study Area. This woodland was observed to mainly occur on the exposed sandstone ridges and slopes in Wonga East and West (see *Figure 3.1* and *Figure 3.2*). Dominant trees include Scribbly Gums (*Eucalyptus racemosa*, *Eucalyptus sclerophylla, Eucalyptus haemastoma*) with Stringybark (*Eucalyptus oblonga*), Red Bloodwood (*Corymbia gummifera*) and Silvertop Ash (*Eucalyptus sieberi*). Mid-storey species include Hairpin Banksia (*Banksia spinulosa* var. *spinulosa*), Paperbark Tea-tree (*Leptospermum trinervium*), Juniper Wattle (*Acacia ulicifolia*) and Finger Hakea (*Hakea dactyloides*). The sparse groundcover includes species such as Blue Mat-rush (*Lomandra glauca*), Upright Panic (*Entolasia stricta*), Blue Dampiera (*Dampiera stricta*) and Curly-wig (*Caustis flexuosa*) (NPWS 2003).

Sandstone Gully Peppermint Forest

Sandstone Gully Peppermint Forest (MU 26 NPWS 2003) is a tall dry shrubby forest common on sheltered slopes and gullies in the Illawarra region, and was observed to occur in Lizard Creek, Wallandoola Creek Bellambi Creek and Cataract Creek, and their tributaries (see *Figure 3.1* and *Figure 3.2*). Dominant overstorey species include Sydney Peppermint *(Eucalyptus piperita),* White Stringybark (*Eucalyptus globoidea*) and Red Bloodwood (*Corymbia gummifera*). Common species within the diverse shrub layer include *Banksia oblongifoila, Grevillea, Haekea sericea and Acacia.* Common understorey and groundcover species include Spiny-headed Mat-rush (*Lomandra longifolia*), *Dianella* sp and *Lomandra* (NPWS 2003).

Upland Swamps: Fringing Eucalypt Woodland

This upland swamp community (MU 45 NPWS 2003) was observed to be an ecotone between dry sandstone woodlands and upland swamp communities. These areas were observed to be predominantly dry and often resembled the adjoining sandstone woodlands in species composition and soil moisture more than the upland swamp communities observed in drainage lines. This community consisted of Scribbly Gum (*Eucalyptus racemosa) and* Broad-leaved Scribbly Gum *(Eucalyptus haemastoma)* with *Banksia oblongifolia* and *Petrophile sessilis,* dominating the ground coverage (NPWS 2003). Common mid-storey species include Heath-leaved Banksia (*Banksia ericifolia* subsp. *ericifolia*), Fern-leaved Banksia (*Banksia oblongifolia*) and Finger Hakea (*Hakea dactyloides*). Dominant understorey species include Slender Twine-rush (*Leptocarpus tenax*) and Pink Swamp Heath (*Sprengelia incarnata*) (NPWS 2003). The community was commonly observed in Lizard Creek and Wallandoola Creek catchments (see *Figure 3.2*).

It should be noted that Upland Swamps: Fringing Eucalypt Woodland is not included in the determination of Coastal Upland Swamps EEC.

Upland Swamps: Sedgeland - Heath Complex

This upland swamp community (MU 44 NPWS 2003) was observed at the majority of upland swamps within Wonga East and Wonga West. Upland swamp mapping by Biosis provided in *Annex A* supersedes the mapping by NPWS as all of the swamps have been visited and boundaries of the vegetation communities defined.

Structurally this community is a mosaic of sedgeland with patches of low dense shrubs. Dominant shrub species include *Baeckea imbricata,* Pink Swamp Heath (*Sprengelia incarnata*), Blunt-leaf Heath (*Epacris obtusifolia*), *Symphionema paludosum* and Swamp Boronia (*Boronia parviflora*). Common understorey species include Slender Twine-rush (*Leptocarpus tenax*), Zig-zag Bog-sedge (*Schoenus brevifolius*) and *S. paludosus* (NPWS 2003).

Biosis (2012) identified 8.71ha of this Upland Swamps: Sedgeland-Heath Complex in Wonga East and 42.44ha in Wonga West compared to the 19.69ha mapped by NPWS in Wonga East and 44.26ha in Wonga West.

Upland Swamps: Tea-Tree Thicket

While not identified in the NPWS mapping for the Study Area, Tea-tree Thicket (MU 43 NPWS 2003) was observed in a number of the headwater swamps generally as small areas amongst other upland swamp communities. This is demonstrated in the differences identified in the two mapping outputs in Section 3.2 of Biosis (2012). No Tea-tree Thicket was recorded in Wonga East by NPWS (2003), while targeted mapping by Biosis (2012) identified that there is approximately 5.2ha of Tea-tree Thicket in Wonga East. Biosis (2012) mapped 13.92ha in Wonga West, compared to only 1.67ha mapped by NPWS (2003).

Tea-tree thicket community occurs on waterlogged soils and is characterised by dense thickets of *Leptospermum juniperum, Banksia robur* and ground cover species of *Lepyrodia scariosa.* The community was observed to be in good condition in the Study Area.

Tea-tree thicket is considered the most limited community in terms of occurrence in the upland swamps as it is dependent upon permanently wet habitat. The presence of tea-tree thickets in a swamp is considered to be an indicator that a swamp is diverse and of 'special significance' in that it is likely to support a variety of the regional upland swamp vegetation communities (DECCW 2011).

Upland Swamp: Banksia Thicket

Upland Swamp: Banksia Thicket (MU 42 NPWS 2003) community is a low dense heath that forms on the fringes of upland swamps (NPWS 2003). The Upland Swamp: Banksia Thicket community was observed in predominantly in the headwater swamps in Wonga East (see *Annex F*).

Generally, this complex was observed to be in good condition, although soils were observed to be drier than expected in February and September 2009. This dryness is likely to be a seasonal feature of the headwater swamps in the area, as in all cases there was moisture within the valley infill swamps nearby and surveys in September 2011 noted areas of swamps supporting this community as waterlogged.

Biosis (2012a) identified 35.15ha of Upland Swamps: Banksia Thicket in Wonga East and 15.76ha in Wonga West compared to the 48.35ha mapped by NPWS in Wonga East and 4.86ha in Wonga West.

Tall Open Blackbutt Forest

Tall Open Blackbutt Forest community (MU 15 NPWS 2003) was observed in Wonga East. This tall forest was dominated by Blackbutt (*Eucalyptus pilularis*), with a variable understorey of *Acacia* sp., *Banksia* sp., and *Leptospermum* sp. The community was generally observed to be in good condition and was well represented on the slopes and gullies of Bellambi Creek and Cataract Creek (see *Figure 3.1*). Some low level weed encroachment was observed adjacent to the powerline easements and historic clearing that has been undertaken in Wonga East.

Moist Blue Gum - Blackbutt Forest

Moist Blue Gum - Blackbutt Forest (MU 6 NPWS 2003) was observed in warm gullies of the Wonga East area and was dominated by Blackbutt and Sydney Blue Gum. Predominantly this community was observed in Cataract Creek and Bellambi Creek gullies, although smaller patches occur elsewhere in Wonga East. The mid-storey of this community is commonly dominated by rainforest species in particular Lilly Pilly (*Acmena smithii*) and ground coverage of *Lomandra longifolia*, *Pteridium esculentum* and other ferns (NPWS 2003). Generally this community was observed to be in good condition, with the exception of transmission line easements and roadways (see *Figure 3.1*).

Coachwood Warm Temperate Rainforest

Coachwood Warm Temperate Rainforest community (MU 2 NPWS 2003) was observed along the drainage lines of upper Bellambi Creek and Cataract Creek. Its distribution was restricted to the warmer protected gullies of Wonga East, and was not observed elsewhere (see *Figure 3.1*). The forest had a dense canopy dominated by Coachwood *(Ceratopetalum apetalum)*, Lilly Pilly *(Acemena smithii)* and Sassafras *(Doryphora sassafras*). Generally the condition of this forest was good, although the proximity of the forest to access trails and the open understorey render it vulnerable to human disturbance. There was evidence of trail bike damage in the understorey and a number of camping shelters apparently used by trespassers.

Rock Plate Heath-Mallee

This dense heath (MU 49 NPWS 2003) was encountered on heavily vegetated sandstone benches and outcrops in isolated localities within Wonga West, although separate localities are also mapped as occurring within Wonga East (see *Figure 3.1*). Generally the overstorey of this community was comprised of mallee formed Red Bloodwood *(Corymbia gummifera)* although the canopy was normally very sparse. The shrub layer was the dominant feature of this community with mallee formed *Banksia ericifolia, Leptospermum polygalifolium* and *Hakea teretifolia* the most common species encountered.

Regenerating Vegetation

Stands of regenerating vegetation were observed in Wonga East around areas that were adjacent to land cleared for transmission line easements and vehicle tracks (see *Figure* 3.1). This regenerating vegetation comprised of Blackbutt *(Eucalyptus pilularis)* and Turpentine (*Syncarpia glomulifera* subsp. *glomulifera*) and often with *A. irrorata* and *Lomandra* sp. This regenerating vegetation could not be identified to community level and the boundaries of the community are not defined on *Figure 3.1*.

Cleared Land

There were areas of cleared land around mine shafts, transmission lines, roads, vehicle tracks and other infrastructure. Cleared land was only encountered in small parts of the Study Area, predominantly in Wonga East (see *Figure 3.1*).

4.3.4 Endangered Ecological Communities (EECs)

Shale Sandstone Transition Forest EEC

Shale Sandstone Transition Forest, as listed under Part 3 of Schedule 1 of the TSC Act, and under the Commonwealth EPBC Act, is represented by Transitional Shale Stringybark Forest and Transitional Shale Tall Open Blue Gum Forest. Shale-Sandstone Transition Forest occurs at the edges of the Cumberland Plain where shale rock and clay soils gradually change to sandstone and is reduced to 23% of its original extent (NPWS 2003). The greatest threat to Shale-Sandstone Transition Forest is clearing for agriculture and urban/rural residential development. Subsidence due to longwall mining is listed as a key threatening process for this EEC.

Within the Study Area this EEC was represented by a healthy and intact canopy in discreet elevated patches of shale based soils in the Wonga West Area (see *Figure 3.2*). Fire Road 8 in Wonga West traverses this community which is easily delineated by the canopy of tall *Eucalyptus saligna* and *E. botryoides* (Tall Open Blue Gum Forest), or *E. globoidea* and *E. eugenoides* (Stringybark Forest). All observed patches of this EEC were observed to be in a healthy condition.

Coastal Upland Swamp in the Sydney Basin Bioregion EEC

Coastal Upland Swamp in the Sydney Basin bioregion has recently been gazetted as an EEC under Part 3, Schedule 1 of the TSC Act. Coastal Upland Swamp EEC occurs in the Sydney Basin bioregion and is associated with periodically waterlogged soils on Hawkesbury sandstone plateau (DEC 2011). Floristically this EEC is described as Upland Swamps: Banksia Thicket; Upland Swamps: Tea Tree Thicket; and Upland Swamps: Sedgeland-Heath Complex. Upland swamps supporting these communities are mapped throughout the Study Area (see *Figure 3.1* and *Figure 3.2*).

Detailed mapping of vegetation communities in the Upland Swamps is provided in Biosis's assessment of Upland Swamps (2012a).

Temperate Highland Peat Swamps on Sandstone EEC

Temperate Highland Peat Swamps on Sandstone is listed as an Endangered Ecological Community under the EPBC Act. The Temperate Highland Peat Swamps on Sandstone EEC is comprised of temporary or permanent swamps with a substrate of peat over sandstone, and vegetation characterised by the presence of sedges, graminoids and forbs with or without shrubs (NSW Scientific Committee 2005). The swamps generally occur at altitudes from around 600m to 1200m above sea level and are restricted to the South Eastern Highlands and Sydney Basin Interim Biogeographic Regionalisation of Australia (IBRA) regions in New South Wales.

Currently the upland swamps of the Woronora Plateau are not identified as part of this EEC however, it is noted that the Commonwealth Threatened Species Scientific Committee is currently reviewing the listing in this respect (DECCW 2011).

Biosis (2012) in their assessment of upland swamps concluded that upland swamps in the Study Area are not in keeping with the Commonwealth listing. Accordingly, this assessment has considered them as representative of the state listed upland swamp EEC. Consideration of this is provided in Biosis (2012a).

4.3.5 Rare and Threatened Flora

Two Rare or Threatened Australian Plants (ROTAPs) *Darwinia grandiflora* (listed as 2RCi) and *Monotoca ledifolia* (listed as 3RC-) were recorded during the field survey in the Wonga West and East. RoTAP species, Shining Guinea Flower is also known to occur (Kevin Mills and Associates 2005).

Two threatened flora species have been recorded during current and previous surveys in the Study Area. The distributions of the recorded specimens are shown in *Figure* 4.3 and *Figure 4.4*.

The Prickly Bush-Pea was recorded by ERM and/or Biosis in CRUS1, CCUS3, CCUS10, CCUS8 and BCUS7 in Wonga East (see *Figure 4.3*); and by Biosis in LCUS27, WCUS5, WCUS1, WCUS4, LCUS14, LCUS13, LCUS15, LCUS16, LCUS33, LCUS17 (Nathan Garvey Biosis 2012 pers comm) in the Wonga West area (see *Figure 4.4*). This species is listed as vulnerable under the TSC Act and the EPBC Act.

Kevin Mills and Associates (2005) previously identified the Prickly Bush-pea near Shaft No 5. Kevin Mills and Associates (2005) have also previously identified the threatened Hairy Geebung in the Wonga West area.

The Study Area also provides potential habitat for the following flora species:

- *Acacia baueri* subsp. *aspera;*
- Bargo Geebung *(Persoonia bargoensis);*
- *Epacris purpurascens* var. *purpurascens;*
- Deane's Melaleuca (*Melaleuca deanei*);
- Needle Geebung *(Persoonia acerosa);*
- Small-flower Grevillea *(Grevillea parviflora* subsp. *parviflora);* and
- Woronora Beard-heath (*Leucopogon exolasius*).

4.4 *FAUNA*

4.4.1 *Frogs*

A total of 13 frog species were recorded within the Study Area during field investigations by ERM, Biosis (2009), Eco Logical (2009) and ERM in 2011. Two of these species, Red-crowned Toadlet (*Pseudophryne australis*) and Giant Burrowing Frog (*Heleioporus australiacus*), are listed as vulnerable under the TSC Act, and the latter species is also listed as vulnerable under the EPBC Act.

Threatened species record locations within the Study Area are shown in *Figure 4.3* and *Figure 4.4*. A full list frog species recorded within the Study Area is provided in *Table 4.2.*

Table 4.2 Frog Species Recorded within the Study Area

Common Name	Scientific Name	TSC Act Status	EPBC Act Status
Common Eastern Froglet	*Crinia signifera*	-	-
Giant Burrowing Frog	*Heleioporus australiacus*	V	V
Banjo Frog	*Limnodynastes dumerilii grayi*	-	-
Striped Marsh Frog	*Limnodynastes peronii*	-	-
Green Tree Frog	*Litoria caerulea*	-	-
Lesueur's Frog	*Litoria leseuri*	-	-
Southern Leaf-green Tree frog	*Litoria nudidigitis*	-	-
Peron's Tree Frog	*Litoria peronii*	-	-
Verreaux's Tree Frog	*Litoria verreauxii*	-	-
Haswell's Frog	*Paracrinia haswelli*	-	-
Red-crowned Toadlet	*Pseudophryne australis*	V	-
Brown Toadlet	*Pseudophryne bibronii*	-	-
Red-backed Brood Frog	*Pseudophryne coriacea*		

1. Source: Biosis 2009 and Eco Logical 2009
2. Status: V = vulnerable

Red-crowned Toadlet was recorded within Lizard Creek at two locations and at the base of the headwater swamp LCUS18 (see *Figure 4.4*).

Habitat searches identified suitable habitat for the Stuttering Barred Frog (*Mixophyes balbus*) within the Cataract Creek in the Wonga East area (Eco Logical 2009; Nathan Garvey Biosis 2012, pers comm). No individuals of this species were observed during any of the field investigations.

Suitable habitat for Heath Frog was recorded within the Wonga West area during field surveys by both Eco Logical (2009) and Biosis (2009) and in some of the 1st and 2nd order streams associated with upland swamps in Wonga East (N. Garvey Biosis pers comm). The condition of the habitat varied from good to poor condition, with some stream and pools being affected by iron-oxidising bacteria scum. The greatest extent of suitable habitat for this species was recorded within the upper reaches of Lizard Creek, the Lizard Creek swamp complex, and within the pooled sections of Wallandoola Creek within the associated swamp complex (Biosis 2009, Eco Logical 2009).

In the 2009 surveys, the Giant Burrowing Frog was recorded within LCT1 and LCT2. Recent assessments undertaken by Biosis for the SMP for Longwalls A2 LW4 and A2 LW5 has identified breeding habitat for the Giant Burrowing Frog and Heath Frog in the 1st order streams associated with upland swamps CRUS1, CRUS2 and CCUS4. Tadpoles of Giant Burrowing Frog were located in the 1st order stream to the south of CRUS2 in August 2012 (N. Garvey Biosis pers comm).

Biosis (2009) recorded one dam which represented poor quality habitat for the Green and Golden Bell Frog, although no individuals were recorded. A visit to the site by Ross Wellington from Eco Logical determined that the dam was not suitable habitat for this species (Eco Logical 2009). Green and Golden Bell Frog have previously been recorded within the NRE Colliery at Russell Vale, which is outside of the Study Area, on the coastal slopes below the Illawarra Escarpment.

4.4.2 Reptiles

A total of 13 reptile species was recorded during investigations by ERM and Biosis in 2009, and Eco Logical in 2009 within the Study Area. None of the species recorded are listed on either the TSC Act or the EPBC Act. A list of reptile species recorded in the Study Area is presented as *Table 4.3*.

Table 4.3 Reptile Species Recorded within the Study Area

Common name	Scientific name	TSC Act status	EPBC Act status
Jacky Lizard	*Amphibolurus muricatus*	-	-
Eastern Snake-necked Turtle	*Chelodina longicollis*	-	-
Copper-tailed Ctenotus	*Ctenotus taeniolatus*	-	-
Eastern Water-skink	*Eulamprus quoyii*	-	-
Dark-flecked Garden Sunskink	*Lampropholis delicata*	-	-
Pale-flecked Garden Sunskink	*Lampropholis guichenoti*	-	-
Lesueur's Velvet Gecko	*Oedura lesueurii*	-	-
Broad-tailed Gecko	*Phyllurus platurus*	-	-
Eastern Water Dragon	*Physignathus lesueurii*	-	-
Red-bellied Black Snake	*Pseudechis porphyriacus*	-	-
Eastern Brown Snake	*Pseudonaja textilis*		
Blackish Blind Snake	*Ramphotyphlops nigrescens*	-	-
Mountain Heath Dragon	*Rankinia diemensis*	-	-

1. Source: Biosis 2009 and Eco Logical 2009

The SCA Special Areas contain a healthy and viable population of Broad-headed Snake, and this species is expected to occur within suitable habitat in the Study Area. In particular, the Broad-headed Snake may utilise wintering habitat on north-west facing rock benches and outcrops with exfoliating rock. Typically, this species occurs in rock shelters that do not contain debris and leaf-litter (R. Wellington, *pers. comm.*). The presence of favoured prey species, Leseur's Velvet Gecko, is also an indicator of suitable habitat.

Habitat searches identified presence of the indicator species Leseur's Velvet Gecko (Biosis 2009, Eco Logical 2009) and potential wintering habitat for Broad-headed Snake along a number of sandstone benches and outcrops adjacent to Lizard Creek with some smaller isolated outcrops in the Wonga East area (see *Annex B*). However, in many instances the areas of exfoliating sandstone shelters contained sand, soil and leaf debris due to previous fire and erosion events, and were considered sub-optimal for the species. In addition, these areas of suitable habitat generally are not considered critical wintering habitat, as they do not have a north-west aspect as preferred by the species.

Accordingly, the Study Area is not expected to provide habitat for a significant proportion of a population of this species, as extensive outcropping of rock benches was not recorded in the Study Area (Eco Logical 2009).

Suitable habitat for Rosenberg's Goanna was recorded within the Study Area, although no individuals were observed (Biosis 2009, Eco Logical 2009). Suitable west facing rock ledges and overhangs, which would be suitable for over-wintering hibernation by the species, were sparsely distributed throughout the Study Area (Eco Logical 2009). Four ground termitaria were recorded, which can be used as nesting chambers by the goanna, although no evidence of nesting was observed (Biosis 2009). It is not expected that the Study Area contains extensive tracts of habitat that would support a significant population of this species (Eco Logical 2009).

4.4.3 Birds

A total of 87 bird species were recorded within the Study Area. Records include two species listed as vulnerable under the TSC Act, two migratory species listed on the EPBC Act and two regionally significant species susceptible to subsidence DECC (2007) (see *Table 4.4*). The location of these records is shown in *Figure 4.3* and *Figure 4.4*.

Table 4.4 Threatened, Migratory and Rare Birds Recorded

Common Name	Scientific Name	TSC Act	EPBC Act
Glossy Black Cockatoo	*Calyptorhynchus lathami*	V	-
Black-faced Monarch	*Monarcha melanopsis*	-	M
Powerful Owl ^	*Ninox strenua*	V	-
Rufous Fantail	*Rhipidura rufifrons*	-	M
Beautiful Firetail*	*Stagonopleura bella*	-	-
Southern Emu Wren*	*Stipiturus malachurus*	-	-

* Species is not listed under TSC Act, but is vulnerable to subsidence (DECC 2007a) Status: V = Vulnerable; M = Migratory

A full list of bird species recorded in the Study Area is provided in *Annex D*.

Suitable habitat for the threatened Eastern Ground Parrot was recorded in the larger upland swamp within upper Lizard Creek and upper Wallandoola Creek. The Ground Parrot was until recently thought to be regionally extinct until it was recently recorded within 18km of the Study Area at Metropolitan Colliery (two records) and in the Bulli Seam Operations study area (detected twice two individuals at one site and one at another) (PAC 2010). These records indicate that the Ground Parrot continues to persist in patches of suitable habitat in the Southern Coalfields region. This species occurs at Barren Grounds, approximately 35km south of the Study Area (NSW Government 2005).

Call broadcasting, spotlighting and searches of suitable habitat undertaken in February 2009 and vegetation surveys in areas of suitable habitat in September 2011 failed to detect any individuals in the Study Area. This species has been assessed as having a high likelihood of occurrence in the upland swamps in the Study Area.

4.4.4 *Mammals*

Twenty-eight (28) mammal species was recorded within the Study Area, including 11 non-volant species, 16 microbats and one flying fox. Species listed on the TSC Act include five bat species detected using Anabat units in the Study Area. A full list of mammal species recorded in the Study Area is shown in *Table 4.5*. Locations of threatened species records are shown in *Figure 4.3* and *Figure 4.4*.

Macropod scats were found within all habitats, with the most commonly observed species being the Eastern Grey Kangaroo (*Macropus giganteus*) and Swamp Wallaby. Wombat scats were also common across the sites. Sugar Gliders were recorded within the forested portions of the Study Area. There were no records of Eastern Pygmy-possum, although the species is known to occur in Exposed Sandstone Scribbly-gum woodland south of Wonga West (ERM 2009).

Seven mammal species were recorded during spotlighting and incidental observations, while five species were recorded from hairs obtained in the hair funnel surveys. All 16 microchiropteran species were recorded from Anabat recordings. Two introduced species were recorded; European Red Fox (*Vulpes vulpes*), and Black Rat (*Rattus rattus*).

Hair funnel surveys had a successful detection rate of 28% with valid hairs obtained from 47 of the 170 funnels. Brown Antechinus (*Antechinus stuartii*) was the most commonly recorded species, with hairs recorded from 26 hair funnels. Five additional Antechinus samples were recorded for which it was only possible to identify to genus level.

Table 4.5 ***Mammal Species Recorded in the Study Areas***

Common name	Scientific name	TSC Act status	EPBC Act status
Non-volant Mammals		-	-
Brown Antechinus	*Antechinus stuartii*	-	-
Eastern Grey Kangaroo	*Macropus giganteus*	-	-
Long-nosed Bandicoot	*Parameles nasuta*	-	-
Sugar Glider	*Petaurus breviceps*	-	-
Bush Rat	*Rattus fuscipes*	-	-
Black Rat^	*Rattus rattus*	-	-
Short-beaked Echidna	*Tachyglossus aculeatus*	-	-
Common Brushtail Possum	*Trichosurus vulpecula*	-	-
Common Wombat	*Vombatus ursinus*	-	-
European Red Fox^	*Vulpes vulpes*	-	-
Swamp Wallaby	*Wallabia bicolor*	-	-
Bats			
Gould's Wattled Bat	*Chalinolobus gouldii*	-	-
Chocolate Wattled Bat	*Chalinolobus morio*	-	-
Eastern Falsistrelle	*Falsistrellus tasmaniensis*	V	-
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	V	
Eastern Freetail-bat	*Mormopterus norfolkensis*	V	-
Freetail Bat	*Mormopterus sp.2*	-	-
Large-footed Myotis	*Myotis macropus (adversus)*	V	-
Unidentified Long-eared Bat	*Nyctophilus sp.*		-
Little Red Flying-fox	*Pteropus scapulatus*	-	-
Eastern Horseshoe Bat	*Rhinolophus megaphyllis*	-	-
Eastern Broad-nosed Bat	*Scoteanax orion*	-	-
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V	-
White-striped Mastiff Bat	*Tadarida australis*	-	-

Common name	Scientific name	TSC Act status	EPBC Act status
Large Forest Bat	*Vespadelus darlingtoni*	-	-
Eastern Forest Bat	*Vespadelus pumilus*	-	-
Southern Forest Bat	*Vespadelus regulus*	-	-
Little Forest Bat	*Vespadelus vulturnus*	-	-

1. ^ = introduced species
2. Status: V = vulnerable

Spotlighting and scat searches failed to detect any Spotted-tailed Quolls (*Dasyurus maculatus*) although it is acknowledged that suitable habitat for this species occurs extensively in the Wonga West area.

Searches of rocky outcrops and overhangs, disused mine infrastructure, road culverts and power supply housings did not detect any bat roosts. No permanent flying fox camps were detected within the Study Area during the entire survey period. Only one individual flying-fox, a Little Red Flying-fox (*Pteropus scapulatus*), was recorded within Study Area. However, timing of the surveys was not optimal for detecting a high abundance of nectar and fruit eating bats. It is considered likely that Grey-headed Flying-fox (listed as vulnerable under the TSC Act and EPBC Act) would utilise the Study Area for foraging during flowering periods.

4.5 HABITAT CONDITION

This section discusses the observed condition of major habitat features within the Study Area that are vulnerable to the impacts of subsidence according to DECC (2007a) and DoP (2008). The nomenclature of streams and swamps follows that of GeoTerra (2012a) and Biosis (2012) as shown in and .

4.5.1 Streams

This section describes the condition of the three fourth order creeks with the potential to be impacted by the proposed action in the Study Area. It should be noted that a detailed description of the stream morphology and condition is also provided in GeoTerra (2012a) and Cardno Ecology Lab (2011).

An assessment of condition of Bellambi Creek is not provided as the creek is well outside of the proposed mine footprint and will not experience effects of subsidence (Seedsman Geotechnics 2012).

Wallandoola Creek

Wallandoola Creek located in Wonga West was observed to vary from good to moderate condition across the Study Area. The upper creek was found to consist primarily of a poorly defined channel in WCUS1 within Upland Swamp: Sedgeland Heath Complex and Upland Swamp: Tea Tree Thicket. In the lower reaches of the swamp there are a number of large standing pools around WC3 and in WCUS7 amongst Upland Swamp: Tea Tree Thicket as seen in *Photograph 4.1*. Downstream of these areas the creek is bound by sandstone benches and platforms above WC4. At the time of each survey in 2009, Wallandoola Creek had negligible water flows, although large standing ponds were observed regularly at the sites stated above.

Visual evidence of iron-oxidised bacteria was recorded in the mid and lower sections of the creek (in WCUS7 and around WC4) in October 2009, as seen in *Photograph 4.2*.

The creek was observed to contain habitat for Heath Frog around WC3 and WCUS7, and this species is predicted to occur within the drainage in parts of the Study Area (Eco Logical 2009). Wallandoola Creek contains a number of shallow perennial ponds that are suitable breeding habitat for Heath Frog around WC3. Suitable breeding habitat for this species was generally restricted to the upper reaches where the water column did not appear to be affected by iron-oxidising bacteria flocculate (Eco Logical 2009). At the base of the swamp complex, the creek gives way to sandstone benching below WCUS7where iron flocculation was found in the ponds, and the condition of the creek deteriorates as it continues downstream, in some cases, surface water disappears entirely before resurfacing 100m downstream (GeoTerra 2012a).

Photograph 4.1 Wallandoola Creek upper reaches around WC3

Photograph 4.2 Wallandoola Creek mid reaches around WC4

Lizard Creek

Lizard Creek is the longest drainage within the Study Area and extends from the south east of Area 3, through the Study Area to join Cataract River north of Areas 3 and 4. The condition of this creek was observed to vary from good to poor condition.

In the upper reaches within upland swamp LCUS1, the creek is fringed by extensive Upland Swamp: Sedgeland Heath Complex with Upland Swamp: Banksia Thicket. LCUS1 is in very good condition, supporting high soil moisture content in February, March and October 2009, despite ongoing dry conditions. The surrounding swamp was undisturbed and contains habitat for Southern Emu-wren (*Stipiturus malachurus*) and Red-crowned Toadlet. There was no evidence of iron-oxidising bacteria in this section of Lizard Creek.

Downstream of the access road to Shaft 4 the riparian vegetation is dominated by Upland Swamp: Fringing Eucalypt Woodland with smaller areas of upland swamps supporting Upland Swamp: Tea-tree Thicket and Upland Swamp: Sedgeland Heath Complex associated with Lizard Creek and its 1st order tributaries.

The condition of the Lizard Creek was noted to deteriorate quite suddenly, where the creek bed appears to have collapsed, as seen in *Photograph 4.3*, and the stream disappears from the surface. Surface flows reappear at the base of the waterfall approximately 100m downstream (GeoTerra 2012a).

Photograph 4.3 Creek bed collapse in Lizard Creek

In the deeply incised valleys in the northern sections of Area 3, there are long stretches of creek between LC5 and LC6 where standing water was only observed in small shallow pools within the existing creek bed. Iron-oxidised bacteria flocculation was observed in the main channel of Lizard Creek below LC6.

A 3rd order tributary of Lizard Creek (LCT1) occurs over the proposed Longwall A3 LW3 flowing into Lizard Creek downstream of monitoring point LC6. This creek is fed from two 2nd order streams flowing from LCUS20 and LCUS21 or LCUS18.

Lizard Creek Tributary 2 (LCT2) occurs to the west of LCT1 joining Lizard Creek at the northern boundary of the Study Area. LCT2 is fed by the 3rd order tributary (LCT2A) associated with LCUS25 and LCT2B tributary (see *Figure 2.2*). LCT2 is predominantly a 2nd order stream over the proposed Longwalls A3 LW4 and A3 LW5 (see *Figure 2.2*).

Giant Burrowing Frog tadpoles were recorded in both LCT1 and LCT2 creeks (for locations, refer to *Figure 4.4*). In the majority of instances, the tadpoles inhabited small pools on sandstone benches within the dry stream channel, as seen in *Photograph 4.4*. In some instances, the tadpoles inhabited small ponds with heavy iron-oxidising bacteria flocculation in LCT1, as seen in *Photograph 4.5*. Given the condition of the pond, it is thought, that these tadpoles had washed downstream from healthy ponds in mid sections of the creek, as there have been no previous records of this species inhabiting heavily flocculated creeks (Ross Wellington, *pers. comm.*).

Photograph 4.4 Giant Burrowing Frog habitat in good condition in Lizard Creek Tributary 1

Photograph 4.5 Giant Burrowing Frog habitat in poor condition in Central Creek (Eco Logical 2009)

Cataract Creek

Cataract Creek occurs in a gully of steep relief in Wonga East and the vegetation consists of Coachwood Warm Temperate Rainforest and Tall Open Blackbutt Forest. The forest habitat in Cataract Creek is in good condition and shows little signs of disturbance west of Mt Ousley Road (between CC5 and CC8). The creek line within this area is optimal for Stuttering Barred Frog (*Mixophyes balbus*), which prefers closed riparian forest with permanent water supply as seen in *Photograph 4.6* (Eco Logical 2009). Despite the good quality habitat for this species observed in Cataract Creek, no individuals were observed. Suitable habitat for this species was also observed upstream of Mt Ousley Road.

Heavily iron-oxidised bacteria flocculation was observed in the tributary downstream of Area 1 (stream monitoring sites CC2 and CC3) and near stream monitoring site CC4 on Cataract Creek. These conditions reduce the suitability of the habitat for this species (Ross Wellington, *pers. comm.*).

Further downstream, below CC8, the condition of the stream and the adjacent vegetation deteriorates due to the influence of water level fluctuation in Cataract reservoir. The creek becomes poorly defined closed forest vegetation becomes sparse and acacia regrowth and herbaceous weeds become common within the channel, as seen in *Photograph 4.7*. In these areas, water was observed to be more turbid and less suitable for the Stuttering Barred Frog (Eco Logical 2009).

Photograph 4.6 Stuttering Barred Frog habitat in Cataract Creek (Eco Logical 2009)

Photograph 4.7 Degraded habitat in Cataract Creek

4.5.2 Upland Swamps

All swamps, with the exception of the north-western most swamp within the Study Area, occur within the Wallandoola Significant Swamp Cluster, identified by DECC (2007a) as providing large contiguous areas of habitat for swamp-dependant species within the Southern Coalfields.

Generally, swamp condition was observed to be very good, with the exception of some of the headwater swamps in Cataract Creek that showed signs of disturbance and LCUS25 in Wonga West that showed signs of scouring and erosion.

A detailed description of the upland swamps is provided in Biosis (2012a) and the findings are summarised in *Sections 2.2.3* and *2.4.2*. The following sections describe the condition of some of the swamps observed during field investigations within the Study Area.

Cataract Creek and Cataract River Swamps

CRUS1, CRUS2 and CRUS3 are headwater swamps above Cataract River. CRUS1 is a large swamp supporting Upland Swamp Tea tree thicket, Upland Swamp Sedgeland Heath Complex and Upland Swamp Banksia Thicket (see *Figure A.1* in *Annex A*). All three of these swamps have been identified as swamps of special significance (Biosis 2012a).

CRUS1 has been noted to be in good condition, and is likely to support habitat for a number of threatened species including Giant Burrowing Frog, Giant Dragonfly (*Petalura gigantea*) and may support ephemeral breeding habitat of Red-crowned Toadlet downstream of the swamp. Two 1st order stream associated with this swamp has been identified as only providing marginal quality breeding habitat for the Heath Frog and Giant Burrowing Frog (N. Garvey Biosis pers comm). The threatened Prickly Bush-pea (V TSC Act and V EPBC Act) was recorded within CRUS1. To avoid impacts on this swamp Longwalls A2 LW4 and A2 LW5 have been shortened (approved workings) and the proposal will now only undermine the most northern section of CRUS1.

Upland swamp CRUS2 has been recognised as an upland swamp of special significance (Biosis 2012a). The 1st order stream associated with this swamp has been identified as good quality breeding habitat for the Heath Frog and Giant Burrowing Frog (N. Garvey Biosis pers comm). In mid-2012 a number of tadpoles of the Giant Burrowing Frog were recorded in this stream (N. Garvey Biosis pers comm). This swamp does not overlay any of the proposed mines and is not at risk of negative environmental consequences from the Project.

CCUS1 is a large headwater swamp of special significance in the upper reaches of Cataract Creek. CCUS1 supports a variety of vegetation communities including Upland Swamps: Tea-tree Thicket. There was a moderate level of disturbance in CCUS1 and the nearby CCUS2 from dirt bikes, historic fly tipping, erosion due to illegal vehicular access from Mount Ousley Road and some weed incursion. The disturbance in CCUS1 is relatively superficial and does not appear to be significantly affecting the hydrology or floristic features of the swamp at this stage. The sandy soils were considered to provide suitable foraging and burrowing habitat for Giant Burrowing Frog, however the swamps were dry during all observation periods and were considered sub-optimal due to poor moisture retention, distance from suitable breeding habitat, relatively small size and inability to support a significant population of the species (Eco Logical 2009).

CCUS3 through to CCUS5 are a series of scattered headwater swamps within the upper reaches of Cataract Creek overlying Wonga East Area 2. These swamps are generally disconnected but showed good floristic diversity and no indication of disturbance. CCUS3 contains an area of sedgland-heath complex surrounded by banksia thicket. This swamp had no observed surface water and was moist to well-drained in areas. The swamp had good floristic structure and the threatened Prickly Bush-pea (V TSC Act and V EPBC Act), and rare *Darwinia grandiflora* (RoTAP 2RCi) were recorded within this swamp. CCUS4 contains banksia thicket and a patch of sedgeland-heath complex (unmapped by NPWS 2003) which was wet with areas of surface water. This sedgeland-heath complex was dominated by sedges and ferns and the area and surrounds provide suitable habitat for the Giant Burrowing Frog, Heath Frog and Red-crowned Toadlet. Though it is noted that the 1st order stream associated with this swamp has been identified as only providing marginal quality breeding habitat for the Heath Frog and Giant Burrowing Frog (N. Garvey Biosis pers comm).

Lizard Creek Swamps

The most extensive upland swamps in the Study Area and nearby areas occur within Lizard Creek. The majority of the Lizard Creek swamps upstream of the waterfall are in very good condition, particularly LCUS1, to the south of the access road has not previously been undermined. LCUS1 occurs in a broad, low gradient channel that drains from the extensive headwater swamp. Surface water was present in every survey period in LCUS1, including during periods when the headwater swamps were seasonally dry.

LCUS4 was also observed to be in good condition but was of lesser extent, occurring within a narrow channel among Fringing Eucalypt Woodland downstream of the access road to Shaft 5. The swamps were predominantly a Sedgeland Heath Complex but sections of Tea-tree Thicket and Banksia thicket also occurred in poorly drained areas. The valley fill swamps had high moisture content and surface water pooling was common even during dry conditions (*see Photograph 4.8*). Water stress was observed in the upland slopes of the headwater swamps, but this is suspected to be a seasonal attribute of headwater swamps in the region as the condition was widespread in areas that have not previously been undermined (GeoTerra 2012a).

Fringing Eucalypt Woodland occurs adjacent to this swamp and others in this section of the creek, as an ecotone between the freshwater swamp and the well drained sandstone woodlands. Due to their reduced ability to retain moisture during dry periods, Fringing Eucalypt Woodlands are less likely to be affected by subsidence impacts than those headwater and valley fill swamps providing habitat for water-dependent species.

Photograph 4.8 Standing Water within the Lizard Creek Swamps (elevation view)

Threatened and rare species recorded within LCUS1 include Southern Emu-wren, Red-crowned Toadlet, Eastern Freetail-bat, Eastern Falsistrelle (*Falsistrellus tasmaniensis*) and Eastern Bentwing-bat (see *Figure 4.4*). The Lizard Creek swamp complex is therefore considered to be a highly significant ecological feature because it provides extensive habitat for swamp-dependent and water-dependent species, even during seasonal and extended dry periods, and because it is part of the Wallandoola Significant Swamp Cluster.

A headwater swamp (LCUS10) occurs just west of No. 5 Shaft and drains into Lizard Creek. This swamp supports Upland Swamps: Sedgeland-Heath Complex interspersed with patches of Upland Swamps: Banksia Thicket. This swamp was observed to be wet with small pools and puddles and no disturbance was evident. Foraging habitat suitable for Giant Burrowing Frog and Red-crowned Toadlet was also noted.

A small headwater swamp (LCUS18) occurs at the headwater of LCT1. LCUS18 occurs on the northern edge of the Transitional Shale Forest EEC, and feeds the 2nd order tributary of LCT1. The swamp was in good condition during the survey period and contains foraging habitat suitable for Giant Burrowing Frog and Red-crowned Toadlet. These two species were recorded within LCT1.

Another small linear headwater swamp (LCUS25) occurs to the west of LCUS18 (see *Figure 2.2*). LCUS25 is comprised of Sedgeland Heath Complex amongst Fringing Eucalypt Woodland and was observed to contain little or no soil moisture at the time of survey in February 2009 and March 2010. Very damp to wet areas (pools and puddles) were observed in this swamp during the surveys in September 2011. At the lower end of LCUS25 there was evidence of scouring and erosion in a number of discrete locations and the swamp and the creek which drained from it were dry during the above dates. Further downstream towards the junction with LCT2, water was again observed within the stream channel, particularly where sandstone benches, pools and riffles occurred. It is in these locations where Giant Burrowing Frog tadpoles were also observed within sandstone bound rock pools.

Wallandoola Creek Swamps

The swamp complex around Wallandoola Creek was comprised of both valley infill swamp (WCUS1 and WCUS7) and headwater swamp (WCUS4 and WCUS11). Valley fill swamps were observed to be in good condition, contained a high moisture content during summer (as seen in *Photograph 4.1*), and occurred within a defined channel in a broad open valley with fringing eucalypt woodland.

WCUS4 and WCUS11 have previously been undermined in the 1980s and there were no observable effects on the quality or quantity of surface water in these swamps (GeoTerra 2012a), and similarly ecological condition of the swamps was consistent with that observed in areas not previously undermined, such as the headwater swamps of upper Lizard Creek. Surveys during September 2011 found that WCUS4 and WCUS11 were in good condition with moist soil and in some areas, contained old wombat burrows filled with water. An area of dry and cracked soil was observed within WCUS4 on the periphery of the Sedgeland Heath. It was observed in this area that the sedgeland abruptly changed from damp to dry soil. Cracks were also observed in the soil (see *Photograph 4.9*). It is unlikely that this is water stress as a result of a seasonal attribute as the swamp was found to be damp elsewhere. It is suspected that this may be evidence of subsidence, and further investigations may be required.

Threatened species observed to occur within the Wallandoola Creek swamps were Eastern Freetail-bat (*Mormopterus norfolkensis*), Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) (see *Figure 4.3* and *4.4*). Eastern Pygmy Possum has previously been recorded in Fringing Eucalypt Woodland within this swamp complex for the V-Mains flora and fauna assessment (ERM 2009).

Photograph 4.9 Potential subsidence in WCUS4

4.5.3 *Rocky Habitat*

The Study Area occurs on a predominantly sandstone geology and therefore contains numerous sandstone outcrops, escarpments, benches and overhangs. The sandstone geology has defined the path of creeklines and as such the majority of sandstone outcropping occurs along creeks and other drainages, particularly along Lizard Creek and Wallandoola Creek and their tributaries.

Reptile Habitat

The Study Area does not contain extensive north-western and/or western facing sandstone benches that could be considered critical wintering habitat for the Broad-headed Snake or Rosenberg's Goanna (Eco Logical 2009). However, there are sandstone benches and overhangs, some with good quality exfoliating slabs that provide habitat for Broad-headed Snake, and the species is expected to inhabit these areas. An example of such habitat is provided as *Photograph 4.10*. Due to the topography of the Study Area and the location of the proposed longwalls, it appears that conflicts between the Project and the habitat requirements of this threatened species have been avoided (Eco Logical 2009).

Photograph 4.10 Broad-headed Snake wintering habitat in lower sections of Lizard Creek

Bat Habitat

Anabat units detected the presence of two threatened cave-roosting bats in the Study Area, Eastern Bentwing-bat and the Large-footed Myotis (*Myotis macropus*). Both Eastern Bentwing-bat and the Large-footed Myotis are known to utilise other roost sites including disused mine shafts and tree hollows (Strahan 1995).

The most likely location for overhangs to occur that may potentially support roosting sites for these bats would be within the deeply incised valley of Lizard Creek, above the fully supported underground driveage in Wonga West. Field surveys did not record any caves or overhangs in Wonga West which were considered suitable for cave-roosting bats, in that they lacked the presence of a deep overhang with a domed roof for maintaining temperature and humidity, and there were no deep, dark tunnels recorded. Notwithstanding this, it cannot be ruled out that a suitable roost cave exists within the Study Area. Scats collected from a low cave in Wonga East are likely to be from a micro bat (N. Garvey Biosis, pers comm).

It should be noted that, it is unlikely that maternity caves for the Eastern Bentwing-bat occur within the Study Area, due their specific breeding requirements. The species is known to breed in only four maternity roost sites in Australia, requiring a dark damp cave, normally in limestone geology, the nearest of which is located near Kempsey on the NSW north coast (Brad Law, Forests NSW, *pers. comm.*).

Large-footed Myotis is known to roost in tree hollows, road culverts and road bridges and prefers sites adjacent to slowly flowing pools along vegetated watercourses, which are their primary foraging resource.

It is likely that the Large-footed Myotis currently roosts and breeds within tree hollows along watercourses within the Study Area. The locations of these roosts have not been confirmed.

4.5.4 *Koala Habitat Assessment*

In accordance with the EP&A Act, the EAR must assess whether the Study Area contains potential or core Koala habitat as defined under SEPP 44. The SEPP outlines the following definitions for the determination of Koala habitat:

- *Potential Koala Habitat* - areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component; and

- *Core Koala Habitat* - an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.

Eucalyptus haemastoma was the only tree species listed on Schedule 2 of SEPP 44 that was recorded in the Study Area. In three instances, relative abundance of this tree species was recorded at between 6% and 20% of canopy cover. *E. haemastoma* is a dominant canopy tree in two vegetation communities in the Study Area: Exposed Sandstone Scribbly Gum Woodland; and Upland Swamp – Fringing Eucalypt Woodland.

Searches of the Atlas of NSW Wildlife database returned five records of Koalas from within 10km of the Study Area. Field surveys did not record any observations, scats, tree scratches or vocalisations of the koala in the Study Area. Ongoing surveys of Koalas in the Study Area by the University of Western Sydney (UWS) have produced records of Koalas in Cataract River, below Cataract Dam (Assoc Prof Robert Close, UWS, *pers. comm.*). Another population is known to exist to the south of the Study Area near Avon Dam, and the animals have been recorded feeding in Silvertop Ash (*Eucalyptus sieberi*) (Assoc Prof Robert Close, *pers. comm.*). There are no records of Koalas from any studies within the current Study Area, but the potential habitat does exist.

The Study Area is potential Koala habitat under SEPP 44 of the EP&A Act, given the dominance of *E. haemastoma* (over 15% of canopy cover) in the two vegetation communities mentioned above. The Study Area is not Core Koala Habitat as there is no evidence to indicate the presence of a resident population of Koalas or recent sightings or historical records of a resident population.

5 EVALUATION OF IMPACTS

This chapter describes the subsidence impacts predicted and the likely consequences for flora and fauna within the Study Area.

The most direct environmental impact of longwall mining is subsidence, which causes changes in the level of the ground surface overlying and adjacent to the area of extraction. The following paragraphs outline the likely impacts on flora and fauna as a consequence of tilt, strain, subsidence, clearing, cracking and alterations to surface and groundwater flows from longwall mining. As the first workings extraction methods in the Study Area are not expected to result in any subsidence greater than 20mm, and there will be no measurable surface deformations (Seedsman Geotechnics 2012), the only aspect of the Project that will cause subsidence is longwall mining.

The *Strategic Review of the Impacts of Underground Coal Mining on Natural Features in the Southern Coalfields of NSW* (DoP 2008) outlines subsidence impacts primarily as tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence, and subsidence depressions or troughs. As a depression/trough is formed, the ground surface is subjected to tilts and strains depending on the geology, depth of cover, panel dimensions and position above the panel (DoP 2008).

Geographical features susceptible to the impacts of subsidence include aquatic ecosystems (streams and creeks), swamps (including upland swamps), and rocky environments (including caves and overhangs) (DECC 2007a, DoP 2008). It is generally recognised that the impacts of subsidence due to longwall mining on terrestrial ecosystems (including Shale Sandstone Transition Forest) are likely to be less significant than those experienced by aquatic-dependent ecosystems (DECC 2008), although rocky habitats are particularly vulnerable (DECC 2007a). Threatened species and ecological communities that rely on some or all of these geographic features in the Southern Coalfields are considered highly susceptible to the impacts of subsidence due to longwall mining (DECC 2007a).

Potential direct and indirect impacts from subsidence are outlined in *Table 5.1* and are discussed in the following sections.

Table 5.1 Potential Impacts to Flora and Fauna from Subsidence

Natural Feature	Subsidence Impact	Potential Consequence for Flora/Fauna
Vegetation	Tensile cracking of ground surface and shallow rock strata in particular on slopes and ridge tops. Surface cracking of gently undulating lands is not commonly observed	There have been no reported changes to ridge top and slope vegetation that have been attributed to mine subsidence (FloraSearch 2010). Changes in surface are likely to be small when compared to existing natural surface gradients.
	Depressurisation of groundwater due to development of the goaf and affects on overlying strata.	Lowering of the watertable beyond the reach of shallow rooted plants, causing degradation of vegetation communities.
Rivers (creeks, streams, tributaries).	Surface cracking due to subsidence.	Reduction in surface flows or water levels (increased frequency, duration and magnitude of drying aquatic habitats).
		Reduction in the extent and/or duration of standing pools leading to a reduction in aquatic or littoral habitats.
		Loss of or reduction in connectivity between pools and riffles may reduce fauna migration opportunities.
		Potential changes to water quality (increased iron oxides, manganese, sulphides and electrical conductivity, and lower dissolved oxygen).
		Reduced diversity of in-stream habitat due to the growth of iron-oxidising bacteria which can also be seen as a rusty-coloured mass in the water.
		Potential release of gas into the water column - oxidation of gas may lead to death of riparian vegetation and in-stream fauna.
	Water-rock chemical interactions along new flow pathways.	Changes in water quality / quantity in streams and creeks including increased iron-oxidisation and bacteria flocculation.
	Tilting of stream beds.	Stream bank erosion altering aquatic and riparian habitat.
	Ponding in subsidence troughs.	Inundation of vegetation.
Upland Swamps	Draining of perched water table and loss of swamp soil moisture due to cracking of clay or shale seals which typically underlie upland swamps.	Reduction of swamp vegetation dependent on high soil moisture or change of species composition.
		Potential reduction in fauna abundance, including threatened species dependent on swamp ecosystems.
		Reduction of water purification and flow regulation function for downstream ecosystems.
		Increased susceptibility to fire, which may increase impacts to swamp dependent species.
		Gullying and erosion of swamps, exacerbating the draining of water from swamp soils.
		Increased fire frequency due to drying.
		Draining/ drying of springs, soaks and dams.

Natural Feature	Subsidence Impact	Potential Consequence for Flora/Fauna
Rocky Habitats	Surface cracking	Reduced health of riparian vegetation an in-stream habitats.
		Loss of or change in shelter sites for wintering reptiles and other animals.
	Cliff collapse and rockfall	Loss of or change in habitat for cave dependent species.
		Loss of or change in habitat for cliff dependent species including rock-orchids and cliff-nesting birds.
	Cracking and movement within rocks below swamps	Potential drop in perched water table leading to impacts on upland swamps as outlined above.
	Surface cracking	Alter and possibly destroy rock shelters and burrows for fauna.

5.1 SUBSIDENCE IMPACTS

Seedsman Geotechnics (2012) has performed a subsidence assessment of the Study Area. The data in that report has been used as the basis for all impact assessments undertaken in this report. It is acknowledged that there are a number of constraints and assumptions that are fundamental to the subsidence predictions (Seedsman Geotechnics 2012).

ERM acknowledges that any impact assessment undertaken based on the values provided by Seedsman Geotechnics is subject to a level of uncertainty equal to that of the subsidence predictions upon which it is based.

The maximum values for the Wonga East and Wonga West domains have been extracted from GeoTerra (2012a) and are provided here for ease of reference.

5.1.1 *Predicted Subsidence Values*

Table 5.2 Wonga East Maximum Subsidence Predictions

Domains	Subsidence (m)	Tilt (mm/m)	Strain (mm/m)	Upsidence (mm)	Valley Closure (mm)
Overall Wonga East Area 1 Mining Domain	1.10	17.0	-13 to 11	120	200
Overall Wonga East Area 2 Mining Domain	1.10	17.0	-14 to 15	120	200
Cataract Creek Main Channel	0.25	4.0	-2 to 8	120	200
Cataract River Main Channel	0	0	0	<60	<100
Bellambi Creek Main Channel	0	0	0	0	0

1. Source: GeoTerra 2012a, Seedsman 2012

Table 5.3 Wonga West Maximum Subsidence Predictions

	Subsidence (m)	Tilt (mm/m)	Strain (mm/m)	Upsidence (mm)	Valley Closure (mm)
Overall Wonga West Area 3 Mining Domain					
Wongawilli seam only	2.5	17.5	-12 to 14	-	-
Overall Wonga West Area 4 Mining Domain					
Wongawilli seam only	1.5	12.5	-10.5 to 6.5	-	-
Lizard Creek Main Channel					
Wongawilli seam only	0.5	4.0	7.0	120	200
Wallandoola Creek Main Channel					
Wongawilli seam only	0.5	4.0	6.0	120	200

1. Source: GeoTerra 2012a, Seedsman 2012

5.1.2 *Features of Special Significance*

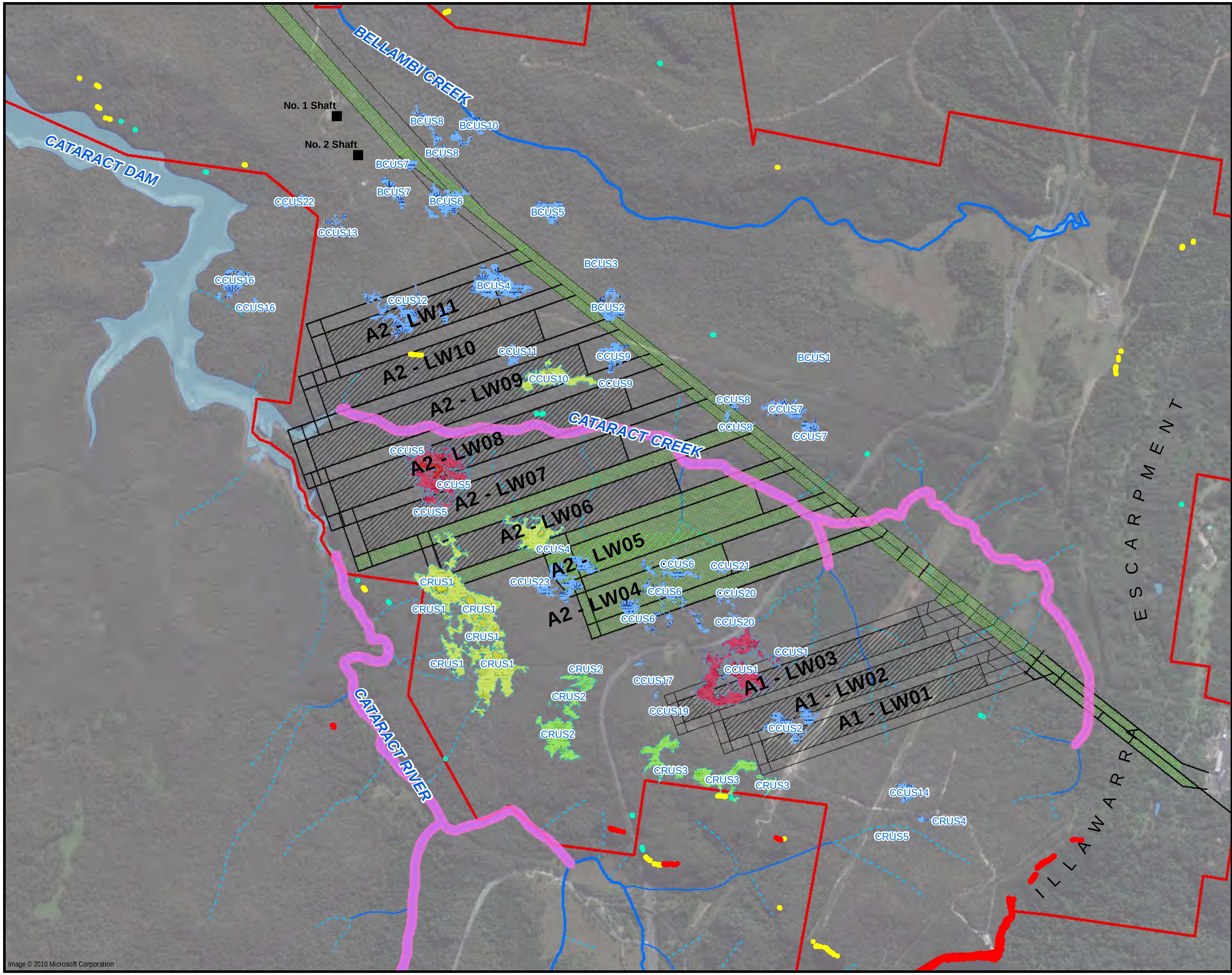
Ecological features of special significance have been identified in the ecological assessment, surface water assessment (GeoTerra 2012a), Upland Swamp Assessment (Biosis 2012a), Aquatic Ecology Assessment (Cardno Ecology Lab 2012) and cliffs and steep slopes assessment (SCT Operations 2012). Some of these have not been eliminated from the subsidence impact areas through avoidance or substitution (Seedsman Geotechnics 2012).

The locations of ecologically sensitive areas in Wonga East are shown in *Figure 5.1* and those occurring in Wonga West are shown in *Figure 5.2*. Predicted subsidence values have been determined by specialist consultants and are provided in *Table 5.4.* These values were based upon the subsidence predictions of Seedsman Geotechnics (2012).

Table 5.4 Predicted Subsidence Impacts for Ecological Features of Special Significance

Habitat Feature	Subsidence (m)	Tensile strain mm/m)	Compressive strain (mm/m)	Max Tilt (mm/m)
Wonga East Area 1:				
Upland Swamp (CCUS1)	0.40	**2.65**	**-6.79**	**11.38**
Upland Swamp (CRUS3)	0	0	0	0
Wonga East Area 2:				
Upland Swamp (CRUS1)	0.89	**4.34**	**-7.2**	**17.51**
Upland Swamp (CRUS2)	0.0	0	0	0
Upland Swamp (CCUS4)	1.00	**4.63**	**-8.03**	**21.04**
Upland Swamp (CCUS5)	1.00	**4.74**	**-8.03**	**21.30**
Upland Swamp (CCUS10)	1.00	**4.60**	**-8.74**	**21.39**
Wonga West Area 3:				
Shale Sandstone Forest EEC over A3 LW4 and A3 LW5	2.3	13	11	16
Shale Sandstone Forest EEC over A3 LW2 and A3 LW1	2.3	5	5	10
Upland Swamp (WCUS1)	0.72	0	0	0
Upland Swamp (WCUS4 headwater)	3.35	**5.03**	**-6.97**	10.58
Upland Swamp (WCUS7)	2.19	**5.45**	-.0.1	10.70
Upland Swamp (WCUS11)	3.27	**5.35**	**-3.8**	8.02
Upland Swamps (LCUS1)	0.87	0	0	0
Upland Swamp (LCUS6)	0.96	0	0	1.93
Upland Swamp (LCUS8)	2.66	**2.75**	**-2.64**	9.15
Upland Swamp (LCUS27)	-	0.0	0	0
Wallandoola Creek Waterfall	<0.02	<1	<1	<1
Lizard Creek Waterfall	<0.12	<1	<1	<1
Wonga West Area 4:				
Caves and overhangs in Lizard Creek gorge	0.1	4	0	3

1. Subsidence values for upland swamps extrapolated by Biosis (2012), values for waterfalls from GeoTerra (2012a), from data provided by Seedsman. Subsidence values for Lizard Creek cliffs from Seedsman (2012).
2. Bold numbers indicate that values for subsidence exceed the criteria at which the upland swamp are considered to be at risk of negative environmental consequences as established by the PAC (2010) and OEH (2012).
3. Subsidence predictions for streams are provided in *Table 5.1* and *Table 5.2*.



Legend
- Project Application Area
- Study Area
- Proposed Longwalls
- Cataract Dam
- Upland Swamps (Biosis 2012)
- Cliffs over 10m
- Cliffs 0 to 5m
- Cliffs 5 to 10m

Swamps of Special Significance (Biosis 2012)
- Negligible Risk
- Low Risk
- Moderate Risk
- Significant Risk
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order and Above Stream
- Streams of Special Significance
- Shaft Locations

Figure 5.1
Wonga East Ecologically Significant Areas

Client: Gujarat NRE Coking Coal Limited
Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment
Drawing No: 0079383s_EARPA2012_G007_R3.mxd
Date: 30/11/2012 Drawing size: A3
Drawn by: KB Reviewed by: NB
Scale: Refer to Scale Bar

N 0 150 300 450m

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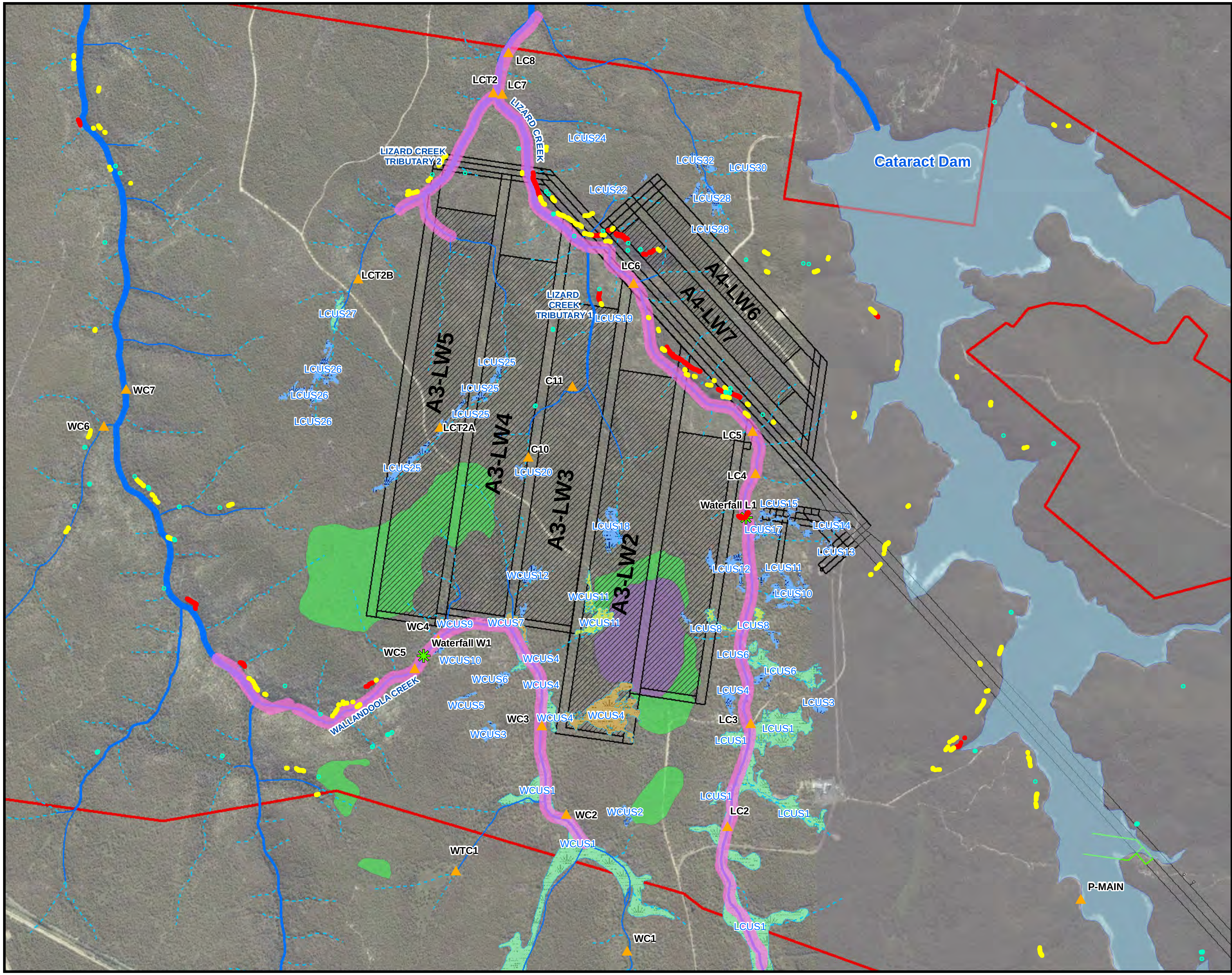

Legend

- Project Application Area
- Study Area
- Proposed Longwall
- Cataract Dam
- Upland Swamps (Biosis 2012)
- Transitional Shale Open Blue Gum Forest EEC
- Transitional Shale Stringybark Forest EEC

Swamps of Special Significance (Biosis 2012)

- Negligible Risk
- Low Impact Risk
- Moderate Impact Risk
- Cliffs 0 to 5m
- Cliffs 5 to 10m
- Cliffs over 10m
- Streams of special significance
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order and Above Stream
- Shaft Locations
- Stream Monitoring Sites (GeoTerra 2010a)

Figure 5.2

Wonga West Ecologically Significant Areas

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment
Drawing No:	0079383s_ECA_G006_R2.mxd
Date:	8/02/2013 Drawing Size: A3
Drawn By:	KB Reviewed By: NB
Projection:	GDA 1994 MGA Zone 56
Scale:	Refer to scale bar

N 0 250 500 750m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

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5.2 *ENVIRONMENTAL CONSEQUENCES OF SUBSIDENCE*

This section describes the effects of subsidence that are likely to be experienced within habitat for flora and fauna in the Study Area. All subsidence affects and their consequences for threatened flora and fauna are discussed further in *Section 0*.

5.2.1 *Predicted Alterations to Surface Water*

Surface cracking as a result of subsidence has the potential to cause significant change in surface water availability, and aquatic and streamside vegetation reliant upon surface water is highly susceptible to the impacts of surface water flows (DECC 2007a and DoP 2008). The impacts to surface water flows have been addressed in detail by GeoTerra (2012a), and are outlined below.

Surface water features within 600m of the proposed secondary workings consist of:

- 1st to 3rd order streams of Wallandoola Creek which drain into the Cataract River, downstream of the Cataract Dam wall at Wonga West;
- 1st to 4th order streams of Lizard Creek which drain into the Cataract River, downstream of the Cataract Dam wall at Wonga West;
- 1st to 4th order streams of Cataract Creek and Cataract River which flow into Cataract reservoir;
- 1st and 2nd order tributaries of Cataract River and Bellambi Creek (upstream of the reservoir) which will not be undermined by the Wonga East workings; and
- Cataract Reservoir, which will not be undermined by the Wonga East workings, although the western end of Longwall WE-A2-LW10 extends into the reservoir high water mark in Cataract Creek.

No extraction is proposed under the 3rd order or higher channel of Lizard and Wallandoola Creeks, with the panel layout designed to avoid or minimise subsidence impacts on the bed of the creeks and Cataract Reservoir.

A potential risk to the integrity of stream flow and connectivity in Wallandoola Creek could be present in the area that may potentially undergo up to 0.5 m of subsidence and 6 mm/m of tensile strain to the south of Longwalls A3 LW3 and A3 LW4.

There is a low potential risk to the integrity of stream flow and connectivity in Lizard Creek in the area that may potentially undergo 6 to 7mm/m of tensile strain to the north of Longwall A3 LW2 and south of the northern end of Longwall A4 LW5.

The 1st, 2nd and 3rd order tributaries, in particular LCT1 (over Longwall A3 LW3) and LCT2 (near the northern end of Longwall A3 LW5) which overly the proposed 20mm subsidence zone are at risk of subsidence related stream bed cracking, enhancement of stream bed underflow, discharge of ferruginous springs and reduced stream water quality at their confluence with Lizard Creek.

It is not anticipated however, that the total volume of water entering Lizard Creek will be adversely affected. It is noted, that all of these aspects of LCT1 are currently adversely affected by existing Bulli workings subsidence (GeoTerra 2012a).

No extraction is proposed under the 3rd order or higher channels of Cataract River (upstream of the reservoir) or Bellambi Creek at Wonga East. Negligible stream flow effects, impacts or consequences are anticipated to occur in Cataract River or Bellambi Creek, upstream of Cataract Reservoir, due to the low to absent levels of predicted strains and subsidence (GeoTerra 2012a).

Cataract Creek is proposed to be undermined by longwalls in Wonga East (Area 2), with a predicted maximum subsidence of 0.8m, along with up to 10mm/m compressive and 5mm/m tensile strains over Longwall A2 LW8 (GeoTerra 2012a). Potential subsidence impacts include potential cracking of the 4th order stream bed due to subsidence near or over Longwalls A2 LW7, A2 LW8, A2 LW9 and A2 LW10. Environmental consequences are potential impact on stream flow, with downstream flow re-emergence; potential effect on pool holding capacity of rock bars and potential iron hydroxide seepage. It is noted, that iron hydroxide seepage is currently occurring (GeoTerra 2012a).

5.2.2 *Predicted Impacts to Upland Swamps*

Both the Metropolitan (PAC 2009) and BSO PAC reports (PAC 2010) provided guidelines for determination of special significance of swamps and for assessment of the potential impacts from subsidence.

The SCI identified that the *subsidence impacts* for valley infill swamps were tensile cracking and movement of joint and bedding planes; and buckling and localized upsidence in the stream bed below the swamp. The primary *environmental consequences* for valley infill swamps are:

- draining of swamps leading to:
    - drying and potential erosion and scouring of dry swamp;
    - loss of standing pools within the swamp;
    - vulnerability to fire damage;
    - change to swamp vegetation communities; and
    - adverse water quality impacts eg iron bacterial matting; and
- loss of stream base flow (DoP 2008).

Secondary *environmental consequences* for valley infill swamps include:

- loss of terrestrial and aquatic habitats and associated fauna, including threatened species dependent on swamp ecosystems; and
- loss of water purification and flow regulation function for downstream ecosystems.

The SCI Panel upon review of available information at that time concluded that *undermining of valley infill swamps has or will cause drainage, water table drop and consequent degradation of swamp water quality and associated vegetation* (DoP 2008).

Headwater swamps are susceptible to *subsidence impacts* from tensile cracking and tensile/shear movement of joint and bedding planes in the rock below the swamp. The primary *environmental consequences* are potential drop in the perched water table leading to draining of the swamp (DoP 2008). The SCI noted that the impacts on headwater swamps are likely to be similar in character but less extensive and significant than for valley infill swamps (DoP 2008). Secondary consequences are the same as for valley infill swamps (DoP 2008).

GeoTerra (2012b) in their assessment of impacts on groundwater identified that, subsidence could affect swamps directly overlying the proposed longwalls due to either transient and/or spatial changes in porosity and permeability of a swamp or its underlying weathered sandstone substrate through generation of cracks or differential displacement of the perched aquifer. If a swamp overlies an extracted longwall panel, it may undergo temporary extensional 'face line' cracking (perpendicular to the long axis of the panel) as a panel advances, followed by re-compression as the maximum subsidence occurs at any one location.

In addition, where a swamp overlies a longwall, it may also undergo both longer term extensional 'rib line' cracking (parallel to the long axis of the panel) along the outer edge of the panel, and compression within the central portion of a panel's subsidence trough. The more susceptible portions of a swamp to increased secondary porosity and/or permeability changes are where it undergoes 'rib line' cracking. Any adverse effects, if they occur, would be related to the extent and degree of cracking that occurs in the underlying weathered sandstone, as cracking is unlikely to manifest in a swamp due to its saturated, clayey, humic, plastic nature (GeoTerra 2012b).

It should be noted that, headwater swamps have undergone up to 1.0 m of subsidence, up to 1.5 mm/m of strain and up to 4.5 mm/m of tilt due to past longwall mining in the Bulli and Balgownie seams between 1979 and 1989, with no apparent adverse effects on their water holding capacity or ecology.

With the listing of the EEC Coastal Upland Swamp in the Sydney Basin Bioregion under the TSC Act, OEH developed draft assessment guidelines for the underground mining industry operating in the southern coalfields (OEH 2012). A risk assessment for the upland swamps of 'special significance' was undertaken in accordance with the OEH (2012) guidelines using the subsidence criteria identified in the PAC (2010) that when exceeded upland swamps are considered to be at risk of negative environmental consequences. The predicted subsidence values for the upland swamps of special significance are provided in *Table 5.4.* Bold numbering in *Table 5.4* identifies when the investigation criteria may be exceeded as a result of subsidence impacts.

Based on an analysis of potential impacts to upland swamps of special significance Biosis (2012) concluded that:

- there is a negligible likelihood of negative environmental consequences for seven (7) upland swamps, including CRUS2, CRUS3, LCUS1, LCUS6, LCUS27, WCUS1 and WCUS4-valley infill swamp;

- there is a low likelihood of negative environmental consequences for five (5) upland swamps, including CCUS4, CCUS10, CRUS1, LCUS8 and WCUS11. It is recommended that NRE undertake monitoring and consider where possible minor changes to longwall layout to reduce impacts to these swamps. It is noted that CCUS4 is in the middle of Longwall A2 LW6;

- there is a moderate likelihood of negative environmental consequences for upland swamps WCUS4-headwater swamp and WCUS7. It is recommended that NRE revise mine plans for Area 3 Longwalls 2, 3 and 4 to avoid, minimise and mitigate impacts to these swamps; and

- there is a significant likelihood of negative environmental consequences for upland swamps CCUS1 and CCUS5 in Wonga East. It is recommended that NRE revise the mine layout of Longwalls A1 LW3, A2 LW7 and A2 LW8 to avoid, minimise and mitigate impacts to these swamps.

5.2.3 Predicted Alterations to Rocky Habitat

The main features of rocky habitats that are of value to flora and fauna include caves, rock shelters (including crevices and exfoliating rock), and cliff faces for orchids, falcons and other rock dwelling species. Consequences of subsidence impacts for rocky habitats are primarily associated with overhang collapse, rock falls and surface cracking (DoP 2008). Plant and animal species dependent upon rocky environments during some part of their lifecycle are most likely to be impacted by subsidence due to longwall mining. Broad-headed Snake and Large-eared Pied Bat (*Chalinolobus dwyeri*) are of primary ecological concern in these areas (DECC 2007a).

Cave-roosting bats generally require dark, humid caves for roosting, although some groups may use large sandstone overhangs with domed roofs, which trap warm humid air suitable for roosting. The field surveys did not record any suitable large overhangs within the Study Area, although there is potential for small overhangs, cracks and crevices to occur in the incised valleys of Lizard Creek and Wallandoola Creek, which would provide potential, but sub-optimal habitat for cave-roosting bats. Damage to caves and cracks, that may be used as shelter sites by these species, may occur within the Wonga West domains of the Study Area, mainly along the incised valley of Lizard Creek.

A number of threatened bat species were recorded in the Study Area including Eastern Bentwing-bat that is known to be a preferential cave-roosting species. It is suspected that it may be utilising either disused mining shafts in the surrounding region or some suitable cave habitats that have not been recorded by either the flora and fauna survey, or the comprehensive aboriginal heritage assessment undertaken by ERM for the Project. It is noted that one suitable cave was identified recently in Wonga East (N. Garvey Biosis, 2012). It is unlikely that any maternity roost for Eastern Bentwing-bat occur in the Study

Area, as all of the four known maternity caves for this species occur in limestone geology and sandstone is not capable of naturally developing the large humid caverns required for breeding (Brad Law, Forests NSW, *pers. comm*).

Burrowing animals including wombats are known to occur within the Study Area, and subsidence has the potential to impact on the shape of animal burrows or collapse them depending upon the location of the burrow in relation to the compressive or tensile strain. It is not possible to quantify the likelihood or number of fissure closures or potential burrow collapses. While subsidence could threaten some roosting and shelter sites, similar habitat is common within the local area and burrows have been recorded in areas that have previously been subjected to longwall mining in the Study Area. As such no significant impacts to burrow distribution or density is predicted to occur.

5.2.4 *Potential Effects on Flora*

It is generally recognised that the impacts of subsidence due to longwall mining on terrestrial ecosystems are likely to be less significant than those experienced by aquatic-dependent ecosystems (DECC 2008). The most significant impacts likely to affect flora are associated with subsidence and cracking induced decrease in surface water availability for swamp and aquatic plant communities, loss of groundwater influence for groundwater dependent ecosystems including swamps, and fracturing of rocky habitats for rock-dwelling species. The potential for these impacts to occur is addressed above, and the likely outcome of these impacts is further discussed in *Section 5.3* and *0*. Additional effects that are not as clearly defined in the literature include the impacts of tilt and strain on flora and vegetation communities.

Tilt

Subsidence can cause a trough on the surface above each longwall panel due to vertical settlement of rock into the void created when coal is removed. As a trough is formed, the ground surface is subjected to certain tilts and strains depending on the geology, depth of cover, panel dimensions and position above the panel (DoP 2008). A series of longwall panels and chain pillars can cause sequential subsidence and upsidence, which results in tilting between the subsidence above longwall panels and the upsidence above supporting chain pillars. This tilting may cause trees and other surface features to lean off axis, and may also cause strain effects on plant root systems. ERM is not aware of any models currently available for predicting the impact of tilt on vegetation therefore the following reasoning is applied.

Within the significant habitat features, there is a maximum permanent predicted tilt up to 16mm/m under the Shale Sandstone Forest (see *Table 5.4*). For a tree of 25m height, this translates to a lean off-axis of 375mm at the crown. It is not expected that a lean of 375mm at the crown would be sufficient to cause tree instability, although there is a possibility that trees that already have a steep lean in the direction of predicted tilt may fall. Conversely, any trees leaning away from the subsidence-induced tilt may be slightly straightened.

It is unlikely that any isolated falls that may occur would significantly alter vegetation community composition in the Study Area, as trees fall in woodland and forest communities as part of an ecosystems lifecycle. However, if numerous or widespread tree falls were to occur, percentage canopy cover would be reduced and increased light penetration may lead to alteration of midstorey and ground storey community composition. Tilting due to subsidence is not expected to cause measurable short or long-term damage to any threatened plants or endangered ecological communities within the Study Area at the subsidence levels predicted.

Strain

Tensile and compressive strains pull and push on structures, commonly damaging inflexible material by stretching and rupturing. Predicted subsidence will cause maximum tensile strains of up to 13mm/m and maximum compressive strains of up to 11mm/m in the significant habitat features (see *Table 5.4*) (Seedsman Geotechnics 2012). As ERM is not aware of any models currently available for predicting the impact of strain on vegetation, the following reasoning is applied.

Compressive and tensile strains caused by subsidence are likely to act on plant roots much the same as root pressure when trees bend due to high winds. Compressive strains of 10mm/m on a 25m high tree would correspond to the impact of wind-induced leaning of 375mm at the tree crown. Such a lean is plausible under natural wind conditions, although no field measurements have been made to confirm these figures. Those plants with shallow root systems are less likely to be impacted by strain due to the opportunity for strain to be ameliorated by low level soil expansion at the surface.

5.2.5 *Potential Effects on Terrestrial Ecosystem Fauna*

The primary impacts to fauna as a result of the proposed action are likely to be associated with degradation and alteration of aquatic habitats including streams and swamps, and degradation of rocky habitats, which have been discussed previously.

5.3 THREATENED SPECIES AND EEC CONSIDERATION

This section addresses threatened species and ecological communities that are listed on the TSC Act. A more complete assessment of the impact of the proposal on threatened species as listed under the EPBC Act and other matters of National Environmental Significance is provided in the EPBC Act Matters assessment report for the Project (ERM 2013b).

Regionally significant species are addressed in *Section 5.4*. RoTAPs are addressed in *Section 5.5*.

Threatened species and ecological communities have been considered for their potential to be affected by subsidence in *Table 5.5, Table 5.6* and *Table 5.7*. The tables were populated with threatened species and ecological communities from the TSC Act and EPBC Act that:

a) have previously been recorded within 10km of the Study Area according to the Atlas of NSW Wildlife;

b) are vegetation types mapped as occurring on-site by NPWS (2003);

c) were recorded in the Study Area during this study, or have previously been recorded in environmental surveys of the Study Area and nearby areas (see literature review in *Section 3.1.1*); and

d) are species within the Southern Coalfields which are considered vulnerable to the impacts of subsidence according to DECC (2007) and DoP (2008).

In order to undertake an Assessment of Significance under Section 94 of the TSC Act, species and ecological communities were considered for their likelihood of occurrence in the Study Area, and their vulnerability to subsidence impacts. Species present in the Study Area and those with a moderate or high likelihood of occurrence, which are vulnerable to the impacts of subsidence according to DECC (2007a), are assessed in *Section 0*. Species which are not vulnerable to the impacts of subsidence according to DECC (2007a), or are considered to have a low likelihood of occurrence in the Study Area have not been subject to an Assessment of Significance. Marine species such as albatross, coastal shorebirds and marine mammals have been omitted from this section as there is no suitable habitat within the Study Area.

Species listed on the TSC Act which were identified as potentially occurring within the Study Area only by the EPBC Act Protected Matters Search Tool, which are not considered vulnerable to the impacts of subsidence according to DECC (2007a), are addressed in the EPBC Act Matters assessment report for the Project (ERM 2013b).

Table 5.5 EECs in the Study Area

Endangered Ecological Community	TSC Act	Distribution and requirements*	Likelihood of Occurrence within Study Area	Vulnerable to subsidence?	Assessment of Significance required?
Shale/Sandstone Transition Forest	E	Occurs in transitional areas between the clay soils derived from Wianamatta Shale and the sandy soils derived from Hawkesbury Sandstone on the margins of the Cumberland Plain.. Mapped as occurring within the Study Area by NPWS (2003).	Present	Yes^	Yes
O'Hares Creek Shale Forest	E	Occurs on the Woronora Plateau on Hawkesbury shale soils above the sandstone plateau. Known to occur within the Cataract Special Area. Is dominated by *Eucalyptus piperita* and *E. globoidea*, and *Angophora costata*.	Low – not mapped within the Study Area (see *Figure 3.1*).	No	No
Coastal Upland Swamps	E#	Occurs in the Sydney Basin bioregion associated with periodically waterlogged soils on Hawkesbury sandstone plateaus.	Present	Yes^	Yes

1. * preferred habitat is a summary of literature reviewed and is not the sole information relied on for assessment of occurrence or impact; ^ Subsidence is listed as a Key Threatening Process for this EEC.
2. Status in NSW as per Schedules 1 and 2 of TSC Act.
3. # Coastal Upland Swamp in the Sydney Basin Bioregion has preliminary listing as an EEC under the TSC Act.

Table 5.6 Threatened Flora in the Study Area

Common/Scientific Name	TSC Act	Preferred Habitat*	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Acacia baueri subsp. *aspera*	V	Populations occur in low, damp heath, often on exposed rocky outcrops over a wide range of climatic and topographical conditions between 400-900 m AHD. Appears to require open conditions - rarely observed where there is any shrub or tree canopy development. Habitat characteristics vary considerably between sites in the Blue Mountains and the coastal sandstone plateaus. Restricted to escarpment/Woronora Plateau at Flat Rock Junction and Stanwell Tops area in coastal heaths and Red Bloodwood-Scribbly Gum heathy woodland on sandstone.	Moderate	Yes	Yes
Bynoe's Wattle *Acacia bynoeana*	E	Occurs in heath and dry sclerophyll forest, typically on sand and sandy clay, often with ironstone gravels and is usually very infertile and well-drained. Often grows among rock platforms. Also found in open and slightly disturbed sites such as trail margins, edges of roadsides, grading spoil mounds and in recently burnt patches. In Illawarra found in coastal heaths and Red Bloodwood-Scribbly Gum heathy woodland on sandstone.	Low	No – the species is commonly found in sandstone and gravel based soils, occasionally on rock platforms.	No
Thick-leaf Star-hair *Astrotricha crassifolia*	V	A shrub to 2.4m which occurs in sclerophyll woodland on sandstone. Known from the Woronora Plateau in coastal heaths and Red Bloodwood-Scribbly Gum heathy woodland on sandstone. The species is considered vulnerable to natural events and human disturbance due to its population sizes and disjunct distribution.	Moderate	No – the species is restricted to sclerophyll woodland.	No

Common/Scientific Name	TSC Act	Preferred Habitat*	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Thick-lipped Spider-orchid *Caladenia tessellata*		Perennial terrestrial orchid found in grassy sclerophyll woodland on clay loam or sandy soils though has been record on stony soils. It is often seen after fire. Known from Sydney, Wyong, Ulladulla and Braidwood in NSW and Victoria. Populations in Kiama and Queanbeyan are presumed extinct. Only known from Pittwater sub-region of the Hawkesbury Nepean CMA.	Not expected	No	No
Eastern Flame Pea Chorizema parviflorum	End popn	Low shrub recorded from between Austinmer and Albion Park in heaths on coastal lowlands in Forest Red Gum and/or Woollybutt forest.	Not expected	NA	No
White-flowered Wax Plant *Cynanchum elegans*	E	Climber or twiner occurring mainly at the ecotone between dry subtropical rainforest and sclerophyll forest / woodland communities.	Moderate	No	No
Illawarra Socketwood *Daphandra johnsonii* syn *D.* sp C *Illawarra*	E	Rainforest tree to 20m tall restricted to Illawarra region in rocky hillsides and gullies of the Illawarra lowlands extending onto upper escarpment slopes in rainforest and moist eucalypt forest on soils derived from volcanic and sedimentary rocks.	Low	No	No
Epacris purpurascens var. *purpurascens*	V	This species is found in a wide range of habitats most of which have a strong shale soil influence. These include drainage depressions supporting wet heath within or adjoining shale cap communities.	Moderate	Yes	Yes
Small-flower Grevillea *Grevillea parviflora* subsp. *parviflora*	V	Crests or upper slopes in light clay soils in woodlands, often with laterite soils. It has been recorded in a range of ecological communities including upland swamps and Shale Sandstone Transitional Forest (Endangered Ecological Community).	Moderate	Yes	Yes
Woronora Beard-heath *Leucopogon exolasius*	V	Prefers woodlands on sandstone and is often associated with rocky hillsides and creek lines. Only known from the Sydney Metro CMA and Hawkesbury Nepean CMA regions (OEH online profile).	Moderate to High – in communites along creeks.	Yes	Yes

Common/Scientific Name	TSC Act	Preferred Habitat*	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Yellow Loosestrife *Lysimachia vulgaris* var. *davurica*	E	This species is only known to occur within the Moss Vale region in the highland peat swamps of the southern highlands of NSW. Only known from Wingecarribee Swamp, Boro area near Braidwood on the southern highlands and Bega River Valley.	Not expected	Yes	No
Deane's Melaleuca *Melaleuca deanei*	V	Occurs in the Sydney basin Bioregion in Wollondilly LGA, and grows on flat broad plateaus and ridges in sandstone ridgetop woodland, coastals sandstone forest and similar vegetation types (OEH online profile). The distribution is consistent with the Study Area.	Moderate	Yes	Yes
Needle Geebung *Persoonia acerosa*	V	Grows in heath, low woodland or dry sclerophyll forest on sandstone, in well drained soils. Prefers ridgetops and plateau. Species frequently occurs on disturbance margins, such as roadsides.	Moderate	No	No
Bargo Geebung *Persoonia bargoensis*	E	Restricted to a small area on the western edge of the Woronora Plateau. Grows in woodland to dry sclerophyll forest on sandstone and clayey laterite on heavier, well drained, loamy, gravelly soils of the Hawkesbury Sandstone and Wianamatta Shale in the catchments of the Cataract, Cordeaux and Bargo River. Species often associated with light disturbance and found along vehicle tracks and cleared areas.	Moderate	Yes	Yes
Hairy Geebung *Persoonia hirsuta*	E	Occurs in woodlands and dry sclerophyll forest on sandy soils over sandstone or very rarely on shale. This species is patchily distributed on the Central Coast and Tablelands around Sydney, in an area bounded by Putty, Glen Davis and Gosford in the North, and Royal National Park and Hill Top in the south.	Present (Kevin Mills and Associates 1995)	No	No
Sublime Point Pomaderris *Pomaderris adnata*	E	Known only from Sublime Point at the edge of Illawarra Escarpment in Silver-top Ash and Red Bloodwood forest in sandy loam over sandstone.	Low	No	No

Common/Scientific Name	TSC Act	Preferred Habitat*	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Brown Pomaderris *Pomaderris brunnea*	V	The species occurs in open forest in association with *Eucalyptus amplifolia*, *Angophora floribunda*, *Acacia parramattensis*, *Bursaria spinosa* and *Kunzea ambigua*. It is often found on sandstone, clay and alluvial soils of floodplains and creek lines. The species has been recorded in the Sydney Cataract Catchment associated with Cumberland Plain forests and alluvial forests (OEH online profile).	Not expected	Yes	No
Prickly Bush-pea *Pultenaea aristata*	V	Prickly Bush-pea occurs on the Woronora Plateau, and can be found within Upland Swamp Banksia Thicket and Restoid Heath Complex, and in areas where drainage is poor in sandstone forest communities (TSSC 2008c). Grows in moist, dry sclerophyll woodland to heath on sandstone; Helensburgh to Mt Keira. Flowering has been recorded in winter and spring.	Previously recorded in Wonga West by Kevin Mills and Associates (1995). Recorded by ERM and Biosis in Wonga East and West	Yes	Yes
Rainforest Cassia *Senna acclinis*	E	Grows in or on the edges of subtropical and dry rainforest on coastal lowlands, foothills and escarpment slopes.	Low	No	No

Preferred habitat is a summary of literature reviewed and is not the sole information relied on for assessment of occurrence or impact.

^ Subsidence risk according to DECC (2007).

Status in NSW as per Schedules 1 and 2 of TSC Act: E = Endangered; V = Vulnerable. Status as per EPBC Act: E = Endangered; V = Vulnerable; Cr E = Critically Endangered.

Table 5.7 Threatened Fauna in the Study Area

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Birds:						
Regent Honeyeater *Anthochaera phrygia*	E	Nomadic species following rich sources of nectar, primarily winter flowering species including Ironbark and Spotted Gum on the South Coast of NSW.	Extremely rare winter visitor.	Not expected	No	No
Australasian Bittern *Botaurus poiciloptilus*		In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleoacharis* spp.). Hides during the day amongst dense reeds or rushes and feeds mainly at night on frogs, fish, yabbies, spiders, insects and snails. Nests are built in secluded places in densely-vegetated wetlands on a platform of reeds.	Rare visitor, declining.	Not expected, local records on coastal lowlands.	No	No
Gang-gang Cockatoo *Callocephalon fimbriatum*	V	In summer, generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter, this species moves to lower altitudes, preferring more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. This species favours old growth attributes for nesting and roosting.	Common resident; stable .	Present.	No – this species is reliant upon terrestrial habitats which are not vulnerable to subsidence.	No
Glossy Black-cockatoo *Calyptorhynchus lathami*	V	Found in forests on sites with low soil-nutrient status, reflecting distribution of *Casuarina* spp. and *Allocasuarina* spp. Prefers drier forest types with less rugged landscapes. Feeds exclusively on seeds from the wood cones of she-oaks. Requires forest with tree hollows for breeding.	Common resident; stable.	Present.	No – the species is restricted to dry forest types which are not	No

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
					vulnerable to subsidence.	
Barred Cuckoo-shrike *Coracina tenuirostris*	V	This Cuckoo-shrike is generally considered to be restricted to the Northern Rivers region of NSW, occurring in rainforest, eucalypt forests and woodlands and woodlands along watercourses.	Vagrant	Not expected	No	No
Eastern Bristlebird *Dasyornis brachypterus*	E	This species is known to inhabit dense, low vegetation including heath and open woodland with heathy understorey in communities where not burnt for at least 15 years. Nests on or near ground. Is difficult to survey due to its elusive behaviour and dense habitat. The largest populations of this species occur on the NSW South Coast near Jervis Bay. This species is very restricted in range due to a long term decline in abundance and distribution.	Remote possibility that still exists.	Low likelihood in upland swamps.	Yes	No
Black Bittern *Ixobrychus flavicollis*	V	Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves. Feeds on frogs, reptiles and small fish.	Rare summer visitor, declining.	Not expected	Yes	No
Swift Parrot *Lathamus discolor*	E	Migratory species frequenting eucalypt forest and woodland, following winter flowering eucalypts (eg. swamp mahogany). Breeds in Tasmania. Often recorded in high number in southern coastal NSW, including within Spotted Gum woodlands.	Extremely rare autumn/winter visitor, declining.	Not expected	No	No
Square-tailed Kite *Lophoictinia isura*	V	Occurs in coastal and sub-coastal NSW and is known to be a breeding migrant to the south coast of NSW (DECCW 2010). Predominantly hunts and feeds aerially, targeting small birds and insects in the canopy of woodlands and forests mostly	Rare visitor.	Not expected	No	No

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
		with grassy understories, particularly along watercourses.				
Hooded Robin *Melanodryas cucullata cucullata*	V	Within Sydney Basin Bioregion mostly restricted to the Hutner, Capertee and Burragorong Valleys in Grassy Box Woodlands. Recent surveys in Cumberland Plain only recorded at one location (DECC 2007d).	Rare resident, declining.	Not expected	No	No
Turquoise Parrot *Neophema pulchella*	V	Eucalypt woodland and open forest with groundcover of grasses and low understorey of shrubs. Usually associated with mixed assemblage of native pine *Callitris* sp and a variety of *Eucalyptus* spp. including, White Box, Yellow Box, Blakey's Red Gum, Red Box, Red Stringy-bark, Bimble Box and Mulga Ironbark. Nests in hollows of small trees, dead eucalypts or in holes, stumps or fenceposts.	Uncommon visitor.	Low	Yes	No
Powerful Owl *Ninox strenua*	V	Mountain forests, gullies and forest margins; sparser hilly woodlands, coastal forests, woodland, urban areas.	Common resident, secure.	Present	No	No
Pink Robin *Petroica rodinogaster*	V	Considered to be predominantly restricted to Tasmania, Victoria and south eastern NSW highlands south of Bombala, but moves north and west across NSW during winter (DECCW 2010).. Inhabits tall rainforest and tall open eucalypt forest and densely vegetated gullies (DECCW 2010).	Extremely rare resident.	Not expected.	No	No
Eastern Ground Parrot *Pezoporus wallicus wallicus*	V	This species can be found in low coastal heaths, upland swamps, sedgelands and button-grass plains. It is known to occur within the Illawarra region. The largest remaining populations of this species occur to the south in Booderee National Park and Bherwerre Peninsula near Jervis Bay. This species is very restricted in range due to a long term decline in abundance and distribution, but has previously been recorded in the SCA Special Areas.	Possibly locally extinct.	Moderate - Potential habitat in upland swamps particular larger swamps.	Yes	Yes

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Rose-crowned Fruit-dove *Ptilinopus regina*	V	Commonly recorded within sub-tropical and dry rainforest, moist forest and other tall forests in NSW and Queensland (DECCW 2010). The species may be locally nomadic as it is entirely frugivorous and reliant upon fruiting events.	Locally extinct.	Not expected	No	No
Superb Fruit-dove *Ptilinopus superbus*	V	Similar to other fruit-doves, this species is entirely frugivorous and restricted to habitats containing an abundance of fruit, including rainforest, dry rainforest and tall forests, generally in northern parts of NSW, although there are records from within 10km of the Study Area.	Extremely rare visitor.	Not expected	No	No
Little Tern *Sterna albifrons*	E	Almost exclusively coastal, preferring sheltered environments. Nests in small scattered colonies on sandy beaches. Has also been recorded in harbours, inlets and rivers (NPWS 1999).	-	Low	Yes	No
Masked Owl *Tyto novaehollandiae*	V	Dry sclerophyll forest and woodland with a low sparse understorey, foraging in open or partly cleared land. Roosting and nest sites in large tree hollows in sheltered aspects.	Rare resident, possibly. declining	Low	No	No
Sooty Owl *Tyto tenebricosa*	V	Occurs in tall forests and woodlands on the coastal side of the Great Dividing Range and the coastal tablelands. Can occur in rainforest, dry-rainforest, moist forest and tall open forest (DECCW 2010).	Uncommon resident, probably stable.	Moderate	No – habitat is not vulnerable to subsidence	No
Mammals:						
Eastern Pygmy Possum *Cercartetus nanus*	V	Wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath including upland swamps.	Uncommon resident, probably stable.	Present (ERM 2009)	Yes	Yes
Large-eared Pied Bat *Chalinolobus dweryi*	V	Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (*Hirundo ariel*), frequenting low to mid-elevation dry open forest and woodland close to these	Uncommon resident, probably declining.	Moderate	Yes	Yes

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
		features. Found in well-timbered areas containing gullies.				
Spotted-tailed Quoll *Dasyurus maculatus maculatus*	V	Found on the east coast of NSW and is recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites	Rare resident, declining. Seen in Cataract Catchment in 2005.	Moderate to High	Yes	Yes
Eastern Quoll *Dasyurus viverrinus*	E	This species prefers dry sclerophyll forest, scrub and heathland, but has not been recorded in NSW for many years (DECCW 2010)	Locally extinct.	Not expected	No	No
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	V	Uncommon resident in tall forest on the Great Dividing Range and adjacent coastal plains. Roosts in tree hollows.	Uncommon resident, probably declining	Present	No – tree-roosting	No
Southern Brown Bandicoot *Isoodon obesulus obesulus*	E	Heathy forest, shrubland and woodland which is usually supported by well-drained soils. A mosaic of post-fire vegetation is an important component of the species' habitat.	Unknown. Records are unconfirmed.	Low likelihood of occurrence	No	No.
Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*	V	Roosts in caves, old mines, stormwater channels; forages above the forest canopy.	Common resident, probably stable	Present	Yes	Yes.
Eastern Freetail-bat *Mormopterus norfolkensis*	V	Wide range of forested habitats including rainforest to dry open forest. Roosts in tree hollows and under loose bark.	Rare resident, probably declining.	Present	No – tree-roosting	No
Large-footed Myotis *Myotis macropus*	V	Roosts in caves, tunnels, under bridges and in dense vegetation. Forages over nearby lakes, rivers, large streams.	Rare resident, probably declining	Present.	Yes	Yes

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Brush-tailed Rock-wallaby *Petrogale penicillata*	E	Occupies rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. Browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees and shelters or basks during the day in rock crevices, caves and overhangs. May be locally extinct in Southern Coalfields (DECC 2007a). Not previously recorded within 10km.	Extremely rare resident, declining.	Not expected	Yes	No
Koala *Phascolarctos cinereus*	V	Forests typically on high nutrient soils characterised by presence of preferred eucalypt feed trees, listed under SEPP 44.	Rare resident. Population in Avon/Upper Nepean catchment.	Low likelihood, potential habitat identified however no evidence and population to south PAA.	No	No
Long-nosed Potoroo (SE Mainland) *Potorous tridactylus tridactylus*	V	Coastal heath and wet and dry sclerophyll forests. Major habitat requirement is thick ground cover where soil is light and sandy. May be locally extinct in the Southern Coalfields, according to DECC (2007a).	Extremely rare resident, declining. Possibly locally extinct.	Low likelihood in upland swamps.	Yes	No
Grey-headed Flying-fox *Pteropus poliocephalus*	V	Forages on fruits, blossoms and nectar of eucalypts. In early summer roosts in large groups (camps) in forests or mangroves. Relatively common in the Sydney basin and surrounding areas.	Locally common resident, declining.	High	No – habitat not vulnerable	No
Greater Broad-nosed Bat *Scoteanax rueppellii*	V	The open canopy above rivers and creeks utilised during foraging and roosting occurs in tree hollows.	Uncommon resident, probably declining.	Present	No – tree roosting	No

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
Reptiles:						
Broad-headed Snake *Hoplocephalus bungaroides*	E	Woodland, open woodland/ heath communities on Sandstone within the Sydney Basin. They utilise rock crevices and exfoliating sheets of weathered sandstone on exposed cliff edges during autumn, winter and spring, and shelter in hollows in large trees within 200 m of escarpments in summer.	Extremely rare resident, declining.	High	Yes	Yes
Rosenberg's Goanna *Varanus rosenbergi*	V	Ground-dwelling species. Termite mounds used as breeding chambers. Inhabits coastal heaths. Shelters in burrows, hollow logs and rock crevices. Coastal heaths, humid woodlands and wet and dry sclerophyll forests. Isolated population in coastal NSW.	Uncommon resident, locally declining.	High	Yes	Yes
Frogs:						
Giant Burrowing Frog *Heleioporous australiacus*	V	Known to inhabit upland swamps and small creek lines in Wonga West. The species breeds in small pools, often on sandstone benches and along ephemeral creeks. Associated with small headwater creek lines and along slow flowing creeks emerging from upland swamps. Inhabit upland swamps and woodland, open woodland and heath.	Uncommon resident, stable. Woronora Plateau contains greatest density of records.	Present	Yes	Yes
Green and Golden Bell Frog *Litoria aurea*	E	In NSW the species occupies disturbed habitats and breeds largely in ephemeral ponds. Predominantly coastal wetlands and disturbed lagoons where Chytrid fungus has not established due to poor water quality.	Extremely rare resident, declining.	Low	Yes	No
Heath Frog *Litoria littlejohni*	V	Occurs along permanent and semi-permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone crops. Breeding occurs in slow flowing pools that receive extended exposure to sunlight, but will also use temporary isolated pools. Inhabits the tree canopy and the ground, and shelters under rocks on	Extremely rare resident, declining.	Moderate to High	Yes	Yes

Common/Scientific Name	TSC Act	Preferred Habitat*	Status in Southern Sydney Region	Likelihood of Occurrence in Study Area	Vulnerable to Subsidence ^	Assessment of Significance required?
		high exposed ridges during summer. Recorded in locality on state database.				
Red-crowned Toadlet *Pseudophryne australis*	V	Known only from Triassic sandstones of the Sydney Basin. Favoured habitats for shelter are between flat sandstone rocks (bush-rock). Prefer permanent soaks with dense vegetation rather than permanently flowing streams (feeder-creeks).	Locally common resident, declining.	Present	Yes	Yes
Stuttering Barred Frog *Mixophyes balbus*	E	Rainforest, Antarctic beech and wet sclerophyll forests (Cogger 2000). The species depends on freshwater streams and riparian vegetation for breeding and habitation. Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor. The southern portion of the Stuttering Frog's range is separated from the northern portion by the Hunter Valley.	Extremely rare resident, declining.	Moderate to High	Yes	Yes
Invertebrates:						
Giant Dragonfly *Petalura gigantea*	E	Occurs in permanent wetlands, both coastal and upland, permanent swamps and bogs with some free water and open vegetation. Known to occur in the SCA Special Areas. Larvae occupy permanent long chambered burrows, built under swamps. The larvae emerge from the terrestrial entrances at night and in wet weather, in search of insects and other arthropods to eat. Larvae are not known to swim and avoid open water.	-	High	Yes	Yes

1. Status in NSW as per TSC Act: CE = Critically Endangered; E = Endangered; V = Vulnerable.
2. Preferred habitat is a summary of literature reviewed and is not the sole information relied on for assessment of occurrence or impact.
3. Status in Southern Sydney Region from DECC (2007d.)
4. ^= Vulnerability to subsidence assessed according to DECC (2007a) and potential vulnerability of habitat.

Assessments of significance were undertaken for 22 species, including seven flora, 13 fauna species and two endangered ecological communities. The assessments are provided in *Annex E*.

The assessments concluded that the Project was likely to have a significant impact on habitat for local populations of the Red-crowned Toadlet and Giant Burrowing Frog specifically in the tributaries of Lizard Creek in the Wonga West area.

The Project will have an adverse effect on potential breeding habitat for the Heath Frog in 1st order streams associated with upland swamps. If a population is present within the affected areas, the Project would accordingly have an effect on the life cycle of this species such that the local population may be placed at risk of extinction.

The assessment for the Large-eared Pied Bat and other cave-dependent bats including the Large-footed Myotis and Eastern Bentwing-bat concluded that there is a negligible to low risk that the Project could modify, destroy, remove or isolate or decrease the availability or quality of breeding habitat associated with the cliffs and/or steep slope habitat in the Study Area.

Another species that occurs in upland swamps that was recorded in the Wonga West and Wonga East is the Prickly Bush-pea (*Pultenaea aristata*). Prickly Bush-pea has been recorded in 15 of the 84 upland swamps in the area. The majority of these records were in the Wonga West area to the west of Shaft No 5. Of the 65ha of confirmed upland swamp habitat in the Study Area, approximately 23ha is at a greater than negligible risk of negative environmental consequences. The changes to hydrology in these areas have been generally reported to be 'potential and minor'. Given that this species is associated with drier vegetation on the fringes of the upland swamps, it is unlikely that the habitat for this species will be modified. Terrestrial habitat for this species will be not removed and is unlikely to be modified by the proposed subsidence. Further discussion of the assessment outcome for this species is provided in *Section 24.5.4*.

The upland swamps are representative of the Coastal Upland Swamp EEC as listed under the TSC Act. Approximately 265ha of Coastal Upland Swamp are present in Wonga East and Wonga West domains of the Study Area. The Project will not directly clear any areas of the EEC. However, the proposed longwall mining may result in subsidence and alter hydrological processes affecting the swamps, in particular headwater swamps, as the mine plan has been revised to avoid the more sensitive valley infill upland swamps along Lizard Creek and Wallandoola Creek in Wonga West.

The Project has a risk of negative environmental consequences for approximately 29 of the 84 upland swamps, including 15 upland swamps of special significance, being approximately 60ha or 23% of that ecological community in the Study Area.

The risk assessment has identified that nine of the 15 swamps of special significance have potential to be subjected to subsidence impacts including:

- five swamps (CCUS4, CCUS10, CRUS1, LCUS8 and WCUS11) with a low likelihood of negative environmental consequences, NRE may wish to consider changes to longwall layouts to reduce potential impacts on these swamps;
- two swamps (WCUS4 (headwater swamp) and WCUS7) with a moderate likelihood of negative environmental consequences, NRE should consider changes to longwall layouts to reduce the risk of impacts on these swamps; and

- two swamps (CCUS1 and CCUS5) with a significant likelihood of negative environmental consequences, NRE should consider implementation of habitat avoidance, minimisation and mitigation measures to reduce impacts on these swamps.

By definition of the PAC (2009, 2010) and OEH (2012) these upland swamps of special significance have a higher relative importance for conservation of habitat beyond that afforded to other areas of coastal upland swamp EEC.

The alteration of habitat following subsidence due to longwall mining is listed as a key threatening process (KTP) under the TSC Act. The alteration or modification of habitat was considered likely to occur for the majority of species assessed as a result of the Project and for these species this is considered the operation of a KTP.

5.4 *REGIONALLY SIGNIFICANT SPECIES*

This section addresses species identified as being regionally significant to the Southern Coalfields region according to DECC (2007), and the DECCW letter to DoP accompanying the DGR's. These species are not listed on the TSC Act or EPBC Act and there is no legislative requirement to address them under a Part 3A submission. However, a discussion relating to the potential impacts on these species is provided here. Regionally significant species are shown in *Table 5.8*.

Table 5.8 Regionally Significant Species

Common Name	Scientific Name	Potential to occur in Study Area?	Vulnerable to subsidence?
Eastern Three-lined Skink	*Acritoscincus duperreyi*	Moderate: Likely to be associated with upland swamps and wet heath areas.	Yes
Chestnut-rumped Heath-wren	*Calamanthus pyrrhopygius*	High: Habitat in low heath and dense upland swamp, one unconfirmed observation in Lizard Creek swamp LCUS4.	Yes
Pheasant Coucal	*Centropus phasianidus*	Moderate: Unconfirmed incidental observation on a fire road in Wonga East.	No
Tawny-crowned Honeyeater	*Gliciphila melanops*	High: occurs primarily in heathland but can be found in woodland with heath understorey and dense upland swamps. Suitable habitat in Wonga West.	Yes
Beautiful Firetail	*Stagonopleura bella*	Present: recorded in Exposed Sandstone Scribbly Gum Woodland in Wonga East and suitable habitat is widespread in the area.	Yes
Southern Emu-wren	*Stipiturus malachurus*	Present: recorded frequently in Lizard Creek swamp complex, particularly in LCUS1.	Yes
Platypus*	*Ornithorhynchus anatinus*	Moderate: Potential habitat within Cataract Creek, but not in other areas.	Yes

Five of the regionally significant species are reliant upon upland swamp, heath and riparian environments for some or all of their lifecycle. These are Eastern Three-lined Skink (*Acritoscincus duperreyi*), Chestnut-rumped Heath-wren (*Calamanthus pyrrhopygius*), Pheasant Coucal (*Centropus phasianidus*), Tawny-crowned Honeyeater (*Gliciphila melanops*) and Southern Emu-wren.

None of the species are entirely aquatic, and all are capable of dispersal within suitable habitat. The extensive swamps of Lizard Creek and Wallandoola Creek are part of the Wallandoola Significant Swamp Cluster, and provide an area of contiguous suitable habitat for swamp-dependent species within the SCA Special Areas.

The proposed mine plan indicates that impacts to the larger valley infill upland swamp communities of Lizard Creek (LCUS1) and Wallandoola Creek (WCUS1) will be largely avoided by the design of the mine layout. However, there are low or higher risk of negative environmental consequences in the upland swamps LCUS8, WCUS11, WCUS7, WCUS4-headwater swamp in Wonga West; and CCUS4, CCUS10, CRUS1, CCUS1 and CCUS5 in Wonga East (Biosis 2012a).

It is likely that effects of subsidence such as shorter duration wetting events for valley infill swamps, increased dry periods, an increase in fire occurrence may reduce habitat suitability in the swamps mentioned above. However, the relative abundance of these species in the Study Area, the connectivity of the Study Area to surrounding healthy habitat areas, and the ability of these animals to disperse within suitable habitat is likely to ameliorate the impacts of the Project on populations of these species within the Study Area.

Beautiful Firetail is often found near rocky outcrops in heath, upland swamps and dry woodlands. It is a seed eating species that forages both on plants and on the ground. The species was recorded in Wonga East in Exposed Sandstone Scribbly Gum Woodland and has been recorded in similar environments in the Southern Coalfields. Due to the diverse habitat associations, it is not considered likely that the Project will lead to adverse effects on the distribution of this species in the Study Area or surrounding habitat.

The Platypus (*Ornithorhynchus anatinus*) may occur within Cataract Creek as habitat appears suitable between Cataract Dam and CC5. GeoTerra (2012a) indicates that there is a risk of reduced water flows in Cataract Creek based upon the subsidence predictions of Seedsman Geotechnics (2012). Based on this information, there is a low risk of subsidence induced effects on this species within the Study Area.

5.5 *RARE OR THREATENED AUSTRALIAN PLANTS*

RoTAPs are flora identified as rare or threatened by Briggs and Leigh (1995) which were listed under the now decommissioned Commonwealth *Endangered Species Protection Act 1992*. This act has been superseded by the EPBC Act. There is no legislative requirement to consider ROTAP species under a Part 3A project.

Three RoTAP species (not listed as threatened) have been recorded in the Study Area and all are considered vulnerable to the impacts of subsidence according to DECC (2007) (See *Table 5.9*).

Table 5.9 ROTAPs recorded in the Study Area

Sensitive flora species Common name	Scientific name	TSC Act status	EPBC Act status	ROTAP status	Vulnerable to subsidence? *
Darwinia grandiflora	*Darwinia grandiflora*	-	-	2RCi	Yes
Shining Guinea Flower	*Hibbertia nitida*	-	-	2RC-	Yes
Monotoca ledifolia	*Monotoca ledifolia*	-	-	3RCa	Yes
1. * Source: DECC (2007)					

Darwinia grandiflora was recorded in Wonga East in sandy soils on the side of the road and in adjacent woodland within Sandstone Scribbly Gum Woodland. The subsidence risk in this area is very low, with a predicted subsidence value of 0.0mm movement. There is not likely to be any impacts in this area. *Darwinia gradiflora* was also recorded in Wonga East on the edge of a sedgeland-heath swamp complex where the vegetation grades into woodland in CRUS3 and CCUS3. There is a negligible likelihood of negative environmental consequences for upland swamp CRUS3 (Biosis 2012a). No assessment of risk was provided for upland swamp CCUS3. This swamp will be undermined by approved works (A2 LW5).

Shining Guinea Flower has been previously recorded in the Study Area by Kevin Mills and Associates (2005) but the location of the records is unknown. The species is commonly recorded on exposed slopes in coastal areas. The likelihood of impacts to this species are not known.

Monotoca ledifolia was recorded in Upland Swamp LCUS6 in the Sedgeland Heath Complex adjacent to Lizard Creek. There is a negligible likelihood of negative environmental consequences in this swamp (Biosis 2012a). Based on this assessment, this population of *M. ledifolia* is not expected to experience adverse effects of subsidence impacts.

5.6 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The EPBC Act Protected Matters Search Tool identified three Threatened Ecological Communities (EECs), 57 threatened species and 44 migratory species listed under the EPBC Act that "*have the potential to occur, or rely on habitat that may potentially occur, within 10 km of the study area*". The ecological assessment has considered all EECs, threatened species and migratory species listed by the search tool when undertaking the impact assessment. Only those species considered likely to occur within the Study Area are discussed in the EPBC Act Matters assessment report (ERM 2013b). Assessment of matters of National Environmental Significance is provided in *Annex T* of the Project.

There is no suitable habitat for marine reptiles, mammals or seabirds, and habitat for wetland birds including egrets, snipes and waders is also absent from the Study Area.

6 MANAGEMENT AND MITIGATION MEASURES

This chapter evaluates the impacts expected from the Project in light of the measures taken by NRE to avoid, minimise and mitigate these impacts. Avoidance measures have been the primary mechanism by which NRE has aimed to reduce the impact of the Project on the ecology of the Study Area.

6.1 ITERATIVE MINE PLANNING

The proposed mining will be in the Wongawilli seam in an area where the Bulli seam and in some places, the Balgownie seam have already been extracted (Olsen, 2009). In order to manage environmental risks, the mining proposal incorporated a risk assessment methodology and applied a hierarchy of risk management strategies during planning. Details of the strategies and the projected outcomes are included in a report prepared by Seedsman Geotechnics Pty Ltd (Seedsman, 2012).

As the baseline surveys of the Study Area progressed, NRE used an iterative mine planning process to avoid and mitigate impacts to the values identified by ERM and associated consultants. The progressive mine plans that were considered and altered throughout the iterative mine planning process are described in Seedsman (2012). The process for avoiding and mitigating impacts to ecological values is discussed below.

6.1.1 Avoidance Measures

The iterative mine planning process involved ongoing examination of longwall options in light of ecological constraints, in order to avoid impact to areas of high conservation value. In 2007 a map of 'ecological risk management zones' was provided to NRE for consideration and these areas including upland swamp communities as known at the time, streams and riparian zones, significant fauna habitats and the Shale/Sandstone Transition Forest EEC as determined at the time. An additional risk management zone of 250m around swamps, and 50m around streams 3rd order or higher was applied. These risk management zones provided the subsidence engineers and mine managers with an understanding of the locations of sites of ecological significance within the Study Area. It also provided an opportunity to refine the mine plans based upon this information.

Areas of ecological significance including upland swamps, streams and sensitive habitat areas for threatened fauna, flora and ecological communities were identified during the ecological assessment in 2009. Utilising an elimination approach for risk management, NRE decided not to undertake longwall extraction under or close to features of ecological significance (Olsen, 2009). In order to avoid impacts to surface features, the design of longwall panel layouts has been such that potential for impacts to 3rd and 4th order streams are reduced (Seedsman, 2012). The proposed mine plans have avoided longwall extraction directly under Lizard Creek, Wallandoola Creek and Cataract River (Seedsman, 2012).

Seedsman (2012) outlines the current mine plans and the abandoned plans which show that the mine plan avoids:

- extraction under the main channel of Lizard Creek and associated upland swamps;

- extraction under Wallandoola Creek and the upland swamp WCUS1; and
- extraction under Cataract River.

Further impacts have been avoided through location of the underground driveage between Wonga East and Wonga West, which will be fully supported (resulting in no subsidence), under Lizard Creek.

The possibility of reducing the width of longwall panels in Wonga West was examined in order to assess feasibility of reduction in magnitude of subsidence above the longwalls. However, the technical options for location of longwall gate roads under Lizard Creek meant that the longwall layouts became uneconomic under these circumstances (Seedsman, 2012).

6.2 *MITIGATION*

NRE has provided an undertaking that the mining operations will be modified as required through adaptive management measures informed through monitoring of actual subsidence impacts, to reduce negative outcomes.

An adaptive management plan will be developed to use the monitoring program to detect the need for adjustment to the mining operations so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences do not occur in upland swamps, streams and rocky habitats associated with cliffs and steep slopes.

Further measures to mitigate potential small scale effects of subsidence are recommended within the Study Area, in order to assist in amelioration of impacts as follows:

- if fracturing does occur and is confirmed to be a result of mining, remediation will be implemented as soon as possible. Methods could include grouting, although the success of this measure is case dependant and potentially non-beneficial. All remediation works undertaken will be controlled and implemented in accordance with a Biodiversity Management Plan;
- if fracturing occurs leading to loss of surface water these areas will be prioritised for remediation, and extraction will be ceased in areas with similar fracture risks;
- if significant cracking occurs in vegetated areas and is confirmed to be a result of mining, then measures such as temporary fencing will be implemented. This will ensure that fauna are not injured or trapped; and
- prior to any remediation works, advice will be sought from an ecologist regarding the potential impacts of such remediation works to plant and animal populations within the area.

In order to mitigate the impacts at the scale of the entire Study Area, ongoing monitoring of sensitive habitats needs to be implemented in accordance with a Biodiversity Management Plan. In addition to the above measures, Biosis (2012a) outlines monitoring, management and contingency measures for the upland swamps.

6.3 *MONITORING*

Although not a mitigation tool, monitoring of the important habitat areas (such as the upland swamps, creeks and rocky habitats) should occur pre and post mining, to allow early detection of impacts as a result of the Project. This would enable mobilisation of mitigation and remediation works to be undertaken in accordance with Biodiversity Management Plans.

OEH (2012) in their upland swamp environmental assessment guidelines provide a framework for monitoring of negative environmental outcomes for upland swamps. While these measures relate specifically to upland swamps, monitoring of these high priority conservation areas will ensure that impacts to swamp dependent species and species associated with upland swamp habitats are detected and minimised through adaptive management plan.

Performance measures to demonstrate negligible environmental consequences for swamps (as adopted by NRE for A2 LW4) are:

- negligible drainage of water from the swamp, or redistribution of water within the swamp;
- negligible change in the size of the swamp;
- negligible change in the function of the swamp; and
- negligible change in the composition or distribution of species within the swamp.

Where negligible has the same meaning as in the PAC, "*small and unimportant, such as to be not worth considering*".

For the purposes of monitoring upland swamps, OEH identify that monitoring of changes in water levels within the swamp is an appropriate and in particular early indicator that other negative environmental consequences may occur. Drawdown of water levels is one of the first parameters that can be detected following the fracture of rock strata (OEH 2012). Negative environmental outcomes have occurred if there is a statistically significant decrease in water levels within the swamp that is directly attributable to subsidence.

The biodiversity management plan prepared by NRE for Longwalls A2 LW4 and 5 (NRE 2012) also outlines measures for management of threatened species and ecological communities. Monitoring effort should focus on natural features at risk of subsidence effects in particular upland swamps and streams in particular, Coastal Upland Swamp EEC, Giant Burrowing Frog, Heath Frog, Red-crowned Toadlet, Stuttering Barred Frog and Broad-headed Snake.

Performance measures to demonstrate negligible environmental consequences for threatened species and EECs (as adopted by NRE for Longwall A2 LW4) are negligible environmental consequences.

Monitoring will inform the ongoing development of longwall panels over time as part of the current proposed mine plan.

Monitoring will be undertaken at regular intervals in appropriate seasonal timeframes for the detection of each individual species. In particular, potential habitat in areas which subsidence risk is greatest will be targeted. The design of ongoing ecological monitoring will be outlined in the Biodiversity Management Plan and should be flexible to account for seasonal and inter-annual variation in ecological conditions.

The objective of the monitoring will be to identify subsidence impacts as early as possible; identify other areas that are vulnerable to similar impacts; and provide recommendations to the proponent to alter the mine plan to reduce the risk of subsidence impacts affecting similar values. In this case, the mitigation measure would be to alter the extraction plans to minimise risk to sensitive features, based on the knowledge gained through ongoing monitoring. A monitoring program would be developed to ensure that the monitoring activities do not cause adverse impact on the species and habitats.

Monitoring plan as outlined in the Biodiversity Management Plan for Longwalls A2 LW4 and A2 LW5 (NRE 2012) will be adopted and expanded for the proposed long wall mining operation in Wonga East and Wonga West. The current monitoring is undertaken according to the Before-After Control-Impact (BACI) design where data is collected before (baseline) and after impact at control and impact sites. Data collected during baseline monitoring will be used for comparison of data collected during and after mining (before) and data collected at impact sites will be compared to data collected at control sites (control-impact) (NRE 2012). Although two years baseline data collection is preferential to ensure adequate variance in biological systems is considered in planning of the mine, planning and changes to sampling methods has meant that the design of the monitoring program has changed. However, impacts to many of the species dependent upon ecologically sensitive areas vulnerable to subsidence are not likely to occur over short intervals and are likely to be preceded by changes to other variables in particular surface and groundwater flows. Therefore, although minimal baseline data has been collected overall trending declines can still be used to identify whether subsidence impacts have negative environmental consequences on flora and fauna.

Monitoring will continue for the duration of mining and for a suitable period post mining as determined in consultation with agencies and the DP&I with consideration given to the annual reports and observed impacts to surface features, surface water and groundwater. Monitoring will be undertaken for a minimum of two years post mining up to five years (NRE 2013).

A summary of biodiversity monitoring program is provided in *Table 6.1*.

Table 6.1 Biodiversity Monitoring Program Framework

Monitoring	Methodology	Frequency
Vegetation – Upland Swamps	Transect based- thirty (30) 0.5m by 0.5m flora quadrats recording presence only. A species can have a maximum score of 30 for any one transect, indicating presence in all quadrats.	Autumn and Spring
Vegetation creeklines	Three 20m by 20m (400m^2) quadrats along Cataract Creek and 3rd order tributaries of Cataract Creek and Lizard Creek	Once in Autumn and once in Spring

Monitoring	Methodology	Frequency
Frogs	Initial survey to identify significant habitat features including breeding pools and sheltering habitat. Diurnal surveys for all potential habitat identified in the initial survey to map habitat features (pools, rockbars) noting presence of species. Ongoing monitoring searching for adult frogs and tadpoles and noting habitat variables	Ongoing monitoring will be undertaken once per season ie four per annum.
Rocky Habitats	Initial survey to identify significant habitat features including overhangs, potential caves and over wintering habitat. Diurnal surveys for potential habitat identified in the initial survey to map habitat features noting presence of species. Ongoing monitoring including searching for adults and juveniles and noting habitat variables and use of Anabat monitoring of suitable habitat to identify species presence.	Ongoing monitoring will be undertaken once per season, ie four per annum.

1. Framework based upon Biodiversity Management Plan prepared by NRE (2012) for Longwalls A2 LW4 and A2 LW5.

7 CONCLUSION

This chapter draws conclusions based on the previous chapters.

The Study Area contains a number of ecological features of special significance including threatened species, endangered ecological communities, regionally significant species and RoTAPs. The Study Area contains a number of upland swamps of special significance that provide habitat for national or state significant threatened species, which form part of the Wallandoola Significant Swamp Cluster (DECC, 2007a) and support a state preliminary listed EEC.

The condition of habitat within the Study Area is generally very good owing to the areas ongoing protection as part of the SCA Special Areas. The Wallandoola Swamp Cluster provides extensive tracts of valley infill swamp and headwater swamp habitat for threatened species and regulate the surface water flows within creeks of the Study Area (GeoTerra 2012a). There are extensive areas of habitat suitable for threatened species within the swamps and creeks that are in good condition and the area is well connected to surrounding habitat.

There is limited surface disturbance around fire roads, existing mine shafts, transmission line easements and frequently trespassed areas within Wonga East. There are indications of previous subsidence impacts within Lizard Creek and Wallandoola Creek, as evidenced by cracking within the stream beds and loss of surface water flows for extensive reaches (GeoTerra 2012a). The condition of Cataract Creek is good, although some tributaries leading into the creek show signs of heavy iron-oxidising bacteria flocculation, and the lower reaches are degraded due to water level fluctuations of Cataract Dam. There is some evidence of scouring and erosion within upland headwater swamp LCUS25.

Elimination of many potential impacts on terrestrial ecology has been achieved by; realigning the longwall panel layouts to avoid sensitive areas identified by ERM in 2007 and the subsequent FMEA (Olsen, 2009), abandoning plans for longwall panels underneath the main channel of Lizard Creek and Wallandoola Creek, abandoning plans for longwall panels underneath Lizard Creek valley infill swamps and much of the Wallandoola Creek valley infill swamps, locating the fully supported driveage underneath Lizard Creek, and realigning and reducing the width of longwall panels in Wonga East. Despite this approach, there remains a risk to a number of the ecological values of the Study Area.

Assessments of Significance under the TSC Act concluded that the Project was likely to have a significant impact on habitat for local populations of the Red-crowned Toadlet and Giant Burrowing Frog. The Heath Frog that may occur in the Study Area also has the potential to be significantly impacted by the Project, if present. The upland swamps are representative of Coastal Upland Swamp EEC. Twenty-nine (29) of the upland swamps are at risk of negative environmental consequences, including 15 swamps of special significance. The risk assessment has identified that nine of the 15 swamps of special significance have potential to be subjected to subsidence impacts including:

- five swamps (CCUS4, CCUS10, CRUS1, LCUS8 and WCUS11) with a low likelihood of negative environmental consequences, NRE may wish to consider changes to longwall layouts to reduce potential impacts on these swamps;

- two swamps (WCUS4 (headwater swamp) and WCUS7) with a moderate likelihood of negative environmental consequences, NRE should consider changes to longwall layouts to reduce the risk of impacts on these swamps; and
- two swamps (CCUS1 and CCUS5) with a significant likelihood of negative environmental consequences, NRE should consider implementation of habitat avoidance, minimisation and mitigation measures to reduce impacts on these swamps.

By definition of the PAC (2009, 2010) and OEH (2012) these upland swamps of special significance have a higher relative importance for conservation of habitat beyond that afforded to other areas of coastal upland swamp EEC.

The alteration of habitat following subsidence due to longwall mining is listed as a key threatening process (KTP) under the TSC Act. The alteration or modification of habitat was considered likely to occur for the majority of species assessed as a result of the Project and for these species this is considered the operation of a KTP.

NRE has provided an undertaking that the mining operations would be modified as required through adaptive management measures informed through monitoring of actual subsidence impacts to reduce the risk of negative consequences. An adaptive management plan will be developed to use the monitoring program to detect subsidence impacts and thereby determine the need for adjustment to the mining operations so that the subsidence predictions are not exceeded and subsidence impacts creating significant negative environmental consequences do not occur in upland swamps. Recommendations provided by Biosis (2012a) in their assessment of upland swamps will be considered in development of the adaptive management plan and future mining plans.

With adoption of the recommendations of Biosis (2012a), implementation of the adaptive management plan, and the commitment to not create a risk of negative environmental consequences, the extent of upland swamps in the locality may not be significantly affected.

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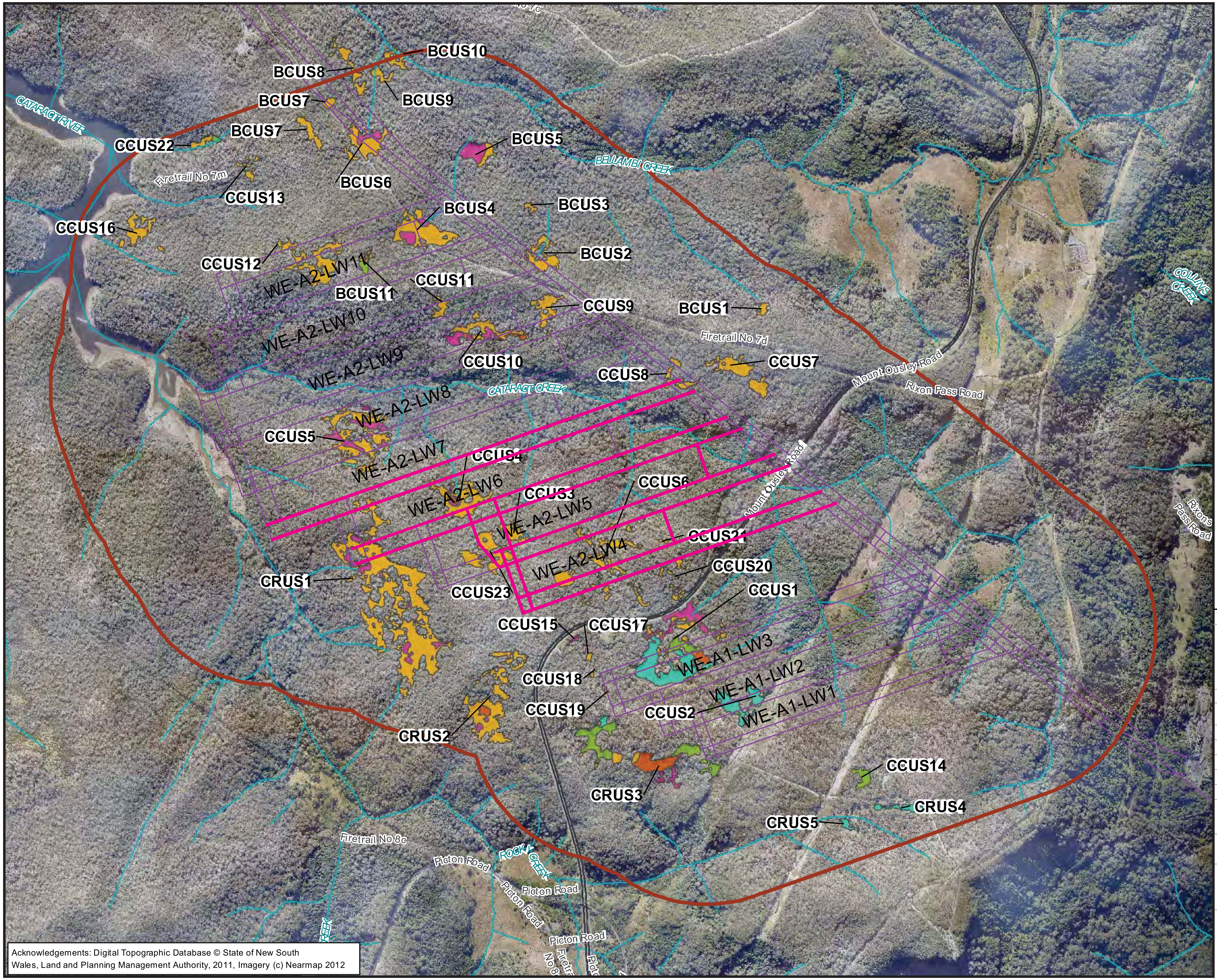
Annex A

Upland Swamp Vegetation Maps (Biosis 2012a)



Legend

Vegetation Sub-Communities

- MU42 Upland Swamps: Banksia Thicket
- MU43 Upland Swamps: Tea-Tree Thicket
- MU44a Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Survey Area

- Wonga East Study Area
- Longwalls
- Approved Workings (MP10_0046)

Matter: 15094,
Date: 31 October 2012,
Checked by: NMG, Drawn by: apritchard
Location:P:\15000s\15094\Mapping\Report Figures\15094 F4_Wonga East Swamps

Annex A - Figure 1

Upland Swamps in Wonga East

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery Ecological Assessment
Drawing No:	0079383h_EARPA2012_C026_R1.cdr
Date:	07/02/13
Drawing size:	A3
Drawn by:	JD
Reviewed by:	NB
Source:	Biosis 2012
Scale:	Refer to Scale Bar

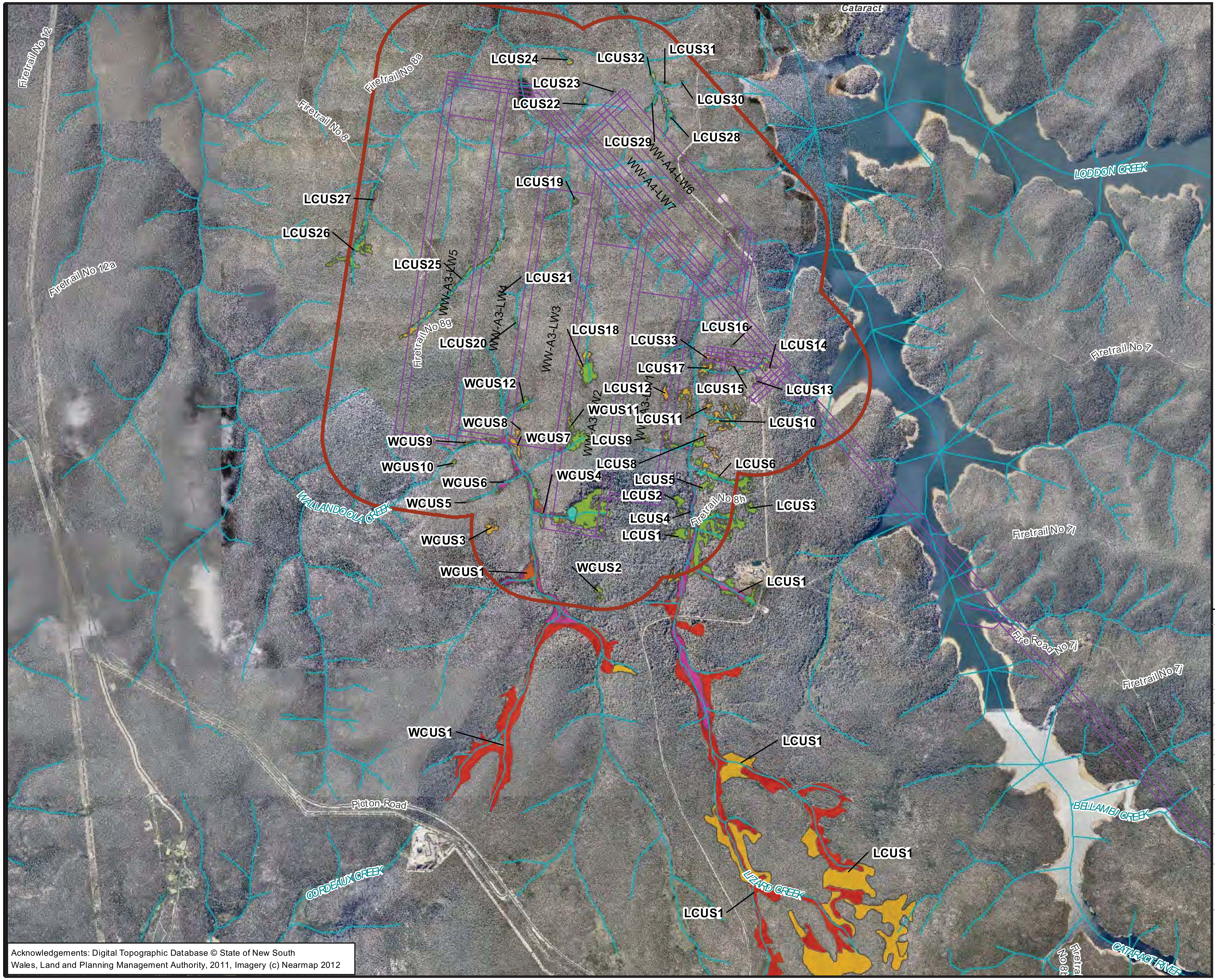
N

0 0.15 0.3 0.45km

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM



Acknowledgements: Digital Topographic Database © State of New South Wales, Land and Planning Management Authority, 2011, Imagery (c) Nearmap 2012

Legend

Vegetation Sub-Communities

- MU42 Upland Swamps: Banksia Thicket
- MU43 Upland Swamps: Tea-Tree Thicket
- MU44a Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Vegetation Outside Current Study Area (NPWS 2003)

- MU44 Upland Swamps: Sedgeland-Heath Complex

Survey Area

- Wonga East Study Area
- Longwalls

Matter: 15094,
Date: 31 October 2012,
Checked by: NMG, Drawn by: apritchard
Location:P:\15000s\15094\Mapping\Report Figures\15094 F5_Wonga West Swamps

Annex A - Figure 2

Upland Swamps in Wonga West

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery Ecological Assessment
Drawing No:	0079383h_EARPA2012_C027_R1.cdr
Date:	07/02/13 — Drawing size: A3
Drawn by:	JD — Reviewed by: NB
Source:	Biosis 2012
Scale:	Refer to Scale Bar

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Annex B

Herpetological Sub-consultant Reports

Mark Branson
Senior Ecologist
ERM Australia
15 April 2009
Our ref: 5388

Re: NRE Gujarat Targeted Herpetological Surveys.

Dear Mark,

The following is a brief report outlining the survey methodologies employed, survey effort, and survey results achieved during the targeted frog and reptile surveys conducted by Biosis Research within the Wonga West and Wonga East study areas between 23 and 27 March, 2009.

The report does not include a discussion of impacts or Assessments of Significance.

Should you have any queries regarding this report, please do not hesitate to contact me at the Biosis Research Sydney office on (02) 9690 2777 or on my mobile: 0427 512 187.

Yours sincerely,

J. Charlton

Jennifer Charlton
Consultant Zoologist
jcharlton@biosisresearch.com.au

1.0 INTRODUCTION

Biosis Research was commissioned by ERM Australia on behalf of NRE Gujarat to conduct targeted herpetological surveys within the Lake Cataract catchment on the Illawarra Escarpment, north-west of Wollongong, NSW.

The aim of the surveys was to locate target threatened species of frog and reptile, and/or their potential habitat, that may be impacted by subsidence due to longwall mining.

Due to the location of the proposed longwalls, the study area has been segregated into two sections: Wonga West and Wonga East. Wonga West occurs immediately west of Lake Cataract near the NRE No. 4 Shaft Site and Wonga East occurs immediately south-east of Lake Cataract, just above the NRE No. 1 Colliery at Russell Vale. Both study areas include Risk Management Zones (RMZ) which contain habitats known to be vulnerable to the impacts of subsidence (i.e. Upland Swamps, rocky outcrops, creeklines and wetlands).

1.1 Target Species and Sites

Table 1 shows the threatened species, as listed on the NSW *Threatened Species Conservation Act* 1995 (TSC Act) and/or Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), that were targeted during the field survey:

Table 1: Target Threatened Species

Scientific Name	Common Name	EPBC Act	TSC Act
Frogs			
Heleioporus australiacus	Giant Burrowing Frog	V	V
Litoria aurea	Green and Golden Bell Frog	V	E1
Litoria littlejohni	Littlejohn's Tree Frog	V	V
Pseudophryne australis	Red-crowned Toadlet	-	V
Reptiles			
Hoplocephalus bungaroides	Broad-headed Snake	V	E1
Varanus rosenbergi	Rosenberg's Goanna	-	V

Key: V = Vulnerable, E1 = Endangered

The threatened species shown in Table 1 can occupy one or more of the habitats known to be vulnerable to the impacts of subsidence (Table 2). Therefore, Upland Swamps, rocky outcrops, creeklines and wetlands occurring within the RMZ of Wonga West and Wonga East were targeted during the field survey.

Table 2: Potential Habitats of Target Species that may be Impacted by Subsidence

Common Name	Potential Habitat			
	Upland Swamp	Rocky Outcrops	Creek Lines	Wetlands / Dams
Giant Burrowing Frog	Yes	Yes	Yes	Yes
Green and Golden Bell Frog	No	No	Yes	Yes
Littlejohn's Tree Frog	Yes	Yes	Yes	Yes
Red-crowned Toadlet	Yes	Yes	Yes	Yes
Broad-headed Snake	No	Yes	No	No
Rosenberg's Goanna	Yes	Yes	No	No

The target species can also occur in other habitats (e.g. woodland) or utilise micro-habitat components (e.g. hollow-bearing trees, termite mounds) that are less likely to be impacted by subsidence. However, each species occupies at least one of the habitat types susceptible to subsidence impacts during an important part of their lifecycle (e.g. breeding, foraging, sheltering).

2.0 METHODOLOGY

The field survey took place between Monday 23 and Friday 27 March, 2009. Jennifer Charlton (zoologist) was the field team leader Monday to Wednesday and Melissa Starling (zoologist) was the field team leader Thursday to Friday. Josephine Dessmann (zoological field assistant) assisted with the surveys Monday to Friday.

During the field survey, weather conditions varied from hot and humid Monday to Wednesday with an electrical storm and rain on Monday night, to overcast and intermittent light showers Thursday to Friday with rain on Thursday night (rain was also noted on Wednesday night however no surveys were conducted this night).

Table 3 shows the average day and night temperatures and relative humidity recorded within the study areas.

Table 3: Average Temperature (^{o}C) and Relative Humidity (%)

	Mon 23rd		Tue 24th		Wed 25th		Thur 26th		Fri 27th	
	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH
Day	32[a]	25[b]	29.7	44[b]	X	X	26.0	98	19.7	98
Night	18.2	98	16.0	98	n/a	n/a	18.5	98	n/a	n/a

Key: a = estimate due to unlikely reading on thermo-hygrometer (which read 52^{o}C); b = reading considered to be inaccurate; X = not recorded.

2.1 Survey Techniques

The 'Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities' (DEC 2004) was followed for survey techniques, however, due to the large size of the study area and limited field time (5 days, 3 nights)[1], the recommended level of survey effort outlined in the guidelines was not achievable.

The following survey techniques were implemented during the field survey. Survey sites are shown on Figure 1a (Wonga West) and 1b (Wonga East).

Diurnal Herpetological Surveys

Targeted species: Broad-headed Snake, Rosenberg's Goanna, Red-crowned Toadlet, Littlejohn's Tree Frog, Giant Burrowing Frog and Green and Golden Bell Frog

Two zoologists conducted diurnal herpetological searches within potential rocky and creekline habitat. Searches consisted of an area search (at least 40 m x 40 m) for 0.5 person hours. Searches involved examining ground litter, turning over logs and rocks, dip-netting, looking through low shrubs and examining rock cavities and crevices (with a head torch or hand-held torch). Termite mounds (breeding habitat for Rosenberg's Goanna) and prey species for the Broad-headed Snake (e.g. Lesueur's Velvet Gecko *Oedura lesueurii* and Southern Leaf-tailed Gecko *Phyllurus platurus*) were also looked for. Any captured animals were identified to species and then released at the site of capture.

Due to time restrictions, a second replicate for each site, on a separate day or otherwise, was not possible.

Diurnal Call-playback

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog and Green and Golden Bell Frog

Species that are particularly cryptic, such as frogs, may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display) from individuals of the same species.

Potential habitat within Upland Swamps and dams/wetlands was targeted. A Samsung MP3 player connected to a 10W TOA megaphone was used to emit the calls. Each call

[1] In addition, it was not possible to safely utilise all daylight or night time hours due to the concurrent running of diurnal and nocturnal surveys.

was emitted for three minutes, followed by three minutes of listening. The call of each targeted species' was not emitted at every site. Any animals encountered were identified by direct observation or by their calls.

Nocturnal Frog Habitat Search

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog, Giant Burrowing Frog and Green and Golden Bell Frog

Two different survey techniques were used to spotlight for frogs within the study area: nocturnal habitat searches (discussed here) and nocturnal watercourse searches (see 'nocturnal watercourse search' below). Two zoologists conducted nocturnal frog habitat searches within potential habitat within the study area. Potential habitat within Upland Swamps and dams were targeted.

Nocturnal frog habitat searches consisted of an initial five minute listening period followed by active searching of an area (at least 40 m x 40 m). Searches involved examining ground litter, turning over logs and rocks and examining low shrubs. Zoologists used a head torch and handheld 50-w spotlight to conduct the surveys. Any captured animals were identified to species and then released at the site of capture.

Due to time restrictions, a second replicate for each site, on a separate night or otherwise, was not possible.

Nocturnal Watercourse Search

Targeted species: Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet and Green and Golden Bell Frog

Nocturnal watercourse searches were conducted within creeklines. Nocturnal watercourse searches consisted of an initial five minute listening period followed by two person hours of active spotlight searching of 200 m of a watercourse. Zoologists used a head torch and handheld 50-w spotlight to conduct the surveys. Any animals encountered were identified by direct observation or by their calls.

Nocturnal Call-playback

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog, Giant Burrowing Frog and Green and Golden Bell Frog

Species that are particularly cryptic, such as frogs, may be detected using call-playback. This technique relies on behavioural responses associated with territory and threat, whereby emitted calls may induce a defending response (either call or display) from individuals of the same species.

Potential habitat within Upland Swamps and creeklines was targeted. A Samsung MP3 player connected to a 10W TOA megaphone was used to emit the calls. Each session began with a five minute listening period to detect any species already present in the area. Each call was emitted for three minutes, followed by three minutes of listening. The call of each targeted species' was not emitted at every site. Any animals encountered were identified by direct observation or by their calls.

Opportunistic Track Spotlight (from vehicle)

Targeted species: Red-crowned Toadlet, Littlejohn's Tree Frog, Giant Burrowing Frog and Green and Golden Bell Frog

Due to rainfall, an opportunistic spotlight of Fire Road 8 (Wonga West) from a slow moving vehicle was conducted for frogs. Two and a half kilometres of wet fire trail was spotlighted for ten minutes.

Opportunistic Spotlighting

Targeted species: Broad-headed Snake

Opportunistic spotlighting was carried out in potential habitat within the study area to detect the Broad-headed Snake. Spotlighting, conducted by one to two zoologists using handheld 50-w spotlights, was concentrated in wooded areas with rocky outcrops and hollow-bearing trees. Any animals encountered were identified by call and/or direct observation.

Habitat Assessment

Habitat assessments were conducted within Upland Swamps, rocky areas, creeklines and dams/wetlands. The presence or absence of specific micro-habitat features required by the targeted species were noted and/or described. Any disturbances such as tracks or powerlines were recorded. The suitability of the habitat for the target species was assessed. Other habitat features, such as connectivity, were also used to assess habitat quality.

Incidental Observations

Both indirect and direct evidence of fauna was recorded and used to identify species presence. Direct evidence of animal species included actual sightings or identification of the species by calls (e.g. birds, frogs and some nocturnal mammals). Indirect evidence of animal species included remains (e.g. skin), scats, diggings or burrows and feeding scars.

Incidental animal observations were recorded each day. The habitat in which species were observed was recorded (e.g. Upland Swamp, ridge, creekline, dam).

2.2 Survey Effort

Table 4 outlines the survey effort achieved during the field survey. All surveys involved one to two zoologists.

Table 4: Survey Effort

Survey Technique	Wonga West			Wonga East				Total No. of Sites	Survey Length /Person Hours
	Upland Swamp	Rocky Outcrop	Creek Line	Upland Swamp	Rocky Outcrop	Creek Line	Dam		
Diurnal Herpetological Surveys	-	3	2	-	4	1	-	**10**	5 p.h.
Diurnal Call-playback	1	-	-	-	-	-	1	**2**	23 mins
Nocturnal Frog Habitat Search	1	-	-	-	-	-	-	**1**	0.5 p.h.
Nocturnal Watercourse Search	-	-	2	-	-	1	-	**3**	6.25 p.h.
Nocturnal Call-playback	3	-	3	1	-	1	-	**8**	3.25 hrs
Opportunistic Track Spotlight (from vehicle)	Fire Trail 8			-				**1**	10 mins (2.5 km)
Opportunistic Spotlighting (for BHS)	Not quantified			Not quantified				**n/a**	n/a
Habitat Assessment	2	3	3	2	4	5	1	**20**	n/a

Survey Technique	Wonga West			Wonga East				Total No. of Sites	Survey Length /Person Hours
	Upland Swamp	Rocky Outcrop	Creek Line	Upland Swamp	Rocky Outcrop	Creek Line	Dam		
Incidental Observations	23/03/09 – 24/03/09			25/03/09 – 27/03/09				**n/a**	n/a

2.3 Limitations

A number of limitations affected the amount of survey effort achieved and/or survey results:

- Due to the large size of the Wonga West and Wonga East study areas and the amount of field time (5 days and 3 nights), it was not possible to carry out all surveys or meet the required survey effort (e.g. second replicates);
- It was not possible to safely utilise all daylight or night time hours due to the concurrent running of diurnal and nocturnal surveys;
- Access to suitable survey sites was limited and time-consuming;
- An electrical storm and rain on Monday (23^{rd}) night interrupted the surveys (e.g. waiting for the electrical storm to pass and too much rain to conduct call-playback);
- The survey timing (early autumn) may have been too early in the season to detect Broad-headed Snakes (in crevices) and Littlejohn's Tree Frogs. Broad-headed Snakes leave their summer tree hollow habitats to enter rock crevices during the cooler months of the year and local populations of Littlejohn's Tree Frog are known to call in greater numbers during winter (personal observations). However, said local Littlejohn's Tree Frog populations were responding to call-playback and vocalising independently in low numbers (south-west of Lake Cordeaux) during the same period of survey (Matt Swan, Biosis Research, pers. comm.); and,
- The survey timing may have been too late to detect Green and Golden Bell Frogs which are best detected in spring and summer.

3.0 RESULTS

All fauna recorded during the field trip (including incidental observations) are shown in Appendix 1, and include seven frog species (plus one unidentified species), 41 bird species (one introduced), four mammal species and six reptile species (plus an unidentified skink and gecko).

The unidentified frog species (two individuals in the same location) was recorded during a nocturnal call-playback survey at Lizard Creek (Wonga West). The unidentified species did not start calling until the recorded call of the Red-crowned Toadlet was played over the megaphone. The two individuals then gave a few ‘squeaks’ but stopped almost as soon as the recorded call was stopped. The frogs squeaked again when the call was started again over the megaphone. Due to high traffic noise on an adjacent road at this time, call-playback for the Red-crowned Toadlet was repeated later the same night at the same location. However, the second session of call-playback did not result in any response. The unidentified frog species was a *Pseudophryne* species and was either the non-threatened Brown Toadlet (*P. bibroni*) or the threatened Red-crowned Toadlet. This species’ location is shown in Figure 2a.

The shed skins of a gecko species were found on a rocky outcrop on the southern side of Cataract Creek (Wonga East). The skins were somewhat disintegrated but were possibly that of the Southern Leaf-tailed Gecko, a favoured prey item of the threatened Broad-headed Snake.

Apart from the possible Red-crowned Toadlet record, no threatened species were recorded during the field trip. However, habitat assessments identified areas of potential habitat for each of the target threatened species. Where possible, these areas of potential habitat are shown in Figure 2a (Wonga West) and 2b (Wonga East). Note that not all parts of the study area were inspected during the field survey and that other areas of potential habitat are considered likely to occur.

Giant Burrowing Frog

The Giant Burrowing Frog occurs in open forest, woodland and heathlands, including Upland Swamps and rocky outcrops, where there are sandy soils. The species generally lives in the heath or forest and will travel several hundred metres to creeks to breed (DEC 2005a). The species tends to emerge from burrows to forage or breed following rain. The species requires deep pools for tadpole development. The Giant Burrowing Frog has been recorded within 10 km of the study area, including within Wonga East, just south of where Fire Road 7D crosses Bellambi Creek (DECC Atlas of NSW Wildlife).

The condition of creek lines and Upland Swamps within the study area varied from poor to good quality. Some creek lines were considered less likely to provide potential habitat for the Giant Burrowing Frog, particularly where Bellambi Creek and Cataract Creek (Wonga East) occur in disturbed rainforest (although the species can occur in rainforest; DEC 2005a). Some sections of Lizard Creek (Wonga West) were completely dry (Plate 1), potentially too rocky or contained iron-stained water. However, other sections of Lizard Creek were considered to provide good potential habitat for the Giant Burrowing Frog (Plate 2). Wallandoola Creek (Wonga West) was not surveyed and may contain potential habitat. A number of Upland Swamps were considered to provide varying degrees of potential habitat for the species (Plate 3), with some swamps being drier than others. Areas of potential habitat are shown in Figures 2a and 2b. Other creek/drainage lines and Upland Swamps occurring in the study area may provide potential habitat for this species.

Green and Golden Bell Frog

This species has the potential to occur in dams, wetlands and stream sides where fringing and emergent bullrushes or spikerushes occur. Only very limited potential habitat for the Green and Golden Bell Frog was identified within the study area. The species' presence could not be ruled out, however is considered unlikely to occur in any of the habitats surveyed during the current study. An example of poor quality potential habitat for the Green and Golden Bell Frog occurring in the study area is shown in Plate 4 (Figure 2b).

Littlejohn's Tree Frog

Littlejohn's Tree Frog occurs in permanent, slow-flowing rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops (DEC 2005b). The species requires deep pools for tadpole development. The species has also been recorded within Upland Swamps.

The condition of creek lines and Upland Swamps within the study area varied from poor to good quality. Some creek lines were considered highly unlikely to provide potential habitat for Littlejohn's Tree Frog, particularly where Bellambi Creek and Cataract Creek (Wonga East) occur in rainforest. Some sections of Lizard Creek (Wonga West) were completely dry (Plate 1) or contained iron-stained water. However, other sections of Lizard Creek were considered to provide good potential habitat for Littlejohn's Tree Frog (Plate 2). Wallandoola Creek (Wonga West) was not surveyed and may contain potential habitat. A number of Upland Swamps were considered to provide varying degrees of potential habitat for the species (Plate 3), with some swamps being drier than others. The species is more likely to inhabit Upland Swamps with a well-defined and wet drainage line (or one that provides access to such a drainage line). Areas of potential habitat are shown in Figures 2a and 2b. Other creek/drainage lines and Upland Swamps occurring in the study area may provide potential habitat.

Red-crowned Toadlet

This species can occur in a variety of habitats (e.g. open forests, Upland Swamps, rock outcrops and creeklines), mostly on Hawkesbury and Narrabeen Sandstones. The Red-crowned Toadlet inhabits ephemeral drainage lines, often below sandstone ridges with loose rocks, dense vegetation, deep leaf litter and fallen timber (DEC 2005c). The species has been recorded within 10 km of the study area, including within Wonga East, north of Bellambi Creek (DECC Atlas of NSW Wildlife). The study area is considered to provide good quality known and potential habitat for the Red-crowned Toadlet; it is likely that the species occurs within the study area. Given the wide range of habitats potentially occupied by the species, no potential habitats have been mapped.

Broad-headed Snake

The Broad-headed Snake can be found on exposed sandstone rocky outcrops (particularly in crevices) during the cooler months of the year and within tree hollows during summer. The species tends to prefer west-facing rock crevices. Rock outcrops and crevices were targeted for this species during the field survey. The study area provides areas of moderate and good quality potential habitat for the Broad-headed Snake (e.g. Plates 5 and 6). A number of extensive rock outcrops were identified, some with west-facing crevices and some with crevices facing other directions (Figures 2a and 2b). Not all rock outcrops occurring in the study area could be surveyed during the current study. The preferred prey items of the Broad-headed Snake (Southern Leaf-tailed Gecko and Lesueur’s Velvet Gecko) were also targeted, however, only a couple of shed gecko skins were found. Despite the lack of records for the snake and its preferred prey, it is considered likely that the Broad-headed Snake occurs within the study area.

Rosenberg's Goanna

This species has the potential to occur in open forest, woodland and heathlands, including Upland Swamps and rocky outcrops. Termite mounds and the vegetation within a 250 m radius of a termite mount are considered critical breeding habitat for the Rosenberg’s Goanna (DEC 2005d). The species will also utilise fallen dead timber and rock outcrops for foraging and sheltering. Given the species can occupy large areas of habitat, termite mounds and rock outcrops were targeted for this species. Only two termite mounds were observed in Wonga East (Figure 2b). However, other habitat components including suitable rock outcrops and fallen hollow timber were plentiful (Plate 7). Given the species is known to occur within 10 km of the study area (DECC Atlas of NSW Wildlife) and the good quality of the potential habitat (and assuming that more termite mounds occur), it is considered likely that the Rosenberg’s Goanna occurs within the study area.

4.0 RECOMMENDATIONS

It is recommended that the following additional surveys be conducted for the target species:

- Wallandoola Creek – habitat assessment, nocturnal call-playback and nocturnal stream search;
- Rock outcrops associated with Wallandoola Creek (if exist) – habitat assessment and diurnal herpetological search;
- Lizard Creek – additional nocturnal stream searches (although access could be difficult) and additional and/or second replicate of nocturnal call-playback;
- Cataract Creek – additional habitat assessment, nocturnal call-playback and nocturnal stream search (if appropriate habitat identified);
- Upland Swamps – a number of Upland Swamps require habitat assessment, nocturnal call-playback and diurnal and/or nocturnal habitat searches;
- Rock outcrops – second replicate surveys and/or additional survey sites for diurnal herpetological searches; and,
- Spring or summer targeted surveys for Green and Golden Bell Frog.

5.0 CONCLUSION

Targeted field surveys were conducted for six threatened species (four frogs and two reptiles), and/or their potential habitat, within Wonga West and Wonga East. Each of these species has the potential to occur within a habitat type that is susceptible to the impacts of subsidence due to longwall mining. Upland Swamps, rocky outcrops, creek lines and dams/wetlands were targeted.

No threatened species were recorded (with the exception of possibly the Red-crowned Toadlet), however, potential habitat exists for each species. Some species were considered more likely to occur than others.

PLATES

Plate 1: Dry section of Lizard Creek.

Plate 2: Potential habitat for Giant Burrowing Frog and Littlejohn's Tree Frog[2].

[2] This photo doesn't show all the potential habitat features (e.g. deep pools, sandy banks) that occur within this section of Lizard Creek.

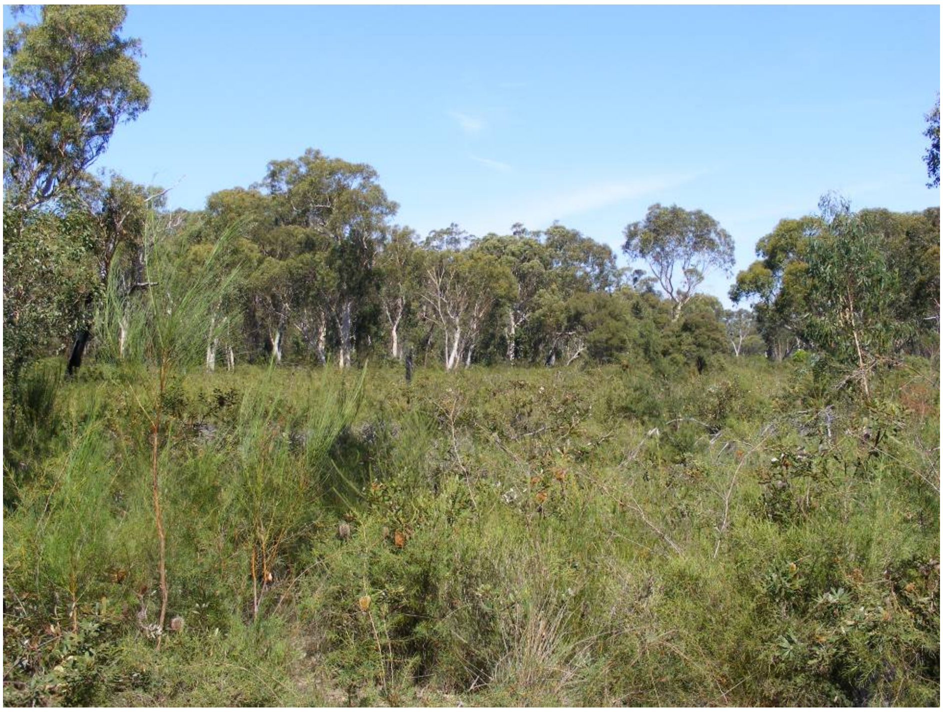

Plate 3: Upland Swamp potential habitat for Giant Burrowing Frog and Littlejohn's Tree Frog.

Plate 4: Dam – poor potential habitat for Green and Golden Bell Frog.

Plate 5: Potential Broad-headed Snake winter habitat (Wonga West).

Plate 6: Potential Broad-headed Snake winter habitat (Wonga East).

Plate 7: Potential Rosenberg's Goanna habitat (although no termite mounds were observed here).

FIGURES

Acknowledgements:
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NEW SOUTH WALES 2015

Figure 1a: Survey Sites - Wonga West

Figure 1a: Survey Sites - Wonga West

Date: 03 April 2009
Checked by: JC
File number: S5388
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N W E S

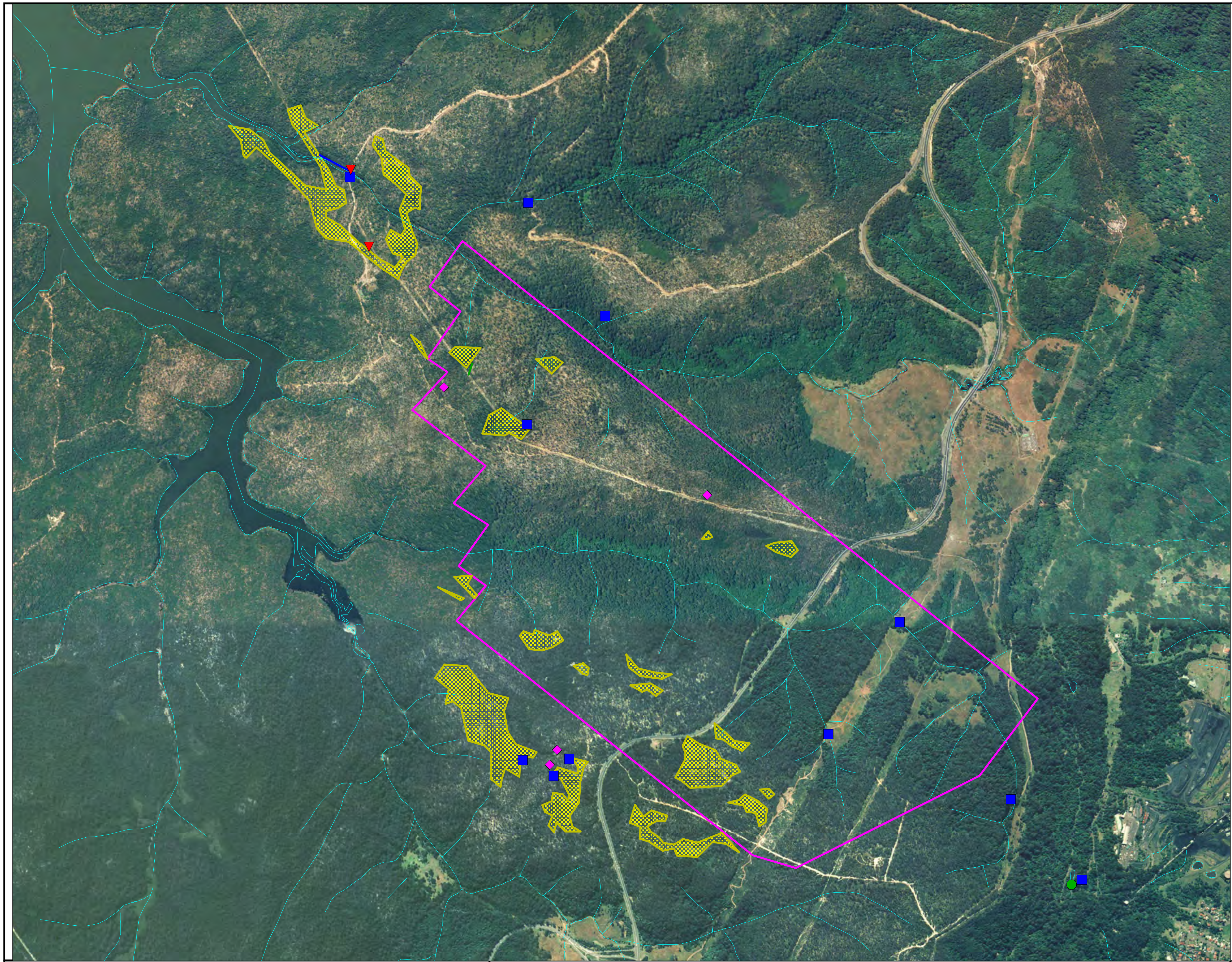

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Figure 1b: Survey Sites - Wonga East

Figure 1b: Survey Sites - Wonga East

Date: 03 April 2009

Checked by: JC

File number: S5388

Location:-..P:\5000\5300s\5388\Mapping\S5388_Figure1b_wongaeast

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N W E S

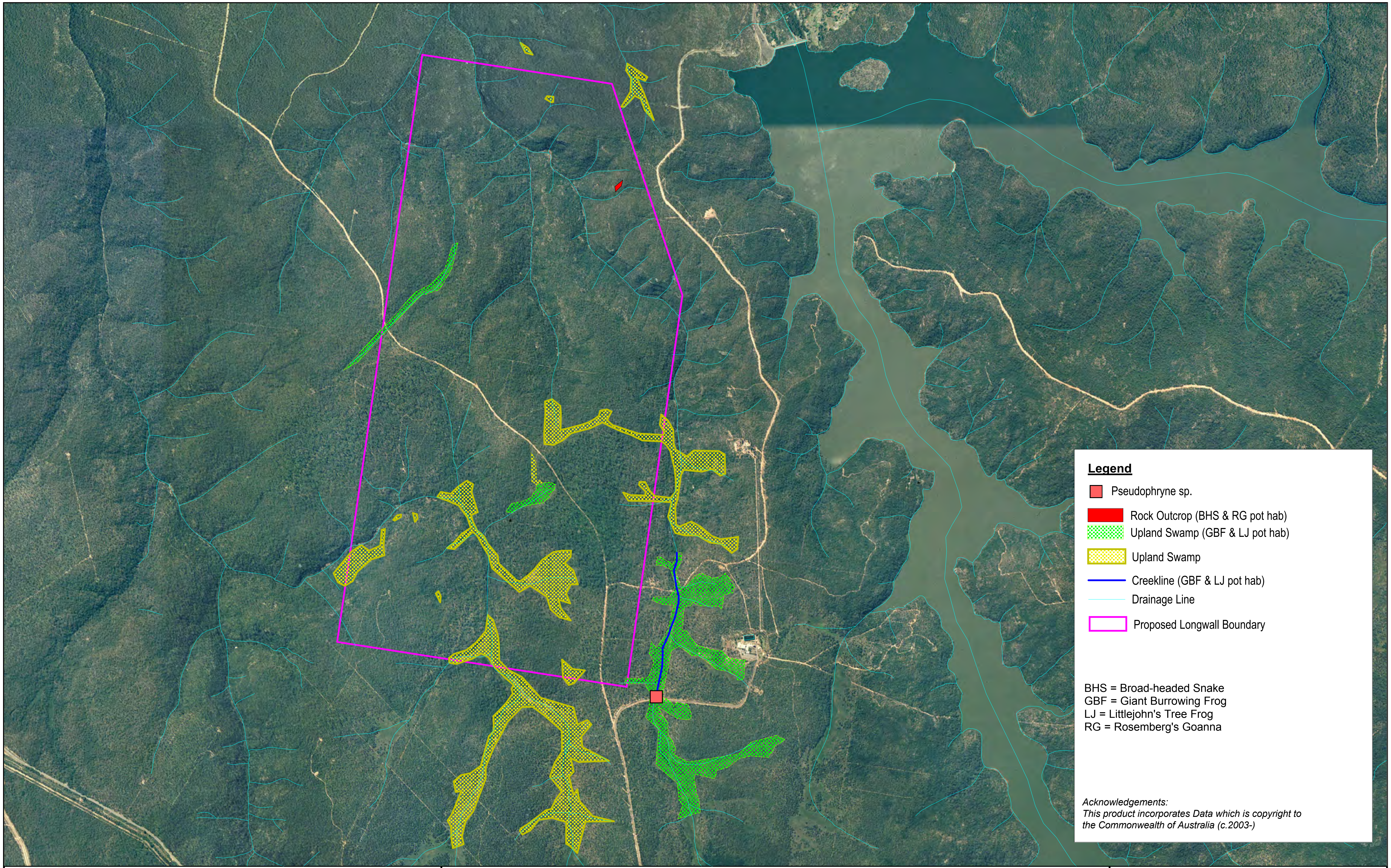

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Figure 2a: Potential Habitats - Wonga West

Figure 2a: Potential Habitats - Wonga West

Date: 09 April 2009
Checked by: JC
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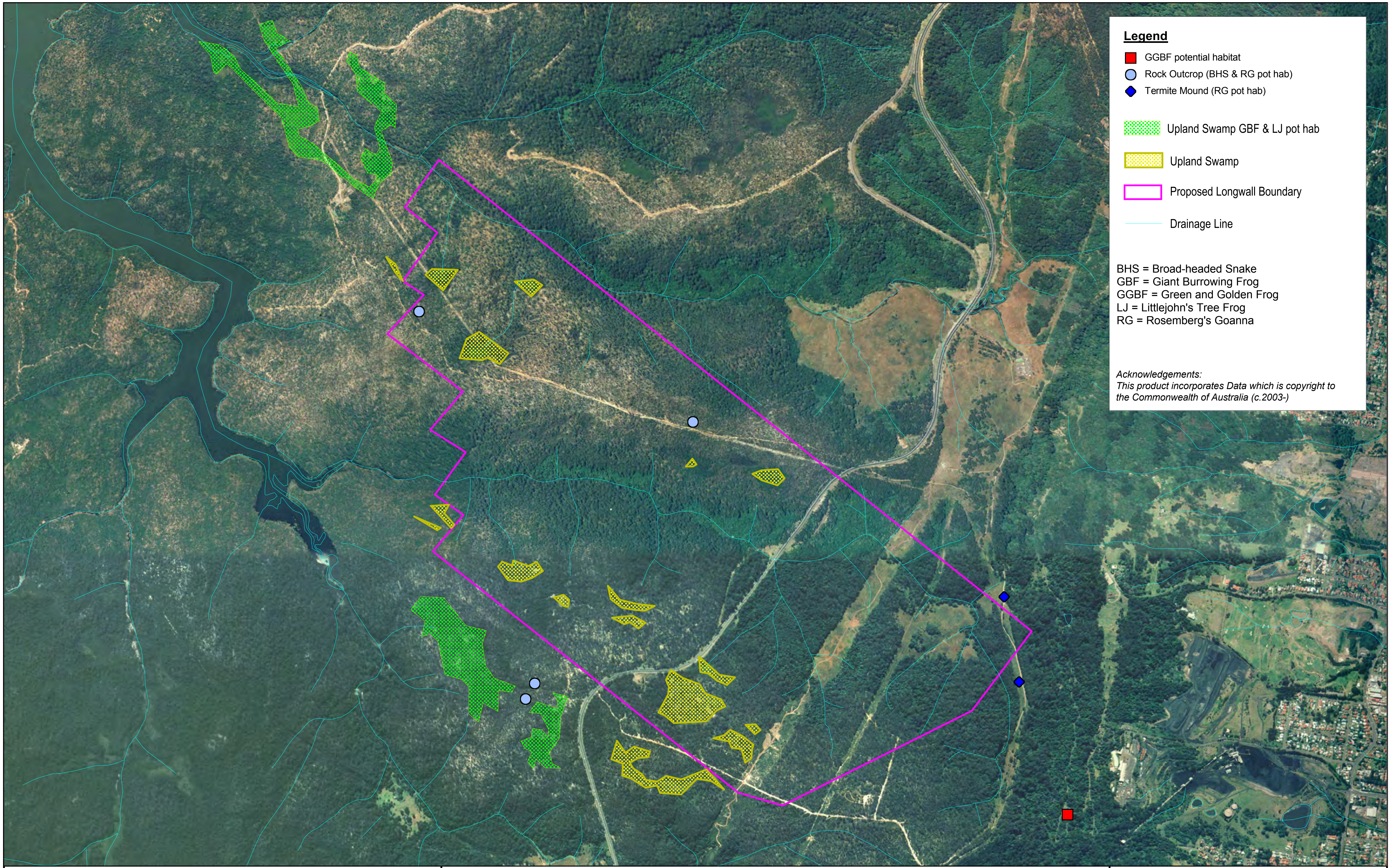

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Alexandria
NEW SOUTH WALES 2015

Figure 2b: Potential Habitats - Wonga East

Date: 09 April 2009
Checked by: JC
File number: S5388
Location:-..P:\5000\5300s\5388\Mapping\S5388_Figure2b_wongaeast

Scale: 0 175 350 525 700 875 Metres

Figure 2b: Potential Habitats - Wonga East

APPENDICES

APPENDIX 1

Survey Results

Table 5: Animal species recorded within the study area.

Scientific Name	Common Name	Wonga West	Wonga East	Upland Swamp	Ridge / Rock Outcrop	Creek Line	Dam / Wetland
Amphibians							
Litoria lesueuri	Lesueur's Frog	O	O			✓	
Litoria phyllochroa/nudidigita	Leaf Green Tree Frog complex	O	O			✓	
Litoria verreauxii	Verreaux's Frog	H		✓			
Crinia signifera	Common Eastern Froglet	H	H	✓	✓	✓	
Limnodynastes peronii	Striped Marsh Frog	H				✓	
Paracrinia haswelli	Haswell's Frog	H				✓	
Pseudophryne bibronii	Brown Toadlet	OH		✓			
Pseudophryne sp.	Pseudophryne sp.	H				✓	
Birds							
Acridotheres tristis	Common Myna*		O		✓		
Accipiter fasciatus	Brown Goshawk	O			✓		
Aegotheles cristatus	Australian Owlet-nightjar	H			✓		
Alcedo azurea	Azure Kingfisher		O			✓	
Cracticus torquatus	Grey Butcherbird	H		✓			
Gymnorhina tibicen	Australian Magpie		O		✓		
Strepera graculina	Pied Currawong	OH		✓	✓		
Calyptorhynchus funereus	Yellow-tailed Black-cockatoo	H	H	✓	✓		
Coracina novaehollandiae	Black-faced Cuckoo-shrike		H	✓	✓		
Vanellus miles	Masked Lapwing	OH			✓		
Psophodes olivaceus	Eastern Whipbird		H			✓	✓
Cormobates leucophaeus	White-throated Treecreeper	H	H	✓	✓	✓	✓
Corvus coronoides	Australian Raven	OH	O		✓	✓	
Dicaeum hirundinaceum	Mistletoebird		H			✓	
Rhipidura albiscapa	Grey Fantail	OH	H		✓	✓	
Dacelo novaeguineae	Laughing Kookaburra		O		✓		
Hirundo nigricans	Tree Martin		OH	✓		✓	
Malurus cyaneus	Superb Fairy-wren		H			✓	
Acanthorhynchus tenuirostris	Eastern Spinebill	OH	H	✓	✓	✓	
Anthochaera carunculata	Red Wattlebird		H	✓			
Anthochaera chrysoptera	Little Wattlebird	OH	H	✓	✓	✓	
Lichenostomus chrysops	Yellow-faced Honeyeater	H	H	✓	✓	✓	
Lichenostomus leucotis	White-eared Honeyeater	OH		✓		✓	
Meliphaga lewinii	Lewin's Honeyeater		H			✓	✓
Philemon corniculatus	Noisy Friarbird	H		✓	✓		
Phylidonyris novaehollandiae	New Holland Honeyeater	OH	H	✓	✓	✓	
Menura novaehollandiae	Superb Lyrebird	H				✓	
Colluricincla harmonica	Grey Shrike-thrush		O		✓		
Pachycephala rufiventris	Rufous Whistler	H	H	✓	✓	✓	
Acanthiza lineata	Striated Thornbill	H		✓			
Acanthiza pusilla	Brown Thornbill	OH	H	✓	✓	✓	✓

Scientific Name	Common Name	Wonga West	Wonga East	Upland Swamp	Ridge / Rock Outcrop	Creek Line	Dam / Wetland
Gerygone mouki	Brown Gerygone		H				✓
Pardalotus punctatus	Spotted Pardalote	H			✓	✓	
Sericornis frontalis	White-browed Scrubwren	H	O		✓	✓	✓
Neochmia temporalis	Red-browed Finch	O	O		✓		
Stagonopleura bella	Beautiful Firetail	H		✓		✓	
Platycercus elegans	Crimson Rosella	H	OH	✓	✓	✓	✓
Trichoglossus haematodus	Rainbow Lorikeet	H				✓	
Ptilonorhynchus violaceus	Satin Bowerbird		H				✓
Ninox novaeseelandiae	Southern Boobook	H	H	✓	✓	✓	
Zosterops lateralis	Silvereye	H	H		✓	✓	
Mammals							
Wallabia bicolor	Swamp Wallaby	O	O		✓		
Tadarida australis	White-striped Freetail Bat	H		✓		✓	
Petaurus breviceps	Sugar Glider	H	H	✓	✓	✓	
Vombatus ursinus	Common Wombat	I	I	✓	✓	✓	
Reptiles							
Amphibolurus muricatus	Jacky Lizard	O			✓		
Physignathus lesueurii	Eastern Water Dragon	O				✓	
Rankinia diemensis	Mountain Dragon	O	O		✓		
Ctenotus taeniolatus	Copper-tailed Skink	O			✓		
Eulamprus quoyii	Eastern Water Skink	O	O			✓	
Lampropholis delicata	Grass Skink	O			✓		
Skink sp.	Unidentified Skink	O	O	✓	✓		
Gecko sp.	Unidentified Gecko		I		✓		

***Key**:* * = Introduced; H = Heard; O = Observed; I = Indirect evidence (e.g. scats, burrows, skins).

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Wonga East and Wonga West

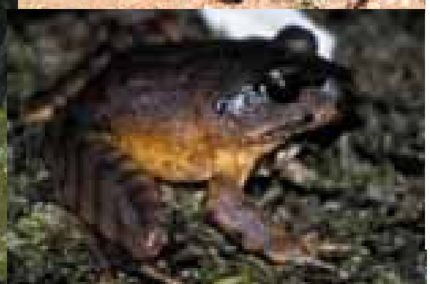
Threatened Fauna Habitat Assessment

Prepared for
ERM Australia

4 November 2009






Wonga East and Wonga West

THREATENED FAUNA HABITAT ASSESSMENT

PREPARED FOR	ERM Australia
PROJECT NO	09SYDPLA-0046
DATE	November 09

DOCUMENT TRACKING

ITEM	DETAIL	
Project Name	Wonga East and Wonga West Threatened Fauna Habitat Assessment	
Project Number	09SYDPLA-0046	
File location	t\Report\Final Reports\G:\Synergy\Projects\09SYDECO\09SYDECO-0046 Wonga East and Wonga West Threatened Herpetofauna Habaitat Assessmen.doc	
Prepared by	Ross Wellington	
Approved by	Robert Mezzatesta	
Status	Final	
Version Number	2	
Last saved on	4 November 2009	

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Mark Branson ERM Australia.

Contents

1 Introduction

1.1 DESCRIPTION OF PROJECT

Gujarat NRE Minerals Pty Ltd (NRE) is proposing to consolidate its existing coal operations in the 'holding area' covered by its various leases and sub-leases in the Illawarra. The holding, which encompasses the study area, is comprised of land that extends from near the Illawarra coastal villages of Russell Vale and Bellambi in the east at its surface facilities on the Illawarra escarpment, west across the plateau beyond the escarpment and including the Cataract Dam special area catchment.

The proposal is intended to include upgrades and additional construction of surface facilities as well as multi-seam coal extraction from the Illawarra coal measures including extraction from the Bulli, Balgownie and Wongawilli seams in particular. The proposal includes longwall mining of the Wongawilli seam in the 'Wonga East' area, beneath previously mined Balgownie and Bulli seam workings, extraction from the Balgownie seam by first workings beneath the existing mined out Bulli seam longwalls in the 'Wonga West' area which is anticipated to have no further direct subsidence impacts, extraction of Wongawilli seam coal from beneath the previously mined Bulli seam workings in the 'Wonga West' area by longwall mining that is anticipated to have some subsidence impacts. (See Figure 1 Location Map).

The Project Application Area (PAA) comprises Consolidated Coal Lease (CCL) 745, Mining Purposes Lease (MPL) 271 and Mining Lease (ML) 1575. An extensive history of underground mining is known to have occurred within the PAA that dates back to the mid 1800s however not all seams were exhausted and substantial quantities of coking and thermal coal remain. It is the capture of these reserves that form the basis of this proposal.

1.2 STUDY AREA

The study area is located within the Sydney Catchment Authority lands of the Cataract Dam 'special area'. The location of the study area is at the surface above the proposed longwall mine workings plan and particularly takes in the surface features that have been identified as being most at risk from possible subsidence impacts. (see Figure 1).

The study area contains high quality, relatively intact native bushland and the area has also been the subject of a number of previous biodiversity related studies that have identified the vegetation communities present and their extent, as well as provide predictive models of threatened fauna species habitat considered likely to occur within the catchment.

The climate of the area is typical of the region, and can be generally described as temperate.

1.3 REPORT OBJECTIVES

The aims of this study are to:

- Undertake opportunistic surveys for a targeted suite of threatened fauna species including: Giant Burrowing Frog *Heleioporus australiacus*, Red-crowned Toadlet *Pseudophryne australis*, Stuttering Frog *Mixophyes balbus*, Littlejohn's Tree Frog *Litoria littlejohni*, Green and Golden Bell Frog *Litoria aurea*, Rosenberg's Goanna *Varanus rosenbergi* and Broad-headed Snake *Hoplocephalus bungaroides*. These have been identified by the preliminary assessment and further specified within the Director General's Requirements as having potential to occur within the study area;

- Report on the extent of actual and potential habitat values for the targeted threatened fauna species on the surface above the proposed underground coal mining extraction and its possible surface impact zone; and

- Identify and map the extent of threatened species habitat occurring at the surface and with a particular focus on surface features with the greatest sensitivity to subsidence impacts eg creek lines, exposed ridgelines and upland swamps/wet heaths.

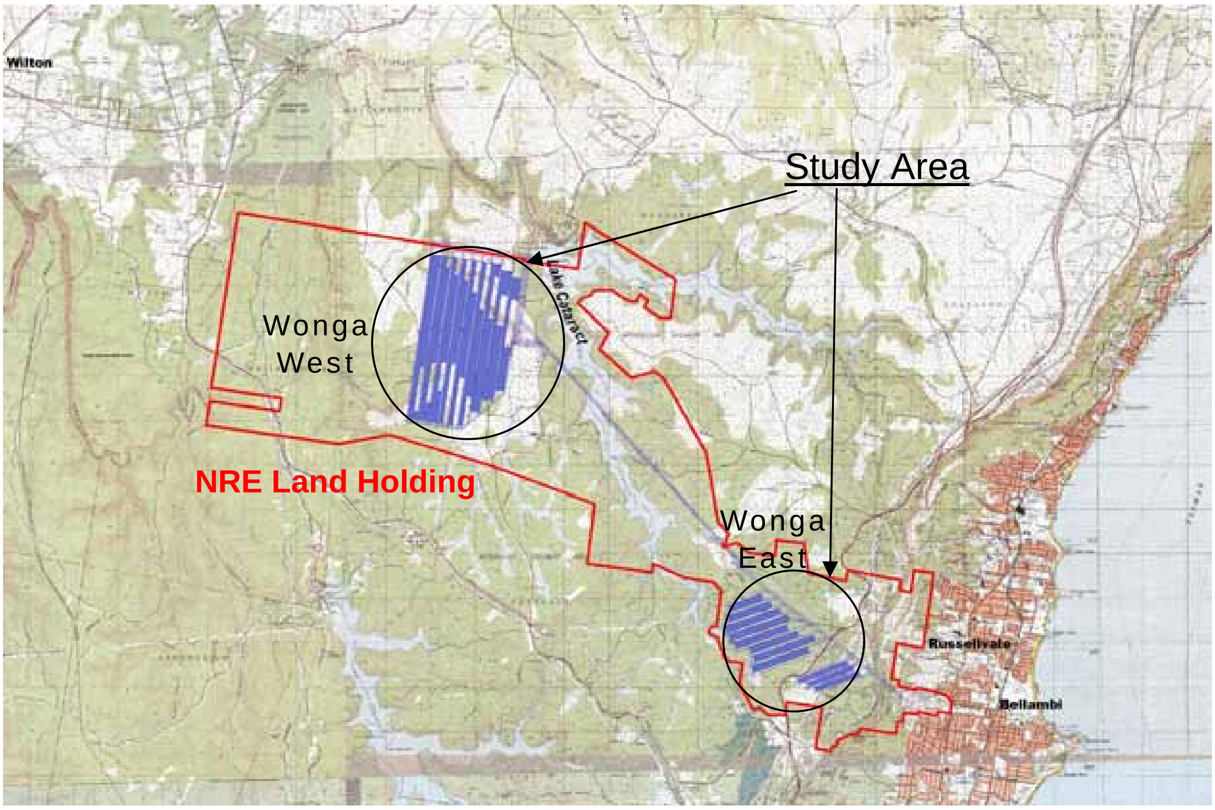


Figure 1: Location of the study area.

1.4 LEGISLATIVE REQUIREMENTS

1.4.1 Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is the principal planning legislation for the state, providing a framework for the overall environmental planning and assessment of development proposals. Other legislation and instruments, such as the NSW *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act), interact with EP&A Act and have been reviewed separately.

Developments in NSW fall generally under Parts 3A, 4 and 5 of the EP&A Act which apply procedures that are dependent on scale and the consent or determining authority with jurisdiction.

Under Part 3 and pursuant to the provisions of *State Environmental Planning Policy – Major Projects 2005*, this Project requires approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.4.2 Part 3A Threatened Species Assessment Guidelines

The Department of Environment and Climate Change (DECC) and the Department of Primary Industries (DPI) prepared Draft Guidelines for the assessment of impacts on threatened species, populations or ecological communities or their habitats arising from development applications to be assessed under Part 3A of the EP&A Act (DECC & DPI, 2005). These guidelines are provided for in section 75F of Part 3A of the EPA Act.

The Assessment Guidelines provide guiding principles for the provision of information to “enable decision makers to ensure that developments deliver the following environmental outcomes”:

1. Maintain or improve biodiversity values (i.e. there is no net impact on threatened species or native vegetation);
2. Conserve biological diversity and promote Ecologically Sustainable Development (ESD);
3. Protect areas of High Conservation value (including areas of critical habitat);
4. Prevent the extinction of threatened species;
5. Protect the long-term viability of local populations of a species, population or ecological community; and
6. Protect aspects of the environment that are matters of National Environmental Significance “(pursuant to the EPBC Act)”.

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by NRE to prepare a Preliminary Assessment Report (PAR) and a Project Application for the proposed development. These documents were submitted to the Department of Planning (DoP) with a request for Director-General’s requirements (DGRs) for the Project. Following receipt of the DGRs an Environmental Assessment Report (EAR) was commissioned and is in progress. The EAR will be submitted to the Minister for Planning seeking project approval under Part 3A of the EP&A Act.

The objectives of this threatened herpetofauna habitat assessment report, in addition to the stated objectives at 1.3 above, are to provide specialist herpetological input on into the EAR to inform the fine detailed planning for the proposal. This is envisaged as identifying whether the proposal can avoid or mitigate impacts on threatened herpetofauna species and/or whether other measures, including undertaking a suitable and approved offset action, may need to be taken.

1.4.3 Threatened Species Conservation Act 1995 (TSC Act)

The TSC Act, as amended, aims to protect and encourage the recovery of threatened species, populations and communities listed under the Act. There are six threatened species (the Giant Burrowing Frog *Heleioporus australiacus*, Red-crowned Toadlet *Pseudophryne australis*, Littlejohn's Tree Frog *Litoria littlejohni*, Stuttering Frog *Mixophyes balbus*, Rosenberg's Goanna *Varanus rosenbergi* and Broad-headed Snake *Hoplocephalus bungaroides*) listed under the TSC Act occur within the lands potentially impacted by the proposal. Other threatened fauna species are also considered to have potential to occur on site but are assessed and addressed elsewhere.

1.4.4 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act establishes a process for assessing the environmental impact of activities and developments where 'matters of national environmental significance' (NES) may be affected. Under the Act, any action which "has, will have, or is likely to have a significant impact on a matter of national environmental significance" is defined as a "controlled action", and requires approval from the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) which is responsible for administering the EPBC Act.

Actions that may have a significant impact on one or more matters of NES need to be referred to the Department under the EPBC Act. The EPBC Act referrals process can produce one of three outcomes:

i. <u>Non-controlled action (NCA)</u>: Assessment and approval under the EPBC Act is **not required**. The project may proceed without further approval under the EPBC Act.

ii. <u>Non-controlled action – specified manner (NCA-SM)</u>: Assessment and approval under the EPBC Act is **not required** provided the action is undertaken in a specific way (similar to conditions).

iii. <u>Controlled Action (CA)</u>: The project will, or is likely, to have a significant impact on one or more matters of national environmental significance. The project **will require** full assessment and approval before it can proceed.

This report considers EPBC NES matters and assesses potential impacts on them and advises if a referral to the Commonwealth Department of Environment, Water, Heritage and Arts (DEWHA) is considered necessary.

1.4.5 Sydney Catchment Authority Special Areas Strategic Plan of Management 2007

The SCA Special Areas Strategic Plan of Management (SASPoM) is aimed at achieving two management goals within the Special Areas, including:

a) Protect and optimise water quality entering storages; and
b) Conserve ecosystem integrity, natural and cultural values (SCA 2007).

The SASPoM outlines specific management targets for the Special Areas that will help achieve the goals of the SASPoM. The management targets that specifically relate to the proposed development by NRE relate to water quality and hydrology risk management, ecosystem management and pest/weed management (SCA 2007).

2 Methods

2.1 DATA AUDIT

The Atlas of NSW Wildlife, and other licensed data sets for which the Department of Environment Climate Change and Water (DECCW – formerly DECC) are custodian, were reviewed to ensure all records were taken into consideration in identifying and/or predicting the subject threatened herpetofauna species for the locality.

Vegetation communities present within the study area were also reviewed (DECC 2007) along with aerial photography of the land holding. A high resolution air photo was used to spatially represent and plot the ground features and extent of habitat identified during field investigations.

The Director General's Requirements (DGRs) for the NRE proposal were also considered. This document was referred to so as to identify particular issues/concerns of the contributing agencies and so further assist with the provision of information to assist the proposal to meet the DGRs.

A search of the Atlas of NSW Wildlife and associated data sets used a radius of 10km around a point Easting 298737; Northing 6202502 (Datum GDA94).

Threatened fauna species and non threatened herpetofauna species were extracted from the database searches to compile predictive lists and identify occurrence potentiality within the study area.

A threatened herpetofauna species list was produced from this search and is provided in Chapter 3 below (Table 2). Reptile and amphibian database records were also used to compile a potential herpetofauna species list for the study area within which those species opportunistically detected during the surveys were recorded (Appendix A).

2.2 FIELD SURVEY

The study area was surveyed by Eco Logical Australia ecologist/herpetologist, Ross Wellington and ERM Australia ecologist Mark Branson, on 29th and 30th September 2009 and 6th and 7th October 2009. Temperatures ranged from cool to hot during the field survey, with some rain falling during parts of the survey. Temperature and Rainfall data during the survey periods recorded at the two nearest weather stations, Bellambi and Camden, NSW (BoM 2009) are provided below in Table 1. The survey focused on flora, vegetation communities, and habitat elements for predicted or identified flora and fauna. Incidental fauna survey observations were also recorded.

Table 1 Meteorological Data during the survey period

Survey Date 2009	29th September			30th September			6th October			7th October		
Meteorological Station	Min ºC	Max ºC	Rain mm	Min ºC	Max ºC	Rain mm	Min ºC	Max ºC	Rain mm	Min ºC	Max ºC	Rain mm
Bellambi, NSW	10.1	19.3	0.2	11.8	25.1	0	12.2	17.5	13.2	8.5	17.5	5.0
Camden, NSW	4.4	23	0	3.5	28.1	0	7.8	21.5	26.2	5.2	17.7	14.0

A targeted herpetofauna survey was undertaken to determine three things.

1. Were any individuals of the targeted threatened herpetofauna species able to be detected to confirm presence.

2. Were there any specific habitat features present that would identify a strong likelihood of occurrence of any or all of the focus species that were unable to be directly detected.

3. The extent of identifiable and important habitat elements for the focus species within the landscape features most at risk of impact from subsidence.

The survey consisted of traversing the main drainage lines and significant laterals, areas of upland swamp and significant areas of exposed ridgeline. All of the features examined were identified as being within or near the potential impact zone on the surface.

Herpetofauna observed opportunistically within the study area are indicated in **Appendix A**.

Survey methods involved undertaking targeted daylight habitat assessment for any obvious habitat elements of each of the focus threatened fauna species. This approach makes use of expert knowledge and extensive field experience with each of the threatened species. No single survey period was opportune for detecting all of the subject threatened species and time constraints and budget considerations precluded an extended survey period; repeated temporally separated site assessments and use of the full suite of possible methods of detecting each of the threatened species. Nevertheless the expert habitat assessment and detection method adopted here is still a valid way of identifying important habitat elements for each of these species and provides a reasonable level of survey effort for opportunistic detection.

- Four full field days by two experienced ecologists were carried out. One of the ecologists (Ross Wellington) had over thirty years herpetological experience with the target species. The field study undertook to investigate:

- The creeklines of Wallandoola Creek, Lizard Creek and Cataract Creek to the full extent to which each is underlain by the proposed workings (see Figures 2 and 3). Traverses included searching for amphibian larvae, detection of calling individuals and searches beneath suitable cover that was considered as having potential for use as shelter.

- Ridgelines and rock outcrops were traversed and searched to identify any high quality benched areas with exfoliating sheets of sandstone suitable for use as shelter habitat by the Broad-headed Snake. Survey timing for Broad-headed Snakes is usually best timed in August and early September but later timed survey can still detect the species but with a reduced likely success rate. Ridgeline assessment also included examining suitable ledges and overhangs that are sometimes utilised by the Rosenberg's Goanna. The study area was also searched for any substantial sized termitaria that are often used as nesting chambers by the Rosenberg's Goanna.

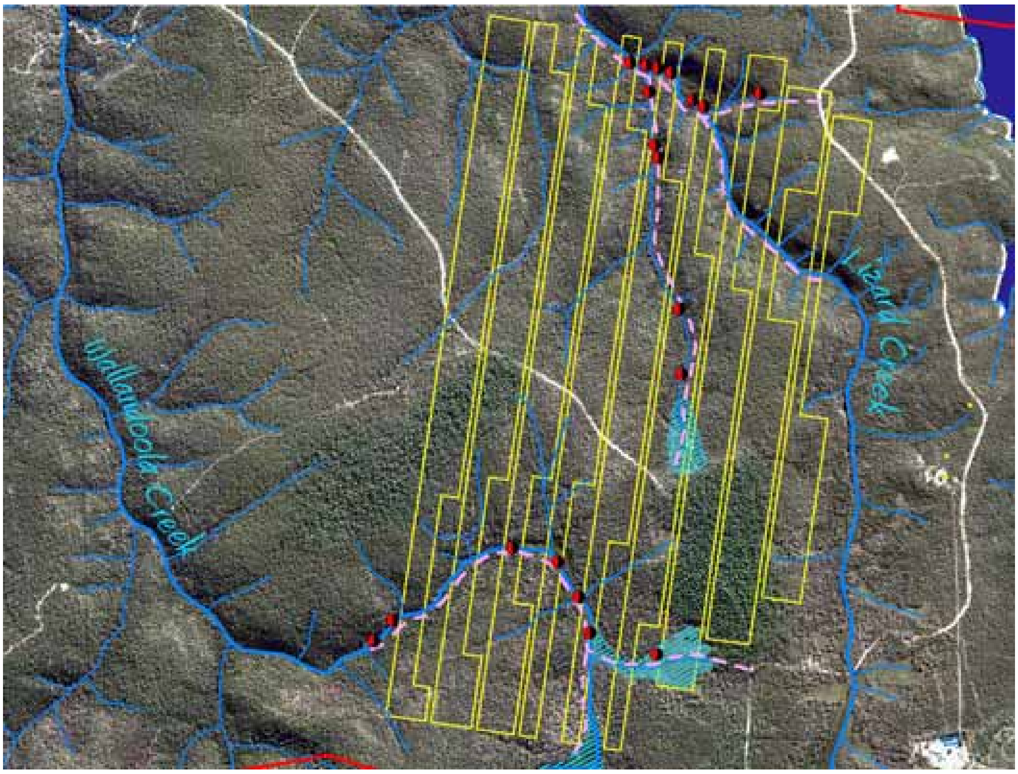


Figure 2 Wonga West Creek line Habitat Surveys

Pink-dashed lines depict extent of creekline traverses; red and black dots represent way points along the route; and turquoise cross-hatched areas depict upland swamp areas traversed or viewed for habitat values.

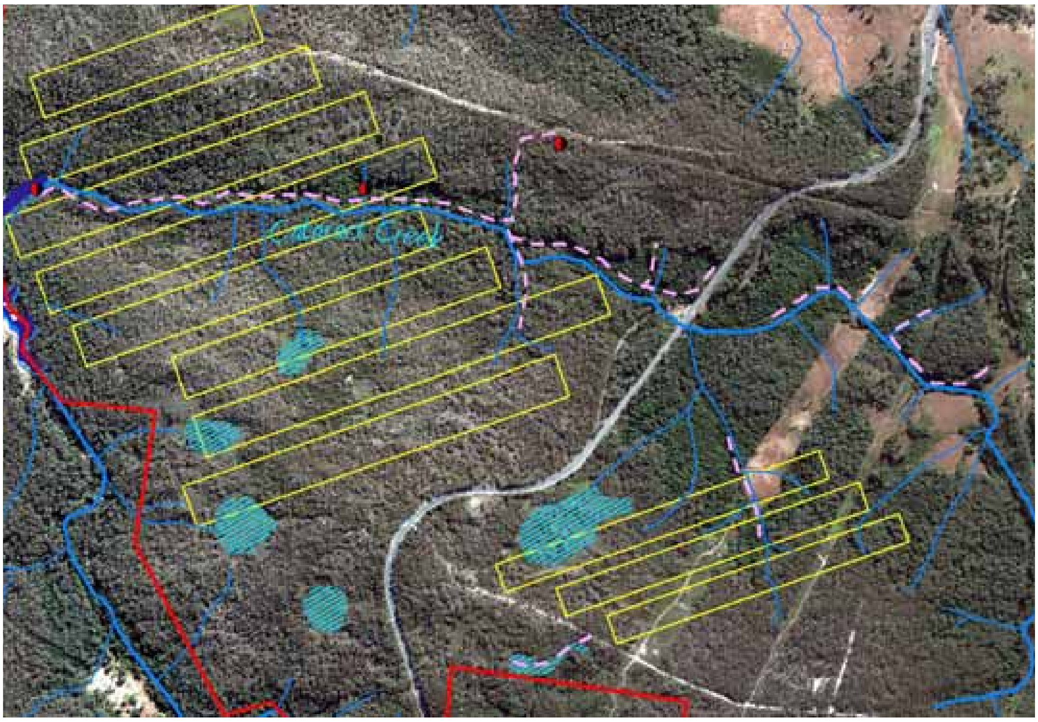


Figure 3 Wonga East Creekline habitat surveys

Pink-dashed lines depict extent of creekline traverses; red and black dots represent way points along the route; and turquoise cross-hatched areas depict upland swamp areas traversed or viewed for habitat values.

3 Results

3.1 VEGETATION COMMUNITIES

The Wonga East and Wonga West proposed mining areas are overlain by a variety of vegetation communities that reflect differences in surface terrain/topography and also likely rainfall. The topographic and related distinctive vegetation differences between Wonga East and Wonga West also reflect the likely occurrence of certain threatened herpetofauna species. The vegetation communities for each of the two component study areas are provided in Table 2.

Table 2. Vegetation Communities Occurring in the Study Area

Wonga East	Map Unit	Vegetation Community	
	MU2	Coachwood Warm Temperate Rainforest	
	MU6	Moist Blue Gum-Blackbutt Forest	
	MU14	Tall Open Peppermint-Blue Gum Forest	
	MU15	Tall Open Blackbutt Forest	
	MU26	Sandstone Gully Peppermint Forest	
	MU29	Exposed Sandstone Scribbly Gum Woodland	
	MU39	Rock Plate Heath-Mallee	
	MU42	Upland Swamps: Banksia Thicket	
	MU44	Upland Swamps: Sedgeland-Heath Complex	
	MU45	Upland Swamps: Fringing Eucalypt Woodland	
Wonga West	MU19	Transitional Shale Open Blue Gum Forest	EEC
	MU23	Transitional Shale Stringybark Forest	EEC
	MU26	Sandstone Gully Peppermint Forest	
	MU28	Western Sandstone Gully Forest	
	MU29	Exposed Sandstone Scribbly Gum Woodland	
	MU39	Rock Plate Heath-Mallee	
	MU42	Upland Swamps: Banksia Thicket	
	MU44	Upland Swamps: Sedgeland-Heath Complex	
	MU45	Upland Swamps: Fringing Eucalypt Woodland	

* shaded cells are vegetation communities occurring in common between Wonga East and West study areas.

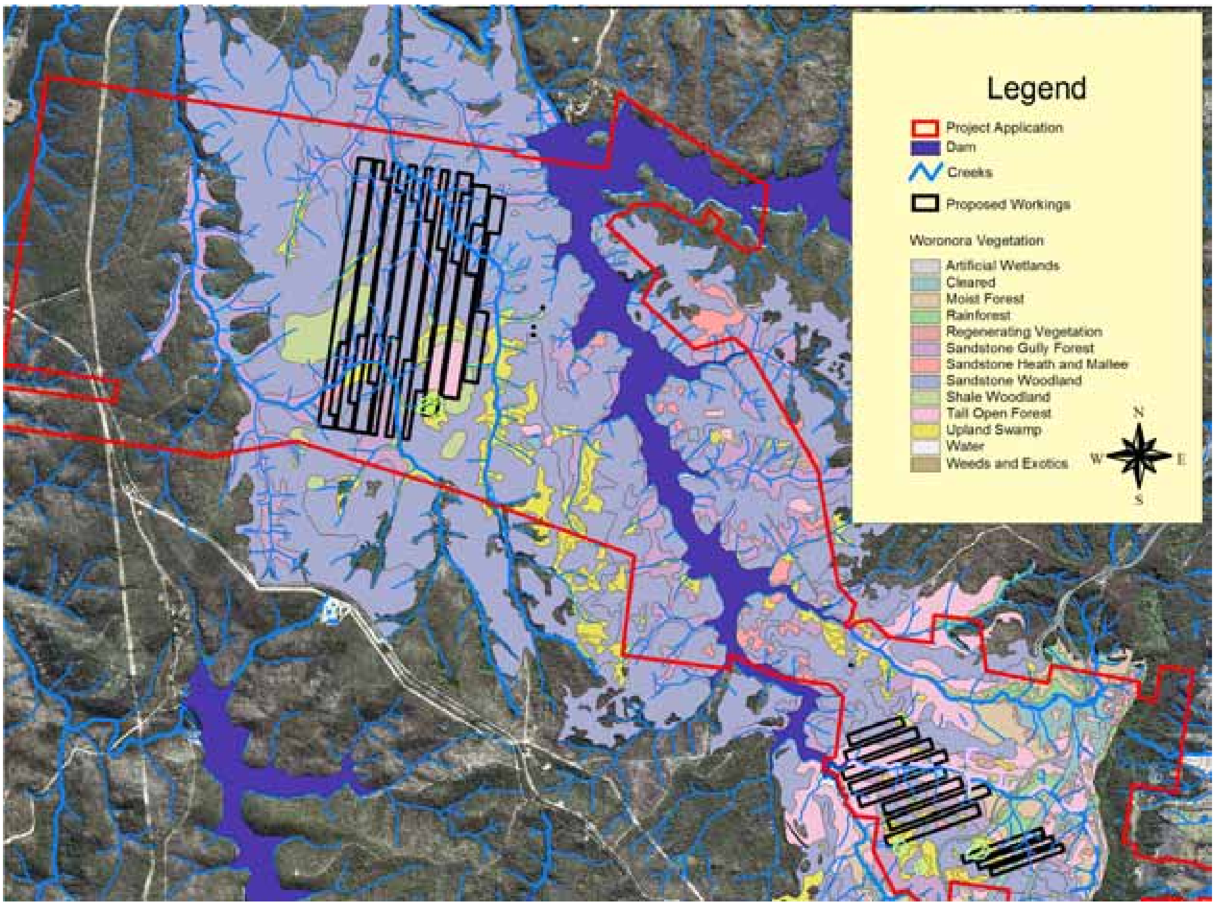


Figure 4: Broad Vegetation Types of the Woronora Area

3.2 FAUNA DATABASE SEARCHES

Interrogation of the NSW Wildlife Atlas and associated data sets revealed that within a 10km radius centred on the middle of the NRE land holding produced a confirmed list of 7 threatened herpetofauna species that correspond with those identified in the DGRs for the proposal.

The threatened herpetofauna species included:

Table 3. Threatened herpetofauna

Group	Common Name	*Scientific Name*	NSW Status	Commonwealth Status	Locality Records	Detected
Amphibians	Giant Burrowing Frog	*Heleioporus australiacus*	V	V	16	Yes
	Green & Golden Bell Frog	*Litoria aurea*	E	V	12	
	Red-crowned Toadlet	*Pseudophryne australis*	V	N/L	18	Yes
	Littlejohn's Tree Frog	*Litoria littlejohni*	V	V	3	
	Stuttering Frog	*Mixophyes balbus*	E	V	2	
Reptiles	Broad-headed Snake	*Hoplocephalus bungaroides*	E	V	7	
	Rosenberg's Goanna	*Varanus rosenbergi*	V	N/L	10	

Overall thirty threatened fauna species have been recorded and were retrieved from database searches (including the above 7 threatened herpetofauna species) within a 10 km radius of the study area.

A review of the DGRs for the proposal provides an indication that there is an expectation that recommendations of the *Southern Coalfields Inquiry* be adopted as part of the planning and mitigation for this proposal. These recommendations include the need for risk management zones to be established to deal with significant 'valley infill' or upland swamps, 3rd order streams (and above) and for severe topographic features such as ridge lines and overhangs. It also refers to the maintenance of water quality and quantity and important biodiversity values.

All these factors identified in the DGRs have implications for some or all of the identified threatened herpetofauna species.

Appendix A provides a list of herpetofauna species that have been recorded from the locality along with incidental herpetofauna observations detected during this survey.

3.3 HABITAT ELEMENTS

The study area included a number of broad habitat types, which included:

- Creeklines with their various ponded or pooled sections of varying depth and size. These factors influence length of time of likely persistence and hence tadpole development time;
- Woodland with heath understorey and their various ground timbers and surface rock potentially used for shelter;
- Upland swamps and associated wet heath with various 'pock-mark' depressions and ephemeral drainage lines. These are used as ephemeral breeding sites when hydrology permits; and
- Outcropping sandstone ledges and benched sections along ridgelines. These features are used as winter shelter for the threatened reptiles.

The quality of fauna habitat within the study area varied. Generally the vegetation immediately adjacent to the creeklines is of high quality. Upland swamp areas which are usually high quality habitat for some of the threatened frogs were generally very dry and showed signs of disturbance and apparent water stress. It was not possible to determine whether the very dry state of some of these upland swamps was a consequence of previous mining activities diverting water or the result of a natural dry episode. Other upland swamps at nearby Maddens Plains all show a much wetter current condition to the Upland Swamps within the Wonga East and Wonga West study areas (pers. obs.).

Drainage lines within Wonga West were generally of lower relief and are bordered by sandstone gully vegetation community. The creeklines along sections of the main creeks appear to have good water quality in some sections but in others both the main creek and some of the smaller tributaries show evidence of iron oxide events that appear to be choking the creek. Some sections were observed to have dried out completely and the water in these sections may have been captured or diverted by previous mining activity.

In Wonga East the Creekline (Cataract Creek) is much wetter and the vegetation communities reflect this and are generally rainforest, grading into other wet forest types. Creek lines in this section of the study area are of slightly higher relief and the pooled sections within the creekline are separated from one another by gravel and litter riffle zones. The canopy of these sections of the creek are generally closed.

No dominant and extensive ridgelines were detected in either Wonga East or Wonga West sections of the study area although smaller less extensive outcrops occur as scattered components of various benches along the margins of each of the creeklines. The eastern most section of Cataract Creek occurs close to the Illawarra escarpment but this is outside the proposed Wonga East workings area.

3.4 FAUNA

Two threatened herpetofauna species were recorded during the field survey along with another 18 herpetofauna species (see Appendix A). All species recorded were native species. The two threatened species detected were the Red-crowned Toadlet which is listed as Vulnerable under the TSC and the Giant Burrowing Frog which is listed as Vulnerable under both the TSC Act and the EPBC Act.

Data base searches reveal that fifty seven (57) herpetofauna species have been identified as occurring within a 10km radius of the NRE Land holding. Of these, 20 (including the two threatened frog species) were detected during our site inspections.

Another five or six non threatened species might reasonably be expected to occur but have not yet appeared in any of the data bases searched. Further surveys overtime would likely add some or all these to the species list for the area that is provided at Appendix A.

The field survey, coupled with expert knowledge of habitat requirements and observations of the various habitat characteristics that occur within the study area, has enabled some indicative maps to be produced that identify actual and potential habitat for the various threatened herpetofauna species (see Figures 11 and 12). The specialised nature of the habitats present and the absence of certain other specific habitat elements assisted to determine the threatened species that were likely or had potential to occur within the study area. The herpetofauna species either known to occur or likely to occur in the study area are listed Appendix A.

Figure 5 Pooled Section of Wallandoola Creek

Figure 6 Upland Swamp in headwaters of Wallandoola Creek

4 Habitat Assessment

4.1 GIANT BURROWING FROG AND RED-CROWNED TOADLET

The Giant Burrowing Frog and Red-crowned Toadlet have a number of specimen records from the surrounding locality. Both species were strongly suspected to be present based on this and predictive habitat models prepared by the Department of Environment and Climate Change (DECC 2007). However, prevailing weather conditions during the survey were less than ideal for detection of active adults. Both species are largely terrestrial frogs generally occupying upland areas and both species have a somewhat flexible breeding period cued to prevailing rainfall and hence water availability.

Giant Burrowing Frogs are notoriously difficult to detect due to their burrowing habit and the fact that when not breeding the adults may range across extensive areas of woodland, open woodland and heath to forage and shelter. This less obvious habitat may be large distances from the more readily identifiable breeding habitat along pooled sections of upland, low relief drainage lines. The Giant Burrowing Frog preferentially breeds during the warmer months of the year and this is when it is most often heard calling, however it may also take advantage of rain events late in Summer and extending into early Autumn. When this occurs it results in the tadpoles not having sufficient time to develop through to metamorphosis before water temperatures fall and the tadpoles remain as larvae until the following Spring. When this occurs they are readily detectable for a large part of the cooler months of the year and so give away the presence of the species. On the other hand, if breeding occurs early in the season they will transform from the tadpole stage in about three months provided the prevailing temperatures and persistence of surface water permits. Consequently when present the tadpoles are a simple way to detect an otherwise difficult to find species. Alternatively, when tadpoles are absent from apparently suitable breeding habitat, absence of the species cannot necessarily be assumed.

During the site inspections a large lateral drainage line to Lizard Creek was traversed to examine its habitat values. Over 60 large late stage tadpoles were observed some with hind limb buds and indicative of having reached Gosner Stage (34-35). The section of creek in which they were found was heavily infested with an iron flocculating bacterial growth. The extent of this growth was such that virtually no other material was available for foraging by the tadpoles. Some tadpoles were observed feeding on the bacterial scum and this may be the first recorded instance of such a feeding behaviour, however the suitability or consequence of using this material as a food resource is unknown.

Figure 7 Giant Burrowing Frog Tadpoles feeding on Iron fixing bacterial scum

Figure 8 Pooled section of Lizard Creek Tributary where Giant Burrowing Frog Tadpoles were observed

Red-crowned Toadlets occupy more ephemeral locations than the Giant Burrowing Frog and breed in soaks and runnels that traverse benched sandstone areas, usually just below the upper ridge or plateau. However they will also less typically occupy the margins and drainage lines that are found associated with upland swamps and wet heath areas. In these locations they may be very difficult to detect in the dense graminoid and rush dominated vegetation and calling males are virtually the only way to detect their presence.

A report by Biosis during an earlier study during March 2009 detected a *Pseudophryne sp.* calling. Based on the habitat occurring where it was identified it was most likely to be a Red-crowned Toadlet. During the site inspections undertaken for this report the species was in fact detected calling from unnamed laterals to Lizard Creek (Waypoints 9 and 22). Numerous other ephemeral drainage lines and depressions were also observed during the site inspections and many of these were likely to be suitable for the Red-crowned Toadlet after sufficient rain.

Both species are reliant on ephemeral or intermittent non-perennial stream flows to form ponded sections and soaks within headwater streams, along feeder creeks and in or adjacent to other poorly defined drainage features as well as within and adjacent to upland swamps.

Such features are often found in broad, low relief headwater valley areas that constitute a significant proportion of the upper parts of the drainage lines on the subject land. The upper sections of many of the drainage lines of the subject land are, by their nature, of low relief and, in combination with shallow water tables, form a habitat mosaic for both species.

This contrasts with the more deeply incised sections of Wonga West drainage where more ‘typical’ habitat prevails in benched sections and where drainage lines are small and more intermittent. These features occur as smaller discrete habitat areas and are more patchy in extent.

Figure 9 Ephemeral drainage features of Lizard Creek tributary where Red-crowned Toadlet was observed.

Both the Red-crowned Toadlet and the Giant Burrowing Frog are sensitive to changes in water quality and pH changes as well as hydrological changes that influence the duration that water persists at the surface (NPWS 2001 a, b; Green *et al.* 2004; Thumm, 1997, Thumm and Mahony 1999, Stauber 2006).

Giant Burrowing Frogs are generally very sparse and in the southern Sydney, Illawarra and Nowra areas have never been detected with numbers greater than 8 calling males at any one location (Daly 1996; G. Daly pers. comm.). They may also be quite sedentary because while they may move substantial distances across the landscape to forage they also show site fidelity in the ponded sections of streams they use for breeding.

The current status of the Red-crowned Toadlet and Giant Burrowing Frog are under review with genetic studies revealing that both species are currently likely to contain a number of cryptic species. Stauber, (1999) has demonstrated that the southern Sydney Red-crowned Toadlet population (incorporating the study area) is genetically and morphologically distinct from other Red-crowned Toadlet populations west and north of Sydney. Southern populations of the Giant Burrowing Frog are also distinctive from northern populations (NPWS, 2001b; DECC 2009). Both species complexes await taxonomic revisions that may change their conservation status and perhaps also their standing under the TSC Act. In any event southern Sydney populations of both species are likely evolutionary significant entities that require consideration as such rather than as more widely distributed species.

4.2 LITTLEJOHN'S TREE FROG OR HEATH FROG

This somewhat enigmatic tree frog has a patchy distribution across a variety of vegetation types that generally include areas within or near heath and open woodland with heath understorey (Daly and Craven, 2007) as well as a limited variety of other vegetation types that are not so well categorised and described. The species is difficult to survey for outside of the breeding season because little is known about the species outside of the observations of its breeding behaviour. Even breeding events can be unpredictable and sites where the species has been detected breeding are, at times, inexplicably vacated for several seasons and then the species may return but to other habitat nearby (Lemckert, 2004; Daly and Craven 2007; pers. observation).

This species has long been known from the Darkes Forest and Maddens Plains areas (Lemckert, 2004) and the extent and type of habitat present on the subject land suggests that it would not be unreasonable to expect a significant population of the species to be present. Suitable breeding ponds and intermittent stream pools are both present across the site. In addition, the species has been recently detected during DECC surveys along Stoney Creek at Maddens Plains and within Dharawal Nature Reserve (DECC 2007).

Too little information is known about the species ecology and preferred habitat to produce a predictive model of its distribution (DECC 2007).

Based on limited information the species does appear to be impacted by changes to fire frequency and appears to have disappeared or undergone significant decline from areas that have been burnt (Lemckert, 2004; Daly, 2007; pers. obs.). Lack of knowledge about the species movement patterns and non breeding habitat utilisation means that only its breeding habitat can be identified with any level of reliability.

Water quality requirements for the species' eggs to hatch and tadpoles to reach metamorphosis are also unknown but sensitivity to water quality changes and hydrological changes would be a reasonable assumption and consistent with the application of precautionary principles and on the basis of such established impacts on other related frog species.

During the survey a number of pooled sections of streams in Wonga West study area were observed and considered to be large enough to accommodate this species. An example that still retains good water quality is illustrated in Figure 6. Numerous other examples exist along various sections of Wallandoola and Lizard Creeks as well as some of their tributaries but most are heavily affected by iron fixing bacterial scum which reduces significantly the likelihood of being suitable for this species as breeding habitat.

Whilst records of this species are sparse in the locality there is high breeding habitat suitability present and other vegetation communities are consistent with records of previous occurrence in the general locality, therefore the species would be likely to occupy the study area.

4.3 STUTTERING FROG

The Stuttering Frog is listed as endangered at state and vulnerable at national levels and is a relatively large stream frog that prefers closed forest type riparian zone vegetation. Suitable habitat for this species was confined to the upper sections of Cataract Creek in the Wonga East section of the study area.

Potential impacts on this species could result from changes to base flows and flow duration if catchment flows were diverted from the relevant sections of Cataract Creek. In-stream pooling of water, flow rates and periods of flow affecting intervening riffle zones between in-stream pools are factors that all influence breeding for this species.

This species has undergone significant contraction in its range from the south, and the study area is at or near the most recent southerly records of the species. Studies by DECC in the southern Sydney and Illawarra area failed to detect the species and this has raised conservation concerns regarding its ongoing survival south of Sydney. Furthermore recent genetic studies have demonstrated that this species is in fact likely to be comprised of at least two taxa with the southern race, south of the Hunter River, likely to have its conservation status upgraded to critically endangered (Donnellan, 2007). This fact places a much higher conservation status on all southern elements of the species population because they have shown the greatest levels of decline in recent times (Hunter and Gillespie, 2006).

Examination of the pooled sections of Cataract Creek, although apparently suitable, failed to detect the species distinctive tadpoles. Based on observed declines of the species and a failure to detect the species during studies of the Special Areas catchments by DECC (DECC, 2007) could be interpreted as the species now being lost as an element of the biodiversity of the local area. However our failure to detect the species in the upper sections of Cataract Creek does not rule out the possibility that it may still occur.

Figure 10 Pooled Section of Cataract Creek with exposed riffle.

4.4 BROAD-HEADED SNAKE

The Broad-headed Snake is a medium sized nocturnal elapid snake that occupies exposed sandstone outcrops during the cooler months and forages more widely in trees of surrounding woodlands and heaths during the warmer months. It is listed as an Endangered species in NSW and Vulnerable nationally.

This species is considered to suffer from the collective effects of bushrock removal, habitat disturbance, changed fire regimes and predation by cats and dogs, as well as pilfering by reptile collectors in more accessible locations.

The subject land is identified as having suitable outcropping and the species has been recorded from the vicinity of the study area previously. Outcrop areas were inspected where they occur above the potential impact zone of the proposed workings. A few patchy areas of sandstone benching were observed in the study area. Some of these outcrops possessed a few seemingly suitable pieces of exfoliating sandstone that were searched, however the area is not considered to possess extensive benching with the appropriate north to north west aspect most frequently used by the species. Certainly other areas of the Cataract Special Areas have such apparently ideal outcropping as can be readily detected from air photographs and topography but such features are generally absent from the study area inspected.

4.5 ROSENBERG'S GOANNA

Rosenberg's Goanna (also called Heath Goanna or Heath Monitor) is probably one of the rarest reptiles in the Sydney Basin. It generally occupies ridgetop locations in areas of Hawkesbury Sandstone geology and has large home range/territories. They are an active predator feeding predominantly on lizards but will also eat small mammals and carrion. They shelter in burrows, within rock ledges and ground logs and often nest in ground termitaria. They suffer a high incidence of road mortality and are suspected to be detrimentally impacted by changes to fire regime which likely impacts directly on the species as well as indirectly via fire impact on prey items. Rosenberg's Goanna occupies heath and woodland vegetation communities and utilise ledges and crevices among sandstone outcrops as over wintering refugia where they aestivate/hibernate. At other times they actively forage across relatively large areas/territories. They have a patchy distribution and are not always present in areas that appear to contain suitable habitat. Little is known regarding carrying capacity or the area of land required to make up a viable territory but the species is known from the Cataract Special Areas catchment. The species is notoriously difficult to detect when in low numbers as they are generally active during high temperature days at which time they are elusive and almost impossible to catch. Therefore little is known about the ecology of the species other than observations made regarding the use of ground termitaria as incubation chambers for their eggs. No obvious large termitaria were observed during the site investigations. Ledges and crevices were examined where they had some potential for use as shelter. Potential subsidence impacts on this species habitat are likely to be restricted to prominent outcrop areas with overhangs although indirect impacts through changes to hydrology of drainage lines and upland swamp heaths should not be discounted. Very little if any suitable shelter habitat with appropriate western aspect was detected during the survey and so little impact on this aspect of the species habitat is likely from subsidence impact in the Wonga East or Wonga West proposed workings area.

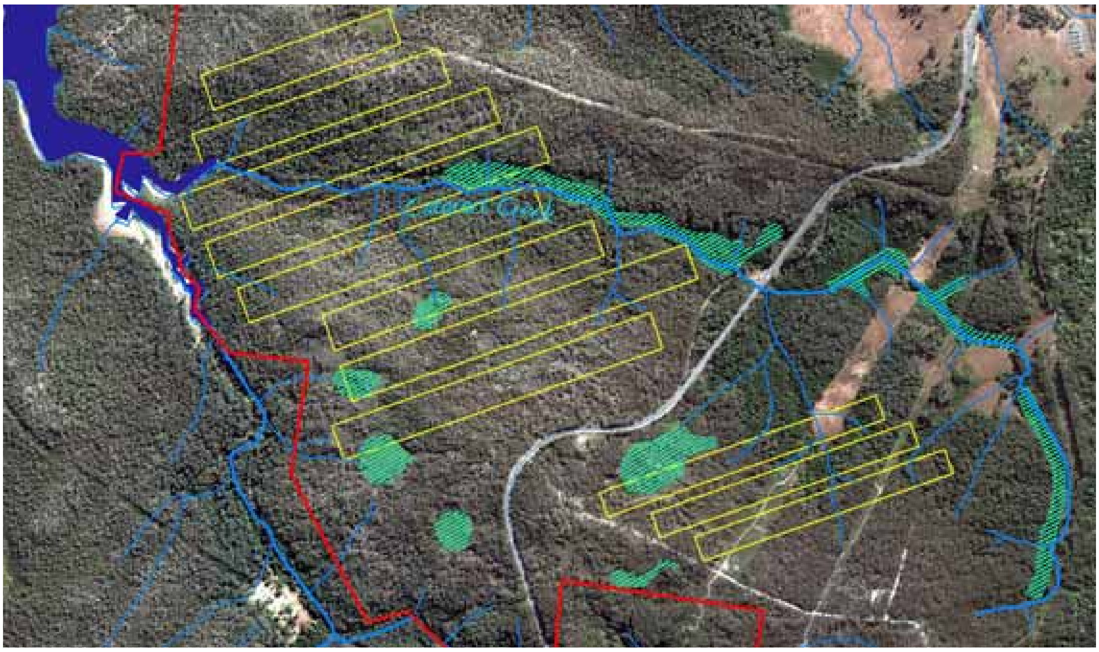


Figure 11 Wonga East Frog Habitat Areas

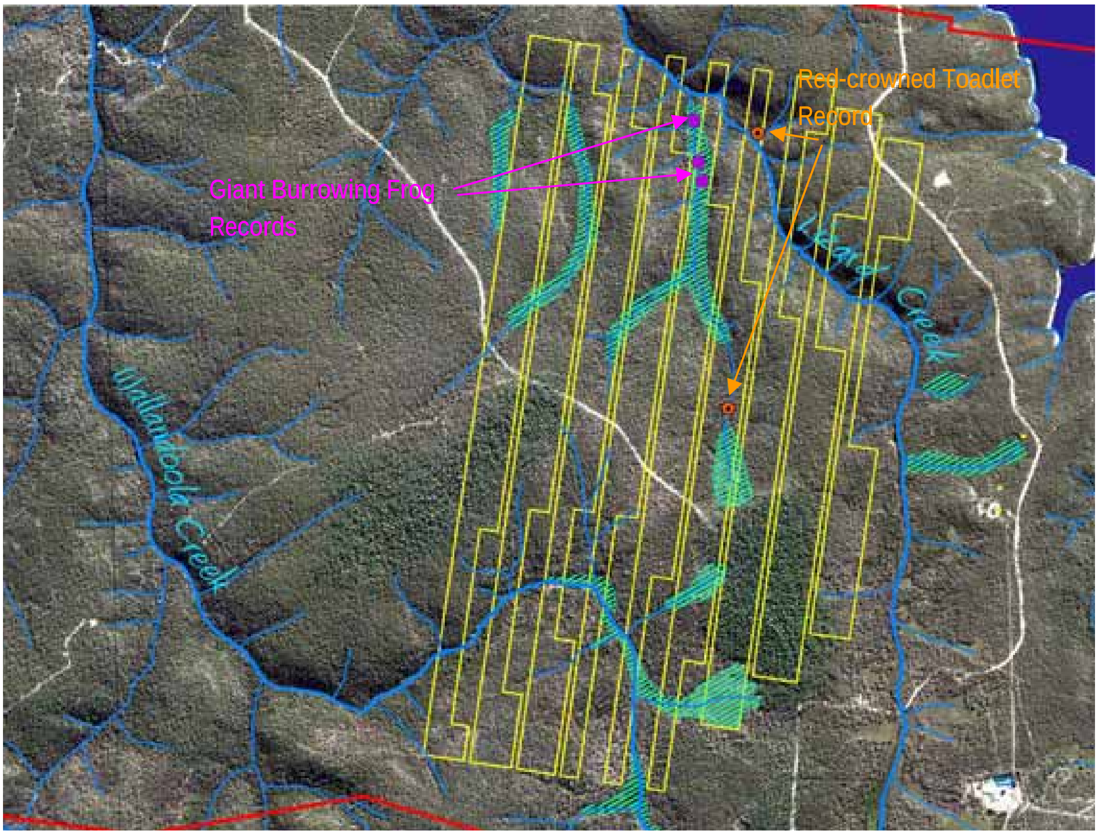


Figure 12 Wonga West Frog Habitat Areas

5 Conclusion

Substantial areas of suitable habitat for all of the subject threatened species, except the Green and Golden Bell Frog, were detected during the habitat assessment surveys of Wonga West and Wonga East study areas. This includes the various habitat components for each of the species but not necessarily the habitat components that are critical/vital to the survival of each of the species.

Rainforest and wet forest sections of Cataract Creek provide good breeding habitat for the Stuttering Frog and this is illustrated in Figure 10 and is mapped in Figure 11.

Giant Burrowing Frog breeding habitat is extensive along much of Wallandoola and Lizard Creeks where in-stream ponding occurs. Foraging and shelter habitat for this species can also be identified in those areas of Upland Swamp that can be readily demarcated.

Red-crowned Toadlet ephemeral breeding habitat is predominantly located along the lateral streams entering Lizard and Wallandoola Creek and is most likely also present in some of the soaks and drainage depressions throughout the Upland Swamp areas. These are what can be considered the only concentrations of potential habitat for this species. The patchy extent of other ephemeral habitat, that includes ill-defined ephemeral drainage depressions across sandstone bench areas, is scattered across large areas of the study area and the impact zone. However most of this species habitat was dry at the time of the study. Mapping of the diffuse, scattered habitat for this species was not possible to achieve in the timeframes available. It could reasonably be predicted to occur along the steep relief, lateral tributaries of Wallandoola and Lizard Creeks. Ephemeral Red-crowned Toadlet habitat that is away from the Upland Swamps in the elevated relief areas is considered less likely to be impacted by subsidence as these areas are predominantly surface flow dependent.

Upland Swamps were uncharacteristically dry and showed evidence of water stress. The factors causing this could not be ascertained but it was noted that other nearby Upland Swamps at Maddens Plains were contemporaneously much wetter, suggesting the possibility that existing/previous mining activities may have altered hydrology to these Upland Swamp areas.

The Upland Meadow Skink *Acritoscincus duperreyi* is most likely to be associated with Upland Swamp and wet heath habitat areas and so protection of this habitat type will also likely provide some protection to this regionally significant, although non-threatened, species however none were observed during the surveys.

Heath Frog habitat, although poorly understood, can be identified particularly as occurring in the large upstream pooled areas of Wallandoola Creek. See Figure 5 for an illustrated example of potential breeding habitat and Figure 12 for a map that depicts (in part) its extent as far as it could be mapped.

Little high quality rocky outcrop habitat, used during winter by the Broad-headed Snake, was observed in the proposed impact zone. Similarly rocky ledges with large crevices that are another typical character of high relief ridgetop habitat used by Rosenberg's Goanna was not detected in the impact zone. It would appear that most of the prominent relief ridgelines are avoided by the proposed workings areas. Both species may still utilise areas of the study area for foraging and/or in making use of other habitat attributes that occur across the whole study area. These other 'non-outcrop' related habitat attributes are considered less at risk from subsidence although possible indirect impacts on habitat caused through changed hydrology of the catchment should not be discounted.

Habitat for the Green and Golden Bell Frog was not detected during the investigations and the dam observed in the upper part of Cataract Creek is not considered to have much habitat value for the species. Similarly no records for the species have been detected from surrounding areas in recent times and no key populations of the species are known from anywhere near the study area. Therefore no impact on this species is considered likely to occur as a result of the proposal.

Most of the lower reaches of all three streams and their tributaries appear to be affected by water quality issues associated with iron oxidation impacts. Whilst these impacts can be natural, the extent of the impacts and the apparent non flow in some 'high energy' sections of the creek lines suggest that previous mining may be a causative factor.

6 Recommendations

- An assessment of the upland swamp areas should be made to determine whether previous mining activity has already impacted the hydrology of these habitat areas.
- Based on the assessment findings the Upland Swamp areas should be afforded protection from possible subsidence induced hydrological impacts.
- The extent of previous mining impacts on creek line iron oxidation should be identified. Those areas of creek lines currently unaffected by iron oxidation issues should be afforded some protective measures so that these unaffected areas remain un-impacted by changed hydrology impacts that expose pyrites layers to oxidation.
- The lateral tributary of Lizard Creek in which a colony of the Giant Burrowing Frog was detected, including its upland catchment area, should be further protected from subsidence impacts.
- Areas of mapped potential Stuttering Frog habitat in Cataract Creek should be protected from subsidence induced hydrological impact.
- Large pooled sections of Wallandoola Creek that are identified potential Heath Frog breeding habitat should be protected from subsidence induced hydrological impact.

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Appendix A – Herpetofauna recorded from the locality and the study area

Reptiles

Group	*Scientific Name*	Common Name	Status	Detected
Reptiles				
Dragons Agamidae	*Amphibolurus muricatus*	Jacky Lizard	P	
	Physignathus lesueurii	Eastern Water Dragon	P	Y
	Pogona barbata	Eastern Bearded Dragon	P	
	Rankinia diemensis	Mountain Heath Dragon	P	Y
Pythons Boidae	*Morelia spilota spilota*	Diamond Python	P	
Terrapins Chelidae	*Chelodina longicollis*	Eastern Snake-necked Turtle	P	Y
Front-fanged Snakes Elapidae	*Cacophis squamulosus*	Golden-crowned Snake	P	
	Demansia psammophis	Yellow-faced Whipsnake	P	
	Drysdalia rhodogaster	Mustard-bellied Snake	P	
	Hoplocephalus bungaroides	Broad-headed Snake	E1	
	Notechis scutatus	Eastern Tiger Snake	P	
	Pseudechis porphyriacus	Red-bellied Black Snake	P	Y

	Pseudonaja textilis	Eastern Brown Snake	P	
	Rhinoplocephalus nigrescens	Small-eyed Snake	P	
	Vermicella annulata	Eastern Bandy-bandy	P	
Geckos Gekkonidae	*Oedura lesueurii*	Lesueur's Velvet Gecko	P	Y
	Phyllurus platurus	Broad-tailed Gecko	P	Y
Skinks Scincidae	*Acritoscincus platynota*	Red-throated Cool-skink	P	
	Acritoscincus duperreyi	Duperrey's Meadow Skink	P	
	Cryptoblepharus virgatus	Cream-striped Shinning-skink	P	
	Ctenotus taeniolatus	Copper-tailed Ctenotus	P	Y
	Cyclodomorphus michaeli	Michael's She-Oak Skink	P	
	Egernia cunninghami	Cunningham's Spiny-tailed Skink	P	
	Egernia whitii	White's Rock-skink	P	
	Eulamprus heatwolei	Warm-temperate Water-skink	P	
	Eulamprus cf kosciuskoi	Alpine Water Skink		
	Eulamprus quoyii	Eastern Water-skink	P	Y
	Eulamprus tenuis	Bar-sided Forest-skink	P	
	Lampropholis delicata	Dark-flecked Garden Sunskink	P	Y
	Lampropholis guichenoti	Pale-flecked Garden Sunskink	P	Y
	Anepischetosia maccoyi	Highlands Forest-skink	P	

	Saiphos equalis	Yellow-bellied Three-toed Skink	P	
	Saproscincus mustelinus	Weasel Skink	P	
	Tiliqua scincoides	Common Bluetongue	P	
Blind-snakes Typhlopidae	*Ramphotyphlops nigrescens*	Blackish Blind Snake	P	Y
Goannas Varanidae	*Varanus rosenbergi*	Rosenberg's Goanna	V	
	Varanus varius	Lace Monitor	P	

Group	*Scientific Name*	Common Name	Status	Detected
Frogs				
Myobatrachidae Ground Frogs	*Crinia signifera*	Common Eastern Froglet	P	Y
	Heleioporus australiacus	Giant Burrowing Frog	V	Y
	Limnodynastes dumerilii grayi	Banjo Frog	P	Y
	Limnodynastes peronii	Striped Marsh Frog	P	Y
	Paracrinia haswelli	Haswell's Froglet	P	
	Pseudophryne australis	Red-crowned Toadlet	V	Y
	Uperoleia laevigata	Smooth Toadlet	P	
Peldryadidae Tree Frogs	*Litoria aurea*	Green and Golden Bell Frog	E1	
	Litoria caerulea	Green Tree Frog	P	Y
	Litoria citropa	Blue Mountains Tree Frog	P	
	Litoria dentata	Keferstein's Tree Frog	P	
	Litoria fallax	Eastern Dwarf Tree Frog	P	

	Litoria freycineti	Freycinet's Frog	P	
	Litoria latopalmata	Broad-palmed Frog	P	
	Litoria lesueuri	Lesueur's Frog	P	
	Litoria littlejohni	Littlejohn's Tree Frog	V	
	Litoria nudigitis	Southern Leaf-green Tree frog	P	Y
	Litoria peronii	Peron's Tree Frog	P	Y
	Litoria tyleri	Tyler's Tree Frog	P	
	Litoria verreauxii	Verreaux's Tree Frog	P	Y

Nb *Litoria nudidigitis* (south of Sydney) and *Litoria wilcoxii* (western Sydney Hawkesbury drainage and north) are cryptic species that have previously been confused within what were treated as state-wide species *Litoria phyllochroa* (now restricted to areas north of Sydney) and *Litoria lesueurii* (now restricted to Illawarra and coastal areas south of Sydney and south coast) respectively.

HEAD OFFICE
Suite 4, Level 1
2-4 Merton Street
Sutherland NSW
T 02 8536 8600
F 02 9542 5622

SYDNEY
Suite 604, Level 6
267 Castlereagh Street
Sydney NSW 2000
T 02 9993 0566
F 02 9993 0573

ST GEORGES BASIN
8/128 Island Point Road
St Georges Basin NSW 2540
T 02 4443 5555
F 02 4443 6655

CANBERRA
Level 14
11 London Court
Canberra ACT 2601
T 02 6103 0145
F 02 6103 0148

HUNTER
Suite 17, Level 4
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 4910 0126

NAROOMA
5/20 Canty Street
Narooma NSW 2546
T 02 4476 1151
F 02 4476 1161

COFFS HARBOUR
35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

ARMIDALE
92 Taylor Street
Armidale NSW 2350
T 02 8081 2681
F 02 6772 1279

BRISBANE
93 Boundary St
West End QLD 4101
T 0429 494 886

WESTERN AUSTRALIA
108 Stirling Street
Perth WA 6000
T 08 9227 1070
F 08 9227 1078

Annex C

Database Search Results

Scientific name	Common name	Class	Family	Status	Most recent record
Flora					
Acacia baueri subsp. aspera		Flora	Fabaceae (Mimosoideae)	V	6/05/1999
Chorizema parviflorum	Chorizema parviflorum population in the Wollongong and Shellharbour LGAs	Flora	Fabaceae (Faboideae)	E2	18/06/1995
Daphnandra sp. C Illawarra	Illawarra Socketwood	Flora	Monimiaceae	E1	25/06/2001
Epacris purpurascens var. purpurascens		Flora	Ericaceae	V	4/06/2001
Pomaderris adnata	Sublime Point Pomaderris	Flora	Rhamnaceae	E1	14/02/2008
Pomaderris brunnea	Brown Pomaderris	Flora	Rhamnaceae	V	2/05/1957
Pultenaea aristata	Prickly Bush-pea	Flora	Fabaceae (Faboideae)	V	12/03/2008
Thesium australe	Austral Toadflax	Flora	Santalaceae	V	Unknown
Fauna					
Arctocephalus pusillus doriferus	Australian Fur-seal	Mammalia	Otariidae	V	13/08/1991
Botaurus poiciloptilus	Australasian Bittern	Aves	Ardeidae	V	20/10/2001
Calidris alba	Sanderling	Aves	Scolopacidae	V	28/10/1991
Callocephalon fimbriatum	Gang-gang Cockatoo	Aves	Cacatuidae	V	6/10/2006
Calyptorhynchus lathami	Glossy Black-Cockatoo	Aves	Cacatuidae	V	22/09/2004
Cercartetus nanus	Eastern Pygmy-possum	Mammalia	Burramyidae	V	31/01/2007
Coracina lineata	Barred Cuckoo-shrike	Aves	Campephagidae	V	25/11/2000
Dasyurus maculatus	Spotted-tailed Quoll	Mammalia	Dasyuridae	V	30/06/2006
Dasyurus viverrinus	Eastern Quoll	Mammalia	Dasyuridae	E1	30/06/1966
Diomedea exulans	Wandering Albatross	Aves	Diomedeidae	E1	30/11/2007
Diomedea gibsoni	Gibson's Albatross	Aves	Diomedeidae	V	12/07/2000
Esacus neglectus	Beach Stone-curlew	Aves	Burhinidae	E1	28/02/1998
Eubalaena australis	Southern Right Whale	Mammalia	Balaenidae	V	13/07/1998
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Mammalia	Vespertilionidae	V	11/06/1997
Haematopus fuliginosus	Sooty Oystercatcher	Aves	Haematopodidae	V	11/03/2006
Haematopus longirostris	Pied Oystercatcher	Aves	Haematopodidae	V	4/05/2001
Heleioporus australiacus	Giant Burrowing Frog	Amphibia	Myobatrachidae	V	27/09/2006
Hoplocephalus bungaroides	Broad-headed Snake	Reptilia	Elapidae	E1	5/10/2006
Ixobrychus flavicollis	Black Bittern	Aves	Ardeidae	V	10/01/2005
Lathamus discolor	Swift Parrot	Aves	Psittacidae	E1	1/07/1983
Litoria aurea	Green and Golden Bell Frog	Amphibia	Hylidae	E1	21/04/2004
Litoria littlejohni	Littlejohn's Tree Frog	Amphibia	Hylidae	V	20/09/2001
Lophoictinia isura	Square-tailed Kite	Aves	Accipitridae	V	30/09/1996
Macronectes giganteus	Southern Giant Petrel	Aves	Procellariidae	E1	27/07/2004
Macronectes halli	Northern Giant-Petrel	Aves	Procellariidae	V	5/07/1999
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Mammalia	Vespertilionidae	V	2/02/2007
Mormopterus norfolkensis	Eastern Freetail-bat	Mammalia	Molossidae	V	27/02/1999
Myotis adversus	Large-footed Myotis	Mammalia	Vespertilionidae	V	6/12/2001
Ninox strenua	Powerful Owl	Aves	Strigidae	V	4/10/2006
Petroica rodinogaster	Pink Robin	Aves	Petroicidae	V	4/09/1988
Phascolarctos cinereus	Koala	Mammalia	Phascolarctidae	V	30/06/2006
Phoebetria fusca	Sooty Albatross	Aves	Diomedeidae	V	30/06/1975
Pseudophryne australis	Red-crowned Toadlet	Amphibia	Myobatrachidae	V	31/10/2004
Pteropus poliocephalus	Grey-headed Flying-fox	Mammalia	Pteropodidae	V	28/02/2003
Ptilinopus regina	Rose-crowned Fruit-Dove	Aves	Columbidae	V	26/09/2004
Ptilinopus superbus	Superb Fruit-Dove	Aves	Columbidae	V	31/05/1979
Puffinus assimilis	Little Shearwater	Aves	Procellariidae	V	31/12/1986
Scoteanax rueppellii	Greater Broad-nosed Bat	Mammalia	Vespertilionidae	V	11/03/1997
Sterna albifrons	Little Tern	Aves	Laridae	E1	19/12/1965
Sterna fuscata	Sooty Tern	Aves	Laridae	V	30/06/1975
Thalassarche cauta	Shy Albatross	Aves	Diomedeidae	V	19/08/1993
Thalassarche cauta salvini		Aves	Diomedeidae	V	3/09/1960
Thalassarche melanophris	Black-browed Albatross	Aves	Diomedeidae	V	5/07/1999
Thalassarche melanophris impavida		Aves	Diomedeidae	V	9/09/1998
Tyto novaehollandiae	Masked Owl	Aves	Tytonidae	V	19/11/1997
Tyto tenebricosa	Sooty Owl	Aves	Tytonidae	V	11/03/2006
Varanus rosenbergi	Rosenberg's Goanna	Reptilia	Varanidae	V	28/11/2006
Xanthomyza phrygia	Regent Honeyeater	Aves	Meliphagidae	E1	31/12/1995

Annex D

Field Survey Results

Common Name	Scientific Name	C Act Sta	BC Act Sta	TAP stat	001	002	003	004	005	006	007	008	009	010	013	014	015	017	018	021	023	024a	024b	025	028	029	101	102	103	104	105	106	107	108	109	112	113	116	117A	117B
Coast Myall	*Acacia binervata*	-	-																								3	1	2					1						
Hickory Wattle	*Acacia falcata*	-	-																																				2	
Broad-leaved Hickory	*Acacia falciformis*	-	-											4			2						2																	
Fern-leaved Wattle	*Acacia filicifolia*	-	-															1																						
Fringed Wattle	*Acacia fimbriata*	-	-				3																																	
White Sallow Wattle	*Acacia floribunda*	-	-						2						1																									
Green Wattle	*Acacia irrorata*	-	-			3			4																		1													
Flax-leafed Wattle	*Acacia linifolia*	-	-								3		2	3		4		3	3	3	3													3	2					
Sydney Golden Wattle	*Acacia longifolia*	-	-			3									2						3						2													
Narrow-leaf Wattle	*Acacia longissima*	-	-															1			3																			
Maiden's Wattle	*Acacia maidenii*	-	-																														1							
Myrtle Wattle	*Acacia myrtifolia*	-	-							3		2	2						3	3				2																
Red-leaved Wattlr	*Acacia rubida*	-	-																	3																				
Sweet-scented Wattle	*Acacia suaveolens*	-	-									3							2	1				1					1										2	
Sunshine Wattle	*Acacia terminalis* subsp. *angustifolia*	-	-		1	1									1			2	3		3								1			2			1					
Prickly Moses	*Acacia ulicifolia*	-	-									2												2				1			3	2		2					2	
Lillypilly	*Acmena smithii*	-	-																														3							
Acrotriche divaricata	*Acrotriche divaricata*	-	-																	1																				
Lesser Flannel Flower	*Actinotus minor*	-	-							2	2	2	2						2	2				2					1										2	
Black She-oak	*Allocasuarina littoralis*	-	-																								1													
Dwarf She-oak	*Allocasuarina nana*	-	-				1	3																																
Swamp She-oak	*Allocasuarina paludosa*	-	-																																					1
Forest She-oak	*Allocasuarina torulosa*	-	-			3	1								3																									
Drooping She-oak	*Allocasuarina verticillata*	-	-																	1																				
Broom Spurge	*Amperea xiphoclada*	-	-																									1												
Aotus ericoides	*Aotus ericoides*	-	-																					2																
Purple Wiregrass	*Aristida ramosa*	-	-						2						2																									
Arthropodium minus	*Arthropodium minus*	-	-									1																												
Necklace Fern	*Asplenium flabellifolium*	-	-																														1							
Pine Heath	*Astroloma pinifolium*	-	-																	1				1																
Walaby Grass	*Austrodanthonia* sp.	-	-		5	2																																		
Austrostipa pubescens	*Austrostipa pubescens*	-	-		1					1	2	2																												
Weeping Baeckea	*Baeckea linifolia*	-	-					2																	2															
Fringed Baeckea	*Baeckea diosmifolia*	-	-				3				1			2		2																								
Baeckea imbricata	*Baeckea imbricata*	-	-																			2				2									2					
Baeckea brevifolia	*Baeckea brevifolia*	-	-							2	2				1	1										1	1		2											
Brush Bloodwood	*Baloghia inophylla*	-	-																																			2		
Heath-leaved Banksia	*Banksia ericifolia*	-	-													3						1													3	2				1
Heath-leaved Banksia	*Banksia ericifolia* subsp. *ericifolia*	-	-																										3											
Silver Banksia	*Banksia marginata*	-	-											1		3		3	3		3						2												3	
Fern-leaved Banksia	*Banksia oblongifolia*	-	-				3	3			4			4			3									3									2					1
Swamp Banksia	*Banksia paludosa* subsp. *paludosa*	-	-																		3																			
Swamp Banksia	*Banksia robur*	-	-														1						1		3											3				
Hairpin Banksia	*Banksia spinulosa*	-	-		1	1				3		2	2		2			3	3	3	3			2				1				1		3						
Old-man Banksia	*Banksia serrata*	-	-							3		2	2					2	1	3				3					3			2		1					3	
River Rose	*Bauera rubioides*	-	-															1																						
Baumea acuta	*Baumea acuta*	-	-								3																													
Pinkwood	*Beyeria viscosa*	-	-																								3													
Hairy Apple Berry	*Billardiera scandens*	-	-		1																													1						
Christmas Bells	*Blandfordia nobilis*	-	-											1								1				1			2											
Gristle fern	*Blechnum cartilagineum*	-	-																											1	2		2							
Fishbone Water Fern	*Blechnum nudum*	-	-						2																															
Sydney Boronia	*Boronia ledifolia*	-	-																								1													
Swamp Boronia	*Boronia parviflora*	-	-					1																																
Variable Bossiaea	*Bossiaea heterophylla*	-	-				3	2																																
Spiny Bossiaea	*Bossiaea obcordata*	-	-							2		2	1						2	2				1																
Bossiaea rhombifolia	*Bossiaea rhombifolia*	-	-																							1														
Bossiaea	*Bossiaea* sp.	-	-									1																												
Hill Daisy	*Brachyscome aculeata*	-	-													4																								
Coffee Bush	*Breynia oblongifolia*	-	-																												1									
Milkmaids	*Burchardia umbellata*	-	-								3								1																					
Crimson Bottlebrush	*Callistemon citrinus*	-	-											1		2	1						2		3	1	1													
Rainbow Fern	*Calochlaena dubia*	-	-																								2	2			3							3		
Carex inversa	*Carex inversa*	-	-				3																																	
Cassytha glabella	*Cassytha glabella*	-	-								1	1						1		2	2													1						
Cassytha pubescens	*Cassytha pubescens*	-	-																1	2	2																		1	
Curly Wig	*Caustis flexuosa*	-	-							1		1	2						2	2				3		3			1					1		2			1	3
Caustis recurvata	*Caustis recurvata*	-	-																			2																		

Common Name	Scientific Name	C Act Sta	BC Act Sta	TAP stat	001	002	003	004	005	006	007	008	009	010	013	014	015	017	018	021	023	024a	024b	025	028	029	101	102	103	104	105	106	107	108	109	112	113	116	117A	117B
*Centaurium tenuiflorum**	*Centaurium tenuiflorum**	-	-						1																															
Coachwood	*Ceratopetalum apetalum*	-	-																											5			4							
Christmas Bush	*Ceratopetalum gummiferum*	-	-																									1												
Long Leaf Smoke Bush	*Conospermum longifolium* subsp. *angustif*	-	-																2																					
Red Bloodwood	*Corymbia gummifera*	-	-										3		3				3	3				2			3		2					1	2					
Bonnet Orchid	*Cryptostylis erecta*	-	-																													1								
Black Tree-fern	*Cyathea australis*	-	-																														1							
Dampiera stricta	*Dampiera stricta*	-	-																									1												
Darwinia grandiflora	*Darwinia grandiflora*	-	-	2RCi																																				
Daviesia squarrosa	*Daviesia squarrosa*	-	-											2																										
Desmodium rhytidophyllum	*Desmodium rhytidophyllum*	-	-																													1								
Large Tick-trefoil	*Desmodium brachypodum*	-	-						1																															
Blue Flax-lily	*Dianella caerulea*	-	-																								1					2					2			
Dianella caerulea var. *producta*	*Dianella caerulea* var. *producta*	-	-																									2												
Blueberry Lily	*Dianella longifolia*	-	-			1			1						1																									
Dichelachne rara	*Dichelachne rara*	-	-																									1												
Kidney Weed	*Dichondra repens*	-	-						3						1											1											1			
Dillwynia floribunda	*Dillwynia floribunda*	-	-																																2					
Dillwynia parvifolia	*Dillwynia parvifolia*	-	-		1		2																			1														
Dillwynia retorta	*Dillwynia retorta*	-	-										1					2						2																
Black Plum	*Diospyros australis*	-	-																																			2		
Dipodium punctatum	*Dipodium punctatum*	-	-																													1								
Prickly Rasp Fern	*Doodia aspera*	-	-						1																								2							
Sassafras	*Doryphora sassafras*	-	-																											5			4							
Bushy Hedgehog-grass	*Echinopogon caespitosus*	-	-												1																									
Blueberry Ash	*Elaeocarpus reticulatus*	-	-																									2												
Empodisma minus	*Empodisma minus*	-	-				3			1	3							2																3			2		2	
Bordered Panic	*Entolasia marginata*	-	-				4																																	
Wiry Panic	*Entolasia stricta*	-	-		2	1												2	2	1	1			3				1	2			3		2						
Fuchsia Heath	*Epacris longiflora*	-	-							1		2																1												
Coast Coral Heath	*Epacris microphylla*	-	-														2																		2					4
Wallum Heath	*Epacris pulchella*	-	-																2	2	2			1															2	
Bnagalay	*Eucalyptus botryoides*	-	-						3																															
Yertchuk	*Eucalyptus consideniana*	-	-																													1								
Thin-leaved Stringybark	*Eucalyptus eugenioides*	-	-		2										2																									
White Stringybark	*Eucalyptus globoidea*	-	-		3	3									3																									
Scribbly Gum	*Eucalyptus haemastoma*	-	-						3			3	3			2					2																			
Blackbutt	*Eucalyptus pilularis*	-	-																									3			3						3	4		
Sydney Peppermint	*Eucalyptus piperita*	-	-															3	2		3						4	3	2		2	3		3						
Narrow-leaved Scribbly Gum	*Eucalyptus racemosa*	-	-				3							1		3													2											1
Eucalyptus racemosa x haemast	*Eucalyptus racemosa x haemastoma*	-	-																	2				2															2	
Silvertop Ash	*Eucalyptus sieberi*	-	-						3			3												2															3	
Ironbark Peppermint	*Eucalyptus smithii*	-	-																											3										
Eurychorda complanata	*Eurychorda complanata*	-	-					2			3			4		2	3					4				4									3					
Rosy Baeckea	*Euryomyrtus ramosissima*	-	-									1																												
Wombat Berry	*Eustrephus latifolius*	-	-																												2						1			
Tall Saw-sedge	*Gahnia clarkei*	-	-																																			3		
Gahnia radula	*Gahnia radula*	-	-																		2																			
Gahnia	*Gahnia* sp.	-	-																												1									
Scrambling Lily	*Geitonoplesium cymosum*	-	-																																		2			
Pouched Coral Fern	*Gleichenia dicarpa*	-	-											3									1						4							2				
Small-leaf glycine	*Glycine microphylla*	-	-						5						2																									
Glycine tabacina	*Glycine tabacina*	-	-						5																															
Large Wedge Pea	*Gompholobium grandiflorum*	-	-																	2																				
Gonocarpus micranthus	*Gonocarpus micranthus*	-	-									1																												
Raspwort	*Gonocarpus teucrioides*	-	-							1								2	2		2			2					1			1		1						
Goodenia bellidifolia	*Goodenia bellidifolia*	-	-																			1				2														
Forest Goodenia	*Goodenia hederacea*	-	-		1			1				1									2																			
Goodenia heterophylla	*Goodenia heterophylla*	-	-												2			1																						
Grevillea capitellata	*Grevillea capitellata*	-	-																1	1																				
Grevillea diffusa subsp. *diffusa*	*Grevillea diffusa* subsp. *diffusa*	-	-																	2																				
Grevillea mucronulata	*Grevillea mucronulata*	-	-							1		1	2					1	1		1																			
Red Spider Flower	*Grevillea oleoides*	-	-									1	1							1																			1	
Pink Spider Flower	*Grevillea sericea*	-	-										1																											
Grey Spider Flower	*Grevillea sphacelata*	-	-																										1											
Button Grass	*Gymnoschoenus sphaerocephalus*	-	-																							3										2				
Finger Hakea	*Hakea dactyloides*	-	-				2	3				2	2	3							3					1								3					3	
Hakea propinqua	*Hakea propinqua*	-	-							1								2	3																					

Common Name	Scientific Name	C Act Sta	BC Act Sta	TAP stat	001	002	003	004	005	006	007	008	009	010	013	014	015	017	018	021	023	024a	024b	025	028	029	101	102	103	104	105	106	107	108	109	112	113	116	117A	117B
Needlebush	*Hakea sericea*	-	-		3	1	1			2	2	2	2	1	2			3	3	3	3			2					2			2		2					3	2
Needlebush	*Hakea teretifolia*	-	-								1			1			1					3				2									3	2				
Purple Coral Pea	*Hardenbergia violacea*	-	-		2	1									1																									
Harmogia densifolia	*Harmogia densifolia*	-	-									1																												
Satin Everlasting	*Helichrysum leucopsideum*	-	-																		1																			
Rough Guinea Flower	*Hibbertia aspera*	-	-												3									2					2										1	
Hibbertia empetrifolia	*Hibbertia empetrifolia*	-	-																													1								
Hibbertia pedunculata	*Hibbertia pedunculata*	-	-													3																					2			
Trailing Guinea Flower	*Hibbertia dentata*	-	-																												2							2		
Hypolaena fastigiata	*Hypolaena fastigiata*	-	-															2																						
Harsh Ground Fern	*Hypolepis muelleri*	-	-																																			1		
Broad-leaf Drumsticks	*Isopogon anemonifolius*	-	-								2	2	2			2			3	3				2											3				2	2
Narrow-leaf Drumsticks	*Isopogon anethifolius*	-	-		1					3				2		3																								
Winged Broom-pea	*Jacksonia scoparia*	-	-												1																									
Juncus pallidus	*Juncus pallidus*	-	-																																					2
Tick Bush	*Kunzea ambigua*	-	-																																					3
Kunzea capitata	*Kunzea capitata*	-	-				3				2					3																			1					
Burgan	*Kunzea ericoides*	-	-					2																																
Mountain Devil	*Lambertia formosa*	-	-				1																																	
Trim Sheild Fern	*Lastreopsis decomposita*	-	-																											1			1							
Creeping Shield Fern	*Lastreopsis microsora*	-	-																											1			1							
Moss	*Lembophyllum divulsum*	-	-																														2							
Lepidosperma filiforme	*Lepidosperma filiforme*	-	-																																					3
Lepidosperma laterale	*Lepidosperma laterale*	-	-										2											2		1														
Lepidosperma limicola	*Lepidosperma limicola*	-	-																																	5				4
Leptocarpus tenax	*Leptocarpus tenax*	-	-				3	1		2	3	2	2				3		3	2			4	3	5	4			3					2	3				3	3
Leptospermum arachnoides	*Leptospermum arachnoides*	-	-				3							1												1														
Prickly Tea-tree	*Leptospermum continentale*	-	-																1																					
Prickly Tea-tree	*Leptospermum juniperinum*	-	-											2		4	3						5		5											4				
Coast Teatree	*Leptospermum laevigatum*	-	-																																	3				
Woolly Teatree	*Leptospermum lanigerum*	-	-														2								2															
Leptospermum parvifolium	*Leptospermum parvifolium*	-	-								3																								2					
Tantoon	*Leptospermum polygalifolium* subsp. *polyg*	-	-				2							2				3			3				1			2	3			2		2	3		3			
Slender Tea-tree	*Leptospermum trinervium*	-	-							2		1	2					3	3	3	2			2					1						1				2	
Lepyrodia anarthria	*Lepyrodia anarthria*	-	-																			4		3																
Lepyrodia scariosa	*Lepyrodia scariosa*	-	-									1					5						5		5			1	3											
Leucopogon esquamatus	*Leucopogon esquamatus*	-	-																	1																				
Leucopogon lanceolatus	*Leucopogon lanceolatus*	-	-												2		2				2						2	3	1		1	2			1	2	3			
Screw Fern	*Lindsaea linearis*	-	-			1	1	2				1	1	1	1				1		2											1			2				2	
Cabbage-tree Palm	*Livistonia australis*	-	-																											1			2					1		
Wattle Mat-rush	*Lomandra filiformis* subsp. *filiformis*	-	-									2	1	2	1				1								2												1	
Pale Mat-rush	*Lomandra glauca*	-	-																					2																
Spiny-headed Mat-rush	*Lomandra longifolia*	-	-		2	2				2					1			2			2			1		2	3	2	2	1	2	3	1	3			4	2		
Many-flowered Mat-rush	*Lomandra multiflora subsp. multiflora*	-	-		3	2	1			2		2	2					2	1	2							2		1									1	2	
Lomandra obliqua	*Lomandra obliqua*	-	-									2									2			1								2							2	
River Lomatia	*Lomatia myricoides*	-	-																								1													
Crinkle Bush	*Lomatia silaifolia*	-	-		2	1								1	1		2	2		2	2			1			1							2						
Slender Clubmoss	*Lycopodiella lateralis*	-	-																																	3				
Scented Paper-bark	*Melaleuca squarrosa*	-	-																																	3				
Weeping Grass	*Microlaena stipoides*	-	-				1	3						1	2	2																								
Mirbelia speciosa	*Mirbelia speciosa*	-	-													1										1														
Mitrasacme polymorpha	*Mitrasacme polymorpha*	-	-								3																													
Monotoca ledifolia	*Monotoca ledifolia*	-	-	3RC-													2																							
Satinwood	*Nematolepis squamea*	-	-																																			3		
Large Mock-olive	*Notelaea longifolia*	-	-																													3					3			
Oplismenus imbecillis	*Oplismenus imbecillis*	-	-																												2									
Wonga Wonga Vine	*Pandorea pandorana*	-	-																														2							
Two-colour Panic,	*Panicum simile*	-	-																																			4		
Common Silkpod	*Parsonsia straminea*	-	-																														1					3		
Leafy Purple-flag	*Patersonia glabrata*	-	-																1																					
Broad-leaved Geebung	*Persoonia levis*	-	-					1																																1
Narrow-leaved Geebung	*Persoonia linearis*	-	-		1		1								3																									
Persoonia mollis subsp. *ledifolia*	*Persoonia mollis* subsp. *ledifolia*	-	-																																	1				1
Persoonia mollis subsp. *nectens*	*Persoonia mollis* subsp. *nectens*	-	-																										2										2	
Pine-leaved Geebung	*Persoonia pinifolia*	-	-		2											2								2			2		3											
Conesticks	*Petrophile pulchella*	-	-							3		2																							2					
Conesticks	*Petrophile sessilis*	-	-				3			3	3	4	2	2		2			3	3				3					2										3	
Silvery Phebalium	*Phebalium squamulosum* subsp. *argenteu*	-	-			1																																		

Common Name	Scientific Name	C Act Sta	BC Act Sta	TAP stat	001	002	003	004	005	006	007	008	009	010	013	014	015	017	018	021	023	024a	024b	025	028	029	101	102	103	104	105	106	107	108	109	112	113	116	117A	117B
Thyme Spurge	*Phyllanthus hirtellus*	-	-																													1								
Slender Rice-flower	*Pimelea linifolia* subsp. *linifolia*	-	-								2	2	1					2	2		2							2						1						
Orange Thorn	*Pittosporum multiflorum*	-	-																											1			2				2	3		
Shrubby Platysace	*Platysace lanceolata*	-	-																								1													
Platysace linearifolia	*Platysace linearifolia*	-	-									2	1						3					1					2						2					
Poa affinis	*Poa affinis*	-	-							1																														
Poa sieberiana	*Poa sieberiana*	-	-			2																																		
Pomaderris andromedifolia	*Pomaderris andromedifolia*	-	-			1																																		
Pomax umbellata	*Pomax umbellata*	-	-																					1																
Poranthera microphylla	*Poranthera microphylla*	-	-			1			2						1													2												
Southern Leek Orchid	Prasophyllum australe	-	-																																					
Victorian Christmas Bush	*Prostanthera lasianthos*	-	-																															1				3		
Pastel Flower	*Pseuderanthemum variabile*	-	-																																			2		
Common Bracken	*Pteridium esculentum*	-	-						3	3					1			2			3						2	3	3			3		2		2		2		
Pultenaea linophylla	*Pultenaea linophylla*	-	-																1																					
Notched Bush-pea	*Pultenaea retusa*	-	-			1															2																			
Rough Bush-pea	*Pultenaea scabra*	-	-		4	1									1											3														
Bush-pea	*Pultenaea* sp.	-	-														2																							
Moss	*Pyrrhobryum parramattense*	-	-																														2							
Rock Felt Fern	*Pyrrosia rupestris*	-	-																														1							
Molucca Bramble	*Rubus moluccanus* var. *trilobus*	-	-																																			1		
Pearl Vine	*Sarcopetalum harveyanum*	-	-																																			2		
Purple Fan-flower	*Scaevola ramosissima*	-	-																	2												2								
Forked Comb Fern	*Schizaea bifida*	-	-															1																						
Swamp Selaginella	*Selaginella uliginosa*	-	-																																2					
Lawyer Vine	*Smilax australis*	-	-																											2	2	2	2							
Sweet Sarsaparilla	*Smilax glyciphylla*	-	-																								1	2									2			
Forest Nightshade	*Solanum prinophyllum*	-	-						1																															
Pink Swamp Heath	*Sprengelia incarnata*	-	-										1																						1					
Snake Vine	*Stephania japonica*	-	-																																			2		
Shiny Fan Fern	*Sticherus flabellatus*	-	-																											1			1							
Umbrella Fern	*Sticherus flabellatus* var. *flabellatus*	-	-																									1												
Turpentine	*Syncarpia glomulifera*	-	-																												4	3					3	3		
Blue Lilly Pilly	*Syzygium oleosum*	-	-																											1										
Brush Pepperbush	*Tasmannia insipida*	-	-																											1			1							
Kangaroo Grass	*Themeda australis*	-	-								1			1																										
Thysanotus juncifolius	*Thysanotus juncifolius*	-	-					1																											3					
King Fern	*Todea barbara*	-	-																											1										
Trachymene incisa	*Trachymene incisa*	-	-																							2									3					
Tree Heath	*Trochocarpa laurina*	-	-																											2			3					3		
Bearded Tylophora	*Tylophora barbata*	-	-						3																						2							2		
Yellow Marsh Flower	*Villarsia exaltata*	-	-																				1																	
Golden Spray	*Viminaria juncea*	-	-		2					1	1	1	2			1			1		1			1			3	1	1			1		2	2	2				1
Ivy-leaved Violet	*Viola hederacea*	-	-																									2												
Vittadinia sulcata	*Vittadinia sulcata*	-	-																								1													
Woollsia pungens	*Woollsia pungens*	-	-											1																					1					
Xanthorrhoea minor subsp. *mino*	*Xanthorrhoea minor* subsp. *minor*	-	-																																				2	
Grass Tree	*Xanthorrhoea resinosa*	-	-					3									1					4													3					3
Woolly Xanthosia	*Xanthosia pilosa*	-	-															2	2	2				2					2											
Xyris operculata	*Xyris operculata*	-	-																							3														3

			Canopy			Midstorey			Ground		
Veg Community	**Site**	**Photo**	**Height (m)**	**Cover (%)**	**Dominant Spp.**	**Height (m)**	**Cover (%)**	**Dominant Spp.**	**Height (m)**	**Cover (%)**	**Dominant Spp.**
Upland Swamp - Sedgeland Heath Complex	001	1, 2	5.0-15.0	30	E. globoidea, E. eugenoides	0.30-2.0	<10	Hakea serrata, Acacia terminalis subsp. Angustifolia	0-0.30	70	Lomandra sp., Epacris sp.
Transitional Shale Stringybark Forest	002	3205, 3206	5.0-15.0	15-20	E. globoidea	0.30-2.0	30	Acacia sp., Hakea sp., Banksia sp.	0-0.3	50	Austrodanthonia sp., Poa sp., Antelasea sp.
Upland Swamp - Fringing Eucalypt Woodland	003	3207, 3208	8.0	10	E. ramosa	Nil	Nil	Nil	1.0	80	Banksia oblongifolia, Petrophile sessilis, Hakea dactyloides, Acacia fimbriata, Leptospermum arachnoides
Upland Swamp - Sedgeland Heath Complex	004	3209, 3210	Nil	Nil	Nil	Nil	Nil	Nil	1.0	40	Hakea dactyloides, banksia oblongifolia, Xanthorrhoea resinosa
Transitional Shale Open Blue Gum Forest	005	3211, 3212	30.0	30	E. saligna, E.botryoides	5.0	35	Acacia irrorata	1.0	15	Pteridium esculentum
Upland Swamp - Fringing Eucalypt Woodland	006	9, 10	5.0-20.0	20	E.haemastoma,E.sieberi	0-1.0	75	Banskia spinulosa, Acacia myrtifolia, Isopogen sp.	Nil	Nil	Nil
Upland Swamp - Sedgeland Heath Complex	007	13, 14	Nil	Nil	Nil	1.5-3.0	15	Banksia oblongifolia, Isopogen anemonifolius, Acacia linearifolia	0-1.5	85	Eurycorda complanata, Leptocarpus tenax, Baumea acuta
Exposed Sandstone Scribbly Gum Woodland	008	7, 8	5.0-15.0	15	E.haemostoma, E.sieberi	0.5-3.0	15	Banksia sp.	0.-0.5	65	Hakea dactyloides, Isopogen sessilis, Grevillea oleoides
Exposed Sandstone Scribbly Gum Woodland	009	1, 2, 3	5.0-15.0	15	E.haemostoma, Corymbia gummifera	0.5-3.0	20	Bansksia sp.	0-0.5	70	Hakea sp., Grevillea sp.
Upland Swamp - Fringing Eucalypt Woodland	010	3215, 3216	10.0	5	E.racemosa	1.5		Banksia oblongifolia, A.falciformis, A.linearifolia	0.5		Eurycorda complanata, Leptospermum sp.
Sandstone Gully Peppermint Forest	013	3213, 3214	20.0	45	E.globoidea, E.eugenoides, Allocasuarina torulosa	2.0	15	Allocasuarina torulosa, Banksia spinulosa, Hakea sericea	0.3	15	Dianella sp. Lomandra sp.
Upland Swamp - Fringing Eucalypt Woodland	014	3219, 3220	7.0	10	E.racemosa, E.haemastoma	1.5	30	Leptospermum juniperum, Acacia linearis, Banksia ericifolia	0.3	30	Isopogen anemonifolius, Hibbertia pedunculata, Kunzea capitata
Upland Swamp - Sedgeland Heath Complex	015		Nil	Nil	Nil						
Sandstone Gully Peppermint Forest	017	11, 12	5.0-20.0	10	E.piperita	1.0-5.0	35	Banksia sp., Grevillea sp., Haekea sp.	0-0.5	20	Fern sp., Bauera rubioides, Gonocarpus teucrioides, Empodisma minus
Exposed Sandstone Scribbly Gum Woodland	018	19, 20, 21	5.0-20.0	10	E.piperita, Corymbia gummifera	0.5-3.0	45	Banksia sp., Isopogon sp., Acacia sp., Leptospermum sp.	0-0.3	15	Entolasia sp., Caustis flexuosa, Leptocarpus sp. Lomandra sp.
Exposed Sandstone Scribbly Gum Woodland	021	22, 23, 24	5.0-15.0	15	E.racemosa x haemastoma, C.gummifera	0.5-3.0	15	Banksia sp., Isopogon sp. Leptospermum sp.	0-0.5	40	Caustis flexuosa, Epacris sp., Lomandra multiflora.
Sandstone Gully Peppermint Forest	023	15, 16, 17, 18	5.0-20	20	E.piperita	1.0-5.0	55	Acacia sp., Banksia sp., Hakea sp.	0-0.5	15	Lomandra longifolia, Gonocarpus teucrioides, Empodisma minus
Upland Swamp - Fringing Eucalypt Woodland	024a	3221, 3222	Nil	Nil	Nil	Nil	Nil	Nil	0.4	90	Xanthorrhoea resinosa, Eurychorda complanata, Lepyrodia anarthria
Upland Swamp - Sedgeland Heath Complex	024b	3223, 3224	2.5	60	Leptospermum juniperum	Nil	Nil	Nil	1.0	60	Lepyrodia scariosa
Exposed Sandstone Scribbly Gum Woodland	025	25, 26	5.0-20.0	10	E. racemosa x haemastoma, Corymbia gummifera, E. seiberi	1.0-5.0	25	Banksia sp., Isopogon sp. Leptospermum sp.	0-1.0	50	Lomandra longifolia, Caustis flexuosa
Upland Swamp - Tea Tree Thicket	028	3225	2.0	60	Leptospermum juniperum, L.l anigerum, Banksia robur	Nil	Nil	Nil	0.5	70	Lepyrodia scariosa
Upland Swamp - Sedgeland Heath Complex	029	3226, 3227	Nil	Nil	Nil	1.0		Banksia oblongifolia, Hakea dactyloides, Hakea teretifolia	0.3		Caustis flexuosa, Leptocarpus tenax, Eurychorda complanata, Gymnoschoenus sphaerocephalus
Sandstone Gully Peppermint Forest	101	3228, 3229	25.0	40	E. piperita, Corymbia gummifera	3.0	25	Acacia binervia, Persoonia isophylla	Nil	Nil	Nil
Tall Open Blackbutt Forest	102	31, 32, 33	5.0-35.0	30	E. piperita, E.p ilularis	1.0-5.0	15	Acacia sp., Leptospermum sp., Leucopogon sp., Elaeocarpus reticulatus	0-1.0	20	Lomandra longifolia , Fern sp.
Exposed Sandstone Scribbly Gum Woodland	103	27, 28, 29, 30	5.0-30	5	E. racemosa, E. piperita	2.0-5.0	15	Banksia sp., Acacia sp., Petrophile sessilis	0-1.0	60	Lomandra sp., Pteridium sp., Gleichenia sp., Caustis flexuosa
Upland Swamp - Banksia Thicket	104		45.0	25	E.smithii	25.0	85	Doryphora sassafras, Ceratopetalum apetalum	0.5		Sparse ferns

Veg Community	Site	Photo	Canopy Height (m)	Cover (%)	Dominant Spp.	Midstorey Height (m)	Cover (%)	Dominant Spp.	Ground Height (m)	Cover (%)	Dominant Spp.
Moist Blue Gum Blackbutt Forest	105	41, 42, 43	10.0-40.0	50	*E. pilularis, Syncarpia* sp.	1.0-5.0	8	*Acmena smithii*	10.0-40.0	50	*E. pilularis, Syncarpia* sp.
Moist Blue Gum Blackbutt Forest	106	34 - 40	5.0-25.0	25	*Eucalyptus* sp.	2.0-5.0	10	*Acacia* sp., *Leptospermum* sp., *Leucopogon* sp.	0-1.0	30	*Lomandra* sp., *Pteridium* sp.
Coachwood Warm Temperate Rainforest	107	3236, 3237	25.0	80	*Acmena smithii, Ceratopetalum apetalum, Doryphora sassafras*	4.0	20	*Doryphora sassafras, Trachocarpa laurina*			
Tall Open Blackbutt Forest	108	44, 45, 46	5.0-40.0	20	*E. pipperita*	1.0-5.0	30	*Banksia* sp., *Acacia* sp., *Hakea* sp.	0-1.0	50	*Lomandra* sp., *Pteridium* sp.
Rock-plate Heath-mallee	109	3230, 3231	6.0	5	*Corymbia gummifera*	1.5	20	*Banksia erecifolia, Leptospermum polygalifolium, Hakea teretifolia*			
Upland Swamp - Sedgeland Heath Complex	112					2.0	35	*Leptospermum juniperum, Banksia robur*	0.5	70	*Lepidosperma* sp., *Gymnoschoenus* sp.
Regenerating Vegetation	113	52, 53, 54	14885.0	55	*E. pilularis, Syncarpia* sp.	1.0-5.0	10	Unidentifiable saplings	0-1.0	40	*Lomandra* sp.
Moist Blue Gum Blackbutt Forest	116	3238, 3239	30.0	60	*E. pilularis, Syncarpia* sp.	6.0	20	*Trochocarpa laurina, Prostanthera lasianthos, Nematolepis squamea*	0.5	25	*Gahnia* sp., Soft fern
Cleared Land	117A	55, 56, 57	5-20.0	15	*E. racemosa, E. seiberi*	1.0-5.0	20	*Banksia* sp., *Acacia* sp., *Empodisma* sp.	0-1.0	40	*Lomandra* sp., *Isopogon* sp., *Leptocarpus* sp.
Upland Swamp - Sedgeland Heath Complex	117B	3240, 3241						*Lepidosperma* sp., *Boronia* sp.			*Xanthorrhoea resinosa, Xyris* sp., *Juncus* sp.

Site & Cover Abundance

Scientific Name	***Common Name***	***WP001***	***WP002***	***WP003***	***WP004***	***WP009***	***WP011***	***WP012***	***WP013***	***WP014***	***WP015***	***WP016***	***WP017***	***WP020***	***WP021***	***WP022***	***WP023***
Acacia linearifolia	Wattle	2															
Acacia myrtifolia	Myrtle Wattle		1														
Acacia rubida																	4
Acacia suaveolens	Sweet-scented Wattle					1											
Acacia ulicifolia	Prickly Moses						1										
Allocasuarina littoralis	Black She-oak									1				2			
Allocasuarina nana	Dwarf She-oak			4	2											1	
Allocasuarina paludosa				3	2											1	
Anisopogon avenaceus	Oat Speargrass								1		1	1					
Asplenium flabellifolium	Necklace Fern									1				3	2	1	2
Banksia ericifolia	Heath-leaved Banksia	6				4	2	6	6	4	6	3	3			3	
Banksia marginata	Silver Banksia	2															
Banksia oblongifolia		2	4	5	6					1				2	2	3	4
Banksia robur	Swamp Banksia					2	2	2		2			2				2
Banksia serrata	Old Man Banksia	1	2														
Banksia spinulosa	Hair-pin Banksia		1														
Bauerea rubioides	River Rose	4					1										
Baumea articulata	Jointed Twig-rush																4
Baumea rubiginosa	Soft Twig-rush		3														1
Baurea microphylla																1	
Boronia parviflora	Swamp Boronia															1	3
Callistemon citrinus	Crimson Bottlebrush																
Cassytha glabella	Slender Devil's Twine	2	1						2		2						
Comersperma ericinum	Matchheads															3	
Conospermum tenuifolium	Grass-leaved Conospermum	2															
Corymbia gummifera	Red Bloodwood								2		2						
Dampiera stricta										2							
Darwinia grandiflora										**1**							
Dillwynia floribunda	Parrot-pea	3	6			3	1	1	1	1	1					1	
Drosera binata	Forked Sundew									1							
Drosera peltata	Pale Sundew					2											
Drosera spatulata	Common Sundew					2		1									
Eleocharis sp.								1									3
Empodisma minus	Spreading Rope Rush					2		1	2		2	2			3		
Entolasia stricta									1		1						2
Epacris microphylla	Coral Heath	2				3	1									2	
Epacris obtusifolia		2				2	2									2	2
Epacris paludosa	Swamp Epacris																
Epacris pulchella	NSW Coral Heath		2														
Eucalyptus racemosa	Scribbly Gum	2	2		1	1						3				2	
Eucalyptus sieberi	Silvertop Ash		2						2		2	2					
Gahnia sieberana	Saw Sedge						1						3				6
Gleichena sp.						1	5						5				
Grevillea diffusa			2			1				1							
Grevillea mucronulata	Green Spider Flower	1	1														
Gymnoschoenus sphaerocephalus	Button Grass					1	4										
Hakea dactyloides	Finger Hakea		1		2		1		1		1						
Hakea sericea	Bushy Needlebush	2	5						2		2	3			3		
Hakea teretifolia	Dagger Hakea	2	4	4	2	2	1	3	2	3	2	3	3			3	1
Hibbertia riparia				2	2											2	
Hibbertia rufa				2	2												
Isopogon anemonifolius	Broad-leaf Drumstick	1	1											2	3	1	
Jacksonia scoparia	Dogwood		1							1							
Lepidosperma laterale	Variable Sword-sedge	1			2			6		4			4			1	

Site & Cover Abundance

Scientific Name	***Common Name***	***WP001***	***WP002***	***WP003***	***WP004***	***WP009***	***WP011***	***WP012***	***WP013***	***WP014***	***WP015***	***WP016***	***WP017***	***WP020***	***WP021***	***WP022***	***WP023***
Lepidosperma sp.					2												
Leptocarpus tenax	Slender Twine-rush	3	4	5	3	4		2	2	3	2			6	6	6	
Leptospermum continentale				3	2												4
Leptospermum juniperinum	Prickly Tea-tree		2			1	1	3									
Leptospermum lanigerum	Woolly Tea-tree					1	1	2		1							
Leptospermum morrisonii						2											
Leptospermum polygalifolium	Lemon-scented Tea-tree								1		1			4	4		
Leptospermum rotundifolium	Round-leaf Tea-tree					5	1	3	3	3	3						
Leptospermum trinervium	Paperbark Tea-tree		3														
Lepyrodia scariosa	Scale Rush								1		1						
Lomandra longifolia	Mat Rush								3		3				3		2
Lomandra obliqua	Fish Bones								2		2						
Lomatia silaifolia	Crinkle Bush	1															
Luecopogon microphyllus	Small-leaved Beard-heath					1											
Luecopogon virgatus			2														
Melalueca decora	White Feather Honey-myrtle		1														
Melalueca squamea	Swamp Honeymyrtle						3										
Melalueca squarrosa	Scented Paperbark						1	3		1							
Melalueca thymifolia	Thyme Honey-myrtle		3	4	4												
Microlaena stipoides	Weeping Rice Grass				2												
Micromyrtus ciliata			2														
Olax stricta	Olax									1							
Parsonia straminea	Monkey Rope								1		1						
Persoonia levis	Smooth Geebung									1							
Persoonia linearis	Narrow-leaved Geebung									1							
Persoonia sp.						1											
Petrophile pulchella			2			2	1		1		1						
Petrophile sessilis	Prickly Cone-stick	2	3														
Pimelea linifolia	Rice Flower		2														
Pteridium sp.	Bracken								1		1						
Pultenaea aristata	**Prickly Bush-pea**					**1**				**1**							
Schoenus brevifolius	Zig-zag Bog-rush					2				6							
Schoenus sp.		6		2	2				6		6						
Selaginella uliginosa			1							2				3		3	
Sprengelia incarnata						2	1	1								2	
Xanthorrhea sp.	Grass-tree	1	1	2		3				1						5	

	Area Search waypoints	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023	024	025													Incidentals	Biosis incidentals
	Point Count waypoints																										001	002	003	005	006	008	009	012	015	020	021	024		
Australian Magpie	*Gymnorhina tibicen*																																							y
Australian Owlet-nightjar	*Aegotheles cristatus*																																							y
Australian Raven	*Corvus coronoides*															3																								y
Azure Kingfisher	*Alcedo azurea*																																						y	y
Beautiful Firetail	***Stagonopleura bella***															**1**																			**y**					**y**
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	2							2			2					2							5																y
Black-faced Monarch	*Monarcha melanopsis*																																						y	
Brown Cuckoo-dove	*Macropygia amboinensis*																																						y	
Brown Gerygone	*Gerygone mouki*									i				1	6			1	1	2						1										y				y
Brown Goshawk	*Accipiter fasciatus*																																							y
Brown Thornbill	*Acanthiza pusilla*					1			1	1						1			1			1			3						y		y		y					y
Brown-headed Honeyeater	*Melithreptus brevirostris*															6								5																
Cicadabird	*Coracina tenuirostris*																			5																				
Common Myna*	*Acridotheres tristis*																																							y
Crimson Rosella	*Platycercus elegans*			3	i	i	1		2		1	i	7	4		6	i		3	2	i						y							y		y	y			y
Crusted Shrike-tit	*Falcunculus frontatus*												4																											
Eastern Spinebill	*Acanthorhynchus tenuirostris*	4	1	3	12	14	11	1		1	8	4		2	1	4	2	8	1	1	3		1	5	7	3					y	y	y	y	y		y			y
Eastern Whipbird	*Psophodes olivaceus*								1			i				1	i	1																		y	y			y
Eastern Yellow Robin	*Eopsaltria australis*			1							1		1	1		1		4							2											y	y			
Fan-tailed Cuckoo	*Cacomantis flabelliformis*																														y	y	y			y				
Galah	*Eolophus roseicapillus*			1																																				
Glossy Black-cockatoo	***Calyptorhynchus lathami***									**i**		**i**	**i**				**1**	**i**	**i**																					
Golden Whistler	*Pachycephala pectoralis*				1				3					2					1					2		2	y		y			y		y		y				
Grey Butcherbird	*Cracticus torquatus*																																							y
Grey Fantail	*Rhipidura albiscapa*			1	2	1		1	1		1	3	2	1			1		2	3	2	5		1	3	2	y	y	y	y	y	y		y	y	y	y			y
Grey Shrike-thrush	*Colluricincla harmonica*																											y				y								y
Laughing Kookaburra	*Dacelo novaeguineae*																																							y
Lewin's Honeyeater	*Meliphaga lewinii*																												y	y						y				y
Little Wattlebird	*Anthochaera chrysoptera*	4	i		1	2	3	5			7	3	3	5		4	7	3			2		2	6		2														y
Masked Lapwing	*Vanellus miles*																																							y
Mistletoebird	*Dicaeum hirundinaceum*																																							y
New Holland Honeyeater	*Phylidonyris novaehollandiae*	9			11	4	7	12			4	1	4	3	2	8	6	6		1	1	5		3	3						y	y	y		y					y
Noisy Friarbird	*Philemon corniculatus*	2	i	28		5	5			i		i		1										6																y
Peregrine Falcon	*Falco peregrinus*																																					y		
Pied Butcherbird	*Cracticus nigrogularis*																						1																	
Pied Currawong	*Strepera graculina*	1				i					3						i		1	i	i	1														y				y
Powerful Owl	***Ninox strenua***																																						**y**	
Rainbow Lorikeet	*Trichoglossus haematodus*			3							2			3				i	2					2																y
Red Wattlebird	*Anthochaera carunculata*																																							y
Red-browed Finch	*Neochmia temporalis*															i																								y
Rufous Fantail	*Rhipidura rufifrons*																		1																					
Rufous Whistler	*Pachycephala rufiventris*																										y		y					y						y
Satin Bowerbird	*Ptilonorhynchus violaceus*																																							y
Silvereye	*Zosterops lateralis*							i																																y
Southern Boobook	*Ninox novaeseelandiae*																																						y	y
Southern Emu-wren	***Stipiturus malachurus***				**2**	**6**				**i**							**1**					**4**	**3**																	
Spotted Pardalote	*Pardalotus punctatus*		2				2				1	2	2		2	4											y	y	y	y				y		y				y
Striated Thornbill	*Acanthiza lineata*																																							y
Sulphur-crested Cockatoo	*Cacatua galerita*																																			y				
Superb Fairy-wren	*Malurus cyaneus*																										y	y					y							y
Superb Lyrebird	*Menura novaehollandiae*																			2		i																		y
Tree Martin	*Hirundo nigricans*																3																							y
Variegated Fairywren	*Malurus lamberti*											1	7									4	6	10	5								y	y						
Welcome Swallow	*Hirundo neoxena*	2															2					3																		
White-bellied Cuckoo-shrike	*Coracina papuensis*			1																																				
White-browed Scrubwren	*Sericornis frontalis*	1	3		4	2			6			3	2	1		2		2	3	1	3	4	6	1	3					y	y		y							y
White-eared Honeyeater	*Lichenostomus leucotis*	3							1					2										1		1														y
White-throated Gerygone	*Gerygone albogularis*					1																		1																
White-throated Treecreeper	*Cormobates leucophaeus*			1	2					1	1	1		1	2	2			2	1		1				1	y					y		y						y
Yellow-faced Honeyeater	*Lichenostomus chrysops*					2	6		1					3				6										y		y				y	y					y
Yellow-tailed Black-cockatoo	*Calyptorhynchus funereus*				i																																			y

Legend		
	i	Incidental observation
	CP	Call playback response
	h	Heard
	y	Presence of species noted, abundance not recorded

Annex E

Assessments of Significance for Threatened Species and Ecological Communities

E.1 ASSESSMENTS OF SIGNIFICANCE

This Annex provides the Assessments of Significance (7 Part Tests) undertaken for the Project pursuant to the TSC Act. Threatened species and ecological communities assessed here have been selected for inclusion following the process outlined in *Section* ***Error! Reference source not found.***.

E.1.1 Threatened Flora

Table E.1 *Acacia baueri* subsp. *aspera*

Acacia baueri subsp. *aspera* is listed as Vulnerable under the TSC Act. Restricted to the Sydney region, populations of this species are known from the Kings Tableland in the central Blue Mountains, the Woronora Plateau in the Royal National Park, the Mount Keira district and Wedderburn (DECCW, 2010). Within this distribution range, this species is found within low, damp heathlands, often on exposed rocky outcrops over a wide range of climatic and topographical conditions (DECCW, 2010). It is identified as a species associated with cliffs, rock benches or overhangs (DECC 2007a).

This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat and was also considered to be vulnerable to impacts associated with subsidence.

Acacia baueri is identified as a species that is not able to withstand loss within the Hawkesbury Nepean Catchment and is considered to have state special significance (DECCW 2011).

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	On the Woronora Plateau, *Acacia baueri* subsp. *aspera* occurs in dry to damp heath associated with more open areas within Sandstone Woodland (Keith 1994). Known populations occur along Mt. Keira Rd and it is considered there is a moderate likelihood that the species occurs in the Study Area. The maximum predicted subsidence in potential habitat areas is up to 2.5 m. This level of subsidence is considered unlikely to impact vegetation communities and it is therefore predicted that the life cycle of will not be affected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area. Therefore, potential habitat and or individuals will not be directly removed. There is potential for modification of habitat to occur as a result of subsidence, however the predicted maximum subsidence of up to 2.5 m is considered unlikely to result in the modification of habitat that would be suitable for *Acacia baueri* subsp. *aspera*.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	There is potential for modification of habitat to occur as a result of subsidence, however the predicted maximum subsidence of up to 2.5 m is considered unlikely to result in the modification of habitat such that habitat would be cleared resulting in fragmentation or isolation.

Table E.1	*Acacia baueri* subsp. *aspera*
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Acacia baueri subsp. *aspera* occurs sporadically, in small populations (usually <30 plants). There will be no removal of, and it is unlikely that modification or fragmentation of habitat for *Acacia baueri* subsp. *aspera* will result from the Project. *Acacia baueri* subsp. *aspera* was not recorded within the Study Area. If the species occurred within the Study Area it may be considered an important population within the local and regional context due to the fragmented distribution of the species and being located within SCA land which is considered a protected area.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for *Acacia baueri* subsp. *aspera*.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for *Acacia baueri* subsp. *aspera*, however NSW DECCW has identified the following actions for the recovery of the species including: • ensure personnel undertaking roadside maintenance are able to identify species and habitat; • introduce measures to prevent habitat degredation related to unrestricted access to habitat; • undertake appropriate weed control activities where necessary; • protect habitat from clearing and fragmentation; and • effective management of species will require greater understanding of role of fire.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Key Threatening Processes (KTP) for *Acacia baueri* subsp *aspera* includes vegetation clearance, inappropriate fire regimes and habitat degradation from invasive weed species. The Project is unlikely to result directly in or increase the impact of any of these KTP. The Project will result in or increase the impact of the KTP alteration of habitat following subsidence due to longwall mining. *Acacia baueri* subsp *aspera* is identified as a species that is not able to withstand loss within the Hawkesbury Nepean Catchment and is considered to have state special significance as a swamp specialist (DECCW 2011). The alteration of *Acacia baueri* subsp. *aspera* habitat (rock benches) is considered unlikely and as a result this is not considered to constitute a KTP.

Table E.2	*Epacris purpurascens* var. *purpurascens*
Epacris purpurascens var. *purpurascens* is listed as Vulnerable under the TSC Act. This species occurs within a restricted distribution range, from Gosford in the north, to Narrabeen in the east, Silverdale in the west and Avon Dam in the south, where it is found within a range of habitat types, most of which have a strong shale soil influence (DECCW, 2010). This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat and is also identified by DECC (2007a) as vulnerable to impacts associated with subsidence.	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Epacris purpurascens var. *purpurascens* is considered to have a moderate likelihood of occurrence within the Study Area. It is most likely to be found in areas with a strong shale influence, in a range of community types; including ridgetop drainage depressions supporting wet heath within or adjoining shale cap communities such as the Shale-Sandstone Transition Forest EEC identified in the Study Area. The species also occurs in riparian zones draining into Sydney Sandstone Gully Forest. The FMEA (Olsen Consulting 2010) identified potential impacts in the Shale Sandstone Transition Forest EEC as low risk. Therefore it is considered unlikely that the Project will have an adverse effect on species within this community. The maximum predicted subsidence in potential habitat areas is approximately 2.3m and is not predicted to impact vegetation communities. It is therefore considered that the life cycle of will not be affected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.

Table E.2	*Epacris purpurascens* var. *purpurascens*
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area. Therefore, the removal of *Epacris purpurascens* var. *purpurascens* habitat will not occur due to the Project. There is potential for modification of habitat to occur as a result of subsidence, however the predicted maximum subsidence of 2.3m is considered unlikely to result in the modification of habitat that would be suitable for *Epacris purpurascens* var. *purpurascens*.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	There is potential for modification of habitat to occur as a result of subsidence, however the predicted maximum subsidence of 2.3m (Seedsman 2012) in potential habitat areas is considered unlikely to result in the modification of habitat that would be suitable for *Epacris purpurascens* var. *purpurascens*. Therefore, it is considered that an area of habitat is unlikely to become fragmented or isolated from other areas of habitat as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	There will be no removal of, and it is unlikely that modification or fragmentation of habitat for *Epacris purpurascens* var. *purpurascens* will result from the Project.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for *Epacris purpurascens* var. *purpurascens*, however, the NSW DECCW has identified the following actions for the recovery of the species including: • Liaise with land managers to encourage the preparation of site management plans and the implementation of appropriate threat abatement measures, such as weed control/bush regeneration, site protection (fencing/signage) and fire management; • Undertake targeted bush regeneration works, where required; and • Monitor known populations so that potential local extinctions are detected before they occur and mechanisms can be put in place to reverse trends.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	The Project may result in or increase the impact of the KTP alteration of habitat following subsidence due to longwall mining. The alteration of *Epacris purpurascens* var. *purpurascens* habitat is considered low risk and as a result this is considered unlikely to constitute a KTP.

Table E.3 Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)

The Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*) is listed as Vulnerable under the TSC Act and Vulnerable under the EPBC Act. This species occurs sporadically throughout the Sydney Basin with the main occurrences centred on Picton, Appin and Bargo (DECCW, 2010). It grows in sandy or light clay soils, usually over thin shales, within a range of vegetation types from heath and shrubby woodland to open forest, and has often been recorded in slightly disturbed areas (e.g. on the edges of tracks) (DECCW, 2010). The species is usually associated with upper slopes and ridge crests.

This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence, in particular within the Shale-Sandstone Transition Forest EEC and sandstone dry forest. Small-flowered Grevillea is identified by DECC (2007a) as vulnerable to impacts associated with subsidence.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Small-flower Grevillea is considered to have a moderate likelihood of occurrence within the Study Area. It has been recorded in a range of vegetation types, from heath and shrubby woodland to open forest including Shale-Sandstone Transition Forest EEC identified in the Study Area.

The Project will not clear potential habitat or directly decrease the size of the population in the Study Area. The FMEA (Olsen Consulting 2010) identified a low risk of potential impacts and negative environmental consequences in the Shale Sandstone Transition Forest EEC. Therefore, it is unlikely that the Project will have an adverse effect on species within this community.

Flowering of Small-flower Grevillea has been recorded from July to December and in April to May. Flowers are insect pollinated and seeds are released at maturity probably with minimal local dispersal of seed. Small-flower Grevillea can regenerate from rhizomes. The potential impacts of the Project are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. Therefore, it is unlikely that the life cycle of the Small-flower Grevillea will be affected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Project will not involve any clearance of vegetation within the Study Area. Therefore, the removal of Small-flower Grevillea habitat will not occur as a result of the Project.

Small-flower Grevillea may occur in a range of vegetation types across the Study Area; from heath and shrubby woodland to open forest including the Shale-Sandstone Transition Forest EEC identified in the Study Area. The FMEA (Olsen Consulting 2010) identified potential impacts in the Shale Sandstone Transition Forest EEC as low risk. It is unlikely that the Project will result in the significant modification of Small-flower Grevillea habitat.

Table E.3	Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Potential habitat within the Study Area for Small-flower Grevillea is widespread throughout the Study Area providing a connectivity of habitat for the species. The Project will not involve any clearance of native vegetation and the up to 2.5m subsidence predicted in suitable habitat areas is not anticipated to impact vegetation communities. The FMEA (Olsen Consulting 2010) has assessed a low risk for adverse impacts to occur in the potential Small-flower Grevillea habitat in Shale Sandstone Transition Forest EEC. Therefore, it is unlikely that there will be any fragmentation or isolation of habitat for Small-flower Grevillea.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	There will be no removal, and it is unlikely there will be fragmentation of potential habitat for Small-flower Grevillea resulting from the Project. According to the FMEA (Olsen Consulting 2010) there is a low risk for subsidence related impacts on Shale Sandstone Transition Forest EEC areas and terrestrial vegetation resulting from the Project.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Small-flower Grevillea.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Small-flower Grevillea, however, the NSW DECCW has identified five priority actions for the recovery of the species including: • liaise with land managers to encourage the preparation of site management plans and the implementation of appropriate threat abatement measures, particularly in fire management, bush regeneration, roadside management, weed control and fencing and signage; • monitor known populations, so that potential local extinctions are detected before they occur and mechanisms can be put in place to reverse trends; and • identify and survey potential habitat to detect new populations.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration of Small-flower Grevillea habitat is considered low risk (FMEA; Olsen Consulting 2010).

Table E.4	Woronora Beard-heath (*Leucopogon exolasius*)
The Woronora Beard-heath (*Leucopogon exolasius*) is listed as Vulnerable under the TSC Act and Vulnerable under the EPBC Act. This species is known from the upper Georges River area and the Heathcote National Park where it is found growing in woodland on sandstone and is often associated with rocky hillsides and creek lines (DECCW, 2010). Woronora Beard-heath is known to be associated with Sydney Coastal Dry Sclerophyll Forests and coastal heath on sandstone plateaus, and riverine forests characterised by Water Gum-Coachwood scrub along sandstone streams (OEH online profile). This species was not recorded within the Study Area during field investigations although was considered to have a moderate to high likelihood of occurrence in communities along the creeks based on the availability of suitable habitat. Woronora Beard-heath is identified by DECC (2007a) as vulnerable to impacts associated with subsidence.	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The Tall Open Peppermint-Blue Gum Forest, Sandstone Gully Peppermint Forest and Exposed Sandstone Scribbly Gum Forest within the Study Area provide potential habitat for Woronora Beard-heath. Areas of all of these communities are located within the subsidence impact zone. Maximum predicted subsidence within these areas is 2.5m (Seedsman 2012); this level of subsidence is considered unlikely to significantly impact vegetation communities.

Table E.4	Woronora Beard-heath (*Leucopogon exolasius*)
	Woronora Beard-heath produces a fruit (drupe) which is most likely distributed by ants. Pollination is most likely by bees or other small insects. The potential impacts of the Project are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. Therefore, it is unlikely that the life cycle of the Woronora Beard-heath will be effected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*In relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area. Therefore, the removal of Woronora Beard-heath habitat will not occur due to the Project. The predicted ground surface movements and valley related movements within the Study Area, in particular areas containing Tall Open Peppermint-Blue Gum Forest, Sandstone Gully Peppermint Forest or Exposed Sandstone Scribbly Gum Forest, are very low and no significant surface impacts to ecology are expected. Therefore, potential modification of Woronora Beard-heath habitat resulting from the Project is considered minimal.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	The forested areas identified as potential habitat within the Study Area for Woronora Beard-heath including Tall Open Peppermint-Blue Gum Forest, Sandstone Gully Peppermint Forest and Exposed Sandstone Scribbly Gum Forest are widespread throughout the Study Area providing connectivity of habitat for the species. The Project will not involve any clearance of native vegetation and predicted impacts to these areas are minimal. Therefore, there will be no fragmentation or isolation of habitat for Woronora Beard-heath.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	There will be no removal or fragmentation of potential habitat for Woronora Beard-heath resulting from the Project and potential for modification of habitat for the species resulting from the Project is low. If the species occurred within the Study Area the Tall Open Peppermint-Blue Gum Forest, Sandstone Gully Peppermint Forest and Exposed Sandstone Scribbly Gum Forest would be considered to be important habitat within the local context due to its connectivity and being located within SCA land which is considered a protected area.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Woronora Beard-heath.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Woronora Beard-heath, however, the NSW DECCW has identified the seven priority actions for the recovery of the species including: • establish ex situ seed bank; • negotiate with public authorities to prepare and implement site management statements to

Table E.4	Woronora Beard-heath (*Leucopogon exolasius*)
	address threats for sites on their land; and • prepare and implement site management statements to address threats at sites on DEC lands.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The Project has potential to cause alteration or modification of Woronora Beard-heath habitat, but this has been classified as low risk and is therefore unlikely to constitute the operation of the KTP.

Table E.5	Deane's Paperbark (*Melaleuca deanei*)
Deane's Paperbark (*Melaleuca deanei*) is listed as Vulnerable under the TSC Act and Vulnerable under the EPBC Act. This species occurs within two distinct areas in the Ku-ring-gai/Berowra and Holsworthy/Wedderburn areas, although more isolated occurrences are also known from the Blue Mountains, Wollemi National Park, the Nowra region and the Hawkesbury River (DECCW, 2010). In the southern area there are three populations known from the Wollondilly LGA and this represents 3.2% of all populations (n=94) (DECCW 2010). Deane's Paperbark was recorded recently at the Metropolitan Colliery (WRI 2009). Within this distribution range, Deane's Paperbark grows in heath communities on sandstone mostly occupying broad flat ridgetops, dry ridges and slopes, strongly associated with sandy loam soils low in nutrients sometimes with ironstone present (DECCW, 2010). This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat and was also considered to be vulnerable to impacts associated with subsidence.	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The Project does not involve clearance of vegetation and potential impacts are related to subsidence and include cracking of surface and sub-surface, lowering of the water table beyond the reach of plants. There is a maximum predicted subsidence of up to 2.5 m and maximum predicted tilt of 15 mm/m under terrestrial vegetation communities on the sandstone plateau in Wonga West. This subsidence is unlikely to result in significant impacts on the vegetation community structure. Deane's Paperbark is an infrequent flowering shrub that is most likely to be pollinated by insects (DECCW 2010). It is a clonal species, that has the ability of re-sprout and this may be the main mechanism for recruitment (DECCW 2010). Seeds are produced in woody capsules held on the plant for several years with release triggered by dehydration (DECCW 2010). The potential impacts of the Project are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. Therefore, it is unlikely that the life cycle of the Deane's Paperbark will be affected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*

Table E.5 Deane's Paperbark (*Melaleuca deanei*)

	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of vegetation within the Study Area. Therefore, the direct removal of Deane's Paperbark habitat will not occur due to the Project. Modification to some of the upland swamps within the study may occur as a result of subsidence associated with the Project. It is not anticipated that there will be more than negligible impacts on terrestrial habitats for this species. While habitat modification may occur as a result of the Project, it is unlikely that habitat will be modified to a degree that would impact the species.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	The Project is unlikely to result in fragmentation or isolation of 'terrestrial' vegetation specifically vegetation associated with the shale/sandstone transition soils in Wonga West. It is unlikely that habitat will be fragmented or isolated as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Potential habitat in the Study Area will not be removed, fragmented and or modified such that it would threaten the survival of the species in the locality.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for Deane's Paperbark.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A draft national and state recovery plan has been prepared for Deane's Paperbark (DECCW 2010b). The overall objective of this recovery plan is to ensure the long-term survival of *Melaleuca deanei* in the wild by promoting in situ conservation. The recovery actions detailed in this plan include: • to protect a representative sample of populations on public and private lands; • to identify and manage the threats operating at sites that contain the species; • to conduct surveys and research that will assist with the management of the species; and • to raise awareness about the threats to the species and involve the community in the recovery program. It is intended that the recovery plan will be implemented over a five-year period. The actions in this plan will primarily be undertaken by OEH. The Project in not inconsistent with any of these objectives, and has added to the program by surveying for the species.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The Project has potential to cause alteration or modification of Deane's Paperbark habitat, but this has been classified as low risk and is therefore unlikely to constitute the operation of the KTP.

Table E.6	**Bargo Geebung (*Persoonia bargoensis*)**
Bargo Geebung (*Persoonia bargoensis*) is listed as Vulnerable under the EPBC Act and Endangered under the TSC Act. Restricted to a small area on the western edge of the Woronora Plateau and the northern edge of the Southern Highland (OEH online profile). Historical limits are Picton and Douglas Park in the north, Yanderra in the south, Cataract River in the east and Thirlmere in the west. Grows in woodland to dry sclerophyll forest on sandstone and clayey laterite or heavier, well drained, loamy, gravelly soils of the Hawkesbury Sandstone and Wianamatta Shale in catchments of the Cataract, Cordeaux and Bargo River, between 100 and 300 m altitude (Weston & Johnson 1991; Harden 1991; Blombery & Maloney 1992; Weston 1995b). Known from Shale/Sandstone Transition Forest. This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat and was also considered to be vulnerable to impacts associated with subsidence.	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Suitable habitat for Bargo Geebung occurs in the Study Area in Shale Sandstone Forest in Wonga West. No vegetation clearance is associated with the Project and therefore potential impacts are related to subsidence and include cracking of surface and sub-surface, lowering of the water table beyond the reach of plants. The maximum predicted subsidence in potential habitat areas is approximately 2.3m and maximum predicted tilt of 15mm/m under the EEC. The mine design approach has recognised that the majority of the surface can be safely subsided (Seedsman 2012) and this level of subsidence is unlikely to impact on terrestrial vegetation communities and the species within them. Bargo Geebung is primarily germinated by bees. The Project is not expected to impact on germination. It is therefore predicted that the life cycle of this species will not be affected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area. Therefore, the removal of Bargo Geebung habitat will not occur due to the Project. There is potential for modification of habitat to occur as a result of subsidence, however the predicted maximum subsidence of 2.3m is considered unlikely to result in the modification of habitat that would be suitable for Bargo Geebung.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	There is potential for modification of habitat to occur as a result of subsidence, however the predicted maximum subsidence of 2.3m is considered unlikely to result in fragmentation or isolation of habitat as a result of the Project.

Table E.6	**Bargo Geebung (*Persoonia bargoensis*)**
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	There will be no removal of, and it is unlikely that modification or fragmentation of habitat for Bargo Geebung will result from the Project. Bargo Geebung was not recorded within the Study Area during field surveys. If the species occurred within the Study Area it would be considered an important population within the local and regional context due to the limited distribution of the species and being located within SCA land which is considered a protected area.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for Bargo Geebung.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for Bargo Geebung, however, the NSW DECCW has identified actions for the recovery of the species including: • Assess all sites to determine recovery priorities; • Incorporate site-specific threat abatement measures for the species into Plans of Management for sites in Sydney Catchment Authority areas; and • Carry out targeted surveys in potential habitat, particularly freehold lands, Crown land that may be alienated, leasehold Crown land and council-managed lands.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration of Bargo Geebung habitat as a result of underground mining is considered unlikely and as a result this is not considered to constitute a KTP.

Table E.7	**Prickly Bush-pea (*Pultenaea aristata*)**
The Prickly Bush-pea (*Pultenaea aristata*) is listed as Vulnerable under the TSC Act and Vulnerable under the EPBC Act. This species is restricted to the Woronora Plateau where it is found growing within dry sclerophyll woodland or wet heath on sandstone (OEH online profile). It is known from Upland Swamp Banksia Thicket and Restoid Heath Complex and in areas where drainage is poor in sandstone forest communities (TSSC 2008). It occurs in moist or dry sclerophyll woodland to wet heath on sandstone. This species has previously been recorded within Wonga West near Shaft No 5 (Kevin Mills and Associates, 1995). Field investigations by ERM and Biosis have identified the species in 15 of the 84 upland swamps in the Study Area, specifically CRUS1, CCUS3, CCUS10, CCUS8 and BCUS7 in the Wonga East area and upland swamps LCUS27, WCUS5, WCUS1, WCUS4, LCUS14, LCUS13, LCUS15, LCUS16, LCUS33, LCUS17 in the Wonga West area. In the majority of these swamps, the Prickly Bush-pea was recorded at the drier edge of the swamp communities. In the Bulli Seam Operation Area, Prickly Bush-pea occurred primarily in Restioid Heath and Fringing Eucalypt Woodland (FloraSearch 2009). The Prickly Bush-pea is considered to be vulnerable to impacts associated with subsidence (DECC 2007). Prickly Bush-pea is identified as a species that is not able to withstand loss of individuals within the Hawkesbury Nepean Catchment and is considered to have national special significance (DECCW 2011). Swamps supporting this species are considered to have national special significance.	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Prickly Bush-pea produces a hard coated seed, with recruitment of individuals occurring after fire. The potential impacts of the Project are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. The Project will not clear habitat for this species. GeoTerra (2012a) and Biosis (2012) reported possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking is predicted in some of the upland swamp areas. In an upland swamp risk assessment, Biosis (2012) have identified those upland swamps of 'special significance' that are at a greater than negligible risk of negative environmental consequence (based on subsidence criteria).

Table E.7	Prickly Bush-pea (*Pultenaea aristata*)
	Those upland swamps containing suitable habitat and identified as at a greater than negligible risk of negative environmental consequence include CCUS10 and CRUS1 in Wonga East and WCUS4 in Wonga West (Biosis 2012a). One other upland swamp (CCUS3) habitat is at a greater than negligible risk of negative environmental consequences and this swamp will be undermined by A2 LW5, and was the subject to separate approval. For all of the areas of confirmed habitat, the changes to hydrology in areas have been generally reported to be 'potential and minor'. Given that this species is associated with drier vegetation on the fringes of the upland swamps, it is considered unlikely that the life cycle of the Prickly Bush-pea will be affected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	Prickly Bush-pea has been recorded in 15 of the 84 upland swamps in the Study Area. This equates to approximately 65ha or 25% of the available upland swamp habitat in the Study Area. The Project will not involve any clearance of native vegetation or direct removal of habitat within the Study Area. GeoTerra (2012a) and Biosis (2012) predicted possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking in some of the upland swamp areas. Of the 65ha of confirmed upland swamp habitat in the Study Area approximately 23ha (35%) is at a greater than negligible risk of negative environmental consequences. Given that this species is associated with drier vegetation on the fringes of the upland swamps, it is unlikely that the habitat for this species will be modified. Terrestrial habitat for this species will be not removed and is unlikely to be modified by the proposed subsidence.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	The woodland areas identified as potential habitat within the Study Area for Prickly Bush-pea are widespread throughout the area providing connectivity of habitat for the species. The Project will not involve any clearance of native vegetation and predicted subsidence is not expected to impact vegetation in these areas. Upland swamp habitats, in particular headwater swamps, naturally occur with a patchy distribution. The majority of swamps in the Study Area occur within the Wallandoola Creek swamp cluster that is recognised as providing connectivity of habitat for swamp specialists. It is unlikely that habitat will be fragmented or isolated as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	There will be no direct habitat removal, and it is unlikely that there will be indirect removal or modification or fragmentation of drier habitat within the upland swamps from predicted subsidence such that this habitat area will be reduced. Notwithstanding this, the importance of the upland swamps in the Study Area for swamp specialist species has been recognised in the identification by DECC (2007a) of the broader Wallandoola Creek Swamp Cluster as one of four significant swamp clusters on the Woronora Plateau.

Table E.7	**Prickly Bush-pea (*Pultenaea aristata*)**
	Further upland swamps supporting this species are considered to have national special significance.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Prickly Bush-pea.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Prickly Bush-pea, however, the NSW DECCW has identified four priority actions for the recovery of the species: • Provide map of known occurrences to Rural Fire Service and seek inclusion of mitigative measures on Bush Fire Risk Management Plan(s), risk register and/or operation map(s); • Reserve Fire Management Strategy to include operational guidelines to protect this species from fire; • Review fire management requirements and apply; and • Confirm location details of existing records.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration of Prickly Bush-pea habitat is considered low risk (FMEA; Olsen Consulting 2010). GeoTerra (2012a) and Biosis (2012) predicted possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking in some of the upland swamp areas. The changes to hydrology in these areas have been generally reported to be 'potential and minor,' however as a result this is considered likely to constitute the operation of a KTP.

E.1.2 Threatened Birds

Table E.8	**Eastern Ground Parrot (*Pezoporus wallicus wallicus*)**
The Eastern Ground Parrot (*Pezoporus wallicus wallicus*) is listed as Vulnerable under the TSC Act. Within NSW, this species occurs in small numbers on the north coast and in the Myall Lakes area on the central coast, with larger populations occurring on the NSW south coast (DECCW, 2010). Within this distribution range, the Eastern Ground Parrot occurs within high rainfall coastal and near coastal areas containing low, dense heathlands and sedgelands that provide a high abundance and diversity of food resources, adequate cover and suitable nesting and roosting opportunities (DECCW, 2010). Home ranges for adults are typically 10ha. This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat. The Eastern Ground Parrot has been assessed as possibly locally extinct in the Greater Sydney Southern Region (DECC 2007c) and has not been recorded in the Metropolitan Special Area with all records from the O'Hares Special Area (DECC 2007d) to the north of the Study Area. The upland swamps on Woronora Plateau once supported many populations of this species however, there have been few records since frequent fires following the extensive fires in 1968 with populations thought to possible survive in the Maddens Plain or Stockyard Swamps area (near Metropolitan Colliery (Chafer pers comm in DECC 2007c). More recently, the Eastern Ground Parrot was detected on two occasions in the proposed Bulli Seam Operation to the north of the Study Area and two records at the Metropolitan Colliery Area (approximately 15km to the north east of the Study Area). It is also known from Barren Grounds Nature Reserve, Budderoo National Park, Jervis Bay area and Nadgee Nature Reserve. The Eastern Ground Parrot is an upland swamp specialist identified by DECC (2007a) as vulnerable to impacts associated with subsidence. Eastern Ground Parrot is identified as a species that is not able to withstand loss within the Hawkesbury Nepean Catchment and swamps that support this species are considered to have state special significance (DECCW 2011).	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Potential habitat for the Eastern Ground Parrot is associated with the Sedgeland-Heathland Complex in the upland swamps in the Study Area. This species has highest likelihood of occurring in the larger upland swamps in particular LCUS1, WCUS1, WCUS4 and smaller swamps associated with Lizard Creek between the access road to Shaft No 4 and the waterfall (see Figure A.2 in *Annex*

Table E.8	Eastern Ground Parrot (*Pezoporus wallicus wallicus*)
	A). The proposed mine will not undermine LCUS1 or WUCS1 or the swamps associate with Lizard Creek downstream of the access road to Shaft No 4. These upland swamps have been assessed as have a negligible (LCUS1, WCUS1) or low (LCUS8) or moderate (WCUS4) likelihood of negative environmental consequences from subsidence. The Eastern Ground Parrot breeds from September to December and nests are constructed in/under dense sedges or shrubs often with a tunnel in the dense vegetation. The Project will not directly clear habitat thereby avoiding disruption of breeding behaviour. It is unlikely that the Project will affect the life cycle of the Eastern Ground Parrot such that a viable local population of the species, if present, would be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation or removal of habitat within the Study Area. Modification to the larger upland swamps within the Study Area that provide potential habitat for the Eastern Ground Parrot in particular the larger swamps WCUS1 and LCUS1 and the upland swamps between the access road and Lizard Creek waterfall are unlikely to occur as a result of subsidence associated with the Project. The FMEA (Olsen Consulting 2010) identified low risk for subsidence impacts to result in loss of water holding capacity, and thus potential habitat for threatened species in the upland swamps. It is unlikely that potential habitat for Eastern Ground Parrot will be removed or modified as a result of the Project.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Upland swamp habitats, in particular headwater swamps, naturally occur with a patchy distribution. The majority of swamps in the Study Area occur within the Wallandoola Creek swamp cluster that is recognised as providing connectivity of habitat for swamp specialists. There is a low risk for subsidence impacts to result in loss of water holding capacity, and thus potential habitat for threatened species in the upland swamps. The potential minor changes to hydrology are considered unlikely to impact vegetation and the foraging and sheltering potential of the Eastern Ground Parrot. It is therefore unlikely that habitat will be fragmented or isolated as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Upland swamps in the Study Area form part of the Wallandoola Creek Swamp Cluster that is recognised as one of four important swamp clusters for specialist species in the region. The larger more complex upland swamps provide the only suitable Eastern Ground Parrot habitat within the Study Area. Within the Woronora Plateau, high and moderate quality habitat is concentrated in the Maddens Plain area to the north of the Study Area and to a lesser extent the upland swamps in the Study Area (DECC 2007c). It should be noted that the habitat map in that publication was not a predictive habitat map and is purely a map showing Sedgeland-Heath Complex as mapped by NPWS and was acknowledged as possibly over-predicting habitat extent (DECC 2007c). As stated above it is unlikely that this habitat will be significantly modified, fragmented or isolated as a result of the Project.

Table E.8	Eastern Ground Parrot (*Pezoporus wallicus wallicus*)
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Eastern Ground Parrot.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Eastern Ground Parrot, however, the NSW DECCW has identified the following actions for the recovery of the species including: • cat and dog management; • undertake fox and feral cat control programs, particularly after fire events; • protect habitat from intense and extensive fire events; • undertake research as to whether Psittacine Circoviral disease present in wild populations; • continue long-term monitoring of poulations to determine fire ecology to inform fire management strategies to include operational guidelines to protect this species from fire; • mapping of known and potential habitats; and • conduct surveys to determine distribution an abundance.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	KTP recognised for the Eastern Ground Parrot include vegetation clearance, too frequent fires, predation by feral cats and foxes, Psittacine Circoviral disease and dieback of heathland habitats from Phytophothora fungus. The Project is unlikely to result in or increase the impact of these recognised KTP for the Eastern Ground Parrot. Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. There is a negligible or low risk (Biosis 2012a) of alteration of potential Eastern Ground Parrot habitat, as a result this is considered likely to constitute the operation of a KTP.

E.1.3 Threatened Mammals

Table E.9	Eastern Pygmy-possum (*Cercartetus nanus*)
The Eastern Pygmy-possum (*Cercartetus nanus*) is listed as Vulnerable under the TSC Act. Within NSW, this species is distributed from the coast, inland to the western slopes as far as Pillaga, Dubbo, Parkes and Wagga Wagga (OEH online profile). This species prefers woodland and heath communities although is known to utilise a broad range of habitats from rainforest, to sclerophyll forest and woodland (including Box-Ironbark) and heath (OEH online profile). Within these communities, tree hollows, rotten stumps, holes in the ground, abandoned bird nests, Ringtail Possum (*Pseudocheirus peregrinus*) dreys or vegetation thickets are used for sheltering purposes (OEH online profile). On a regional scale the Eastern Pygmy-possum has been classified as an uncommon rare resident, possibly stable in the Southern Sydney region in Royal and Heathcote national parks and the Metropolitan Special Area in particular the Cataract and Cordeaux catchments (DECC 2007c). Habitat is associated with a high cover abundance of *Banskia ericifolia*, flatter areas and areas with a low coverage of grass (DECC 2007c). This species was recorded within the Study Area during field investigations in Exposed Sandstone Scribbly Gum Woodland and Upland Swamp: Fringing Eucalypt Woodland. The Eastern Pygmy-possum is considered to be vulnerable to impacts associated with subsidence (DECC 2007a). Eastern Pygmy-possum is identified as a species that is able to withstand loss within the Hawkesbury Nepean Catchment and swamps that support this species are considered to have regional significance (DECCW 2011).	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The Eastern Pygmy-possum has been recorded within the Study Area in Exposed Sandstone Scribbly Gum Woodland and Upland Swamp: Fringing Eucalypt Woodland. In woodland communities subsidence may result in tree fall/tilt and lowering of the water table below the reach of plant roots. The maximum predicted subsidence in the woodland potential habitat areas is up to 2.5m (Seedsman 2012); this level of subsidence is considered unlikely to result in degradation of the woodland communities. The FMEA (Olsen Consulting 2010) identified low risk for subsidence impacts to result in loss of

Table E.9	**Eastern Pygmy-possum (*Cercartetus nanus*)**
	water holding capacity, and thus potential habitat for threatened species in the upland swamps. The community Upland Swamps: Fringing Eucalypt Forest occurs on the drier margins of the upland swamps. This community was not included in the risk assessment undertaken by Biosis (2012a) and has been excluded from the EEC determination for Coastal Upland Swamps. Given that this community does occur on the drier margins there is a reduced reliance upon groundwater systems relative to other upland swamp communities and this community is more likely to able to withstand some losses in groundwater that may occur in undermined upland swamps. GeoTerra (2012a) and Biosis (2012a) reported possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking predicted in some of the upland swamps. The Eastern Pygmy-possum will utilise a wide range of habitats and is unlikely to be reliant upon areas that may potentially be affected by subsidence. It is therefore unlikely that the life cycle of the Eastern Pygmy-possum will be affected by the Project such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation and therefore no clearance of habitat within the Study Area. GeoTerra (2012a) and Biosis (2012a) reported potential minor changes to hydrology in some of the upland swamps. The potential minor changes to hydrology are considered unlikely to significantly impact vegetation to the degree that would impact the foraging and sheltering potential of the Eastern Pygmy-possum across the Study Area. The maximum predicted subsidence in the woodland potential habitat areas is 2.5m (GeoTerra 2012a). This level of subsidence is unlikely to result in modification of the woodland habitat.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Habitat for the Eastern Pygmy-possum is widespread across the Southern Sydney region and the species does not seem to occur in isolated sub-populations (DECC 2007c). As described above, it is unlikely that the Project will result in significant removal or modification of Upland Swamp: Fringing Eucalypt Woodland or woodland areas that provide habitat for the Eastern Pygmy-possum. Therefore, it is unlikely that habitat will become fragmented or isolated as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	The Eastern Pygmy-possum has been recorded within the Study Area in Exposed Sandstone Scribbly Gum Woodland and Upland Swamp: Fringing Eucalypt Woodland. These habitats are extensive over the Study Area, and continue outside of the Study Area.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Eastern Pygmy-possum.

Table E.9	Eastern Pygmy-possum (*Cercartetus nanus*)
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Eastern Pygmy-possum, however, the NSW DECCW has identified actions for the recovery of the species including: • control and monitor abundance of feral predators, especially cats, where there are known populations of EPP in areas of high quality habitat and encourage night-time curfews for cats on urban fringes adjacent to these habitats; • encourage research on the ecology, movements, habitat use and genetics of populations; and • reserve fire management strategies to include operational guidelines to protect this species from fire, with fire frequency of >10 years.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration of Eastern Pygmy-possum habitat is considered low risk (FMEA; Olsen Consulting 2010), however GeoTerra (2012a) and Biosis (2012a) reported potential minor changes to some of the upland swamp habitat areas and as a result, this is considered likely to constitute the operation of a KTP.

Table E.10	Large-eared Pied Bat (*Chalinolobus dwyeri*)
The Large-eared Pied Bat (*Chalinolobus dwyeri*) is listed as Vulnerable under the TSC Act and Vulnerable under the EPBC Act. The current distribution of the species is poorly known. Records exist from Shoalwater Bay, north of Rockhampton, Queensland, through to the vicinity of Ulladulla, NSW in the south (Hoye 2005). In NSW, this species has been recorded from a large range of vegetation types including: dry and wet sclerophyll forest; Cypress-pine dominated forest; tall open eucalypt forest with a rainforest sub-canopy; sub-alpine woodland; and sandstone outcrop country (Duncan, 1999). Little is known about the roosting requirements of the Large-eared Pied Bat, but natural roosts may depend heavily on sandstone outcrops. It has also been found roosting in disused mine shafts, caves, overhangs and disused Fairy Martin (*Hirundo ariel*) nests for shelter and to raise young (Hoye & Dwyer 1995; Schulz 1998). In the Southern Sydney region most records of this species were found in the Greater Blue Mountains (DECC 2007c). Despite considerable survey effort there are no records of this species in sandstone woodlands and open forests of the Woronora Plateau records are concentrated on the Grassy Box Woodlands and Red-Gum Ironbark communities of the wider fertile valley floors, coastal plains and some easterly rivers (DECC 2007c, d). This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat. The Large-eared Pied Bat is considered to be vulnerable to impacts associated with subsidence (DECC 2007a).	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Cave roost dependent bats such as the Large-eared Pied Bat are susceptible to loss of roost sites, changes in micro-climate of roost sites and reduction in foraging habitat. The Study Area contains some sandstone outcropping and benching which may contain overhangs and small caves suitable for roosting habitat. The forest and woodland vegetation provides suitable foraging habitat however it should be noted that regional habitat model identifies preferred habitat associated with the Grassy Box Woodlands and Red-Gum Ironbark communities of the wider fertile valley floors (DECC 2007c to the west of the Study Area. Predicted maximum subsidence resulting from the Project under the terrestrial areas is 2.5 m (GeoTerra 2012a) and this is not predicted to significantly impact vegetation communities. The majority of sandstone outcropping and benching is located around Lizard Creek, Wallandoola Creek and their tributaries with the most likely location for caves and overhangs to support these bats within the deeply incised valley of Lizard Creek, above the fully supported underground

Table E.10 Large-eared Pied Bat (*Chalinolobus dwyeri*)

	drivage in Wonga West. Damage to caves and cracks used as roost sites by the species may occur within the Wonga West domains of the Study Area, specifically caves and overhangs in Lizard Creek gorge are predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012). Those habitat features that are located over the longwall panels in Area 4 may be subject to minor and negligible environmental consequences (SCT Operations 2012). Negligible environmental consequences are predicted for cliff formations not directly above the proposed longwall panels (SCT 2012). For the low height rock formations in Wonga East, rock falls are expected to be limited in extent (SCT 2012). Minor to negligible damage to Large-eared Pied Bat roosting habitat may occur over Area 4 within the Study Area and negligible impact to other areas of suitable habitat as a result of the Project. Maternity roost sites are important for the survival of all cave roosting bat species. No maternity roosts have been identified in the vicinity of Lizard Creek gorge. The likelihood of a maternity cave occurring within the Study Area is considered low, given that the species requires deep, dark caves for breeding and such caves are rarely formed within sandstone geology (Brad Law, Forests NSW, pers. comm.). If roosting habitat was lost through subsidence related impacts, it is unlikely that a viable local population of the species, if present, would be placed at risk of extinction as other suitable roosting habitat is likely to be present in the locality, particularly within the surrounding SCA Special Areas.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area. Therefore, the removal of Large-eared Pied Bat foraging habitat will not occur due to the Project. The Project is unlikely to modify foraging habitat, with maximum predicted subsidence in forest areas being 2.5m (GeoTerra 2012a). There is a negligible to low risk of damage to caves and cracks used as roost sites by the species may occur within the Wonga West domains of the Study Area, specifically any caves or overhangs that may occur in Lizard Creek gorge. Mitigation measures, including additional surveys and pre and post mining monitoring will assist in the identification of any impacts and targeted remediation for the species, if impacts do occur.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	The most extensive stands of potential roosting habitat for the Large-eared Pied Bat is along the Lizard creek gorge. There is minor to negligible risk of damage to these features however, this would not result in habitat fragmentation. The Project is considered unlikely to modify foraging habitat, therefore fragmentation of foraging habitat is considered unlikely as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	On a regional scale the forested habitats associated with the Grassy Box Woodlands and Red-Gum Ironbark communities of the wider fertile valley floors (DECC 2007c) to the west of the Study Area have been predicted as higher quality habitat. The regional study has identified that while

Table E.10 Large-eared Pied Bat (*Chalinolobus dwyeri*)

	sandstone country provides roosting habitat these bats do not appear to be foraging in the sandstone country (DECC 2007c). The quality of potential roosting habitat observed during field surveys including rocky caves and overhangs are considered to be potentially important roosting habitat for the Large-eared Pied Bat in the local and regional context. However, the Study Area is unlikely to support a maternity roost given that the species requires deep, dark caves for breeding and such caves are rarely formed within sandstone geology (Brad Law, Forests NSW, pers. comm.). There is negligible likelihood of negative environmental consequences for removal or modification of potential foraging and roosting habitat in the Study Area.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Large-eared Pied Bat.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Large-eared Pied Bat, however, the NSW DECCW has identified actions for the recovery of the species including: • Ensure protection of caves and overhangs in area of suitable geology (offsets should include nearby remnants in high productivity) or other land assessment tools; • Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes; and • Implement key threat abatement actions for longwall mining. One priority action is directly relevant to the Project and is listed as 'high' priority. The implementation of key threat abatement actions for longwall mining is would be the responsibility of OEH.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. It is predicted that there may be minor to negligible damage to the cliffs along Lizard Creek gorge that may provide potential habitat. The alteration of Large-eared Pied Bat roosting habitat may occur as a result of subsidence; as a result this is considered the operation of a KTP.

Table E.11 Spotted-tailed Quoll (*Dasyurus maculatus*)

The Spotted-tailed Quoll (*Dasyurus maculatus*) is listed as Vulnerable under the TSC Act and Endangered under the EPBC Act. Within NSW, this species is known to occur from the sub-alpine zone to the coastline within a range of habitat types including rainforest, open forest, woodland, coastal heath and inland riparian forest (OEH online profile). Hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky cliff faces are used as den sites (OEH online profile).

This species was not recorded within the Study Area during field investigations and is considered to have a moderate likelihood of occurrence based on the availability of suitable habitat. On a regional scale the Spotted-tailed Quoll has been classified as a rare resident, possibly declining in the Southern Sydney region (DECC 2007c). A single sighting was made in recent surveys near Bellambi Creek in October 2005 (DECC 2007c).

The Spotted-tailed Quoll is considered to be vulnerable to impacts associated with subsidence (DECC 2007a).

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The Spotted-tailed Quoll inhabits a variety of habitats, with extensive suitable habitat for the species occurring in the Wonga West area. The home range of a male Spotted-tailed Quoll is very large and could contain the entire Wonga West area. Rocky outcrops and caves would be important sheltering habitat and the densely vegetated creek lines may be used by the Spotted-tailed Quoll for traversing its home range. In Lizard Creek gorge, where suitable habitat may be impacted, maximum vertical subsidence of

Table E.11	Spotted-tailed Quoll (*Dasyurus maculatus*)
	100mm and maximum tilt of 3mm/m is predicted (SCT Operations 2012). There is a negligible to low potential that this amount of subsidence will damage caves and latrine sites located above the proposed longwall panels and a negligible potential where these features do not occur over longwall panels, It is unlikely the level of disturbance would limit the availability of this habitat resource. It is also unlikely that potential subsidence would impact on the availability of habitat resources for prey species such that the availability of prey would be adversely affected. It is unlikely that the Project would have an adverse effect of the life cycle of the species such that a viable local population would be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	There is a negligible risk of modification of potential habitat for the Spotted–tailed Quoll in the Study Area. There is negligible to low risk of damage to caves that may be used as shelter for the Spotted-tailed Quoll. Mitigation measures, including additional surveys and pre and post mining monitoring will assist in the identification of any impacts and targeted remediation for the species, if required.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	The most extensive stands of potential denning habitat for the Spotted-tailed Quoll is associated with steep slopes and cliff lines along the Lizard creek gorge. There is minor to negligible risk of damage to these features however, this would not result in habitat fragmentation. Given the wide ranging habitat of this species, the Project is considered unlikely to modify habitat, therefore fragmentation of habitat is considered unlikely as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Potential sheltering habitat for the Spotted-tailed Quoll, particularly in Lizard Creek gorge, may be modified as a result of the Project. It is considered that this habitat feature would not be critical to the long term survival of a population in the locality. There is low likelihood that other habitat areas may be impacted by the Project however it is considered unlikely that this would occur over an area large enough to significantly limit the potential of a local population of Spotted-tailed Quolls to survive in the long term.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Spotted-tailed Quoll.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A draft national recovery plan has been prepared for the Spotted-tailed Quoll (Long and Nelson 2010). The plan has 11 objectives and 35 actions including: • determine distribution and status of the Spotted-tailed Quoll; • increase knowledge of biology and ecology of the Spotted-tailed Quoll to refine management of the species and its habitat;

Table E.11 Spotted-tailed Quoll (*Dasyurus maculatus*)

- reduce rate of habitat loss and fragmentation of habitats;
- evaluate and manage risks of silviculture practices;
- determine and manage threats of introduced predators and their control programs;
- determine and manage impact of fire regimes;
- reduce deliberate killings;
- reduce frequency of road mortalities;
- assess threat posed by Cane Toads;
- determine likely impact of climate change; and
- increase community awareness.

The Project is consistent with the draft recovery plan in so far that it will not clear or fragment habitat nor provide for an increase in road transport across the escarpment.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration or modification of Spotted-tailed Quoll habitat may occur as a result of subsidence, as a result this is considered the operation of a KTP.

Table E.12 Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)

The Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) is listed as Vulnerable under the TSC Act. This species is found along the east and north-west coasts of Australia (DECCW, 2010). They hunt in forested areas and roost primarily in caves though also use derelict mines, storm-water tunnels, buildings and other man-made structures (DECCW, 2010).

On a regional scale the Eastern Bentwing-bat has been classified as a common resident in the Southern Sydney region with the higher quality habitat concentrated along the easterly edge of the Woronora Plateau (DECC 2007c), including the Study Area.

This species was recorded within the Study Area during field investigations. The Eastern Bentwing-bat is considered to be vulnerable to impacts associated with subsidence (DECC 2007a).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Cave roost dependent bats such as the Eastern Bentwing-bat are susceptible to loss of roost sites and changes in micro-climate of roost sites, in particular maternity roosts, and reduction in foraging habitat. The Eastern Bentwing-bat was recorded within the Study Area during field surveys however, no roosting sites were observed.

The Study Area contains some sandstone outcropping and benching providing potential roosting habitat and the forested areas throughout the Study Area provide suitable foraging habitat above the tree tops. The Study Area is unlikely to support structures that may provide suitable microclimate for maternity roost sites. Potential impacts to foraging/hunting habitat over forested areas within the Study Area include tree fall and tilt. Predicted maximum subsidence due to the Project in these areas is 2.5 m (GeoTerra 2012a) and this is not predicted to significantly impact vegetation communities. Forested areas within the Study Area are widespread providing a broad range of foraging habitat for the Eastern Bentwing-bat.

The majority of sandstone outcropping and benching is located around Lizard Creek and Wallandoola Creek and their tributaries in Wonga West. The most likely location for caves and overhangs to support these bats occurs within the deeply incised valley of Lizard Creek, above the fully supported underground drivage in Wonga West. Within Wonga East subsidence is not expected to cause cracking of rock that would result in damage to caves and overhangs. Damage to caves and cracks used as roost sites by the species may occur within the Wonga West domains of the Study Area, specifically caves and overhangs in Lizard Creek gorge are predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012).

Due to the geology of the Study Area, it is highly unlikely that a maternity roost would be present, as all four known sites within NSW occur in limestone. Damage to Eastern Bentwing-bat roosting

Table E.12 Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)

	habitat may occur on the site as a result of the proposed works; however it is considered that the Project is unlikely to impact on maternity roost sites and accordingly the life cycle will not be affected such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area. Therefore, the removal of Eastern Bentwing-bat foraging/hunting habitat will not occur due to the Project. Damage to caves and cracks used as roost sites by the species may occur within the Wonga West domains of the Study Area, specifically caves and overhangs in Lizard Creek gorge are predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012). Mitigation measures, including additional surveys and pre and post mining monitoring will assist in the identification of any impacts and targeted remediation for the species, if impacts do occur.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	The potential impacts to roosting habitat for the Eastern Bentwing-bat is present due to predicted subsidence of up to 100mm vertical subsidence and 3mm/m tilt (SCT Operations 2012) in the potential habitat area of caves and overhangs in Lizard Creek gorge. There is a negligible to low likelihood of the cave habitat features being altered by the Project and any change is not expected to result in habitat fragmentation. The forested areas are widespread throughout the Study Area and surrounding areas providing a broad range of foraging habitat for the Eastern Bentwing-bat. Predicted impacts to these areas are minimal. Therefore, there will be no fragmentation or isolation of habitat for the Eastern Bentwing-bat.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	There will be no removal or fragmentation of Eastern Bentwing-bat habitat resulting from the Project, modification of Eastern Bentwing-bat habitat resulting from the Project is considered minimal. Due to the species being recorded within the Study Area and quality of potential habitat observed during field surveys, the rocky caves and overhangs are considered to be potentially important roosting habitat for the Eastern Bentwing-bat in the local and regional context. Given that known maternity roosting sites are associated with limestone, no maternity roosting sites are expected in the Study Area. However, mitigation measures including additional surveys and pre and post mining monitoring will assist in the identification of any impacts and targeted remediation for the species, if impacts do occur.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Eastern Bentwing-bat.

Table E.12	Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Eastern Bentwing-bat, however, the NSW DECCW has identified the following actions for the recovery of the species which include: • compile register of all known roost sites in natural and artificial structures including current and historical data and identify significance of roost, e.g. maternity, hibernation, transient roost; • monitor the breeding success of a representative sample of maternity colonies in cave roosts over a number of years to determine the viability of regional populations; • confirm species taxonomy of NSW populations, relative to other Australian populations; • research to identify important foraging range and key habitat components around significant roosts; and • study the ecological requirements of maternity colonies and their environs and migratory patterns.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration or modification of Eastern Bentwing-bat habitat may occur as a result of subsidence; as a result this is considered the operation of a KTP.

Table E.13	Large-footed Myotis (*Myotis macropus*)
	The Large-footed Myotis (*Myotis macropus*) is listed as Vulnerable under the TSC Act. This species occurs within the coastal band from the north west of Australia, across the top-end and south to western Victoria and is rarely found more than 100km inland, except adjacent to major rivers (DECCW, 2010). Foraging over streams and pools, this species generally roosts in small groups in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage within close proximity to water sources (DECCW, 2010). On a regional scale the Large-footed Myotis has been classified as a rare resident, possibly declining in the Southern Sydney region (DECC 2007c). This species is strongly associated with the Cumberland Plain from the Georges River catchment around Liverpool and Campbelltown and the Nepean River with occasional records in the sandstone environment of the Woronora Plateau (DECC 2007c). This species was recorded within the Study Area during field investigations. Large-footed Myotis is considered to be vulnerable to impacts associated with subsidence (DECC 2007a).
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Cave roost dependent bats such as the Large-footed Myotis are susceptible to loss of roost sites, changes in micro-climate of roost sites and reduction in foraging habitat. The Large-footed Myotis was recorded within the Study Area during field surveys however, no roosting sites were observed. Large-footed Myotis may also utilise hollow-bearing trees and dense foliage as roosting habitat. The Study Area contains some sandstone outcropping and benching providing potential roosting habitat and the creeks, pools and nearby dams provide prime foraging habitat. Potential impacts to foraging habitat within the Study Area include subsidence and cracking resulting in the drying up of creeks and pools. Cataract Dam within 2km of the prime roosting habitat provides suitable foraging habitat, and will not be impacted by the Project. Other foraging habitat may be associated with the 3rd order and higher streams. GeoTerra (2012a) concluded that the worst case prediction of the longwall panels under Cataract Creek may reduce stream flows, pool holding capacity of the rock bars and potential changed water chemistry. Implementation of adaptive management measures would minimise potential adverse environmental consequences on the foraging habitat values of Cataract Creek. According to GeoTerra (2012a), there is potential risk to the integrity of stream flow and connectivity in Wallandoola Creek in particular in the area to the south of A3 LW3 and A3 LW4

Table E.13	Large-footed Myotis (*Myotis macropus*)
	and a low potential risk to the integrity of stream flow and connectivity in Lizard Creek to the north of Longwall A3 LW2 and A3 LW5 in Wonga West. The majority of sandstone outcropping and benching is located around Lizard Creek and Wallandoola Creek and their tributaries. The most likely location for caves and overhangs to support these bats occurs within the deeply incised valley of Lizard Creek, above the fully supported underground drivage in Wonga West. Within the Wonga East subsidence is not expected to cause cracking of rock that would result in damage to caves and overhangs. There is minimal to negligible risk of damage to caves and cracks used as roost sites by the species may occur within the Wonga West domains of the Study Area, specifically caves and overhangs in Lizard Creek gorge (predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012)). Damage to Large-footed Myotis roosting and foraging habitat is considered possible but not likely within the site as a result of the proposed works. It is unlikely that the Project will have an adverse effect on the life cycle of the species such that a viable local population will be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area. With implementation of monitoring and an adaptive mine plan there is not expected to be any impact to surface flows in Cataract Creek in Wonga East (GeoTerra 2012a). According to GeoTerra (2012a) it is possible, although not anticipated to be likely, that cracking could occur in the creek bed which could lead to loss of flow into the underlying dilated strata or enhanced drainage of pools in Lizard and Wallandoola creeks in Wonga West. There is minor to negligible risk of damage to caves and cracks that may be used as roost sites by the species, specifically caves and overhangs in Lizard Creek gorge. Mitigation measures, including additional surveys and pre and post mining monitoring will assist in the identification of any impacts and targeted remediation for the species, if impacts do occur.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Potential impacts to roosting habitat for the Large-footed Myotis may be due to predicted subsidence of up to 100mm vertical subsidence and 3mm/m tilt (SCT Operations 2012) in potential habitat area of caves and overhangs in Lizard Creek gorge. The cave habitat features may be altered by the Project however this would not result in habitat fragmentation. With implementation of monitoring and an adaptive mine plan there is not expected to be any impact to surface flows in Cataract Creek in Wonga East (GeoTerra 2012a). According to GeoTerra (2012a) it is possible, although not anticipated to be likely, that cracking could occur in the creek bed which could lead to loss of flow into the underlying dilated strata or enhanced drainage of pools in Lizard and Wallandoola creeks in Wonga West. Suitable foraging habitat for the species occurs in Cataract Dam within 2km of the potential impact areas and due to the mobility of the species fragmentation and isolation is not considered to be likely.

Table E.13	Large-footed Myotis (*Myotis macropus*)
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	With implementation of monitoring and an adaptive mine plan there is not expected to be any impact to surface flows in Cataract Creek in Wonga East (GeoTerra 2012a). According to GeoTerra (2012a) it is possible that cracking could occur in the creek bed which could lead to loss of flow into the underlying dilated strata or enhanced drainage of pools in Lizard and Wallandoola creeks in Wonga West. This foraging habitat would be considered moderately important to the species in the locality. Due to the species being recorded within the Study Area and quality of potential habitat observed during field surveys, the rocky caves and overhangs are considered to be potentially important roosting habitat for the Large-footed Myotis in the local and regional context. However, mitigation measures including additional surveys and pre and post mining monitoring will assist in the identification of any impacts and targeted remediation for the species, if impacts do occur.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Large-footed Myotis.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Large-footed Myotis, however, the NSW DECCW has identified actions for the recovery of the species which include: • resolve species taxonomy by morphology/genetics and reassess conservation status; • encourage recovery of natural hydrological regimes, including retention and rehabilitation of riparian vegetation; and • research to identify important foraging range and key habitat components for this species. Identify the importance of riparian vegetation to the species.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration or modification of potential roosting and foraging habitat for Large-footed Myotis could occur within the Study Area; as a result this is considered the operation of a KTP.

E.1.4 *Threatened Reptiles*

Table E.14 Broad-headed Snake (*Hoplocephalus bungaroides*)
The Broad-headed Snake (*Hoplocephalus bungaroides*) is listed as Endangered under the TSC Act and Vulnerable under the EPBC Act. This species is known from the coast and ranges of NSW, within an area approximately 250km from Sydney (DECCW, 2010). Largely confined to Triassic and Permian sandstones (including the Hawkesbury, Narrabeen and Shoalhaven groups), this species shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring and hollows in large trees during summer (DECCW, 2010). On a regional scale the Broad-headed Snake has been classified as an extremely rare resident, possibly declining in the Southern Sydney region (DECC 2007c). The Woronora Plateau is identified as likely to be core to the species survival (DECC 2007c). This species was not recorded within the Study Area during field investigations although was considered to have a high likelihood of occurrence based on the availability of suitable habitat. The Broad-headed Snake is considered to be vulnerable to impacts associated with subsidence (DECC 2007a).

Table E.14 Broad-headed Snake (*Hoplocephalus bungaroides*)

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The Broad-headed Snake is expected to occur in suitable wintering habitat on north-west facing rock benches and outcrops with exfoliating rock particularly along Lizard Creek and Wallandoola Creek and their tributaries. The Study Area is not expected to provide habitat for a significant proportion of a population of this species, as extensive outcropping of rock benches, which would provide critical wintering habitat, was not recorded (Eco Logical 2009). Rocky habitats that occur along valley sides and cliffs are vulnerable to subsidence impacts, particularly where they occur directly above a mined area and resulting goaf. The FMEA (Olsen Consulting 2010) identified adverse subsidence impacts resulting in loss of wintering habitat for threatened rock-dwelling reptiles as low risk. Rocky overhangs in Lizard Creek gorge are predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012). Those habitat features that are located over the longwalls in Area 4 may be subject to minor and negligible environmental consequences (SCT Operations 2012). Negligible environmental consequences are predicted for cliff formations not directly above the proposed longwalls (SCT Operations 2012). For the low height rock formations in Wonga East, rock falls are expected to be limited in extent (SCT 2012). Due to the topography of the study area and the location of the proposed longwalls, it appears that conflicts between the Project and the habitat requirements of this threatened species have been avoided (Eco Logical 2009). It is therefore unlikely that the Project will have an adverse effect on the life cycle of the Broad-headed Snake such that a viable local population, if present, is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area; as a result removal of habitat is not expected to occur. The main habitat areas for the Broad-headed Snake include wintering habitat on north-west facing rock benches and outcrops with exfoliating rock and summer habitat of hollow bearing trees within 200m of escarpments. The FMEA (Olsen Consulting 2010) identified adverse subsidence impacts resulting in loss of wintering habitat for threatened rock-dwelling reptiles as low risk. Therefore it is considered unlikely that significant modification of rocky habitat will occur. The potential areas of hollow bearing tree habitat occur in forest and woodland communities around ridgelines in the vicinity of the rocky outcrops along Lizard Creek and Wallandoola Creek and their tributaries. These habitat areas are expected have a maximum subsidence of 2m (Seedman Geotechnics 2012). This level is considered unlikely to result in significant modification of habitat that would result in loss of hollow bearing trees.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Rocky outcrop areas are patchily distributed and discontinuous in nature within the Study Area. It is considered unlikely that the Project will result in significant modification of habitat, therefore fragmentation or isolation is also considered unlikely.

Table E.14	Broad-headed Snake (*Hoplocephalus bungaroides*)
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	While, the Broad-headed Snake may occur in suitable wintering habitat on north-west facing rock benches and outcrops with exfoliating rock, particularly along Lizard Creek and Wallandoola Creek and their tributaries; the Study Area is not expected to provide habitat for a significant proportion of a population of this species, as extensive outcropping of rock benches that would provide critical wintering habitat, was not recorded (Eco Logical 2009). Therefore, it is considered that the habitat in the Study Area is not critical to the long-term survival of the species in the locality.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Broad-headed Snake.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Broad-headed Snake, however, the NSW DECCW has identified actions for the recovery of the species including: • identify key populations and important habitat and assess threats at these sites to establish priorities for management; • promote options to control and regulate bushrock removal; and • undertake threat management, site protection and restoration works at identified priority sites, in accordance with approved threat management and restoration guidelines. The Project is unlikely to impact on availability of potential habitat for the Broad-headed Snake and is not in conflict with DECCW priority actions.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. There is a low to minor risk of alteration of potential Broad-headed Snake habitat as a result of the Project.

Table E.15 Rosenberg's Goanna (*Varanus rosenbergi*)
Rosenberg's Goanna (*Varanus rosenbergi*) is listed as Vulnerable under the TSC Act. Within NSW, this species is known from areas containing heath, open forest and woodland that are underlain by Sydney sandstone from the Wollemi National Park to the north-west of Sydney and also the Goulburn and Cooma areas (DECCW, 2010). Termite mounds are a critical habitat component for breeding and hollow logs, rock crevices and burrows are used for sheltering purposes (DECCW, 2010). On a regional scale Rosenberg's Goanna has been classified as an uncommon resident with local declines in the Southern Sydney region (DECC 2007c). The Woronora Plateau is identified as one of the most important population centres for this species in NSW (DECC 2007c). This species was not recorded within the Study Area during field investigations. It is considered to have a high likelihood of occurrence based on the availability of suitable habitat. Rosenberg's Goanna is considered to be vulnerable to impacts associated with subsidence (DECC 2007a).

Table E.15 Rosenberg's Goanna (*Varanus rosenbergi*)

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Suitable habitat for Rosenberg's Goanna was recorded within the Study Area, although no individuals were observed (Biosis 2009, Eco Logical 2009). West facing rock ledges and overhangs, which are suitable for over-wintering hibernation by the species, are sparsely distributed throughout the Study Area (Eco Logical 2009). Four ground termitaria were recorded, which can be used as nesting chambers by the goanna, although no evidence of nesting was observed (Biosis 2009). The Study Area is not expected to contain extensive tracts of habitat that would support a significant population of this species (Eco Logical 2009). Rocky habitats that occur along valley sides and cliffs are vulnerable to subsidence impacts. The FMEA (Olsen Consulting 2010) identified adverse subsidence impacts resulting in loss of wintering habitat for threatened rock-dwelling reptiles as low risk. Rocky overhangs in Lizard Creek gorge are predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012). Those habitat features that are located over the longwall panels in Area 4 may be subject to minor and negligible environmental consequences (SCT Operations 2012). Negligible environmental consequences are predicted for cliff formations not directly above the proposed longwall panels (SCT 2012). For the low height rock formations in Wonga East, rock falls are expected to be limited in extent (SCT 2012). It is unlikely that the Project will have an adverse effect on the life cycle of Rosenberg's Goanna such that a viable local population is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation within the Study Area and as a result removal of habitat is not expected to occur. Rosenberg's Goanna habitat consists of west facing rock ledges and overhangs for winter hibernation, and during active times includes open forest, woodlands and heaths. The FMEA (Olsen Consulting 2010) identified adverse subsidence impacts resulting in loss of wintering habitat for threatened rock-dwelling reptiles as low risk, and also recorded low risk for impacts to upland swamp (heath) areas. The open forest and woodland habitat areas are expected have a maximum subsidence of 2.5 m (GeoTerra 2012a). This level is considered unlikely to result in significant modification of habitat.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Suitable wintering habitat for Rosenberg's Goanna is currently sparsely distributed in the Study Area. Open forest, woodland and upland swamps provide suitable foraging habitat for the species. It is considered unlikely the habitat for the species will become fragmented or isolated as a result of the Project.

Table E.15	**Rosenberg's Goanna (*Varanus rosenbergi*)**
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	The Study Area is not expected to contain extensive tracts of habitat that would support a significant population of this species (Eco Logical 2009). However, suitable habitat does exist and it is considered highly likely the species would occur in the Study Area. Suitable habitat for this species has the potential to be modified as a result of the Project; however it is not considered that this habitat is critical to the long-term survival of the species in the locality.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Rosenberg's Goanna.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Rosenberg's Goanna, however, the NSW DECCW has identified actions for the recovery of the species including: • develop habitat identification, management and enhancement guidelines; • implement management strategies that reduce the prevalence of bush rock removal, including surveillance; and • identify key habitats or areas for protection and enhanced management on private land through management agreements and incentives. The Project is not in conflict with DECCW recovery actions.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration or modification of Rosenberg's Goanna habitat may occur as a result of the Project; and is therefore is considered the operation of a KTP.

E.1.5 Threatened Amphibians

Table E.16 Giant Burrowing Frog (*Heleioporous australiacus*)
The Giant Burrowing Frog (*Heleioporous australiacus*) is listed as Vulnerable under the TSC Act and Vulnerable under the EPBC Act. This species is known from two distinct areas within south eastern NSW and Victoria; the northern population being largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla and the southern population occurring from near Narooma through to Walhalla in Victoria (OEH online profile). In the Southern Sydney Region the Giant Burrowing Frog is assessed as an uncommon resident stable population with the Woronora plateau containing the greatest density of records (DECC 2007c). It spends approximately 95% of its time in foraging habitat which includes heath, woodland and open dry sclerophyll forest on a variety of soil types (except those that are clay based) though not generally where there is a grassy groundlayer. Preferred breeding habitat is generally soaks or pools within first or second order semi-permanent streams and upland swamps. Giant Burrowing Frog may breed throughout the year though mainly in autumn immediately before or following heavy rain. This species was recorded within the Study Area during field investigations in Lizard Creek Tributary 1 and Lizard Creek Tributary 2 in Wonga West. Potential habitat for the Giant Burrowing Frog occurs in the majority of the upland swamps and associated 1st or 2nd order streams in the Study Area. Tadpoles were identified in the 1st order stream to the south of CRUS2 in Wonga East in 2012 (Biosis pers comm). The Giant Burrowing Frog is identified by DECC (2007a) as vulnerable to impacts associated with subsidence. Giant Burrowing Frog is identified as a species that is able to withstand loss within the Hawkesbury Nepean Catchment and swamps that support this species are considered to have national special significance (DECCW 2011).

Table E.16	**Giant Burrowing Frog (*Heleioporous australiacus*)**
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The Giant Burrowing Frog was recorded within Lizard Creek Tributary 1 (LCT1) and Lizard Creek Tributary 2 (LCT2) in Wonga West; and in a 1st order stream downstream of upland swamp CRUS2. Potential habitat occurs in most of the 84 upland swamps recorded in the Study Areas. The FMEA (Olsen Consulting 2010) identified a high risk for subsidence related impacts to result in the loss of breeding habitat for the Giant Burrowing frog. It is likely that surface cracking as a result of mine subsidence will lead to a reduction in surface water availability including standing pools within the LCT1 and LCT2 where this species was recorded. This is expected to have direct consequences for the availability of breeding habitat for Giant Burrowing Frog. Upland swamps of special significance have been identified in both Study Areas. These swamps may represent better quality habitat in that they are larger and/or support a diversity of vegetation communities including more moisture dependent communities. A risk assessment of the upland swamps of special significance has identified that this subset of the upland swamps within the two Study Areas are predicted to experience negligible through to significant environmental consequences from the Project. For the breeding habitat confirmed associated with CRUS2, it is predicted that the Project will have negligible environmental consequences as the swamp will not be directly undermined. The above impacts are expected to have direct consequences for the availability of breeding habitat for Giant Burrowing Frog. The FMEA (Olsen Consulting 2010) also identified a high risk for subsidence related impacts to result in the loss of breeding habitat for the Giant Burrowing Frog. Therefore it is considered likely that the Project will have an adverse effect on the life cycle of the species such that a viable local population is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation or removal of habitat within the Study Area. The Giant Burrowing Frog forages in forests and woodlands within 300 m of breeding habitat. The maximum predicted subsidence in these areas is 2.5m, and is not likely to result in significant modification of terrestrial habitat. Breeding habitat for the Giant Burrowing Frog occurs within creeks and pools, and upland swamps with pooling water. Modification to the upland swamps and the stream LCT1 and LCT2 may occur as a result of subsidence from longwall mining. Subsidence related impacts as a result of the Project may result in modification of Giant Burrowing Frog breeding habitat.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Breeding habitat of the Giant Burrowing Frog is likely to be impacted as a result of the Project. The breeding habitat is within first and second order streams and upland swamps. Due to the unpredictable nature of subsidence, some areas of creeks may be impacted and others less effected. As a result some areas of the streams may still provide suitable breeding habitat while other nearby sections may become unsuitable. In this case, tadpoles may be washed out of suitable

Table E.16 Giant Burrowing Frog (*Heleioporous australiacus*)

	habitat and into unsuitable habitat. It is likely that areas of habitat will become fragmented as a result of the Project. For the breeding habitat confirmed associated with CRUS2, it is predicted that the Project will have negligible environmental consequences as the swamp will not be directly undermined.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Any upland swamp that supports the Giant Burrowing Frog would be considered a swamp of national special significance. The modification and fragmentation of Giant Burrowing Frog breeding habitat is likely to occur as a result of the Project. Breeding habitat is considered to be critical to the long term survival of the population of Giant Burrowing Frogs in the locality.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Giant Burrowing Frog.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Giant Burrowing Frog, however, the NSW DECCW has identified actions for the recovery of the species including: • resolve the taxonomic uncertainty regarding the northern and southern populations; • develop and test a protocol for monitoring populations of the Giant Burrowing Frog throughout its range; • encourage and support research projects that contribute to the conservation and management of the Giant Burrowing Frog; • provide advice to inform assessment of impacts; and • habitat protection and management. The Project may result in modification and loss of breeding habitat and this is not in keeping with recovery plan strategies.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration or modification of Giant Burrowing Frog habitat is considered likely to occur as a result of the Project; as a result this is considered the operation of a KTP.

Table E.17 Heath Frog (*Litoria littlejohni*)

Heath Frog or Littlejohn's Tree Frog (*Litoria littlejohni*) is listed as Vulnerable under the TSC Act and Vulnerable under the EPBC Act.

This species has a distribution range that includes the plateaus and eastern slopes of the Great Dividing Range from the Watagan State Forest south to Buchan in Victoria, with the majority of records from within the Sydney Basin Bioregion (DECCW, 2010). The Heath Frog was assessed as an extremely rare resident within the Southern Sydney region with the Woronora Plateau recognised as one of the two key areas in the region for the species (DECC 2007c).

Non-breeding habitat is heath based forests and woodlands, within 100 m of breeding habitat, where it shelters under leaf litter and low vegetation. Breeding habitat includes the upper reaches of permanent rocky streams with fringing vegetation and perched swamps (DECCW, 2010).

This species was not recorded within the Study Area during field investigations although was considered to have a moderate to high likelihood of occurrence based on the availability of suitable habitat.

The Heath Frog is identified by DECC (2007a) as vulnerable to impacts associated with subsidence. Heath Frog is identified as a species that is able to withstand loss within the Hawkesbury Nepean Catchment and swamps that support this species are considered to have national special significance (DECCW 2011).

Table E.17 Heath Frog (*Litoria littlejohni*)

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Suitable habitat for Heath Frog was recorded within Wonga West during field surveys by both Eco Logical (2009) and Biosis (2009) in the 3rd order reaches of Wallandoola Creek and Lizard Creek. The condition of the habitat varied from good to poor condition, with some stream and pools being affected by iron-oxidising bacteria scum. The greatest extent of suitable habitat for this species was recorded within the upper reaches of Lizard Creek, the Lizard Creek swamp complex, and within the pooled sections of Wallandoola Creek within the associated swamp complex (Biosis 2009, Eco Logical 2009). In Wallandoola Creek, suitable breeding habitat for Heath Frog was recorded in WCUS7, where the water column did not appear to be affected by iron-oxidising bacteria flocculate (Eco Logical 2009). There is also potential habitat in the majority of upland swamps within the Study Area. Subsidence and related disturbance including cracking of creek beds has the potential to reduce water quality in these areas and limit the breeding potential of the species. GeoTerra (2012a) predicts that it is unlikely that stream flow and ponding will be significantly impacted in theses creeks. GeoTerra (2012a) acknowledges that it is possible, although not anticipated to be likely, that cracking could occur in the creek bed which could lead to loss of flow. If cracking were to occur, the Project may have an adverse effect on the life cycle of the species such that a viable local population is likely to be placed at risk of extinction Upland swamps of special significance may represent better quality habitat in that they are larger and/or support a diversity of vegetation communities including more moisture dependent communities. A risk assessment of the upland swamps of special significance has identified that this subset of the upland swamps within the two Study Areas are predicted to experience negligible through to significant environmental consequences from the Project. Upland swamps of special significance that may experience moderate or significant environmental risk are WCUS4, WCUS7, CCUS4, CCUS5 and CCUS1. Habitat values of these swamps and associated 1st order streams may be adversely affected such that it may affect individuals dependent upon these habitats. However, a number of the larger upland swamps will experience negligible environmental consequences and will provide alternative habitat for the population in the Study Areas. For the breeding habitat downstream of CRUS2 and CRUS1 it is predicted that the Project will have negligible to low environmental consequences. Overall there is a low risk that the Project will have an adverse effect on the life cycle of the species such that a viable local population is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.

Table E.17	**Heath Frog (*Litoria littlejohni*)**
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The greatest extent of suitable habitat was recorded within the upper reaches of Lizard Creek, the Lizard Creek swamp complex, and within the pooled sections of Wallandoola Creek within the associated swamp complex (Biosis 2009, Eco Logical 2009). The Project will not involve any clearance of native vegetation within the Study Area, therefore foraging and non-breeding habitat in forest areas is considered unlikely to be affected by the Project. The overall area of occupancy is not likely to be altered as the species forages widely within heath habitats, which are not likely to be altered. In Wallandoola Creek suitable breeding habitat for Heath Frog is generally restricted to the upper reaches where the water column did not appear to be affected by iron-oxidising bacteria flocculate (Eco Logical 2009). There is potential for impacts to potential breeding pools in the northern section of WCUS7. Degradation of one to two breeding pools may occur, depending upon the severity of any cracking experienced in the subsidence area in WCUS7. Mitigation measures, including additional surveys and pre and post mining monitoring will assist in the identification of any impacts and targeted remediation for the species, if impacts do occur.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Suitable habitat for the Heath Frog varied from good to poor condition, with some stream and pools being affected by iron-oxidising bacteria scum (Eco Logical 2009; Biosis 2009). The greatest extent of suitable habitat for this species was recorded within the upper reaches of Lizard Creek, the Lizard Creek swamp complex, and within the pooled sections of Wallandoola Creek within the associated swamp complex (Biosis 2009, Eco Logical 2009). No significant modification of habitat for the species is predicted therefore fragmentation or isolation of habitat beyond that which already occurs is not expected to result from the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	The modification and fragmentation of Heath Frog breeding habitat is considered unlikely to occur as a result of the Project. Breeding habitat within the Study Area may be significant to the long term survival of the population of Heath Frogs in the locality.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for Heath Frog.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for Heath Frog, however, the NSW DECCW has identified actions for the recovery of the species including: • improve understanding of the species ecology and general biology; • assess the threat of changed hydrological regimes on the habitat of this species. Include the impacts of increasing urbanisation, groundwater extraction, and climate change into this assessment; • maintain hydrological regimes and protect water flows and water quality around the upper reaches of streams and perched swamps; and • ensure that there is adequate assessment of the impact of longwall mining on this species and that cumulative impacts are adequately addressed in all mining proposals within the habitat and distribution of this species. Three of the recovery strategies concern longwall mining or hydrology and are considered to be associated with this Project. This assessment considers these strategies.

Table E.17 Heath Frog (*Litoria littlejohni*)

(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration or modification of Heath Frog habitat may occur as a result of subsidence could occur within the Study Area; as a result this is considered the operation of a KTP.

Table E.18 Red-crowned Toadlet (*Pseudophryne australis*)

The Red-crowned Toadlet (*Pseudophryne australis*) is listed as Vulnerable under the TSC Act. This species has a restricted distribution, confined to the Sydney Basin from Pokolbin in the north, to the Nowra area in the south and west to Mount Victoria in the Blue Mountains (DECCW, 2010). Inhabits periodically wet drainage lines below sandstone ridges within open forests that often have shale lenses or cappings and shelters under rocks, fallen logs, amongst dense vegetation or piles of leaf litter (DECCW, 2010). Breeding habitat is under litter or debris in either ephemeral drainage lines, heath or eucalypt forest on sandstone and it will generally forage within 50m of breeding habitat.

This species was recorded within the Study Area during field investigations in Lizard Creek (LCUS1) and in the tributary downstream of the headwater swamp LCUS18. Red-crowned Toadlet is identified by DECC (2007a) as vulnerable to impacts associated with subsidence. Red-crowned Toadlet is identified as a species that is able to withstand loss within the Hawkesbury Nepean Catchment and swamps that support this species are considered to have regional significance (DECCW 2011).

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The Red-crowned Toadlet was recorded in Lizard Creek (LCUS1) and LCT1 within the Study Area. Suitable habitat for the species was also found within upland swamp (LCUS18) associated with LCT1 and their tributaries. Suitable habitat may also occur in streams associated with other upland swamps throughout the Study Area in particular those associated with the upland swamps (WCUS11, LCUS2, LCUS8, LCUS9, LCUS11, LCUS12, LCUS25, LCUS20, LCUS21) below the Transitional Shale/Sandstone forest EEC in Wonga West (see *Figure 5.2*). The upland swamps WCUS11 is characterised by shallow groundwater that will dry out following periods of low rainfall (Biosis 2012a). This swamp has a low risk of negative environmental consequences as areas that are likely to be subject to greatest impact from subsidence do not support vegetation sub-communities that are reliant on permanent of frequent waterlogging (Biosis 2012a). The headwater section of LCUS8 complex may be subject to fracturing however the location of the swamp over the pillar for Longwall A3 LW1 and drier communities within this swamp indicate that the impacts are unlikely to be significant, the swamp is considered to be at a low risk of negative environmental consequences (Biosis 2012a). The upland swamp LCUS1 is the largest upland swamp in the Study Area and includes areas of headwater swamp with valley infill swamp along the main channel of Lizard Creek. This swamp is has been avoided by mine plan and has been assessed as being at negligible risk of negative environmental consequences (Biosis 2012a). Upland swamps LCUS12, LCUS18, LCUS20, LCUS21 and LCUS25 have not been assessed by Biosis (2012a) however all five swamps would be undermined and at risk of negative environmental consequences as will experience subsidence impacts above the criteria identified by OEH (2012). LCUS2 and LCUS11 will not be undermined and are not anticipated to be at risk of negative environmental consequences. It is likely that surface cracking as a result of mine subsidence will lead to a reduction in surface water availability including standing pools within LCT1 and its tributaries and the reach of LCT2 over the northern end of Longwall A3 LW5 (GeoTerra 2012a). This is expected to have direct consequences for the availability of known habitat for the Red-crowned Toadlet. The species appears to be largely restricted to the immediate vicinity of suitable breeding habitat and are usually found as small colonies scattered along ridges coinciding with the positions of suitable refuges near breeding sites. Due to this tendency for discrete populations to concentrate at particular sites, a relatively small localised disturbance may have a significant impact on a local population if it occurs on a favoured breeding or refuge site (DECCW, 2010). It is likely that the Project will have an adverse effect on the life cycle of the species associated with

Table E.18	Red-crowned Toadlet (*Pseudophryne australis*)
	LCT1 and LCT2 such that a viable local population of the species in Wonga West may be placed at risk of extinction. However, other areas of potential habitat have a low or negligible risk of negative environmental consequences and are expected to continue to provide habitat for the population.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*In relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation or remove habitat within the Study Area. The Red-crowned Toadlet utilises habitat including forests and woodlands for foraging purposes. The maximum predicted subsidence in these areas is up to 2.5m, and is not considered likely to result in significant habitat modification. Breeding habitat for the Red-crowned Toadlet occurs within temporary pools on ridges and in upland swamps with pooling water. LCUS18 (2.5ha) which is on LCT1, is known habitat for the species and is at risk of negative environmental consequences. It is likely that surface cracking as a result of mine subsidence will lead to a reduction in surface water availability including standing pools within LCT1 and its tributaries and the reach of LCT2 over the northern end of Longwall A3 LW5 (GeoTerra 2012a). Change in the water flow or quality is likely to result in modification of Red-crowned Toadlet breeding habitat in LCT1, LCT2 and associated upland swamps. The location near the record on Lizard Creek, downstream of LCT1 is over the supported driveage and is likely to be subjected to minimal subsidence impacts (subsidence 0.02m) and therefore habitat is unlikely to be modified or removed in that area. Approximately 144ha of habitat occurs in the upland swamps identified in consideration (a) alone. As stated in (a) these upland swamps are predicted to be at negligible or low likelihood of negative environmental consequences and that the impacts are unlikely to be significant. This area of potential habitat is not likely to be removed or modified as a result of the Project.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Subsidence related impacts as a result of the Project are considered likely to result in modification of Red-crowned Toadlet breeding habitat to an extent that it would reduce breeding success within at least part of the local population. Suitable habitat associated with the 3rd reach of Lizard Creek and the associated 1st order streams and upland swamps in that area are not likely to become fragmented or isolated by the Project. Suitable habitat for the species is naturally patchily distributed throughout the Study Area and fragmentation or isolation is not expected to result from the Project beyond that which already occurs.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Red-crowned Toadlet is identified as a species that is able to withstand loss within the Hawkesbury Nepean Catchment and swamps that support this species are considered to have regional significance (DECCW 2011). Subsidence related impacts as a result of the Project are considered likely to result in modification of Red-crowned Toadlet breeding habitat to an extent that it would reduce breeding success within at least part of the local population.

Table E.18 Red-crowned Toadlet (*Pseudophryne australis*)

(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Red-crowned Toadlet.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Red-crowned Toadlet, however, the NSW DECCW has identified the 14 actions for the recovery of the species including: • develop best practice management strategies that buffer and protect important headwater/ridge top breeding sites from changes to water flow, flow regimes and water quality changes; • assess the threat of changed hydrological regimes on the habitat of this species. Include the impacts of increasing urbanisation, groundwater extraction, and climate change into this assessment; and • develop models of the preferred habitat of the species throughout its distribution. Two of the 14 listed actions refer to hydrology and this assessment considers these actions.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration of Red-crowned Toadlet habitat is considered likely to occur as a result of the Project; as a result this is considered the operation of a KTP.

Table E.19 Stuttering Barred Frog (*Mixophyes balbus*)

The Stuttering Barred Frog (*Mixophyes balbus*) is listed as Endangered under the TSC Act and Vulnerable under the EPBC Act. Within NSW, this species is found in rainforest and wet, tall open forest on the foothills and escarpment of the eastern side of the Great Dividing Range, where the Dorrigo appears to be a stronghold for the species (DECCW, 2010). This species breeds in streams and shelters in deep leaf litter and thick understorey vegetation outside of the breeding season (DECCW, 2010).

In the Southern Sydney Region Stuttering Barred Frog is assessed as extremely rare resident; known from Macquarie Pass National Park, Mt Werong in the Blue Mountains National Park and near Helensburgh (DECC 2007c). Based on surveys in Metropolitan SA, DECC (2000b) assess Stuttering Barred Frog as probably locally extinct with habitat in rainforests and moist forest.

Stuttering Barred Frog was not recorded within the Study Area during field investigations, although was considered to have a moderate to high likelihood of occurrence based on the availability of suitable habitat and identification of good quality breeding habitat in the reaches of Cataract Creek upstream of proposed Longwall A2 LW8 in Wonga East. Stuttering Barred Frog is considered to be vulnerable to impacts associated with subsidence.

Table E.19 Stuttering Barred Frog (*Mixophyes balbus*)

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Habitat searches identified suitable habitat for the Stuttering Barred Frog within the upper reaches of Cataract Creek in the Wonga East area (Eco Logical 2009), however no individuals were recorded during surveys. . GeoTerra (2012a) concluded that the worst case predictions extraction of the longwall panels in this reach (between surface water monitoring sites CC5 and CC9) may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. Implementation of adaptive management measures would minimise potential adverse environmental consequences. Without implementation of the adaptive mine plan, the Project may effect habitat values in this reach of Cataract Creek. Without adaptive management to minimise environmental consequences, the Project may have an adverse effect on the life cycle of the species. With adaptive management, the Project is unlikely to affect the life cycle of the species, such that a viable local population of the species is likely to be placed at risk of extinction. Habitat for Stuttering Barred Frog extends upstream of Mount Ousley Road. There is negligible potential for negative environmental consequences on the stream (GeoTerra 2021a) and accordingly habitat value in this section of Cataract Creek. With implementation of an adaptive mine plan it is unlikely that the Project will lead to a long-term decrease in habitat and therefore unlikely to affect the life cycle of the species, such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The upper reaches of Cataract Creek in Wonga East are considered to represent suitable habitat for the Stuttering Barred Frog in the Study Area (Eco Logical 2009). GeoTerra (2012a) concluded that the worst case predictions extraction of the longwall panels in this reach (between surface water monitoring sites CC5 and CC9) may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. Implementation of adaptive management measures would minimise potential adverse environmental consequences. The areas of suitable habitat for the Stuttering Barred Frog within the Study Area that were recorded in good condition are mainly upstream of Longwall A2 LW7 and the majority of it is not anticipated to be adversely affected by the Project. Subsequently, no habitat removal or modification is expected for the best quality habitat for Stuttering Barred Frog. Implementation of adaptive management measures would minimise potential adverse environmental consequences as a result of the Project in those areas identified by GeoTerra (2012a) (between surface water monitoring sites CC5 and CC9) that the Project may have an adverse impact on.

Table E.19	Stuttering Barred Frog (*Mixophyes balbus*)
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Potential habitat for Stuttering Barred Frog occurs upstream of proposed Longwall A2 LW8 either side of Mount Ousley Road. Predicted subsidence impacts are anticipated to be mainly associated with Longwall A2 LW8 and to a lesser degree with Longwall A2 LW7. There is no habitat identified downstream of these panels. The Project is not expected to fragment or isolate areas of habitat as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	No impacts to the habitat of the Stuttering Barred Frog are expected to result from the Project. Suitable habitat is present in the upper reaches of Cataract Creek in the Wonga East. It is considered that this area of habitat would be significant for the long term survival of a local population, if present.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Stuttering Barred Frog.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A draft national recovery plan has been prepared for the Stuttering Barred Frog (Hunter and Gillespie 2010). The objectives of the recovery plan are: 1. Determine the distribution, habitat requirements, conservation status, taxonomy and structure of Stuttering Frog populations; 2. Identify and address the causal factors of the decline, and prevent the local extinction of important populations of the Stuttering Frog across its geographic range; and 3. Build community support for the Stuttering Frog recovery program. The Project is considered to be consistent with these objectives and is unlikely to cause local extinction of the species as no adverse effects on stream water quality are anticipated in the suitable habitat for the species in Cataract Creek.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The alteration of Stuttering Barred Frog habitat is unlikely in the Study Area. Modification, destruction or removal of habitat will occur in the habitat closest to Longwalls A2 LW7 and A2 LW8. However, there is negligible potential for environmental consequences upstream of Longwall A2 LW6, and as a result this is not considered the operation of a KTP.

E.1.6 *Threatened Insects*

Table E. 20 Giant Dragonfly (*Petalura gigantea*)

The Giant Dragonfly (*Petalura gigantea*) is listed as Endangered under the TSC Act. Within NSW, this species is found along the coast and is not known west of the Great Dividing Range (DECCW, 2010). This species inhabits permanent swamps and bogs containing some free water and open vegetation (DECCW, 2010). This species was not recorded within the Study Area during field investigations although was considered to have a high likelihood of occurrence based on the availability of suitable habitat. The Giant Dragonfly is identified by DECC (2007a) as vulnerable to impacts associated with subsidence. The Giant Dragonfly is identified as a species that is not able to withstand loss within the Hawkesbury Nepean Catchment and swamps that support this species are considered to have state special significance (DECCW 2011).	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	The upland swamp habitats within the Study Area provide suitable habitat for the Giant Dragonfly. It is considered highly likely that a local population/s occur within the Study Area.

Table E. 20 Giant Dragonfly (*Petalura gigantea*)

	The upland swamps that are likely to provide potential habitat would be the larger swamps that support Upland Swamp: Tea-tree Thicket an indicator of more permanent water and greater complexity of habitat types and the valley infill swamps along Lizard Creek and Wallandoola Creek. Biosis (2012a) have identified the majority of these swamps as upland swamps of 'special significance'. Swamps of special significance (n=15) cover approximately 216.8ha of the total 265ha of upland swamp mapped in the Study Area. Of these swamps 9 upland swamps covering 39ha have a greater than negligible risk of negative environmental consequences. The larger valley infill swamps LCUS1 (130ha) and WCUS1 (36ha) are predicted to have a negligible risk of negative environmental consequences. While possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking is predicted in some of the upland swamps (Biosis 2012a, GeoTerra 2012a) for large areas of suitable habitat that may provide permanent water there is a negligible risk of changes to hydrology (GeoTerra 2012a) and it is therefore considered unlikely that the life cycle of the Giant Dragonfly will be affected by the proposed works such that a viable local population of the species is likely to be placed at risk of extinction.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Not applicable.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	Not applicable.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The Project will not involve any clearance of native vegetation or removal of habitat within the Study Area. The extent to which habitat may be removed or modified as a result of subsidence associated with the Project have been summarised in (a). Avoidance of the larger valley infill swamps in Lizard Creek and Wallandoola Creek has avoided loss of potential habitat for this species.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Potential minor changes to hydrology in some of the upland swamps is predicted (GeoTerra 2012a). The larger valley infill swamps occur upstream of the proposed longwall mining and are unlikely to become fragmented or isolated from other areas of potential habitat by the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Upland swamps provide potential habitat for the Giant Dragonfly within the Study Area. The upland swamps would be critical to the long term survival of a local population.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for the Giant Dragonfly.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for the Giant Dragonfly, however, the NSW DECCW has identified actions for the recovery of the species including: • assess known sites for threats, monitor changes in site condition, and develop and implement

Table E. 20 Giant Dragonfly (*Petalura gigantea*)

strategies to address threats;

- ensure that impacts of longwall mining on this species are assessed appropriately and where possible avoided. Where they cannot be avoided then minimises and appropriately offset any damage to habitat;
- maintain hydrological regimes of swamp habitats and protect water flows and water quality;
- develop and implement a monitoring program for adults and larvae across the species range; and
- assess the threat of changed hydrological regimes on the habitat of this species. Include the impacts of increasing urbanisation, groundwater extraction, longwall mining and climate change into this assessment.

The Project is directly relevant to two of the recovery actions that concern longwall mining, and related to the maintenance of hydrological regimes.

(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. There is a greater than negligible risk of negative environmental consequences as the result of subsidence for approximately 23% of the upland swamp (by area) potential habitat for the Giant Dragonfly in the Study Area. Given that, 73% of the potential habitat in the Study Area is predicted to have none or negligible impact this is not considered the operation of a KTP.

E.1.7 *Threatened Ecological Communities*

Table E.21 Coastal Upland Swamps in the Sydney Basin Bioregion

Coastal Upland Swamps in the Sydney Basin Bioregion **(**Coastal Upland Swamps**)** has been recently listed as an Endangered Ecological Community under the TSC Act. This community is associated with periodically waterlogged soils on Hawkesbury sandstone plateaus, generally where annual rainfall exceeds 950 mm. (TSSC, 2011). The vegetation is dominated by sclerophyll shrubs and/or sedges, in a mosaic of sedgelands, open heath and tall scrub.

Coastal upland swamps are highly diverse and variable mosaics of vegetation in response to soil conditions and fire regimes. Waterlogged zones have deep peaty, gleyed soils and tend to be dominated by *Leptospermum* species, *Melaleuca squarrosa*, *Banksia robur* and *Epacris paludosa* with a dense layer of *Gleichenia* sp and/or sedges. On the Woronora Plateau, this community is mapped as Upland Swamps: Tea-tree Thicket.

Where water table is less frequently sustained near the surface, the vegetation is more typically an open graminoid heath dominated by shrubs including *Banksia robur*, *Leptospermum juniperinum*, *Almaleea paludosa* and/or *Hakea teretifolia*, sometimes with *Banksia ericifolia*. Sedges dominate the areas between the shrubs. On the Woronora Plateau, this community is mapped as Upland Swamps: Sedgeland-Heath Complex.

Vegetation on the least frequently waterlogged zone is highly variable depending on soil and fire history, but typically forms a dense heath dominated by *Banksia* sp. This zone tends to dominate smaller swamps and edges of large swamps. On the Woronora Plateau, this community is mapped as Upland Swamps: Banksia Thicket.

Coastal Upland Swamps occur on impermeable sandstone plateaus in the headwater valleys of streams and on sandstone benches with abundant seepage moisture. Coastal Upland Swamps occur in the Somersby-Hornsby plateau area to the north of Sydney and on the Woronora plateau to the south of Sydney (TSSC 2011). Approximately 5360 ha have been mapped in Sydney Basin with approximately 83% on the Woronora plateau (TSSC 2011).

Biosis (2012a) have mapped and undertaken a risk assessment of the upland swamps of special significance in the Study Area. The results of that assessment have informed this impact assessment.

Eighty-four (84) upland swamps have been identified across the Study Area covering a total area of 265ha. Thirty-nine (39) upland swamps were recorded in Wonga East (total area 49ha) and 45 in Wonga West (total area 216ha including all of LCUS1).

Table E.21 Coastal Upland Swamps in the Sydney Basin Bioregion

Upland swamps in Wonga East are upland swamps while Wonga West is characterised by valley infill swamps along the main channels of Wallandoola Creek and Lizard Creek with headwater swamps associated with the tributaries of both streams.

(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Approximately 5360 ha have been mapped in Sydney Basin with approximately 83% on the Woronora plateau (TSSC 2011). It is estimated that up to 10% of this community may have been cleared in the recent past (TSSC 2011). The majority of remaining areas of this community are protected from disturbance as they occur within national park estate or water catchment area.

Approximately 265ha of Coastal Upland Swamp are present in Wonga East and Wonga West area. The Project will not directly clear any areas of the EEC. However, the proposed longwall mining may result in subsidence and alter hydrological processes of the swamps. This is likely to be particular evident in headwater swamps as the mine plan had been revised to avoid the more sensitive valley infill upland swamps associated with the main channel of Lizard Creek and Wallandoola Creek in Wonga West.

Possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking is predicted in some of the upland swamps. The Project has a risk of negative environmental consequences for approximately 29 of the 84 upland swamps, being approximately 60ha or 23% of the community in the Study Area. Of the 29 upland swamps assessed at risk (Biosis, 2012), 14 occur within Wonga East and 15 in Wonga West. These upland swamps occur over the proposed longwalls and are predicted to be subjected to strains and tilts above the assessment levels identified by OEH (2012).

In Wonga East, approximately 31ha of upland swamp (n = 14) is at risk of negative environmental consequences; of this, 9.8ha occurs in CRUS1, 4.8ha in CCUS1, 3.45ha in CCUS5, 1.8ha in CCUS4 and 1.6ha in CCUS10. The remaining 9.6ha occurs in 9 smaller swamps that are dominated by Upland Swamp: Banksia Thicket. This community is more able to withstand water loss provided rainfall recharge is adequate such that trees cannot establish.

CRUS1 is a swamp of special significance assessed as being at low risk of negative environmental consequences (Biosis 2012a), mainly attributed to the proposed mine plan for Longwalls A2 LW4 and A2 LW5 having been revised as part of approval for MP10_0046 to avoid a large portion of this swamp. CCUS4 and CCUS10 are both small, floristically diverse swamps of special significance assessed as being at low risk of negative environmental consequences (Biosis 2012a). CCUS1 and CCUS5 are both swamps of special significance assessed as being at significant risk of negative environmental consequences (Biosis 2012a).

In Wonga West, approximately 29ha of upland swamp (n = 15) is at risk of negative environmental consequences; of this, 11ha occurs in WCUS4, 3.3ha in LCUS25, 2.8ha in WCUS11, 2.5ha in LCUS18, 2.1ha in LCUS8 and 2ha in WCUS7. The remaining 4.8ha occurs in 9 smaller swamps. These smaller swamps are all headwater swamps that are typically dominated by Upland Swamps: Sedgeland-Heath Complex (Restiod Heath). Restiod Heath is located on the swamp margins and upper slopes where the water table rarely reaches the surface (Biosis 2012a). This community is more able to withstand loss of water, provided rainfall recharge is adequate such that trees cannot establish (Biosis 2012a).

WCUS4 is a headwater and valley infill swamp of special significance assessed as being at moderate risk of negative environmental consequences in particular in the headwater swamp over Longwall A3 LW2 (Biosis 2012a). WCUS11 is a headwater swamp of special significance assessed

Table E.21 Coastal Upland Swamps in the Sydney Basin Bioregion

as being at low risk of negative environmental consequences (Biosis 2012a). LCUS25 and LCUS18 are not identified as a swamp of special significance and Biosis (2012a) did not undertake a risk assessment. LCUS25 may be at risk given that the swamp overlies Longwalls A3 LW5 and A3 LW4. LCUS18 may be at risk given that the swamp overlies the western edge of Longwall A3 LW2. WCUS7 is a valley infill swamp of special significance assessed as being at moderate risk of negative environmental consequences (Biosis 2012a). LCUS8 is a headwater and valley infill swamp of special significance assessed as being at low risk of negative environmental consequences (Biosis 2012a).

NRE has provided an undertaking that mining operations would be modified as required through adaptive management measures informed through monitoring of actual subsidence impacts, to reduce negative environmental consequences. An adaptive management plan will be developed to use the monitoring program to detect the need for adjustment to the mining operations, so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences do not occur in coastal upland swamps. Recommendations provided by Biosis (2012a) in their assessment of coastal upland swamps will be further considered in development of the adaptive management plan and future mining plans.

With implementation of the adaptive management plan, and the commitment to not create a significant risk of negative environmental consequences, the extent of coastal upland swamps in the locality may not be significantly affected such that the local occurrence of the mapped area of EEC is likely to be placed at risk.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Theoretically, reductions in surface and/or groundwater availability in the coastal upland swamps would dry and thereby alter the floristics of the swamps and increase the fire risk of the vegetation and ecological community; while changes in grade may result in ponding that in turn may result in microhabitat floristic changes providing for establishment of vegetation with a higher tolerance to inundation.

Coastal Upland Swamps located parallel to a longwall, and in areas of low tilts and strains, are less likely to undergo changes in gradient due to tilts and/fracturing resulting from strains. Swamps spanning multiple longwall panels undergo significant and multiple changes in gradient and strains are most susceptible to impact. The vegetation communities within a swamp also determine susceptibility to impacts. In particular, Tea-tree Thicket is reliant upon permanent water and Cyperoid Heath is reliant on frequent waterlogging, and susceptible to reduction in water flows. Other communities are more able to withstand some loss of water flow provided that rainfall recharge is adequate such that trees cannot establish in the Coastal Upland Swamps.

As stated above, there are a number of the swamps at risk of negative environmental consequences due to subsidence impacts. Biosis (2012a) have prepared a detailed risk assessment of the upland swamps of special significance, including modelling of changes in flow pathways within the swamps. The full results of the assessment are provided in Tables 12 and 13 of Biosis (2012a).

In summary, the Biosis (2012a) assessment identified that valley infill swamp in Wonga West are not predicted to undergo significant changes in flow accumulation, largely due to the fact that they are located along the main channels of Lizard and Wallandoola Creek, are not located above longwalls and are thus largely subject to minimal levels of subsidence (Biosis 2012a).

Areas of Tea-tree Thicket and Cyperoid Heath are associated with existing flow accumulation paths within the headwater swamps. These communities are susceptible to changes in flow accumulation as they are reliant on permanent or frequent waterlogging. In CCUS1 flow accumulation modelling post-mining indicates that tilts in A1 LW3 may result in a reduction of flow accumulation and therefore reduced saturation in the area of Cyperoid Heath and potential for changes in vegetation composition. Conversely, in CCUS4, the modelling predicts an increase in flow accumulation and increased saturation in Cyperoid Heath in the west of the swamp (Biosis 2012a).

Flow accumulation modelling indicated that upland swamps CCUS1, CCUS4, CCUS5 and WCUS4 may undergo changes in flow accumulation that may result in changes in groundwater availability. This change in groundwater availability could result in changes in vegetation communities within these swamps (Biosis 2012a).

Table E.21 Coastal Upland Swamps in the Sydney Basin Bioregion

	This assessment was not undertaken for other upland swamps overlying the proposed longwall panels. For the smaller swamps, especially those dominated by Upland Swamps: Banksia Thicket, subsidence impacts are not likely to generate any significant change in the potential for ponding, scouring or erosion in the swamps, however strains may result in changes to the Hawkesbury Sandstone which in turn has the potential to cause hydrological changes. These changes may modify the composition of the small upland swamp, which due to the small size may limit the ability of the swamp to recover. With implementation of the adaptive management plan, in particular implementation of the recommendations provided in Biosis (2012a) for the swamps of special significance; and, the commitment to not create a significant risk of negative environmental consequences for these swamps; the potential for changes in composition of these upland swamps would be reduced such that the local occurrence of Coastal Upland Swamps is not placed at risk.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	As stated above, the Project has a negligible or greater risk of negative environmental consequences for approximately 29 of the 84 upland swamps in the Study Area, being approximately 60ha (or 23%) of the mapped community. The risk assessment by Biosis (2012a) has identified that 21ha (or 8%) of upland swamp EEC (CCUS1, CCUS5, WCUS4 and WCUS7) has a moderate or significant risk of negative environmental consequences. These changes are predicted to be associated with modification of areas of Upland Swamps: Tea-tree Thicket and Upland Swamps: Cyperoid Heath given that both of these communities are reliant upon permanent or frequent waterlogging and are therefore more susceptible to loss of water.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	Upland swamp habitats, in particular headwater swamps, naturally occur with a patchy distribution. While there is potential for changes in some of the upland swamps, the changes are not likely to fragment or isolate habitat for EECs.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	The majority of swamps in the application area occur within the Wallandoola Creek swamp cluster that is recognised by DECC (2007a) to be of particular conservation significance as providing connectivity of habitat for swamp specialists. The PAC (2009, 2010) identified that some highly significant ecological features are classified as features of 'special significance'. Where, 'special significance' status is based on assessment of a natural feature that determines the feature to be so special that it warrants a level of consideration (and possibly protection) well beyond that accorded to others of its kind. Biosis (2012a) identified 15 upland swamps in the Study Area as being of 'special significance' based upon the most recent criteria defined by OEH (2012). Upland swamps of special significance are mapped on *Figure 5.1* and *5.2*. Of the 15 upland swamps, nine have potential to be subjected to subsidence impacts including: • five swamps (CCUS4, CCUS10, CRUS1, LCUS8 and WCUS11) with a low likelihood of negative environmental consequences, NRE may wish to consider changes to longwall layouts to reduce potential impacts on these swamps; • two swamps (WCUS4 (headwater swamp) and WCUS7) with a moderate likelihood of negative environmental consequences, NRE should consider changes to longwall layouts to reduce impacts on these swamps; and • two swamps (CCUS1 and CCUS5) with a significant likelihood of negative environmental consequences, NRE should consider implementation of habitat avoidance, minimisation and mitigation measures to reduce impacts on these swamps. By definition of the PAC, these upland swamps of special significance have a higher importance for conservation of habitat beyond that afforded to other areas of coastal upland swamp EEC.

Table E.21	Coastal Upland Swamps in the Sydney Basin Bioregion
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for this community.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for this community.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. There is potential for alteration of the Coastal Upland Swamp and as a result this is considered likely to constitute the operation of a KTP.

Table E.22	Shale Sandstone Transition Forest in the Sydney Basin Bioregion
Shale Sandstone Transition Forest is listed as an Endangered Ecological Community under the TSC Act and Endangered under the EPBC Act. This community occurs at the edges of the Cumberland Plain in Western Sydney, where clay soils derived from shale rock intergrades with sandstone derived soils or where shale caps overlay sandstone (DECCW, 2010). This community was recorded as two stands in Wonga West within the Study Area. The EEC occurs as Transitional Shale Open Blue Gum Forest between Lizard Creek and Wallandoola Creek spanning over Longwalls A3 LW1 and A3 LW2 and as Transitional Shale Stringybark Forest in the west of the Study Area over Longwalls A3 LW4 and A3 LW5. This community is identified as vulnerable to impacts associated with subsidence (DECC 2007a).	
(a)	*in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(b)	*in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
	Not applicable.
(c)	*in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
	(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
	Transitional Shale Stringybark Forest and Transitional Shale Tall Open Blue Gum Forest communities are listed under Shale Sandstone Transition Forest EEC; and are present in areas above Wonga West domains of the Study Area. No clearance of native vegetation are associated with the proposed longwall extraction and therefore potential impacts are related to subsidence and include cracking of surface and sub-surface, lowering of the water table beyond the reach of plants. There is a maximum predicted subsidence of 2.3m and maximum predicted tilt of 15mm/m under the EEC. This subsidence is considered unlikely to result in significant impacts on the EEC, and accordingly is unlikely to affect the extent of this community in the locality.
	(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
	The FMEA (Olsen Consulting 2010) identified low potential impact on the Shale Sandstone Transition Forest EEC. Maximum predicted subsidence in this community is 2.3 m (see ***Error! Reference source not found.***). Potential impacts as a result of subsidence include tree tilt/fall and lowering of the watertable beyond the reach of plants causing degradation to the vegetation community. There is a maximum permanent predicted tilt of 16 mm/m under the EEC in the Study Area (Seedsman 2012). It is not expected that such a tilt would lead to a lean that would be sufficient to cause instability, although there is a possibility that trees that already have a steep lean in the direction of tilt may fall. It is unlikely that any isolated falls that may occur would

Table E.22 Shale Sandstone Transition Forest in the Sydney Basin Bioregion

	significantly alter vegetation community composition in the Study Area. In the event of broad scale tree falling, significant damage to vegetation would occur. In addition, tilt will not directly affect shrubs, herbs or grasses, as they are too short to exert significant leverage on root systems. Tilting due to subsidence is not expected to cause measurable short or long-term damage to the EEC within the Study Area. Therefore, it is unlikely that the Project will substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction. The FMEA recommends visual inspection and seasonal reporting on forest conditions to assist in the identification of any impacts and aid targeted remediation, if impacts do occur.
(d)	*in relation to the habitat of a threatened species, population or ecological community:*
	(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
	The habitat of the Shale Sandstone Transition Forest EEC will not be removed. There is potential for the habitat to be modified as a result of tree tilt/fall and lowering of the watertable beyond the reach of plants, however the FMEA (Olsen Consulting 2010) identified low potential impact on the Shale Sandstone Transition Forest EEC. The FMEA recommends visual inspection and seasonal reporting on forest conditions to assist in the identification of any impacts and aid targeted remediation, if impacts do occur.
	(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
	The potential impacts on the Shale Sandstone Transition Forest EEC have been identified as low risk by the FMEA (Olsen Consulting 2010); therefore it is considered unlikely that an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the Project.
	(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
	Before European settlement Shale-Sandstone Transition Forest was extensive at the edges of the Cumberland Plain and covered 43,990 hectares. Today, it is reduced to 22.6% of its original extent. An area of 141.61 hectares of EEC in good condition has been identified in the Study Area; which represents approximately 1.4% of the total remaining area of Shale-Sandstone Transition Forest EEC. Modification is the only potential impact, as has been assessed as low risk by the FMEA (Olsen Consulting 2010). Therefore it is considered that the while the habitat can be seen as important in the locality, the low potential for impacts would mean that it is unlikely that the Project would threaten the long-term survival of the EEC in the locality.
(e)	*whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*
	No areas of critical habitat have been declared for this community.
(f)	*whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*
	A recovery plan has not been prepared for this community specifically; however, a Recovery Plan for the Cumberland Plain area that addresses Shale Sandstone Transition Forest EEC has been prepared by DECCW (2010). The overall objective of the recovery plan is to provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. The Cumberland Plain Recovery Plan seeks to focus recovery efforts on those lands which represent the best opportunities to secure viable, long-term conservation outcomes in the region (DECCW 2010). These areas have been named priority conservation lands. The Study Area occurs at the edge of the Cumberland Plain, but is not mapped in the recovery plan as part of the Cumberland Plain, therefore no priority conservation lands are mapped in the Study Area. Subsidence impacts are not mentioned in the plan. NSW DECCW has also identified actions for the recovery of the EEC including: • manage, to best practice standards, areas of EECs which have conservation as a primary objective, or where conservation is compatible. Priorities are to be based on DEC conservation significance assessment; • develop and implement Cumberland Plain Reservation Strategy and create a protected

Table E.22	Shale Sandstone Transition Forest in the Sydney Basin Bioregion
	bushland network through targeted land acquisition as land becomes available; and • investigate the development of a regular monitoring program to assess the change in extent of vegetation across the Cumberland Plain.
(g)	*whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*
	Alteration of habitat following subsidence due to longwall mining is listed as a Key Threatening Process. The potential for alteration of the Shale Sandstone Transition Forest EEC habitat is considered low risk (FMEA – Olsen Consulting 2010) and as a result is considered unlikely to constitute the operation of a KTP.

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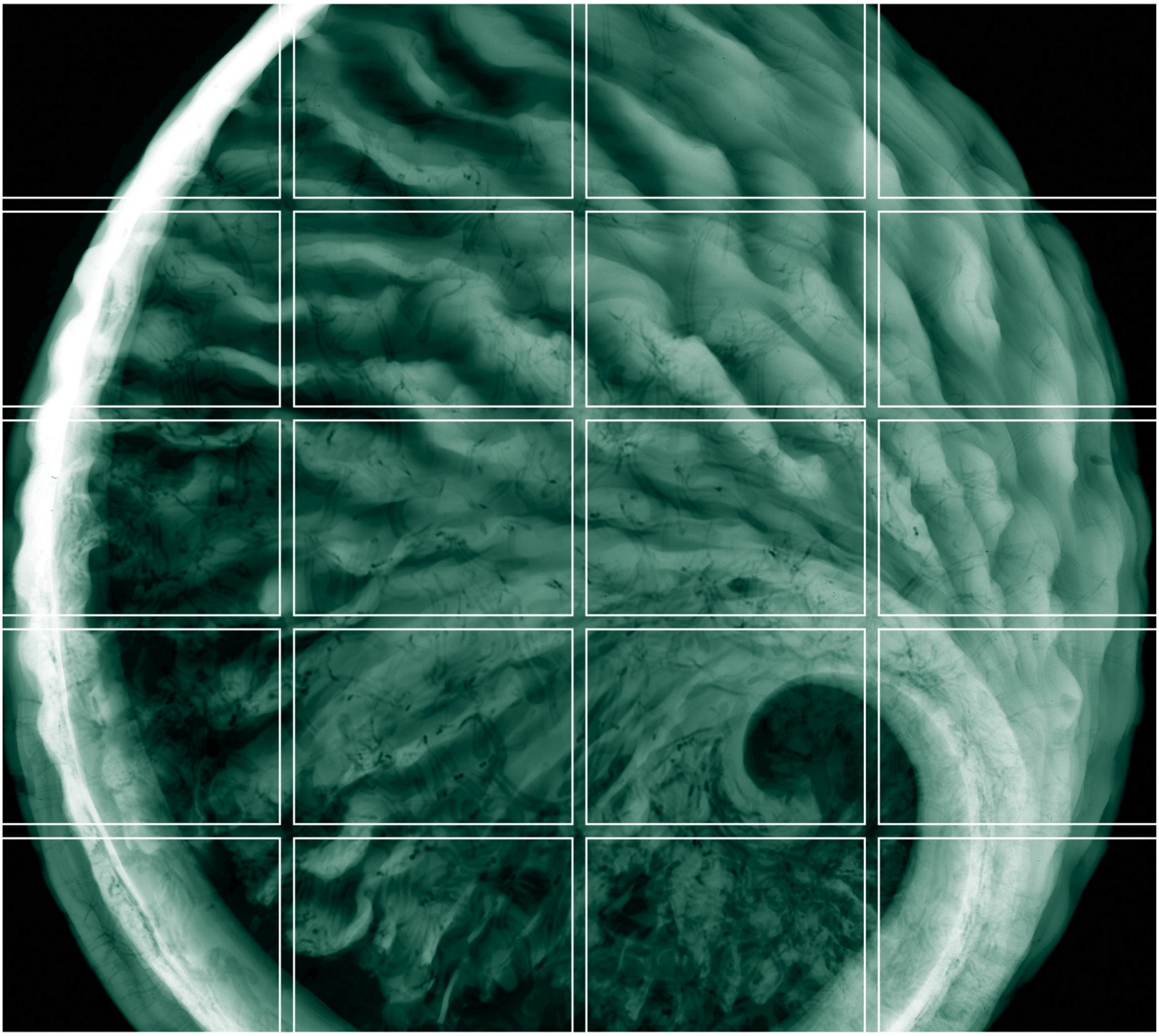
Environmental Resources Management

PO Box 3071
Thornton NSW 2322
53 Bonville Avenue
Thornton NSW 2322

T: +61 2 4964 2150
F: +61 2 4964 2152
www.erm.com

Annex T

EPBC Act Matters



NRE No.1 Colliery Longwall Mining in Wonga East and Wonga West

EPBC Act Matters of National Environmental Significance

Gujarat NRE Coking Coal Pty Ltd

February 2013

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Gujarat NRE Coking Coal Limited

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Prepared by:	*Naomi Buchhorn*
Position	*Project Manager*
Signed:	
Date:	*8 February 2013*
Approved by:	*Steve O'Connor*
Position:	*Technical Director*
Signed:	
Date:	*8 February 2013*

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FINAL REPORT

Gujarat NRE Coking Coal Limited

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February 2013

0079383_EPBC

Environmental Resources Management Australia
Building C, 33 Saunders Street
Pyrmont, NSW 2009
Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800
www.erm.com

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GLOSSARY OF TERMS

angle of draw	The angle between the vertical and the line joining the edge of the mining void with the limit of vertical subsidence, usually taken as 20 millimetres.
anthropogenic	Associated with human activities and development.
aquifer	A permeable body of rock or regolith that both stores and transmits groundwater
arboreal	Adapted for living in and/or moving around in trees.
base flow	The flow of water entering stream channels not attributable to direct runoff from rainfall and usually from groundwater or related sources.
bioregion	Region where the boundaries are primarily determined by (or reflect) similarities in geology, climate and vegetation.
Bulli West	Area of first workings west of existing workings.
cleared land	Where the native over-storey has been cleared, there is no native mid-storey and less than 50% of the groundcover vegetation is native species or greater than 90% of the groundcover (dead or alive) is cleared.
clearing	Clearing of native vegetation is defined in the *Native Vegetation Act 2003* as any one or more of the following: cutting down, felling, thinning, logging or removal; killing, destroying, poisoning, ringbarking, uprooting or burning
coking coal	Coking coal is coal that can be used in the production of coke which in turn is used in the blast furnace in the production of pig iron. Ash content of less than 10% and volatile matter of 21-23%.
community	The recognisable association of species that regularly occur together in similar environments.
consequences (subsidence)	Changes to terrestrial ecological features as a result of subsidence impacts (this may include stream flow alterations, groundwater losses, rock falls, damage to flora, fauna and their habitat) (DoP 2008)
continuous miner	A remote-controlled, tracked, electrically powered coal cutting and loading machine used to form mine roadways and extract coal pillars.
critical habitat	Habitat declared to be critical in relation to that species or ecological community under the *Threatened Species Conservation Act 1995* or the *Environment Protection and Biodiversity Conservation Act 1999*.
depth of cover	The depth of the roof of the coal seam from the ground measured in metres.
driveage	An horizontal or inclined underground roadway that provides vehicular access to coal reserves.
ecological community	An assemblage of native species that inhabits a particular area.
ephemeral stream	Stream that may or may not have a well-defined channel, generally with unpredictable flow, only during and immediately after rain.
endangered	A species, population or ecological community that is likely to become extinct or is in immediate danger of extinction.
endangered ecological community	Ecological community specified as endangered under Part 3 of Schedule 1 of the *Threatened Species Conservation Act 1995* or under the *Environment Protection and Biodiversity Conservation Act 1999*.
endangered population	Population identified as endangered under Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995*.
endangered species	Species identified as endangered in Part 1 of Schedule 1 of the *Threatened Species Conservation Act 1995* or under the *Environment Protection and Biodiversity Conservation Act 1999*.

endemic	Restricted to a particular area having originated there.
exfoliating sandstone	Sandstone that has separated from the main body of rock into small sheets on the surface, as part of the natural weathering process. These sheets are often used as a shelter by reptiles.
exotic species	A non-indigenous species.
floristics	Species composition of a plant community.
first order stream	Stream that does not have any other stream feeding into it.
first workings	Involves the development of 'headings' or 'roadways', using continuous miners with integrated roof and rib bolting rigs, to provide access to the coal resource. First workings leave the coal pillars intact and the overlying strata fully supported resulting in 'zero' subsidence.
gate roads	Access roadways connecting the longwall working face with the main roadways.
goaf	The mined out area in an underground mine into which the immediate roof strata breaks.
groundcover	Structural layer closest to the ground containing grasses, forbs, ferns, sub-shrubs, and sedges.
groundwater	Water that occurs beneath the surface of the ground that has filtered down to zone where the earth or rocks are fully saturated.
groundwater dependent ecosystem	Ecosystems which have their species composition and their natural ecological processes determined by groundwater.
habitat	An area or areas occupied or periodically occupied by a species, population or ecological community and includes any biotic or abiotic component necessary to sustain survival and reproduction.
headwater swamp	Headwater swamps are freshwater wetlands situated in areas high in the catchment near catchment divides, located in areas of shallow, impervious substrate formed by either sandstone or clay horizons. Headwater swamps are likely to have perched water tables within the sediments that are independent of the water table in the Hawkesbury sandstone, dependent upon rainfall and surface runoff.
hibernation	To spend winter in close quarters in a dormant condition.
hollow-bearing tree	Tree where the base, trunk or limbs contain hollows, holes or cavities that have formed as a result of decay, injury or other damage.
indigenous	Native to, or originating in, a particular region or country.
intermittent stream	Stream with a well-defined channel that carries water for at least part of the year, but ceases to flow occasionally or seasonally because bed seepage and evapotranspiration exceed the available water supply.
iron oxidizing bacteria	Bacteria that derive energy by converting iron in the ferrous form to the ferric form, which then combines with oxygen to produce iron oxide, often appearing as a rusty red or orange 'fluffy' clumps or stains in the stream. Reaction is dependent on oxygen presence and is more likely to be found where oxygen-poor groundwater is reaching the surface of the stream.
key threatening process	Threatening process identified as such in Schedule 3 of the *Threatened Species Conservation Act 1995* or under the *Environment Protection and Biodiversity Conservation Act 1999*.
life cycle	The series or stages of reproduction, growth, development, ageing and death of an organism.

local population	The population that exists in the study area as well as any individuals occurring in the adjoining areas known or likely to utilise habitats in the study area.
longwall mining	A high capacity underground mining method that utilises a mechanical shearer to cut the coal. The loosened coal falls onto a conveyor for removal from the mine.
longwall panel	A large contiguous block of coal, typically suitable for longwall extraction.
native groundcover or understorey	Is where at least 50% of the perennial vegetation cover in the groundcover strata or understorey is made up of native species and not less than 10% of the area is covered with vegetation (dead or alive).
upland swamp	Upland swamps are vegetated freshwater wetlands occurring in shallow basins located in low hills, plateaus of mountains.
native or indigenous	Species that existed in NSW before European settlement.
non-volant	An animal not capable of active flight (includes gliders)
offset (biodiversity)	One or more appropriate actions put in place in an appropriate location to counterbalance or offset an impact on biodiversity values.
Perched water table	Saturated soil horizon with a free water surface generally above the normal water table.
perennial stream	Stream with a well-defined channel that flows continuously all year during a year of normal rainfall with the aquatic bed located below the water table for most of the year.
population	A group of animals or plants of the same species, potentially capable of interbreeding and sharing the same habitat in a particular area at a particular time.
regeneration	Where native vegetation is allowed to return naturally to an area generally by removing existing impacts such as grazing or slashing.
regrowth vegetation	Defined in the *Native Vegetation Act 2003* as any native vegetation that has regrown since 1 January 1990 (or 1 January 1983 Western Division). Excluding regrowth after illegal clearing or natural events such as bushfire, floods and drought.
remnant vegetation	Any native vegetation that is not regrowth.
revegetation	Use of methods such as planting of tubestock and direct seeding to return native vegetation to an area.
riffle	A section of a stream with shallow, fast-flowing water with a distinctly disturbed surface and usually with a gravel or pebble base.
riparian	Associated with drainage lines.
risk of extinction	The likelihood that the local population will become extinct either in the short term or long term as a result of direct or indirect impacts on the viability of that population.
risk management zone	An identified area containing significant natural features as defined by DoP (2008), delineated from the outside extremity of the surface feature, either by a 40° angle from the vertical down to the coal seam which is proposed to be extracted, or by a surface lateral distance of 400 m, whichever is the greater.
run-of-mine	Raw coal as mined that has not undergone any screening, crushing or washing.

second order stream	Stream formed where two first order streams come together.
second workings	Extraction of coal by pillar extraction methods.
Special Areas	Areas surrounding SCA's dams which are subject to additional management measures to protect the quality of drinking water. These areas are declared under the *Sydney Water Catchment Management Act 1998* for their value in protecting the quality of the raw water used to provide drinking water to greater Sydney and for their ecological integrity.
Special significance status	Special significance status is based on an assessment of a natural feature that determines the feature to be so special that it warrants a level of consideration (and possibly protection) well beyond that accorded to others of its kind. It may be based on a rigorous assessment of scientific importance, archaeological and cultural importance, uniqueness, meeting a statutory threshold or some other identifiable value or combination of values (PAC 2009).
strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points, as a result of underground coal mining.
stratum (singular) **strata (plural)**	An arbitrary horizontal layer of plants within a vegetation community used to describe the vegetation community structure.
subsidence or subsidence effects	The deformation of the ground mass surrounding a mine due to the mining activity. The term is a broad one, and includes all mining-induced ground movements, including both vertical and horizontal displacement, tilt, strain and curvature (DoP 2008).
subsidence impacts	The physical changes to the ground and its surface caused by subsidence effects. These impacts are principally tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence but also include subsidence depressions or troughs.
subsidence impact zone	The surface area that is likely to be affected by the proposed underground mining.
termitaria	Nest chambers built by termites a.k.a. termite mounds.
third order stream	Stream that forms where two second order streams come together.
threatened species	A plant or animal identified in the *Threatened Species Conservation Act 1995* or *Environment Protection and Biodiversity Conservation Act 1999* as extinct, critically endangered, endangered, or vulnerable. This term may be extended to encompass threatened species, populations or ecological communities.
threatening process	A process that threatens, or may threaten the survival, abundance or evolutionary development of species, populations or ecological communities.
tilt	Change in slope of the surface landform as a result of underground mining.
understorey	Collective term for vegetation which grows below the canopy of a forest or woodland.
upsidence	Relative upward movement, or uplift, created by the horizontal compression and buckling behaviour of the rock strata in the vicinity of the valley floor.

valley infill swamp	Valley infill swamps form on the floor of incised second or third order stream valleys on sediment deposited possibly as a result of channel blockage such as a log jam (DoP 2008). Valley infill swamps are likely to have direct connection to regional water table and may receive water from multiple sources including rainfall, stream flow and groundwater seepage (PAC 2010).
vertical subsidence	Vertical downward movements of the ground surface caused by underground coal mining.
viable	The capacity to successfully complete each stage of the life cycle under normal conditions.
volant	An animal capable of active flight (does not include gliders).
vulnerable	A species, population or ecological community that is likely to become extinct or is in immediate danger of extinction.
Wonga East	The eastern area of proposed Stage 2 workings
Wonga Mains	Main driveage through the Wongawilli seam
Wonga West	The western area of proposed Stage 2 workings
Zero subsidence	Defined as vertical downward movement of the ground surface that is less than or equal to 20 mm.

ABBREVIATIONS

A1, A2, A3, A4	Area 1, Area 2, Area 3, Area 4
BoM	Australian Government Bureau of Meteorology
BSO	Bulli Seam Operation
BCUS	Bellambi Creek Upland Swamp
CCUS	Cataract Creek Upland Swamp
CEMP	construction environment management plan
CL	Coal Lease
CMA	Catchment Management Authority
CRUS	Cataract River Upland Swamp
DEC	Department of Environment and Conservation (NSW)
DECC	Department of Environment and Climate Change (NSW) including the Parks and Wildlife Division, Cultural Heritage Division and Environment Protection and Regulation Division (Formerly DEC)
DECCW	Department of Environment, Climate Change and Water (NSW) (Formerly DECC)
DEWHA	Department of Environment, Water Heritage and Arts (Commonwealth)
DMR	Department of Mineral Resources
DNR	Department of Natural Resources (NSW)
DoP	Department of Planning (NSW)
DP&I	Department of Planning and Infrastructure (NSW)
DPI	Department of Primary Industries
DRE	NSW Department of Trade and Investment, Division of Resources and Energy
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth)
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EP&A Act	*Environmental Planning and Assessment Act, 1979*
EP&A Regulation	Environmental Planning and Assessment Regulation, 2000
EPA	Environment Protection Authority (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act, 1999*
EPI	Environmental Planning Instrument
ERM	Environmental Resources Management Australia Pty Ltd
ESD	Ecologically Sustainable Development
FMEA	Failure Mode and Risk and Effect Analysis
GDE	Groundwater Dependent Ecosystems
GIS	Geographic information system
ha	hectares
km	kilometres
LCUS	Lizard Creek Upland Swamp
LCT1	Lizard Creek Tributary 1
LEP	Local Environmental Plan
LGA	Local Government Area

m	Metres
ML	Mining Lease
mm	Millimetres
mm/m	millimetres per metre
MOP	Mine Operations Plan
MSB	Mine Subsidence Board
Mt	Million tonnes
Mtpa	Million tonnes per annum
NPWS	National Parks and Wildlife Service
NRE	Gujarat NRE Minerals Pty Ltd
NSW	New South Wales
NV Act	*Native Vegetation Act, 2003*
OEH	Office of Environment and Heritage (formerly DECCW)
PAC	NSW Planning Assessment Commission
PWP	Preliminary Works Project
RMZ	Risk Management Zone
ROM	Run of Mine (raw coal prior to washing).
ROTAP	Rare or Threatened Australian Plant
SCA	Sydney Catchment Authority
SCI	Southern Coalfields Inquiry
SEPP	State Environmental Planning Policy
SMP	Subsidence Management Plan
sp./spp.	species singular / plural
subsp./subspp.	sub-species singular / plural
Tpa	Tonnes per annum
TSC Act	*Threatened Species Conservation Act, 1995*
WC	Wallandoola Creek
WCUS	Wallandoola Creek Upland Swamp
%	percent
° C	degree Celsius

EXECUTIVE SUMMARY

Gujarat NRE Coking Coal Limited (NRE) is seeking approval for continuation, consolidation and expansion of underground coal mining at its NRE No1 Colliery located at Russell Vale, NSW. The Project Application Area (PAA) supports habitat for a number of threatened species and one endangered ecological community (EEC) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This report specifically covers EPBC Act matters of National Environmental Significance (NES)..

All listed threatened species and ecological communities with the potential to occur in the Study Area were considered for their vulnerability to subsidence effects. Those species which were identified to have a moderate to high likelihood of occurrence, and which are also susceptible to subsidence, were assessed under the EPBC Act guidelines.

Assessments in accordance with the EPBC Act *Significant Impact Guidelines 1.1* (DEWHA 2009a) were undertaken for 16 species, including nine fauna species and six flora species and one EEC. The full assessments are provided in *Annex B*.

The assessment of the Giant Burrowing Frog concluded that the proposed action may potentially modify, destroy, remove or isolate or decrease the availability or quality of habitat within tributaries of Lizard Creek, thereby disrupting the breeding cycle of a population of the species in the Wonga West area.

The Heath Frog is likely to occur within the Wallandoola Creek drainage, and suitable habitat for breeding occurs within the valley infill swamp WCUS7. This swamp is likely to be subject to subsidence impacts such as cracking of substrate (GeoTerra 2012b). If cracking of pond bars or substrate were to occur, the period of wetting will be reduced, so the swamp habitat condition may decline, resulting in a consequence such as the Heath Frog successfully breeding within WCUS7. The assessment found that, if that were the case, the proposed action may disrupt the breeding cycle of part of an important population.

Suitable habitat and good quality breeding habitat for the Stuttering Barred Frog (*Mixophyes balbus*) has been identified in the reaches of Cataract Creek upstream of proposed Longwall A2 LW8 in Wonga East. Based on worst case subsidence predictions, certain habitat areas for the Stuttering Barred Frog above A2 LW8 and A2 LW7 would be affected by the proposed action. Although a large tract of habitat for this species occurs upstream of the potentially affected reach of Cataract Creek, the proposed action is predicted to have negligible consequence on this species.

The threatened Macquarie Perch (*Macquaria australasica*) and a hybrid of the freshwater cod species Murray Cod (*Maccullochella peelii peelii*) and Trout Cod (*Maccullochella macquariensis*) are known from the waters of Cataract Reservior and have been recorded periodically in the waters of Cataract Creek. Due to barriers downstream, none of these fish species are expected to occur in Lizard Creek and Wallandoola Creek. The worst case subsidence predictions identify that extraction of the longwall panels in this section of Cataract Creek may reduce stream flow, stream pool volumes and stream water chemistry (GeoTerra 2012a).

Such a physical change may affect habitat values required for fish spawning, should spawning actually occur in this section of Cataract Creek. The proposed action will not impact the main habitat for any of these species in Cataract Reservoir.

In relation to potential subsidence impacts on fluvial and palustrine environments, NRE commit to monitor actual subsidence of longwall panels to validate predictions about the consequences of subsidence on aquatic habitats and biota. NRE will terminate mining beneath Cataract Creek should subsidence and ground movements exceed 250 mm. With adaptive management for subsidence, the action is unlikely to affect the population of these fish species (Cardno Ecology Lab 2012).

Three terrestrial fauna species which may occur in the Study Area, Spotted-tailed Quoll (*Dasyurus maculatus*), Large-eared Pied Bat (*Chalinolobus dwyeri*) and Broad-headed Snake (*Hoplocephalus bungaroides*) rely upon rocky habitats (overhangs, shelves and/or caves) that occur predominantly along Lizard Creek and Wallandoola Creek and their tributaries. The assessment concluded that there is a negligible to low risk (SCT Operations 2012) that the action could modify, destroy, remove or isolate or decrease the availability or quality of breeding or denning habitat associated with the cliffs and/or steep slope habitat in the Study Area.

Prickly Bush-pea (*Pultenaea aristata*) has previously been recorded in Wonga West near Shaft No 5 (Kevin Mills and Associates 1995) and was recorded in two locations during surveys by ERM in Wonga East in September 2011 (CRUS1 and CCUS3), and in various locations by Biosis in Wonga East (CCUS10, CCUS8 and BCUS7) and Wonga West (LCUS27, WCUS5, WCUS1, WCUS4, LCUS14, LCUS13, LCUS15, LCUS16, LCUS33, LCUS17) during 2012 (N.Garvey Biosis, pers comm). It may be present in a range of vegetation types, from heath in upland swamps to dry sclerophyll woodlands such as Exposed Sandstone Scribbly Gum Woodland and Upland Swamp Fringing Eucalypt Woodland and Upland Swamp: Restioid Heath that are widespread in the Study Area. While the proposed action would not clear potential habitat nor directly decrease the size of the population in the Study Area, there is potential for impact to individual specimens inhabiting the drier marginal fringes of the Upland Swamps. Given that Prickly Bush-pea is typically associated with drier vegetation on the fringes of the upland swamps, it is unlikely that the proposed action will lead to an impact on an important population of the Prickly Bush-pea.

It is generally recognised that the impacts of subsidence due to longwall mining on terrestrial ecosystems (including Shale Sandstone Transition Forest EEC) are likely to be less significant than those experienced by aquatic-dependent ecosystems (DECC 2008). Subsidence prediction values for the areas of Shale/Sandstone Transition Forest EEC indicate a maximum predicted subsidence of 2.3 m and maximum permanent predicted tilt of 15 mm/m under the EEC in the Study Area. This subsidence is unlikely to result in significant impacts on the EEC.

The Woronora Beard-heath (*Leucopogon exolasius*), Deane's Paperbark (*Melaleuca deanei*), Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*) and Bargo Geebung (*Persoonia bargoensis*) may occur in the Study Area. These species are reliant upon the 'terrestrial' sandstone woodland, forest or dry heath habitats. While maximum subsidence predictions in these potential habitat areas is approximately 2.3 m and maximum predicted tilt of 15 mm/m, the mine design approach has recognised that the majority of the surface can be safely subsided (Seedsman 2012) and this level of subsidence is unlikely to impact on terrestrial vegetation communities and the species within them. It is unlikely that the changes in conditions would cause significant damage to vegetation communities and subsequently a long-term decrease in the size of any important population of these species.

The proposed action is unlikely to impact on other matters of NES in particular migratory bird species that have been recorded in the Study Area.

NRE are currently preparing a referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) for the proposed action.

1 INTRODUCTION

1.1 BACKGROUND

Gujarat NRE Coking Coal Limited (NRE) is seeking approval for continuation, consolidation and expansion of underground coal mining as Stage 2 of the proposed expansion of the NRE No1 Colliery located at Russell Vale, NSW. The proposal involves longwall mining activities in areas of the colliery holding known as Wonga East and Wonga West.

At the time of lodgement, pursuant to provisions of NSW State Environmental Planning Policy – Major Projects 2005, the project requires approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

An aquatic ecology assessment report prepared by Cardno Ecology Lab (2012) and the terrestrial flora and fauna assessment prepared by ERM (2012a) have identified that the Project Application Area (PAA) supports or provides habitat for a number of threatened and/or migratory species as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This report specifically provides an assessment of EPBC Act matters of National Environmental Significance (NES) applying to the action as described in the EPBC Act and Schedule 4 of the EPBC Regulations 2000.

This report does not constitute a referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPC). A referral of the action is being prepared separately.

1.2 OBJECTIVE OF THE PROPOSED ACTION

NRE is seeking approval from the NSW state government under Part 3A of the EP&A Act for continuation, consolidation and expansion of underground coal mining at its NRE No1 Colliery located at Russell Vale, NSW (see *Figure* 1.1). The proposal includes expansion of surface operations and underground mining including longwall mining within two mining domains known as Wonga West and Wonga East.

The objective of the longwall mining is to extract high quality coking coal to be exported and used in the steel making industry, primarily in India.

The Project will have social and economic benefits including:

- improved environmental efficiency through stormwater and mine water management systems upgrades and better management of noise and air quality at the Russell Vale site by upgrading infrastructure;

- upgraded coal handling infrastructure with the potential to better manage noise and dust emissions for the site;

- provision of employment and training;

- economic benefits to the Wollongong community via capital injection and value added spending;
- enhancement of the economic position of NRE which in turn will fuel investment in other projects;
- extraction of a valuable mineral resource before the site reverts to other uses, thus preventing the potential sterilisation of the resource;
- extension of the life of mining at the Colliery ensuring continued provision of government royalties; and
- preservation of the historical heritage of the site for future generations.

The Project objectives can only be realised if the proposed longwall mining is able to proceed. If mining does not continue, the associated contributions to industry within the Wollongong and broader region will cease resulting in unemployment for many, if not all, of the mine personnel, and both direct and indirect negative impacts on the local community.

1.3 PROJECT APPLICATION AREA

NRE Colliery No.1 is located approximately eight kilometres (km) north of Wollongong and 70km south of Sydney (see *Figure 1.1*), within the Local Government Areas (LGAs) of Wollongong and Wollondilly in the Illawarra region of NSW.

The colliery holding comprises Consolidated Coal Lease (CCL) 745, Mining Purposes Lease (MPL) 271 and Mining Lease (ML) 1575. The colliery holding is identified as the PAA on *Figure 1.2*.

NRE has surface leases at Russell Vale on the coast and six other surface sites on the Woronora plateau including: No. 4 Shaft (for men, materials and ventilation) and the associated surface facilities; MPL 271; and the four ventilation shaft sites No. 1, 2, 3 and 5 Shafts (see *Figure 1.2*). Other surface infrastructure unrelated to the mine includes a Telstra fibre optic cable, electrical transmission lines, the Southern Freeway or Mount Ousley Road, unsealed fire trails (Fire Road No 8 and Fire Road No 7) and Picton Road.

Longwall mining is proposed within Wonga East and Wonga West as shown on *Figure 1.2*. Wonga East is located within the Wollongong local government area (LGA), either side of Mount Ousley Road, while Wonga West straddles the Wollongong and Wollondilly LGAs.

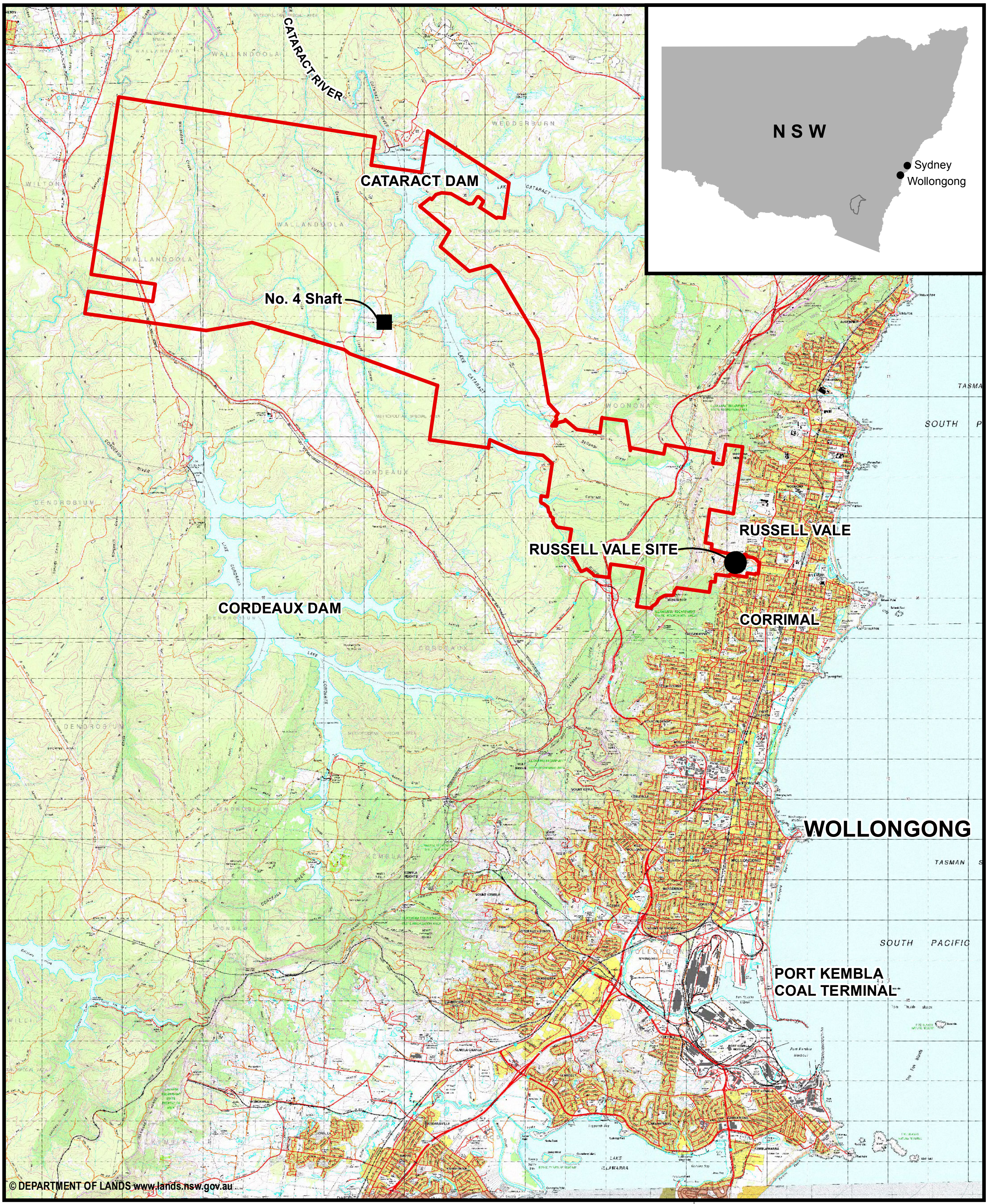
The PAA occurs on the Woronora Plateau and extends to the east over the Illawarra Escarpment to Russell Vale at the foothills of the escarpment. The Princes Highway bounds the Russell Vale site to the east, with residential areas of Russell Vale and Corrimal to the east and south, respectively. The Woronora Plateau and steep slopes of the escarpment are heavily vegetated. Along the escarpment, the Illawarra Escarpment State Conservation Area occurs to the north and south of the lease area.

The majority of the surface area in the PAA and the Wonga East and Wonga West mining domains is native bushland with the waters of Cataract Dam between the two mining domains. A large part of the longwall operation is designated Schedule 1 Restricted Access Area (Metropolitan Special Area) under the *Sydney Water Catchment Management Act 1998* (SWCM Act). The Metropolitan Special Area is managed by the Sydney Catchment Authority (SCA) in accordance with the Special Areas Strategic Plan of Management 2007, to protect water quality and provide high quality raw water in reservoirs, by protecting ecological integrity and natural and cultural values of the area.

1.4 DEFINITION OF THE STUDY AREA

Within the PAA ecological assessments were concentrated within the Study Area, defined as the proposed mining footprints in Wonga East and Wonga West with an additional surrounding surface perimeter of 600 metres (m) (see *Figure 1.2*). The Study Area boundary was determined as the area in which impact of mining in the proposed Wonga West and Wonga East may occur using the recommendations for risk management zones as established by the Southern Coalfield Inquiry (Department of Planning (DoP) 2008).

The Study Area covers approximately 2,623ha. The original Study Area was larger than the defined area in this report, because the original mine layout plans covered significantly greater area than the final proposed layout. As the ecological values of the Study Area were realised during the assessment, NRE mine planners altered the mine layout to avoid significant environmental values as part of the iterative process. As a result, much of the original survey work for this assessment occurred in areas that are now outside of the Study Area.



Legend

Project Application Area

Figure 1.1

Locality Map

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 EPBC Report

Drawing No: 0079383s_ECA_G001_R1.mxd

Date: 27/11/2012 Drawing size: A4

Drawn by: GC Reviewed by: MB

Scale: Refer to Scale Bar

N

0 1 2 3km

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Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

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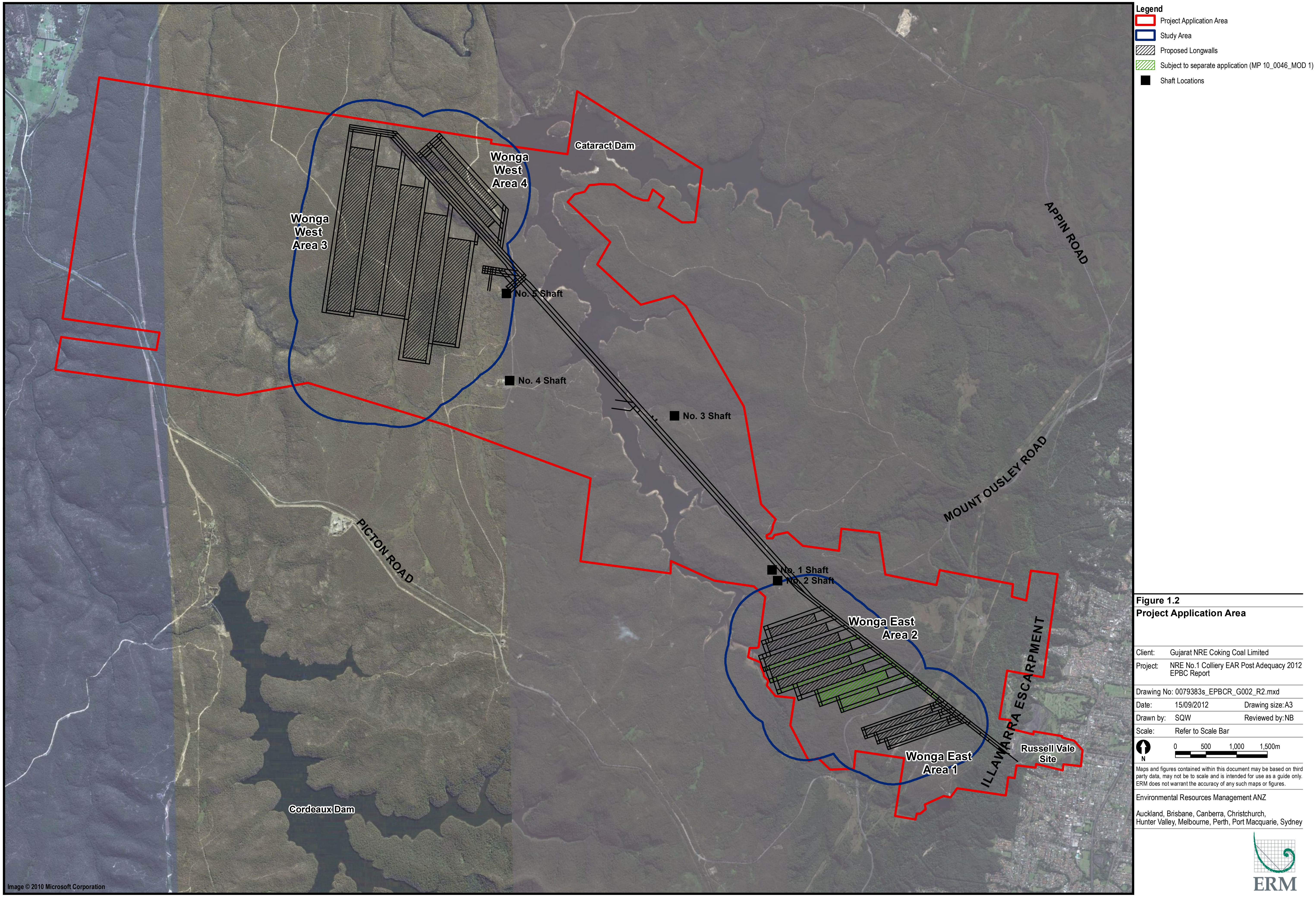

Figure 1.2

Project Application Area

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery EAR Post Adequacy 2012 EPBC Report
Drawing No:	0079383s_EPBCR_G002_R2.mxd
Date:	15/09/2012 Drawing size: A3
Drawn by:	SQW Reviewed by: NB
Scale:	Refer to Scale Bar

N

0 500 1,000 1,500m

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1.5 BACKGROUND TO DEVELOPMENT OF THE PROPOSED ACTION

1.5.1 *History*

The South Bulli Coal Mining Company commenced mining on the slopes of the Illawarra Escarpment at NRE No.1 Colliery (formerly the South Bulli Mine) in the mid-19th Century. Continuous mining has been a feature of the PAA since 1887 and surface facilities have operated at the Russell Vale site since this time.

With the advent of more sophisticated mining methods in the 1960s, workings progressed further west of the Illawarra Escarpment. Subsequently, four ventilation shafts (Shaft Numbers 1, 2, 3 and 5) and a shaft to provide personnel and materials access to the workings (No.4 Shaft) were sunk to the west of the escarpment. Mining commenced in the early 1990s beneath the catchment and stored waters of Cataract Dam.

In August 2004, production temporarily ceased and the mine was placed on care and maintenance until 3 December 2004 when NRE purchased the mine from Bellpac Pty Ltd. Mining recommenced at NRE No.1 Colliery in July 2005. The coal washery at Russell Vale ceased operation in March 2003, and all run-of-mine (ROM) coal is now transported unwashed to Port Kembla Coal Terminal for export.

1.5.2 *Geology and Resource Description*

The PAA is located within the Southern Coalfield of the Sydney-Bowen geological basin. The strata include a gently folded succession of sandstones, shales, claystones and coal, of Permian to Triassic age (Geological Survey NSW 1966). The north-westerly plunging South Bulli Syncline is the dominant geological structure at NRE No. 1 Colliery. West of the escarpment, the Permian deposits are overlain by the Triassic Narrabeen Group, comprising sandstone, siltstone, claystone, shale and tuffaceous claystone.

Further west, extending across the majority of the PAA, these deposits are overlain by Hawkesbury Sandstone, characterised by quartz sandstone with some shale. There are some relatively small areas where the Hawkesbury Sandstone is overlain by the Liverpool sub group (Geological Survey NSW 1966). East of the Illawarra Escarpment, the geology of the PAA comprises Permian age Illawarra Coal Measures, underlain by units of the Shoalhaven Group.

In the Southern Coalfield, the economic coal seams occur within the Illawarra Coal Measures. The three commonly mined coal seams of these measures are the upper most Bulli seam, below which is the Balgownie seam and then the Wongawilli seam.

The Bulli seam has been extensively mined for more than 120 years within CCL 745. The thinning of the seam to the north-west represents the general trend. The immediate roof may be carbonaceous shale, a mudstone-shale or a laminite. The immediate floor is comprised of coaly shale, grading down to shale, to siltstone, to laminite, to sandstone. This sandstone layer averages about nine metres thick and forms the roof of the underlying Balgownie seam.

The Balgownie seam was mined by longwall in the 1970's and more recently by first workings in 2002 to 2003. The roof is invariably cross-bedded sandstone, and the floor is formed by a carbonaceous mudstone grading down to mudstone and to siltstone.

Two minor seams, the Cape Horn seam and the Hargraves seam, lie between the Balgownie and Wongawilli seams, but are too thin and too high in ash to be of economic significance.

The top of the Wongawilli seam is 22m to 25m below the Balgownie seam and is typically nine to 11m thick. The Wongawilli seam consists of interbedded bands of (occasionally) kaolinitic brown mudstone or carbonaceous shale (with occasional thin pyrite or siderite lenses) and coal layers. Only the lower section of the seam is of economic value due to deterioration from thickening and increasing numbers of stone bands in the working section progressing northward in the Coalfield. The seam has been mined by longwall methods at others collieries in the Southern Coalfield and has been mined most recently in A2 LW4 in accordance with an approved subsidence management plan. In NRE No.1 there is a basal section varying between 1.9m to 2.6m selected as a potential economic mining section. This is a thicker section than that used for the last resource evaluation in 2010 (Bureau Veritas, 2010). The floor is composed of mudstone or siltstone grading down into a laminite.

More than 300 million tonnes of coking coal resources remains within the NRE lease areas in these seams (Bureau Veritas 2010). Coking coal from NRE No.1 Colliery within the Wongawilli Seam is of high quality due to its strong coking properties, low phosphorous (<0.005ppm), sulphur and ash content, high calorific value, good fluidity and reflectance and suitability for direct feed into coke ovens. It is well suited to production of high quality metallurgical coke.

1.5.3 *Current Operations*

Current production at NRE No. 1 Colliery is approximately one million tonnes per annum (Mtpa). Coal handling facilities are situated as the Russell Vale site. Coal is currently transported unwashed by truck from Russell Vale to Port Kembla Coal Terminal (PKCT).

Current approvals allow workings to be undertaken in the Bulli seam including pillar extraction in the 'T and W Mains' and 'V mains' areas; first workings in the 'P' Panel in the central portion of the site (between Wonga East and Wonga West); and the 'P and R' drifts driveage to the east of the 200 longwall series. There are no current workings in the Balgownie seam.

Current approvals allow workings to be undertaken in the Wongawilli seam that constitute the Wonga Mains driveage.

The development of these roadways commenced at the Russell Vale site in 2007 and will connect the proposed Wonga East and Wonga West longwall areas. With approval of the SMP in March 2012, longwall mining of Longwall Panel 4 (LW4) in Area 2 of Wonga East mining domain commenced in April 2012 and completed in August 2012. In keeping with the current approval, development of the exploratory driveage of LW5 is proposed to commence in October 2012.

Further to the SMP for LW4, a separate application to modify the Preliminary Work Project (MP 10_0046), was prepared by Cardno (2012) and lodged with the Department of Planning and Infrastructure (DoPI) in August 2012.

The modification application was approved on 24 December 2012 and allows extraction of coal from longwall panels 4 and 5; and, development of maingate 6 in Wonga East.

1.6 THE PROPOSAL

NRE seeks approval to continue its underground coal mining operations at NRE No. 1 Colliery and to increase coal production to a maximum of three million tonnes per annum (3Mtpa) over a period of up to 18 years.

NRE proposes to undertake mining in the Bulli, Balgownie and Wongawilli seams as follows:

- Bulli seam - first workings in the 'Bulli West' area;
- Balgownie seam - limited to first workings only, beneath overlying Bulli seam workings; and
- Wongawilli seam - longwall mining in Wonga East and Wonga West.

First workings in the Balgownie and Bulli seams are fully supported and will not result in subsidence and consequent surface impacts. The action being assessed is the longwall mining of the Wongawilli seam in Wonga East and Wonga West domains.

1.7 HOW THE ACTION RELATES TO ANY OTHER ACTIONS IN THE REGION AFFECTED BY THIS ACTION

Actions that directly relate to the NRE No.1 Colliery include the Preliminary Works Project. NRE has received approval from the NSW State Government for the continuation of mining and ancillary operations at the NRE No. 1 Colliery through a Project known as the Preliminary Works Project. This approval enables a continuation of existing surface mining operations (no longwall mining) within the H panel area, T&W Mains and V-Mains in the area above the current proposed longwall mining, and some environmental improvement works at the Russell Vale site.

The Preliminary Works Project was declared a controlled action as the Project may involve the removal of potential habitat for the vulnerable Green and Golden Bell Frog (*Litoria aurea*) near the Russell Vale site.

The proposed works that are subject to this declaration are at the Russell Vale site on the coastal lowlands as opposed to the upland catchment area, which is the location of the proposed longwall mining action. Approval for this action under the EPBC Act was issued on 12 January 2012.

A number of other underground coal mines operate within the Illawarra coalfields along the Illawarra Escarpment on the Woronora Plateau including:

- Appin and Appin West Colliery (immediately to the north of NRE No. 1 mining lease and part of Illawarra Coal Holdings Bulli Seam Operation);
- Tahmoor Colliery (to the west of Appin Colliery);

- West Cliff Colliery (to the north east of Appin Colliery, part of Illawarra Coal Holdings Bulli Seam Operation);
- Metropolitan Colliery (under the Waratah Rivulet in the upper catchment of the Woronora River (approval issued in 2009));
- Dendrobium Colliery (to the south of NRE No. 1 and north of NRE Wongawilli Colliery); and
- Wongawilli Colliery (previously known as Elouera).

Of these mines only the nearby BHP Billiton Illawarra Coal Holding operated colliery (Bulli Seam Operations) is identified as a controlled action (EPBC 2010/5350). The Bulli Seam Operation was the subject of assessment by the NSW Planning and Assessment Commission in 2010. The Bulli Seam Operations relates to continuation of longwall mining operations at the Appin Mine and West Cliff Colliery including the above listed North Cliff Colliery. The Bulli Seam Operation lease area immediately adjoins the northern boundary of the NRE No. 1 Colliery and covers the area downstream of the Cataract Dam. Approval for this action under the EPBC Act was issued on 15 May 2012.

1.8 STATUTORY CONSIDERATIONS

1.8.1 Commonwealth

The EPBC Act requires approval of the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (the Minister) for actions that may have a significant impact on matters of NES. The EPBC Act also requires Commonwealth approval for actions on Commonwealth land.

Matters of NES under the Act include the following:

- World Heritage properties;
- National Heritage places;
- Great Barrier Reef marine park;
- Ramsar wetlands of international importance;
- threatened species or ecological communities listed in the EPBC Act;
- migratory species listed in the EPBC Act;
- Commonwealth marine environment; and
- nuclear actions.

Any proposed action that is expected to have an impact on matters of NES must be referred to the Minister for assessment under the EPBC Act.

Implications for the Project

The Project is not located within the Great Barrier Reef marine park, a world heritage area, Ramsar wetland or a Commonwealth marine environment. The Project does not contain national heritage places, or involve nuclear actions.

The ecological investigations undertaken by Cardno Ecology Lab (2012) and ERM (2012a) concluded that proposed mining and continuation of ancillary activities associated with the proposal may potentially impact on threatened species listed under the provisions of the EPBC Act. As such, a referral to the Minister for Environment is required.

1.8.2 State and Local Legislation

The following state and local legislation are required or may be required to be considered for the proposed action. It should be noted that under the Part 3A approval path state environmental planning instruments other than State Environmental Planning Policies do not apply however the objectives of the legislation have been considered in the assessment.

The Environmental Assessment (EA) Report for the Project prepared by ERM (2012b) has considered state and local legislation and applicability to the project. Approval for the Project under the EP&A Act is being sought from the NSW Minister for Planning and Infrastructure with referral to appropriate departments and agencies in the NSW government including the Office of Environmental Heritage (OEH).

The Terrestrial Flora and Fauna Assessment has considered the aims and objectives of relevant legislation in particular threatened species listings under the state *Threatened Species Conservation Act 1995* (TSC Act).

Environmental Planning and Assessment Act 1979

Part 3A of the EP&A Act details the approval process for major infrastructure and other significant 'projects'. The proposal is a Major Project according to State Environmental Planning Policy (Major Projects) 2005 (SEPP MP) and as such, is to be assessed under the provisions of Part 3A of the EP&A Act, with the Minster for Planning as the Consent Authority for the Project Application.

In September 2011, Part 3A of the EP&A Act was repealed, however Schedule 6A of the EP&A Act outlined the transitional arrangements for projects formally identified as Part 3A projects prior to the repeal. This proposal continues to be assessed under Part 3A of the Act.

Under Section 75R of the EP&A Act, environmental planning instruments other than State Environmental Planning Policies do not apply to a 'Major Project'. However, in accordance with Section 75J, the Minister, when assessing the project, may take into account the provisions of any environmental planning instrument (EPI). In this regard, the Minister is not bound by environmental planning instruments other than SEPPs but is obliged to consider such instruments.

Section 5A (s.5A) of the EP&A Act lists seven factors that must be taken into account in the determination of the significance of potential impacts of a proposed development on 'threatened species, populations or ecological communities (or their habitats) listed under the TSC Act. The 'seven part test' is used to determine whether a proposed development is 'likely' to impose 'a significant effect' on threatened biota.

There is no requirement for the consent authority to consider s.5A of the EP&A Act when determining a Project Application under Part 3A of the Act. However, seven part tests pursuant to s.5A of the EP&A were utilised in the terrestrial flora and fauna assessment (ERM 2012a) and aquatic ecology assessment (Cardno Ecology Lab 2012) to determine if the proposed development will have a significant impact on threatened species, populations and communities as listed under state legislation.

Threatened Species Conservation Act 1995

Projects determined by a statutory authority of the NSW State Government are required to be assessed in accordance with the EP&A Act, as amended by the TSC Act. The TSC Act lists threatened species, populations and ecological communities under Schedules 1 and 2 of the Act, that are priorities for conservation within NSW. A number of threatened species and endangered ecological communities have been identified as occurring or suitable habitat has been identified in the PAA. These species and communities were assessed in the terrestrial flora and fauna assessment (ERM 2012a) and aquatic ecology assessment (Cardno Ecology Lab 2012). Some of these species and communities are also listed under the Commonwealth EPBC Act and will be assessed herein.

Schedule 3 of the TSC Act lists Key Threatening Processes for species, populations and ecological communities within NSW. It is noted that under the TSC Act the '*Alteration of habitat following subsidence due to longwall mining*' is listed as a Key Threatening Process under the TSC Act. This process has been assessed in the terrestrial flora and fauna assessment (ERM 2012).

Fisheries Management Act 1994

The *Fisheries Management Act 1994* is administered by Fisheries NSW unit of the Department of Primary Industries and includes provisions to declare and list threatened species of fish and marine vegetation, endangered populations and ecological communities, and key threatening processes.

Section 75U of the EP&A Act excludes projects approved under Part 3A from requiring permits under this Act. Threatened species as listed under this Act and the EPBC Act are discussed in this report. Cardno Ecology Lab (2012) have undertaken background monitoring and prepared an impact assessment report, the results of which have informed this report.

Native Vegetation Act 2003

The *Native Vegetation Act 2003* (NV Act 2003) aims to provide flexibility and incentives to manage native vegetation, end broad scale clearing (unless it improves or maintains environmental outcomes) and encourage healthy and productive landscapes.

Clause 12 of the NV Act states *native vegetation must not be cleared except in accordance with:*

(a) a development consent granted in accordance with this Act, or

(b) a property vegetation plan'.

In accordance with Section 75U of the EP&A Act, an authorisation to clear native vegetation under Section 12 of the NV Act is not required for projects approved under Part 3A of the EP&A Act.

State Environmental Planning Policy No 44 – Koala Habitat Protection

State Environmental Planning Policy 44 (SEPP 44) - Koala Habitat Protection aims to '*encourage the proper conservation and management of areas of natural vegetation that provide habitat for Koalas, to ensure permanent free-living populations over their present range and to reverse the current trend of population decline*'.

Potential habitat for Koala (*Phascolarctos cinereus*) is defined under SEPP 44 as vegetation that incorporates a minimum of 15 per cent of tree species in the 'upper or lower strata of the tree component' listed in Schedule 2 of SEPP 44. And *Core* Koala habitat is defined as '*an area of land with a resident population of Koalas, evidenced by attributes such as breeding females…and recent sightings of and historical records of a Koala population*'.

An assessment of Koala habitat is provided in the terrestrial flora and fauna assessment (ERM 2012a).

Sydney Water Catchment Management Act 1998

A large part of the study area is designated as a *Schedule 1 Restricted Access Area (Metropolitan Special Area)* under the *Sydney Water Catchment Management Act 1998* and is managed by the SCA. The Drinking Water Catchments Regional Environmental Plan (DWCREP) No. 1 applies to land within the hydrological catchments that contribute to Sydney's drinking water supply. It aims to create healthy water catchments that will deliver high quality water whilst sustaining diverse and prosperous communities.

The *Sydney Water Catchment Management Act 1998* is administered by the Sydney Catchment Authority. The role of the SCA is to:

a) to manage and protect the catchment areas and catchment infrastructure works, and

(b) to be a supplier of raw water, and

(c) to regulate certain activities within or affecting the outer catchment area as well as the inner catchment area.

Consultation with the SCA has been undertaken throughout the Project assessment process to ensure that the Project is consistent with the aims of the *Sydney Water Catchment Management Act 1998.*

The Sydney Catchment Authority Special Areas Strategic Plan of Management 2007 (SASPoM) was prepared to protect the water quality in Sydney's drinking water catchment.

The Special Areas are the lands, which surround Sydney's drinking water storages and are declared under the *Sydney Water Catchment Management Act 1998*. Due to protective management and restricted access the Special Areas have high ecological values.

As the part of the lease fall within the Metropolitan Special Area, the SASPoM is relevant to the proposed development. The goals of the SASPoM are to "*protect and optimise water quality entering storages*" and "*conserve ecosystem integrity, natural and cultural values*."

2 DESCRIPTION OF THE PROJECT

2.1 UNDERGROUND MINING METHODS

2.1.1 First Workings

First working will be used initially to develop all proposed mining areas. First workings will involve development of headings or roadways within the coal seam, and interconnecting cut-throughs with approximate dimensions of 5.2 m wide by 3.2 m high. These will provide access to the coal resource, mine ventilation and corridors for personnel and material movement within the seam and coal conveyor network.

First workings will be developed using continuous miners typically with integrated roof and rib bolting rigs. The roadway roof will be supported by installation of steel roof bolts into the stone above the coal seam, and by forming pillars of coal, which are left behind. Coal will be transported from the continuous miners to the conveyor system via shuttle cars.

First workings leave the coal pillars intact and the overlying strata fully supported resulting in 'zero' subsidence, which is defined by Department of Resources and Energy (DRE) as vertical downward movement of the ground surface that is less than or equal to 20 millimetres (mm).

2.1.2 Longwall Mining

Following the completion of first workings, the retained panels of coal in the Wonga East and Wonga West areas will be extracted by the retreating longwall mining method of secondary extraction. This mining method uses an electrically powered shearer, which passes back and forth across the width of the longwall panel cutting the coal. The coal is continuously removed from the working face on to a series of conveyors that transfer the coal to the surface. As the face is cut away, both the shearer and the hydraulic roof supports advance forward for the next shear, and the unsupported strata behind the longwall face collapses in to the goaf. The goaf being the mined out area in an underground mine into which the immediate roof strata breaks.

2.2 MINING AREAS

As described in *Section 1.6*, NRE proposes to undertake mining in the Bulli, Balgownie and Wongawilli seams. Development of 'Bulli West' area (see *Figure 2.1*) in the western part of CCL745 is proposed via first workings for underground access roadways only.

It is proposed that the 'Wonga Mains' driveage that commenced in the Preliminary Works Project, continue westward to access the underground mining areas of Wonga East and Wonga West (see *Figure 2.1*). The Wonga Mains driveage will be developed using first workings. The driveage will provide access to the coal resource, mine ventilation and corridors for movement of personnel and material.

First workings in the Balgownie and Bulli seams are fully supported and will not result in subsidence and consequent surface impacts. The action being assessed is longwall mining in the Wongawilli seam.

2.2.1 Wonga East

Mining is proposed in the Wonga East area located to the west of the Illawarra Escarpment. The proposed Wonga East panels are located within the Wongawilli seam below areas of existing mine workings in the Balgownie and Bulli seam. The proposed panel layout is shown on *Figure 2.1* and *Figure 2.2.*

(Note that extraction of longwall panel 4 in Area 2 has been undertaken in accordance with the approved SMP and that mining of longwall panel 5 and development of the maingate for panel 6 in Area 2 is the subject of MP 10_0046_MOD 1 approval. These panels are shown in a different colour in the graphics).

The proposed Wonga East panels include Area 1 to the east of Mount Ousley Road and Area 2 to the west of Mount Ousley Road. No extraction is proposed beneath the Mount Ousley Road.

Wonga East Area 1

Wonga East Area 1 comprises three 105m wide panels with 40m wide pillars. These panels are A1 LW01, A1 LW02 and A1 LW03, (see *Figure* 2.2). The panel configuration is designed to accommodate projected geological conditions and allow safe mining operations beneath the overlying Balgownie and Bulli seam workings.

Area 1 underlies steeply sloping, northerly draining, first and second order tributaries of Cataract Creek with a depth of cover of approximately 237m to 255m. On the outer edge of A1 LW03, the undermined tributaries join to form a third order stream which immediately to the east of Mount Ousley Road forms a fourth order, steeply sloping, westerly draining main channel of Cataract Creek.

To the south and south east of Area 1 are the first and second order tributaries of the Cataract River that flows in a westerly to north westerly direction to the upper reaches of Cataract Dam.

The Area 1 panels underlie two upland headwater swamp clusters in the Cataract Creek catchment identified as CCUS1 and CCUS2 (see *Figure 2.2*). A third upland swamp (CRUS3) occurs in the Cataract River catchment, to the south of the abutment pillar for panel A1 LW02, and will not be undermined. CCUS1 and CCUS2 were undermined by Bulli Seam first workings in the early 1900s (GeoTerra 2012a). Biosis (2012) have assessed CCUS1 and CRUS3 as being of 'special significance'.

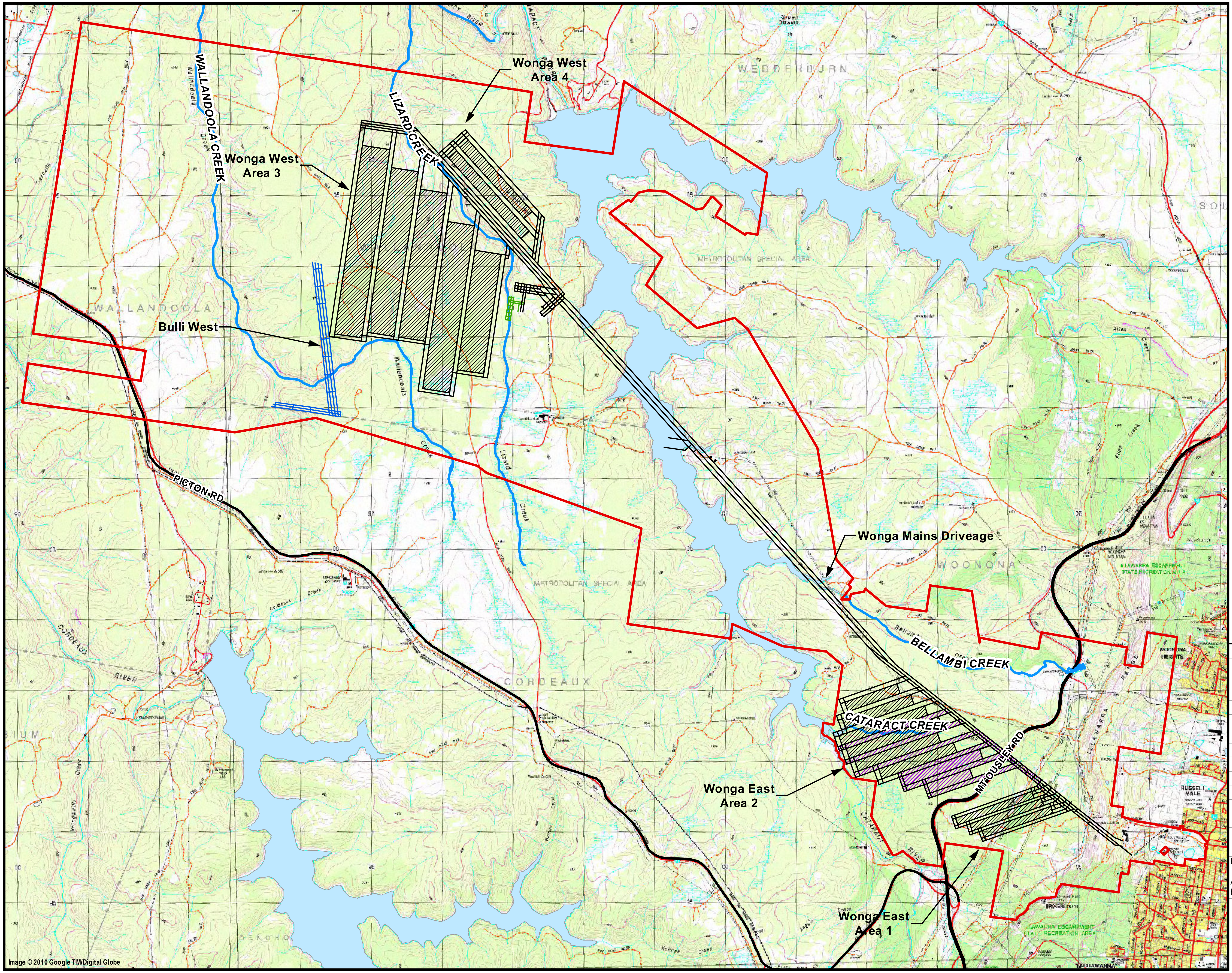
Wonga East Area 2

Wonga East Area 2 comprises eight panels (Panels A2 LW04 to A2 LW11) up to 150m wide with 60m wide chain pillars. Extraction of Panels A2 LW4 and A2 LW5 and development of the gateroad/maingate for A2 LW6 were recently approved under a modification application to the Preliminary Works Project (MP 10_0046).

The panels are positioned so that vertical subsidence under third order or higher order stream channels will be restricted to less than 250 mm, while the use of narrow extraction panels and wide chain pillars at Wonga East provides a management tool for subsidence risks on all surface features, including Cataract Creek and the upland swamps.

Two of the Wonga East Area 2 longwall panels (A2 LW8 and A2 LW9) underlie the fourth order channel of Cataract Creek with approximately 267m to 320m depth of cover. The abutment pillars of A2 LW5 and A2 LW7 underlie Cataract Creek. The western end of Panel A2 LW10 also marginally underlies the peripheral high water mark of Cataract Creek in the upper backwaters of Cataract Dam, which may marginally overlie the panel edge during periods of high water level in the dam. Other panels in Area 2, specifically A2 LW4, A2 LW5, A2 LW6, A2 LW7 and A2 LW8, underlie first and second order tributaries of Cataract Creek.

Eleven upland headwater swamps overly the proposed Area 2 panels (see *Figure* 2.2). One of these swamps occurs in the Cataract River catchment (CRUS1) and overlies the initial part of panel A2 LW6. CRUS1 was undermined by Bulli Seam first workings in the early 1900s (GeoTerra 2012a). Eight upland headwater swamps occur in the Cataract Creek catchment in Area 2: CCUS6 overlies panels A2 LW4; CCUS3 and CCUS23 overlie panel A2 LW5; CCUS4 overlies panel A2 LW6; CCUS5 overlies panel A2 LW7 and A2 LW8; CCUS10 overlies panel A2 LW9; CCUS11 overlies panel A2 LW10; and CCUS12 overlies panel A2 LW11. Two upland headwater swamp (BCUS11 and BCUS4) occur in the Bellambi Creek catchment and overlie the end of panel A2 LW11. All of these swamps have been undermined previously.



Legend

- Project Application Area
- Proposed Longwalls
- Subject to separate application (MP 10_0046_MOD 1)
- Proposed Bulli Seam first workings
- Proposed Balgownie Seam first workings
- Major Road
- Watercourse

Figure 2.1
Proposed Workings

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery EAR Post Adequacy 2012 EPBC Report
Drawing No:	0079383s_EPBCR_G003_R1.mxd
Date:	13/11/2012 Drawing size: A3
Drawn by:	SQW Reviewed by: NB
Scale:	Refer to Scale Bar

N

0 500 1,000 1,500 m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

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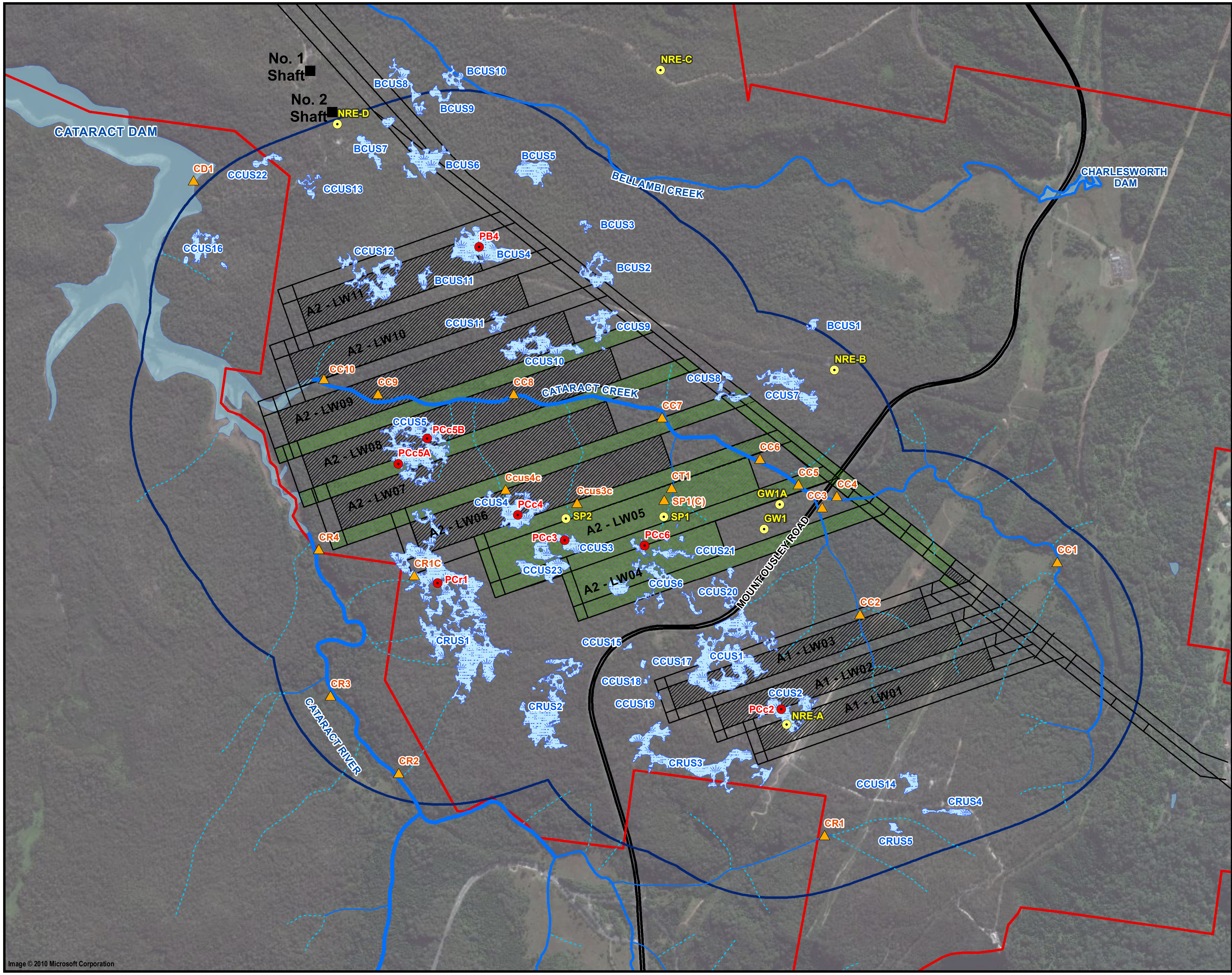

Legend

- Project Application Area
- Study Area
- Upland Swamps (Biosis 2012)
- Subject to Separate Application (MP 10_0046_MOD 1)
- Cataract Dam
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order and AboveStream
- Major Road
- Shaft Locations
- CC4 Stream Monitoring Sites (GeoTerra 2012)
- Swamp Piezometers (GeoTerra 2012)
- Basement Piezometers (GeoTerra 2012)

Figure 2.2

Proposed Wonga East Longwalls, Monitoring Locations andStream Classification

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 EPBC Report

Drawing No: 0079383s_EPBCR_G011.mxd

Date: 13/11/2012 Drawing size:A3

Drawn by: SQW Reviewed by:NB

Scale: Refer to Scale Bar

N 0 150 300 450m

Environmental Resources Management ANZ

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2.2.2 *Wonga West*

The Wonga West area is located to the west of Cataract Dam (see *Figure 2.1*). In Wonga West, Area 3 panels occur to the south west of Lizard Creek and Area 4 to the north east of Lizard Creek. The panel layout has been designed to avoid the main channel of Lizard Creek, Cataract Dam and Wallandoola Creek (see *Figure 2.3*). All seven panels in the Wonga West area underlie the watersheds and steeply sloping first to third order streams within sub-catchments of Lizard Creek and Wallandoola Creek.

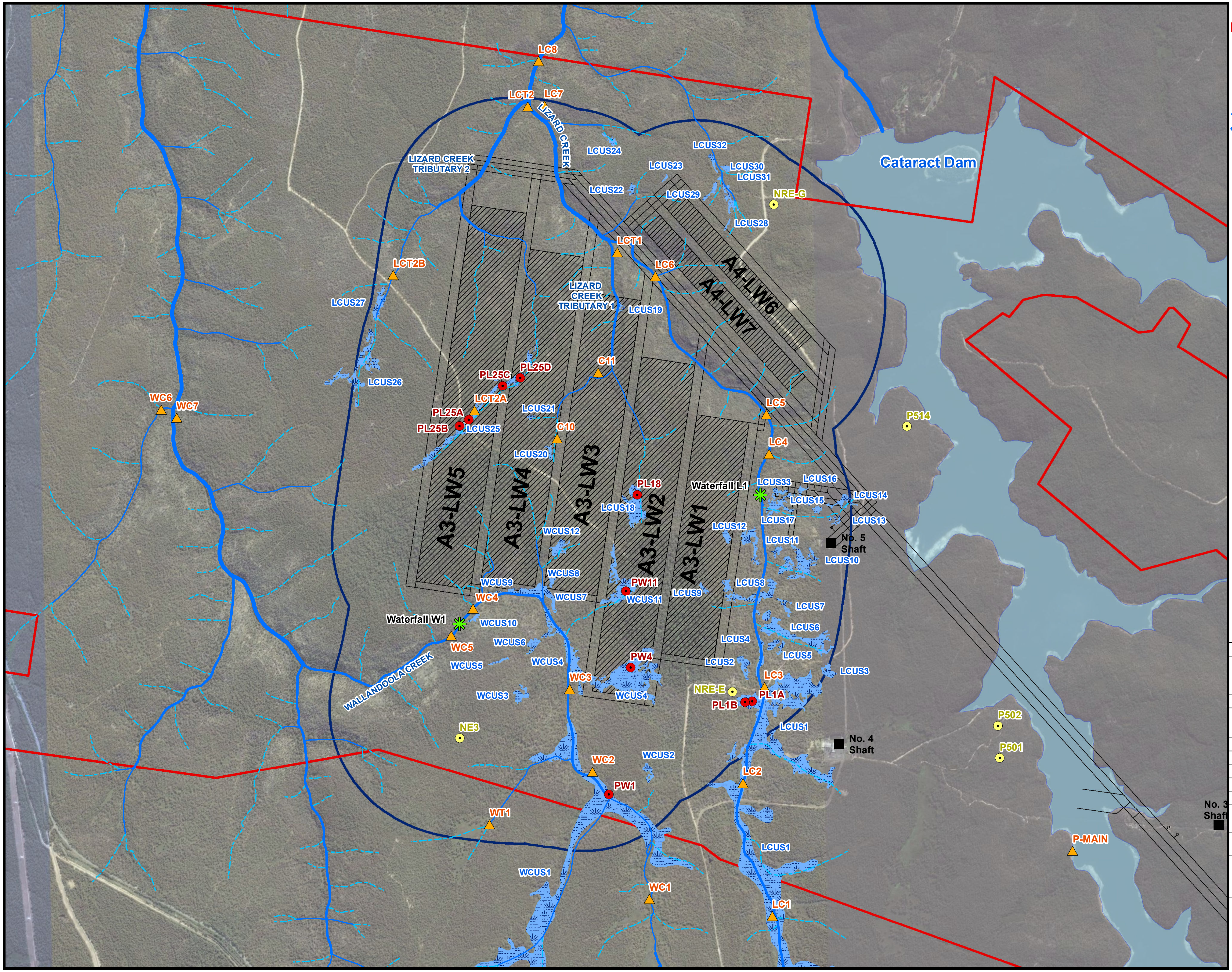
Wonga West Area 3

Area 3 is located to the south west of Lizard Creek and comprises five panels referred to as Panels A3 LW1 to A3 LW5. Longwall mining is proposed in Area 3 for approximately 40m below the Bulli coal seam with orientation determined by the previously mined Bulli longwalls. The Wonga West longwall panels are planned to be up to approximately 380m wide separated by 65m chain pillars. The chain pillars that form the gateroads for each longwall panel are designed to be directly beneath the goaf of the overlying Bulli longwalls to minimise in-situ stress and adverse ground conditions by adding to the stability of these gate roads.

Twelve upland headwater swamps overlie the proposed panels in Area 3 (see *Figure 2.3)*. In the Wallandoola Creek catchment, upland swamps over the longwall panels include WCUS4, WCUS11, WCUS12 and WCUS8. Upland swamp WCUS7 partially overlies the abutment panels of A3 LW3 and A3 LW4 (see *Figure* 2.3). In the Lizard Creek catchment, upland swamps over the workings include LCUS9, LCUS18, LCUS20, LCUS21 and LCUS25. Part of LCUS12 overlies A3 LW1 while a large part of the same swamp complex occurs to the east of the proposed gateroad. Similarly part of LCUS8 complex occurs over the proposed gateroad to A3 LW1 while the large part of the swamp extends over Lizard Creek.

Wonga West Area 4

Area 4 proposed panels are located to the north of Lizard Creek and comprise two panels referred to as Panels A4 LW6 and AW LW7 (see *Figure 2.3*). The panels are each 155m wide with 65m pillars. The panels are located at least one kilometre from the Cataract Dam wall and positioned to avoid subsiding or cracking Lizard Creek, as well as avoiding generation of a hydraulic connection via subsidence cracking between the 20mm subsidence zone and Cataract Reservoir. There are no upland swamps mapped over the longwall panels in Area 4 however LCUS28 overlies the gateroad to A4 LW6.



Legend

- Project Application Area
- Proposed Longwall
- Cataract Dam
- Upland Swamps (Biosis 2012)
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order and Above Stream
- Shaft Locations
- Waterfall
- CC4 Stream Monitoring Sites (GeoTerra 2012)
- Swamp Piezometers (GeoTerra 2012)
- Basement Piezometers (GeoTerra 2012)

Figure 2.3

Proposed Wonga West Longwalls, Monitoring Locations and Stream Classification

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery EAR Post Adequacy 2012 EPBC Report
Drawing No:	0079383s_EPBCR_G012_R1.mxd
Date:	30/11/2012 Drawing Size: A3
Drawn By:	KB Reviewed By: NB
Projection:	GDA 1994 MGA Zone 56
Scale:	Refer to scale bar

N 0 250 500 750m

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2.3 PROJECT ALTERNATIVES

Multiple options for key project components have been canvassed over the project's development phase. Consultation with the NSW Department of Planning and Infrastructure (DP&I, previously Department of Planning), feedback received during the community consultation process, engineering and environmental specialist input, was fundamental in modifying the project plans.

Alternative mine plans were considered in both Wonga East and Wonga West. The options are summarised in *Table 2.1* and *Figure 2.4*.

2.3.1 *Iterative Mine Planning*

The proposed mining will be in the Wongawilli Seam in an area where the Bulli Seam and in some places, the Balgownie Seam have already been extracted. In order to manage environmental risks, the mining proposal incorporated a risk assessment methodology and applied a hierarchy of risk management strategies during planning. Details of the strategies and the projected outcomes are included in a report prepared by Seedsman Geotechnics Pty Ltd (Seedsman 2012). NRE developed the original mine plan proposal for the Wonga West and Wonga East areas based on economic extraction requirements. Using this as the baseline proposal NRE then considered significant environmental and heritage issues to refine the mine plan.

As the baseline surveys of the study area progressed, NRE used an iterative mine planning process to avoid and mitigate potential impacts to the environmental values identified by ERM and specialist sub-consultants. The progressive mine plans considered are described in detail in Seedsman Geotechnics (2012) and the EA Report (ERM 2012b).

2.3.2 *Avoidance Measures*

The iterative mine planning process involved ongoing examination of longwall options in light of ecological constraints, to avoid and/or minimise impact to areas of natural significance in particular areas of 'special significance'. Features of special significance are defined in the Planning and Assessment Commission reports for Bulli and Metropolitan Collieries as natural features that are so special that they "*warrant a level of consideration (and possibly protection) well beyond that accorded to others of its kind*" (PAC 2009). Features of special significance include: upland swamps, rivers and higher order streams (third order and larger), major cliff lines and Aboriginal heritage site.

Seedsman Geotechnics (2012) outlines the current mine plans and the abandoned plans, which show that:

- extraction under the main channel of Lizard Creek and upland swamps associated with the main channel has been ruled out to avoid impacts to these areas;
- extraction under the main channel of Wallandoola Creek and the valley infill upland swamp WCUS1 has been ruled out to avoid impacts to these areas;
- extraction under Cataract River and associated headwater upland swamps has been ruled out;

- extraction under higher order sections of Cataract Creek has been designed to include narrow longwalls to avoid increased risk of impacts to Cataract Creek; and
- the underground driveage between Wonga East and Wonga West will be fully supported (resulting in no subsidence), is under Lizard Creek to avoid the opportunity for future longwall extraction under the creek in the Wongawilli Seam, thereby avoiding future impacts to this creek.

The possibility of reducing the width of longwall panels in Wonga West was examined in order to assess feasibility of reduction in magnitude of subsidence above the longwalls. However, the technical options for location of longwall gate roads under Lizard Creek meant that the longwall layouts became uneconomic under these circumstances (Seedsman Geotechnics 2012).

2.3.3 Mine Plan

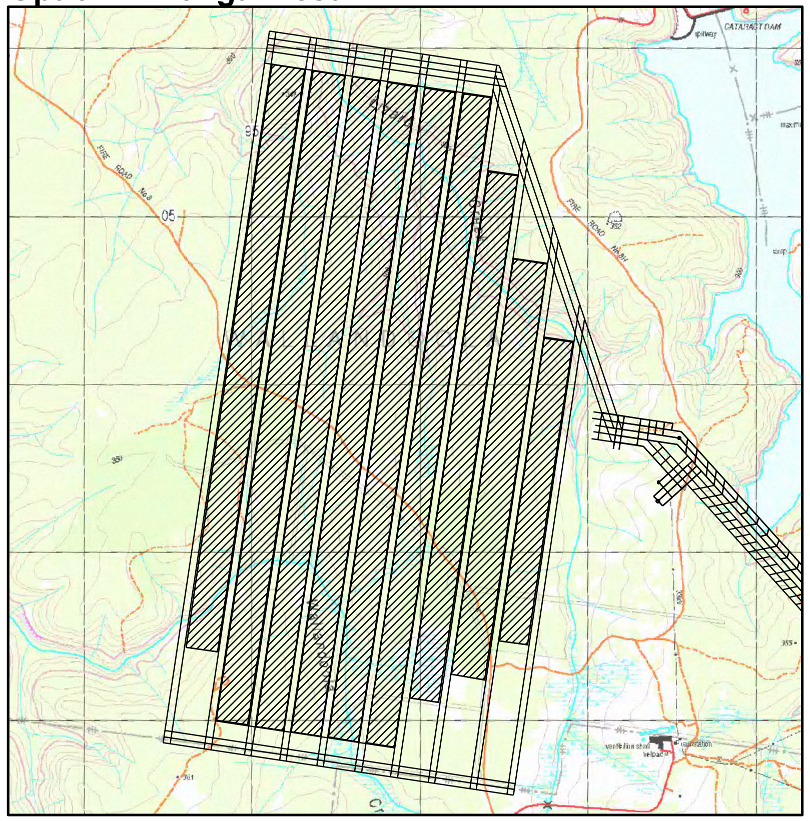
A number of 'alternative' plans were reviewed in the process of determining the final design. The final proposed mine plan was determined with consideration given to geotechnical suitability and safety, presence of geological structures, presence of previous mine workings in the above coal seam/s and associated impact, if any, on significant surface features. Further consideration was also given to both natural and built features. Options were considered both for Wonga West and Wonga East areas. The options are illustrated in *Figure 2.4* and assessed in *Table 2.1.*

Three options were considered for multi-seam mining. These options are assessed in *Table 2.1.* Option 3 mining in the Wongawilli seam with first workings in the Balgownie and Bulli seams, was selected as the preferred option for multi-seam mining.

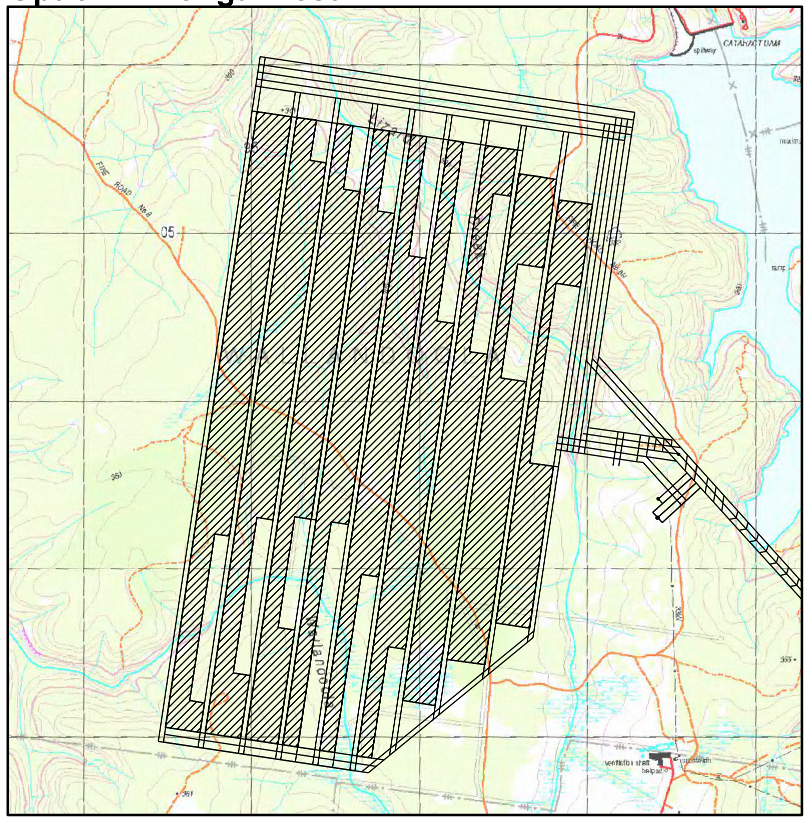
Legend

Proposed Longwall

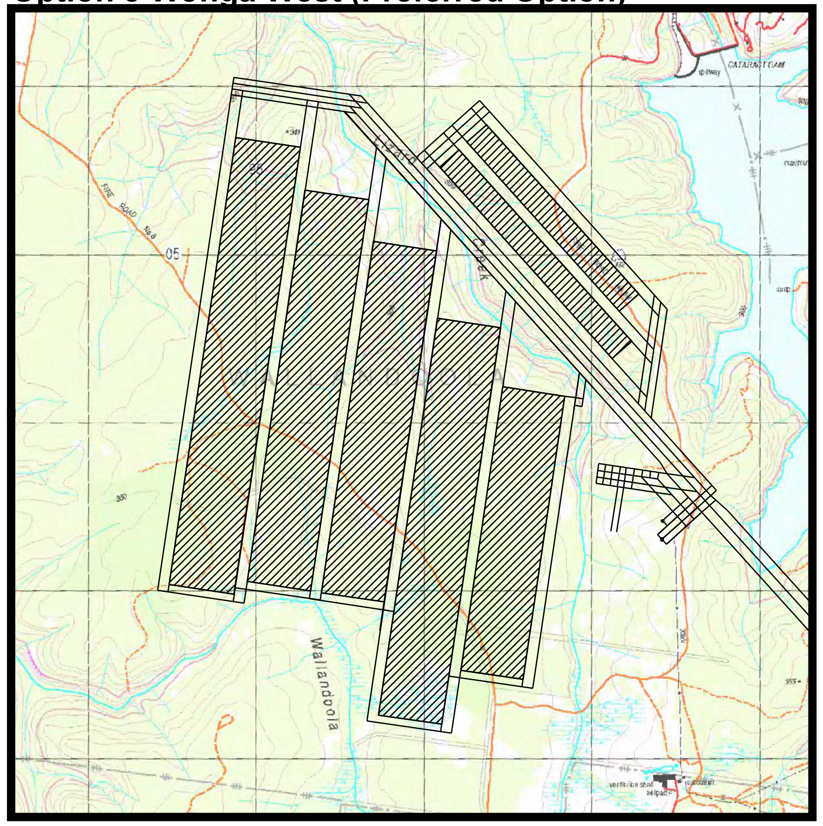
Option 1 Wonga West



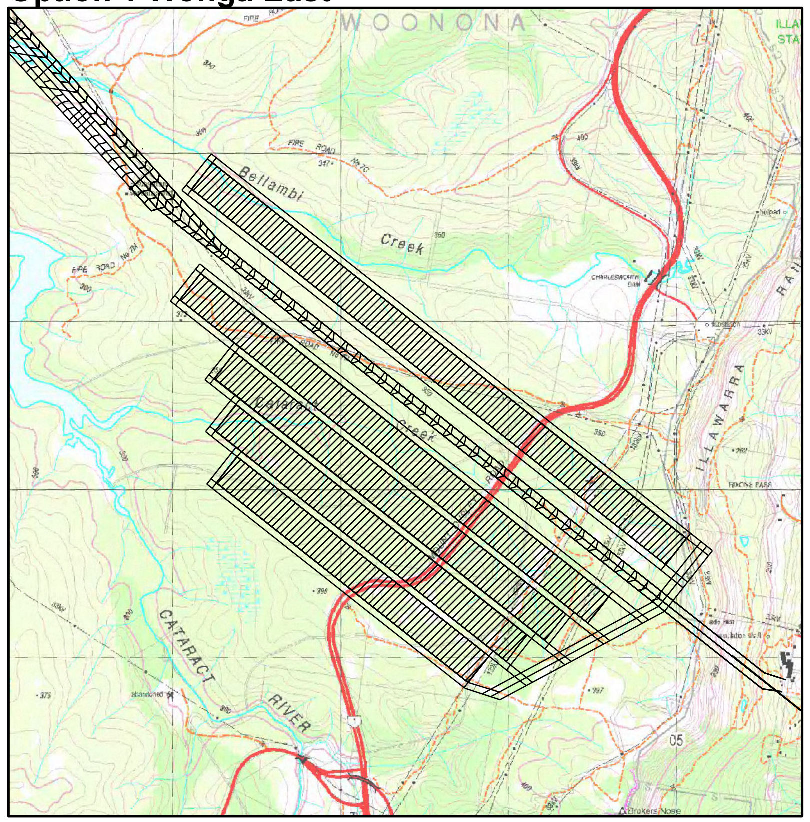
Option 2 Wonga West



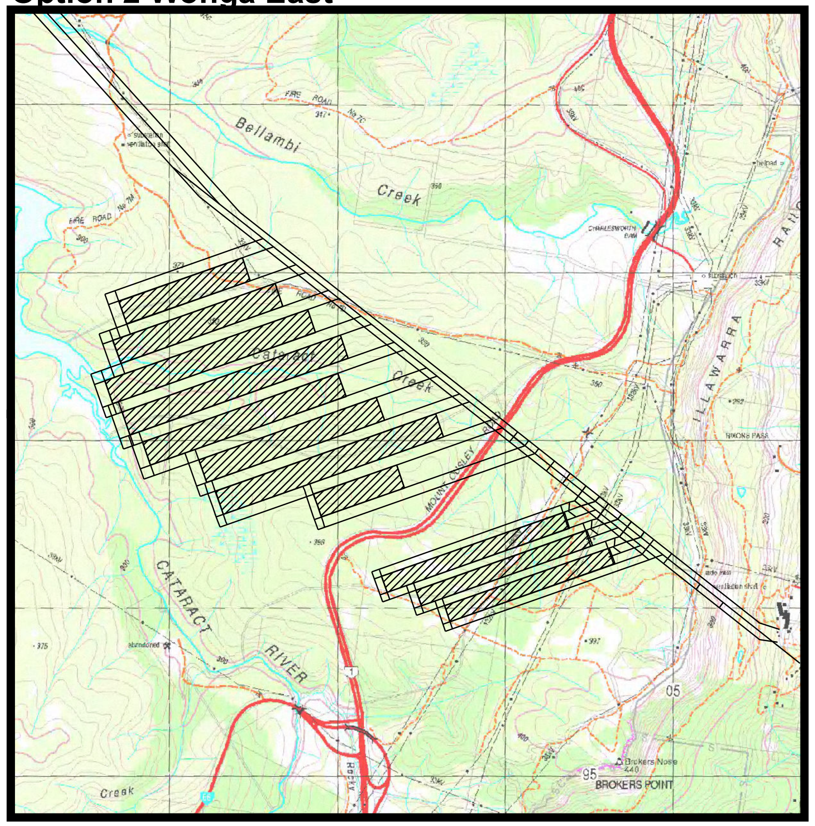
Option 3 Wonga West (Preferred Option)



Option 1 Wonga East



Option 2 Wonga East



Option 3 Wonga East (Preferred Option)

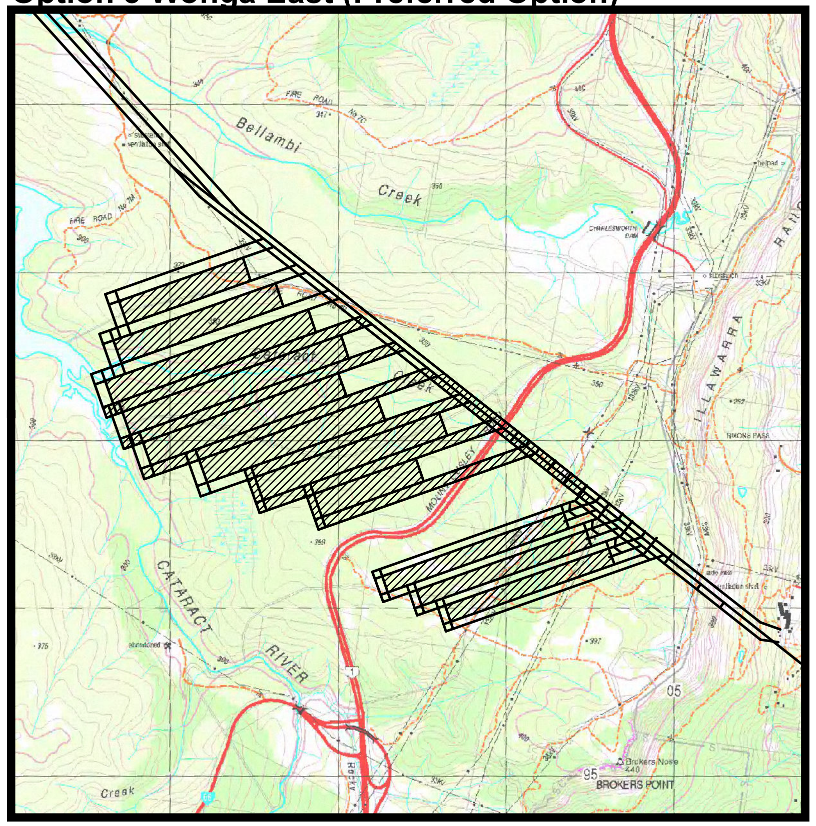


Figure 2.4

Mine Layout Alternatives

Client: NRE Coking Coal Limited

Project: NRE No.1 Colliery EPBC Report

Drawing No: 0079383s_EPBCR_G013_R0.mxd

Date: 30/11/2012 Drawing size: A3

Drawn by: KB Reviewed by: MK

Scale: Refer to Scale Bar

N 0 490 980 1,470m

Environmental Resources Management Australia Pty Ltd
Building C, 33 Saunders St, Pyrmont, NSW 2009
Telephone +61 2 8584 8888

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Table 2.1 Summary of Options Assessed for Major Project Components

Component	Description	Advantages	Disadvantages	Preferred Option
Mine Plan Wonga East	Option 1	• Maximise coal return.	• High impact of natural features. • Undermining of Mt Ousley Road would cause significant subsidence stress to the road with unpredictable consequences. • By varying the wall length and width and increasing the chain pillars, the subsidence could be minimized, however geological features (dyke running parallel to the mains) would render this orientation to be un-economical. • Potential for adverse geotechnical and mining conditions due to orientation to old workings and joints.	NO
Mine Plan Wonga East	Option 2	• Minimises impact on significant natural features including Cataract Dam and Cataract River. • Longwall widths minimise subsidence with large chain pillars whilst ensuring the longwall domains are still economically viable. • Provides advantageous geological/ geotechnical mining conditions.	• Does not achieve maximum coal return. • Narrow longwalls require higher development costs per tonne of longwall coal, therefore is less cost effective. • Higher levels of resource sterilisation.	**NO**
Mine Plan Wonga East	Option 3	• Minimises impact on significant natural features including Cataract Dam and Cataract River. • Avoids impact on large upland swamp CRUS1. • Longwall widths minimise subsidence with large chain pillars whilst ensuring the longwall domains are still economically viable. • Provides advantageous geological/ geotechnical mining conditions.	• Does not achieve maximum coal return. • Narrow longwalls require higher development costs per tonne of longwall coal, therefore is less cost effective. • Higher levels of resource sterilisation.	**YES -** This is the preferred option as it considers significant natural features in the mining domain while ensuring that mining is still economically viable.

Component	Description	Advantages	Disadvantages	Preferred Option
Mine Plan Wonga West	Option 1	• Maximise coal return. • Panel orientation consistent with overlying mine workings.	• Additional subsidence resulting from interactions with workings from previous overlying seams in the strata. • Subsidence under streams of up to 3 metres.	NO
Mine Plan Wonga West	Option 2	• Panel orientation consistent with overlying mine workings. • Greater coal return in comparison to Option 3.	• Problems with ventilation of the narrowed longwalls. • Narrow longwalls require higher development costs per tonne of longwall coal, therefore is less cost effective. • Not economic.	NO
Mine Plan Wonga West	Option 3	• Panel orientation consistent with overlying mine workings. • Minimises impact on significant features including Cataract Dam, main channel and waterfalls on Lizard Creek and Wallandoola Creek, large valley infill upland swamps in Lizard Creek and Wallandoola Creek.	• Does not achieve maximum coal return. • Narrow longwalls require higher development costs per tonne of longwall coal, therefore is less cost effective. • Shorter longwall require higher development costs.	**YES** - This is the preferred option as it takes into consideration the significant natural features and other surface features while ensuring that mining is still economically viable.
Multi-seam mining	Mining only in the Wongawilli seam	• Extends life of mine utilising existing infrastructure. • Provides ongoing employment.	• Does not mine a viable resource. • Potential to sterilise coal resources. • Limits life of mine and return on investment and future royalties.	NO
	Full seam extraction in multiple seams (i.e. Balgownie and Wongawilli)	• Increased ROM coal production.	• Requires purpose built mining equipment to access low height coal seam. • Will result in unacceptable subsidence. • Poses a safety risk. • Potential unacceptable impacts on surface features.	NO

Component	Description	Advantages	Disadvantages	Preferred Option
	Mining in the Wongawilli seam with first workings in the Balgownie and Bulli seams	• Increased ROM coal production. • Extends life of mine utilising existing infrastructure. • Provides ongoing employment. • Provides access to future coal resources to the west.	• Poses considerable issues with programming production. • May require duplication of conveyor infrastructure and segregation on coal stock piles.	**YES** – Development of first workings only in the Bulli seam is proposed to provide access to future coal resources.

3 ECOLOGICAL SETTING

3.1 PREAMBLE

This chapter provides a summary of ecological setting of the proposed action and the matters of NES that are likely to occur within the Study Area. This is based upon a number of other reports prepared for the proposed action and included as annexes to the EA Report (ERM 2012b), including:

- *Terrestrial Ecology Assessment* prepared by ERM (2012a) with specialist herpetologists from Biosis and Eco Logical (see *Annex S* of this EA);

- vegetation surveys of all areas of upland swamp in the Study Area and an assessment of the impact of the proposal on the upland swamps were undertaken by Biosis (2012) in accordance with the draft guidelines for assessment of upland swamps by OEH (2012) and are provided in theire report *NRE No. 1 Colliery Major Expansion – Upland Swamp Assessment* (see *Annex Q* of this EA);

- aquatic ecology field investigations undertaken by Cardno Ecology Lab (2011) in autumn and summer from 2008 until 2012 providing up to four years of baseline data (see *NRE No 1 Mine, Russellvale Baseline Aquatic Ecology Monitoring* in *Annex R* of this EA); and

- an environmental impact assessment of the impacts of the proposed action on aquatic biota has been prepared by Cardno Ecology Lab (2012) (see *NRE No 1 Mine Assessment of Mine Subsidence Impacts on Aquatic Habitat and Biota* in *Annex R* of this EA).

The ecological setting, the results of field work and literature reviews provided in these three reports have been relied upon to inform this assessment of impacts on matters of NES.

3.2 ECOLOGICAL SETTING

The PAA is characterised by native vegetation and a large body of water behind the Cataract Dam wall that dominates the Cataract River catchment and separates the Wonga East and Wonga West mining areas.

Existing vegetation mapping of the Study Area was sourced from the National Parks and Wildlife Service (NPWS) publication *Native Vegetation of the Woronora, O'Hares Creek and Metropolitan Catchments* (NPWS 2003). The mapping identifies that the Study Area contains approximately 19 vegetation units as classified by NPWS (2003) as shown in *Figure 3.1* and *Figure 3.2*.

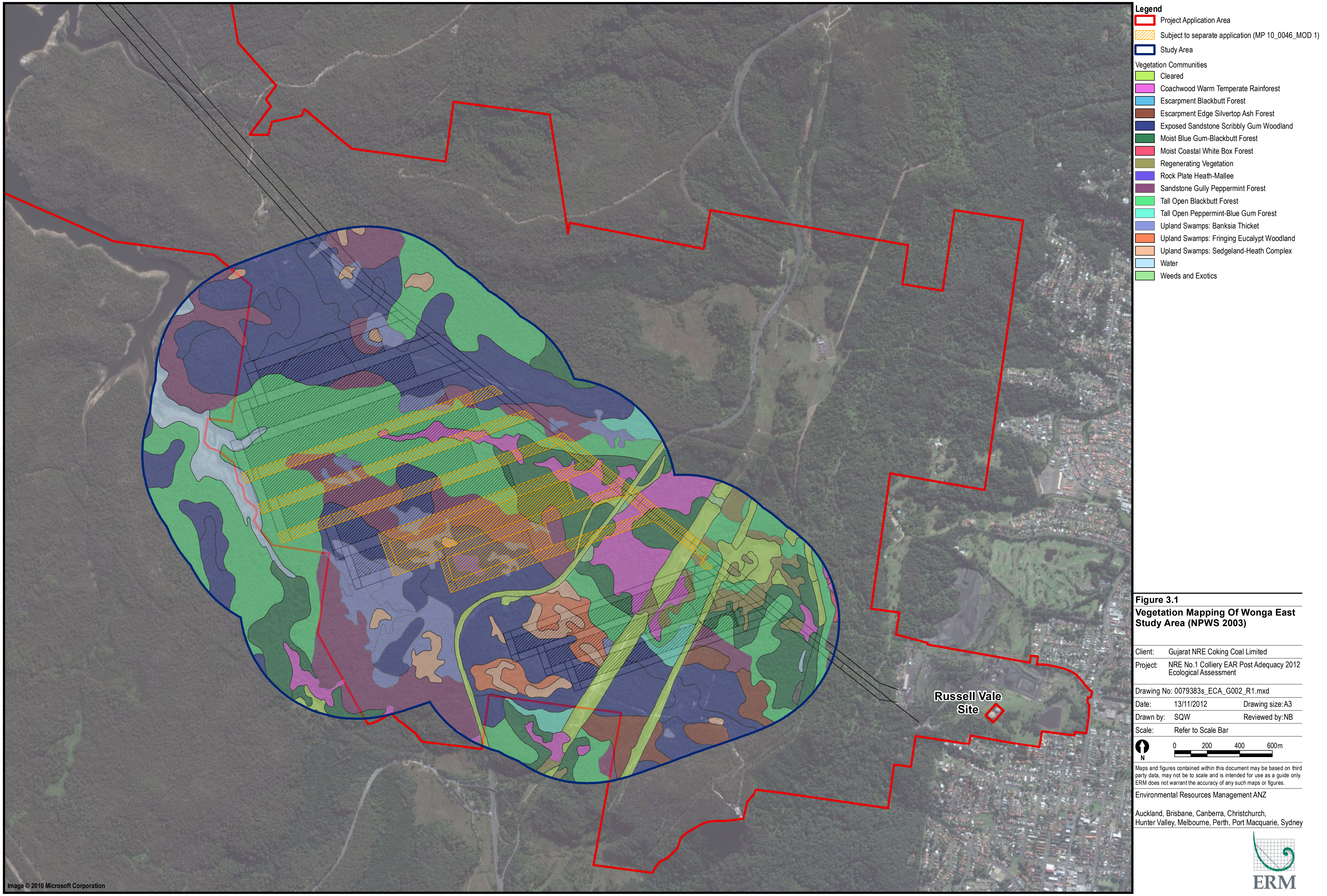

Figure 3.1

Vegetation Mapping Of Wonga East Study Area (NPWS 2003)

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G002_R1.mxd

Date: 13/11/2012 Drawing size: A3

Drawn by: SQW Reviewed by: NB

Scale: Refer to Scale Bar

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Environmental Resources Management ANZ

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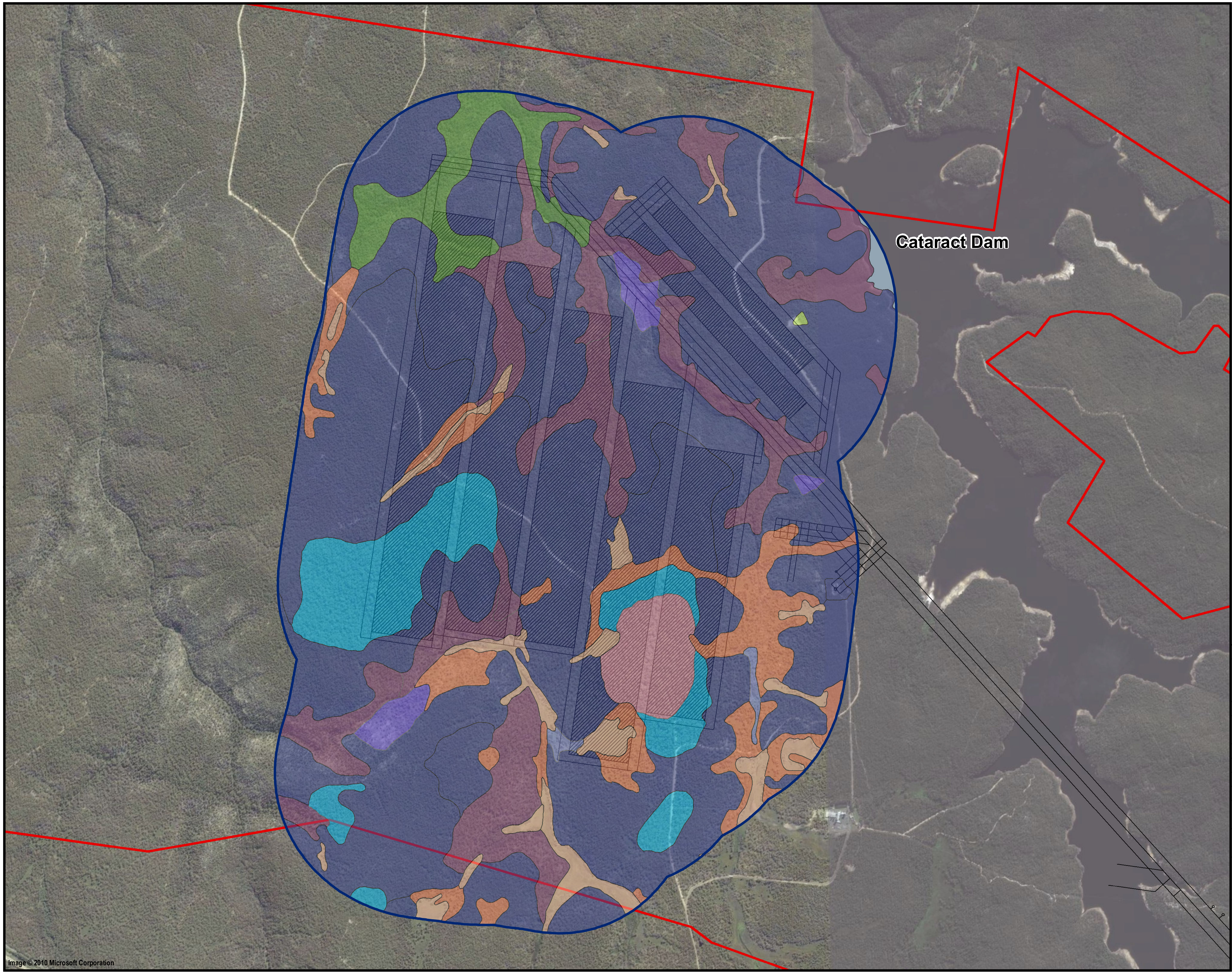
ERM



Legend

- Project Application Area
- Proposed Longwall
- Study Area

Vegetation Communities

- Cleared
- Exposed Sandstone Scribbly Gum Woodland
- Rock Plate Heath-Mallee
- Sandstone Gully Peppermint Forest
- Transitional Shale Open Blue Gum Forest
- Transitional Shale Stringybark Forest
- Upland Swamps: Banksia Thicket
- Upland Swamps: Fringing Eucalypt Woodland
- Upland Swamps: Sedgeland-Heath Complex
- Water
- Western Sandstone Gully Forest

Figure 3.2

Vegetation Mapping Of Wonga West Study Area (NPWS 2003)

Client: Gujarat NRE Coking Coal Limited

Project: NRE No.1 Colliery EAR Post Adequacy 2012 Ecological Assessment

Drawing No: 0079383s_ECA_G017_R1.mxd

Date: 27/11/2012 Drawing size: A3

Drawn by: SQW Reviewed by: MB

Scale: Refer to Scale Bar

N

0 250 500 750m

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ERM

3.2.1 *Forested Habitat*

Native vegetation within the PAA is dominated by dry sclerophyllous woodlands on the exposed sandstone plateau. Within the gullies and gorges tall moist forests predominate with some temperate rainforest also occurring in the deeper gullies in Wonga East.

Large areas of habitat are un-fragmented for both flora and fauna and therefore important both locally and regionally. Small areas of native vegetation have been cleared for existing infrastructure, including at the Russell Vale site, the primary personnel and equipment shaft (Shaft 4), other ventilation shafts and along access tracks.

Within the Study Area, the EPBC Act listed EEC Shale/Sandstone Transition Forest occurs represented by two vegetation types: Transitional Shale Stringybark Forest; and Transitional Shale Tall Open Blue Gum Forest. The EEC occurs in discreet elevated patches of shale based soils in the Wonga West area. All observed patches of this EEC are considered to be in a healthy condition (ERM 2012a).

3.2.2 *Streams*

The Study Area contains ephemeral 1st order streams, intermittent 2nd order streams and perennial 3rd and 4th order streams and channel pools, and extensive upland swamps that are expected to provide habitat for a diverse array of species, particularly in dry periods. Watercourses over the proposed longwall mining area include Cataract Creek, Bellambi Creek, Lizard Creek, Wallandoola Creek and the Cataract River.

Wallandoola Creek and Lizard Creek are deeply-incised streams cut into Hawkesbury Sandstone. The surrounding vegetation of Wallandoola and Lizard Creeks within the Wonga West Study Area was generally open dry sclerophyll woodland and heath. Within the Study Area both creeks are unshaded to moderately shaded and the substratum dominated by bedrock and boulders with sand and fine sediment accumulated in some of the deeper pools and channel sections. Aquatic macrophytes including *Vallisineria gigantea* and *Eleocharis* sp. are present (Cardno Ecology Lab 2012).

There is a variety of different habitat features within these creeks including relatively deep, permanent pools and sections of shallow flow over bedrock bars. Soft sediment banks with overhanging vegetation and instream features such as submerged woody debris is also present (Cardno Ecology Lab 2012).

The proposed Wonga East longwalls are located within the Cataract River catchment, to the north east of the Cataract River arm of the reservoir. Cataract Creek is a 4th order stream bordered by temperate rainforest riparian vegetation that joins Cataract River in the waters of the reservoir. The canopy along Cataract Creek is a closed temperate rainforest and the creek is shaded. The channel morphology of the creek is characterised by an alternating series of long pools and shorter bars and riffles.

Cataract Creek is predominantly shallow with occasional deep holes. Bars and riffles are composed of various combinations of bedrock, boulders, cobble, pebble and gravel. Large woody debris was relatively common, forming dams and submerged snags in pools. There is natural variation in water levels both within and between seasons (Cardno Ecology Lab 2012).

Aquatic habitats suitable for the threatened Macquarie Perch were identified in Cataract Creek Sites 5 and 6. The current supply level of Cataract Reservoir extends upstream into Cataract Creek and provides suitable habitat for Macquarie Perch and a freshwater cod species. Occasional riffles and bars further upstream may create minor barriers to passage during low to moderate flows or when water levels within the Cataract Reservoir are low (Cardno Ecology Lab 2012).

Cataract Creek has been identified as providing potential breeding habitat for the Stuttering Barred Frog (*Mixophyes balbus*) (see *Photograph 3.1*). While a number of 1st order streams were assessed as providing suitable breeding habitat for Heath Frog (*Litoria littlejohni*) and/or the Giant Burrowing Frog (*Heleioporus australiacus*). Giant Burrowing Frog tadpoles were recorded in Lizard Creek Tributary 1 (LCT1) in Wonga West (*see Photograph 3.2*) and downstream of the upland swamp CRUS2 in Wonga East.

Photograph 3.1 Stuttering Barred Frog habitat in Cataract Creek (Eco Logical 2009)

Photograph 3.2 Giant Burrowing Frog habitat in good condition in LCT1

3.2.3 *Upland Swamps*

Stream headwaters in the PAA are characterised by extensive upland swamps leading into broad, shallow streams with poorly defined channels and a low bed gradient. Upland swamps are recognized as significant biodiversity features that provide habitat for a high diversity of plant and animal species, many of which are threatened or endemic (DECC 2007a). Upland swamps regulate the quality and quantity of surface-water discharge by releasing moisture over extended (often dry) periods. This water availability means that many species are dependent upon upland swamps and their associated perennial streams for some or all of their lifecycle. Contiguous networks of intact upland swamps, including the Wallandoola Creek swamp cluster are considered to be of particular conservation significance (DECC 2007a). The Wallandoola Creek significant swamp cluster extends across part of the Study Area, including the majority of swamps in the Lizard Creek and Wallandoola Creek uplands.

The Bulli PAC report (2010) identified that OEH consider upland swamp communities within the Woronora Plateau to be consistent with the EPBC Act listed *Temperate Highland Peat Swamps on Sandstone* EEC. Biosis (2012) reviewed whether the upland swamps are representative of the Commonwealth EEC and concluded that the upland swamps in the PAA are not representative of the current listing (see Section 1.2.3 of *Annex Q*). This was based on the upland swamps in the PAA not meeting three criteria of altitudinal range, distribution and soils (Biosis 2012). Upland swamps throughout the PAA are representative of the *Coastal Upland Swamp in Sydney Basin Bioregion EEC* listed under the state TSC Act.

In the Study Area upland swamps support wetland vegetation communities of primarily sedges and wet heaths that fall within the Coastal Heath Swamps class of Keith (2004). These wetlands are restricted to sites of permanently or periodically waterlogged soils and tend to be treeless with a dense to sparse shrub layer depending on fire history.

On the Woronora Plateau upland swamps support a mosaic of Upland Swamp: Sedgeland-Heath Complex, Upland Swamp: Tea-tree Thicket and Upland Swamp: Banksia Thicket (NPWS 2003) in response to soil moisture and fertility. Of these communities, Upland Swamp: Tea-tree Thicket is dependent upon permanently wet habitat while the others are more tolerant of decreased moisture levels (OEH 2012). The presence of Upland Swamp: Tea-tree Thickets is an indicator that a swamp is likely to support a more complex vegetation structure. *Photograph 3.3* shows CCUS1 in the Cataract Creek catchment over Area 1 in Wonga East. This upland swamp supports Upland Swamp: Banksia Thicket, Upland Swamp: Tea-tree Thicket, Upland Swamp: Restioid Heath and Upland Swamp: Cyperoid Heath. Upland Swamp: Fringing Eucalypt Woodland borders the mosaic of moisture dependent communities. Although the upland swamps in the Study Area are not classified as EECs, they do provide habitat for EPBC listed threatened species. Field investigations by ERM and Biosis have identified the Vulnerable plant Prickly Bush-pea (*Pultenaea aristata*) in upland swamps CRUS1, CCUS3, CCUS10, CCUS8 and BCUS7 in the Wonga East area and upland swamps LCUS27, WCUS5, WCUS1, WCUS4, LCUS14, LCUS13, LCUS15, LCUS16, LCUS33, LCUS17 in the Wonga West area.

Photograph 3.3 Upland Swamp CCUS1 in Wonga East (Biosis 2012)

Upland swamps are habitats of high conservation value supporting high diversity of flora species and providing habitat, in particular drought refuge for invertebrate and vertebrate fauna. On the Woronora Plateau, upland swamps are the highest priority habitat for conservation of vertebrate fauna (DECC 2007b). Upland swamps provide potential habitat for nationally listed fauna species including the Eastern Bristlebird (*Dasyornis brachypterus*), Giant Burrowing Frog, Heath Frog and Long-nosed Potoroo (*Potorous tridactylus*).

The location of upland swamps and streams in Wonga East are shown in *Figure 2.2* and those occurring in Wonga West are shown in *Figure 2.3*.

3.2.4 Rocky Habitat

An inspection of cliff formations and steep slopes within both Wonga East and Wonga West was undertaken by SCT Operations (2012) and is provided in Annex V of the EA.

In Wonga East cliff formations along Cataract Creek are typically less than a few metres high, but up to five metres high for about 30m above A2 LW8 and five to 10m high for about 50m above A2 LW10 (SCT 2012). Several cliff formations higher than 10m are located along Rocky Creek, tributary of Cataract River in the south of the Study Area.

Wonga West is located entirely within Hawkesbury Sandstone strata dominated by gently sloping area with areas of steep slopes and tiers of smaller cliff formations along the channels of Lizard Creek and Wallandoola Creek downstream of the waterfalls, and along LCT1 (SCT 2012). A 300m long section of continuous cliff formation greater than 10m high is located on the northern side of Lizard Creek (SCT 2012). Along LCT1 there are numerous steep slopes and smaller sandstone cliff formations that typically extend laterally for more than 20m. A previously undermined 10 to 15m high cliff formation of about 100m length is located immediately to the north of A3 LW3 (SCT 2012).

The Study Area does not contain extensive northern western and western facing sandstone benches that could be considered critical wintering habitat for the threatened Broad-headed Snake (Eco Logical 2009). However, there are sandstone benches and overhangs, some with good quality exfoliating slabs that provide isolated patches of habitat for Broad-headed Snake, and the species is expected to inhabit these areas. An example of such habitat is provided as *Photograph 3.4*. Due to the topography of the Study Area and the location of the proposed longwalls, it appears that conflicts between the proposed action and the habitat requirements of this threatened species have been avoided (Eco Logical 2009).

Photograph 3.4 Broad-headed Snake wintering habitat in lower sections of Lizard Creek

3.3 *NATURAL FEATURES OF SPECIAL SIGNIFICANCE*

The Southern Coalfield Inquiry (DoP 2008) found that the coalfields underlie a landscape containing highly significant ecological features that are sensitive to subsidence impacts as a result of longwall mining. The sensitive landscape features include streams, swamps, rocky habitats, EECs and threatened species.

The Bulli Seams Operation (BSO) Planning Assessment Commission (PAC) report (PAC 2010) and Metropolitan Colliery (PAC 2009) identified that some highly significant ecological features are features of 'special significance'. 'Special significance' status is based upon an assessment of a natural feature that determines the feature to be so special that it warrants a level of consideration (and possibly protection) well beyond that accorded to others of its kind. This decision may be based on a rigorous assessment of scientific importance, archaeological and cultural importance, uniqueness, meeting a statutory threshold or some other identifiable value or combination of values (PAC 2009).

Assessments for the Project have identified a number of natural features that are of special significance within the Study Area including EECs (ERM 2012a), upland swamps (Biosis 2012), streams (GeoTerra 2012a, Cardno Ecology Lab 2012) and cliffs (SCT 2012). All of these natural features provide potential habitat for matters of NES.

3.3.1 *Endangered Ecological Communities*

EECs listed under the EPBC Act are considered priority habitats for conservation within NSW due their species composition, extent and distribution in the landscape. Both PAC reports (2009, 2010) and the SCI (DoP) recognise EECs as significant natural features.

Subsidence consequences due to longwall mining are likely to be less severe in terrestrial EECs than those associated with swamps and streams (DECC 2007a).

The EEC Shale/Sandstone Transition Forest that is known to occur in the Southern Coalfields is identified in the key threatening process determination as likely to be impacted by subsidence due to longwall mining and other associated mining activities (DECC 2008)..

This community is represented by Transitional Shale Stringybark Forest and Transitional Shale Tall Open Blue Gum Forest. Within the Study Area this EEC was represented by a healthy and intact canopy in discreet elevated patches of shale based soils in the Wonga West area. Fire Road 8 traverses this community, which is easily identified by the canopy of tall Sydney Blue Gums (*Eucalyptus saligna*) and (*E. botryoides*) in the Tall Open Blue Gum Forest, or *E. globoidea* and *E. eugenoides* (Stringybark Forest). All observed patches of this EEC were observed to be in a healthy condition (ERM 2012a).

Upland swamps in the Study Area are representative of the TSC Act listed *Coastal Upland Swamp in Sydney Basin Bioregion EEC*. The upland swamps in the Study Area are not consistent with EPBC Act listed *Temperate Highland Peat Swamps on Sandstone* EEC, because they do not meet three key criteria including altitudinal range, distribution and soils (Biosis 2012; see Section 1.2.3 of *Annex Q*). Although the upland swamps of the Woronora Plateau are not identified as part of this EEC, the Commonwealth Threatened Species Scientific Committee is currently reviewing the listing in this respect (DECCW 2011).

3.3.2 *Upland Swamps*

In accordance with the OEH (2012) guidelines, an upland swamp is of special significance when it meets three of the following five criteria:

- statutory thresholds, indicated by the presence of threatened ecological communities or threatened species; or
- swamp size greater than 7.4ha being in the top 10% of swamps in the region;
- unusual complexity or biodiversity supported by a full range of habitats associated with a mosaic of hydrological characteristics from drier fringing areas to permanently wet areas. Where vegetation mapping has been undertaken, complexity is indicated by the presence of Banksia Thicket, Tea-tree Thicket and Sedgeland-Heath Complex. Where mapping of NPWS (2003) is relied upon, the presence of Tea-tree Thicket is an indicator of unusual complexity; or
- closely proximate habitat being a swamp occurring in one of the four key clusters of swamps (as defined by the PACs); or

- importance for scientific research being those swamps in Dharawal upland swamp scientific research area plus paired reference sites.

All upland swamps mapped as a part of this assessment meet the statutory threshold criterion as they are representative of the Coastal Upland Swamp EEC. In addition, a number of upland swamps within the Study Area are, either known to support threatened species and / or provide potential habitat for threatened species.

All upland swamps in the Study Area form part of the Wallandoola Creek swamp cluster while none meets the criterion of importance of scientific research. Accordingly, determination of 'special significance' for each of the upland swamps identified in the PAA was based upon whether it is a large swamp, or unusual complexity or biodiversity.

Biosis (2012) identified that of the 84 upland swamps occurring in the Wonga East and Wonga West areas, 15 are considered to be of 'special significance' using the definition for special significance as provided in the OEH (2012) guidelines.

Biosis (2012) identified that seven (7) of the 39 uplands swamp in Wonga East are considered to be of 'special significance' according to criteria set out in OEH (2012) including CCUS1, CCUS4, CCUS5, CCUS10, CRUS1, CRUS2 and CRUS3. Of these five (5) swamps of special significance have potential to be subject to subsidence (CCUS1, CCUS4, CCUS5, CCUS10 and CRUS1).

Eight (8) of the 45 uplands swamp in Wonga West are considered to be of 'special significance' according to criteria set out in OEH (2012), including LCUS1, LCUS27, LCUS6, LCUS8, WCUS1, WCUS4, WCUS11 and WCUS7. Of these, four (4) swamps of special significance have potential to be subject to subsidence (LCUS8, WCUS4, WCUS7 and WCUS11).

A risk assessment for the upland swamps of 'special significance' was undertaken in accordance with the OEH (2012) guidelines, and is provided in *Chapter 18.*

3.3.3 Streams

The SCI identified that streams of the Southern Coalfields are considered a high priority for protection if they have some or all of the following characteristics:

- perennial or intermittent/ephemeral streams with pools;
- a diverse array of in-stream habitats that provide feeding, breeding or drought refuge;
- and/or they support threatened species, iconic species or a high diversity of species (DECC 2007a).

The parameters that contribute to whether a stream is of special significance as outlined in the Metropolitan PAC (2009) and Bulli Seam Operations PAC (2010) include size or scale of the stream, hydrological values to the catchment and water use, ecological values, environmental qualities or naturalness, visual amenity and community values.

The Study Area is known to contain intermittent and perennial streams and channel pools that are expected to provide habitat for a diverse array of species, particularly in dry periods. The Bulli Seam Operations PAC (2010) identifies Wallandolla Creek as a stream of special significance status. An assessment of stream values has been undertaken for the Project and is presented in Chapter 16 of the EA Report and in GeoTerra (2012a).

The assessment identified that Cataract Creek is a stream of special significance. Cataract Creek is characterized by permanent flow; a diversity of habitats; is known to support threatened fish species; provides habitat for the threatened Adams Emerald Dragonfly (Cardno Ecology Lab 2012); has headwater upland swamps in its catchment and these swamps provide habitat for threatened species; and water supply values.

Cataract River is a stream of special significance for naturalness, hydrological values to the catchment and water supply, ecological values, visual amenity and community values.

Lizard Creek was not considered a stream of special significance in the Bulli PAC (2010) given diminished naturalness values attributed to the effects of previous mining (dry in affected reaches after extended lack of rainfall, highly ferruginous). Notwithstanding this, the PAC considered Lizard Creek a significant stream because of scale, hydrological value and the environmental quality of its physical form and largely pristine setting worthy of protection from more than negligible impacts (PAC 2010). Since that time, upland swamps within the creek and its tributaries have been identified as an endangered ecological community. Monitoring of the creek by Cardno Ecology Lab (2012a) indicates that while the AUSRIVAS 'health' of aquatic macroinvertebrates varied seasonally but this was in keeping with variation in the control sites, however the SIGNAL2 scores indicated that Lizard Creek is more polluted than control sites.

On the basis that the connected linear network of Lizard Creek and its 'naturalness' is "*diminished by the effects of previous mining*" the third order or higher reach of the main channel of Lizard Creek within the subsidence area is not deemed to have special significance.

However, it should be noted that the Lizard Creek waterfall has not been adversely affected by loss of stream flow or water reduction in the downstream plunge pool and is considered a feature of 'special significance'.

The Bulli PAC (2010) considered Wallandoola Creek, downstream of the Study Area, to be both important and rare, and based on its 'naturalness' was considered a candidate for special significance status. Within the subsidence impact zone Wallandoola Creek the 'naturalness' is diminished by the effects of previous mining and that reach is not considered to have special significance. However, although the stream has been impacted by previous mining subsidence, which has diminished the naturalness of the creek in the WC4 to WC5 reach, the catchment is essentially undisturbed and has a high level of naturalness, except where mining subsidence is present.

3.3.4 *Cliffs*

The PAC reports (2009, 2010) defined cliffs of special significance status as those that are longer than 200m, higher than 40m, and higher than 5m that constitute waterfalls.

SCT (2012) identified three features in the Study Area that are of special significance:

- waterfall on Lizard Creek;
- waterfall on Wallandoola Creek; and
- a 300m long cliff line on the northern side of Lizard Creek (SCT 2012).

All of the features of special significance occur in the Wonga West area. In addition to these the line of cliff formations above longwall A4 LW6, that is semi-continuous over the panels and extends for approximately 700m to the north west of the panel, is considered border line special significance depending on how the length of cliff is defined. Although there is approximately 300m or so of the cliff line directly above the panel, the cliff line is discontinuous and isolated rock falls are not considered likely to be of high significance (SCT 2012).

The Illawarra Escarpment is recognised as a feature of special significance. However, the mine plan was modified early in the planning process to provide the required risk management zone buffer to the escarpment.

3.3.5 *Threatened Species*

Adverse consequences of subsidence for threatened species are most severe for species reliant upon habitats vulnerable to the impacts of subsidence (DECC 2007a). Specifically these habitats include streams, swamps and rocky habitats (DECC 2007a).

The DECC submission to the SCI outlines threatened and rare species that are vulnerable to the impacts of subsidence, which should be considered when undertaking Environmental Assessments in the Southern Coalfields (DECC 2007a). Commonwealth EPBC listed threatened species are provided in *Table 3.1* and *Table 3.2*.

Table 3.1 Listed Fauna Species likely to occur within Southern Coalfields Habitats

Common Name	Scientific Name	EPBC Act Status[3]	Regional Conservation Priority[2]	Swamp Specialist and Significance Level[3]	Key regional Habitats that are vulnerable to Subsidence[1]		
					Upland swamp	**Creeks or rivers**	**Cliffs, rock benches or overhangs**
Broad-headed Snake	*Hoplocephalus bungaroides* #	V	High	-	No	No	**Yes**
Brush-tailed Rock Wallaby*	*Petrogale penicillata*	V	Highest	-	No	No	**Yes**
Eastern Bristlebird*	*Dasyornis brachypterus*	E	Highest	No – national significance	**Yes**	No	No
Giant Burrowing Frog	*Heleioporus australiacus* #	V	Moderate	Yes – national significance	**Yes**	**Yes**	No
Green and Golden Bell Frog*	*Litoria aurea* #	V	Highest	Yes – national significance	No	**Yes**	No
Heath Frog or Littlejohn's Tree Frog	*Litoria littlejohni* #	V	High	Yes – national significance	**Yes**	**Yes**	No
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	High	-	No	No	**Yes**
Long-nosed Potoroo *	*Potorous tridactylus*	V	Highest	Yes – national significance	**Yes**	No	No
Stuttering Barred Frog	*Mixophyes balbus*	V	Highest	-	No	**Yes**	No

1 Vulnerability to Subsidence from DECC (2007a, 2008)

2. Regional conservation priority of species in the Woronora, O'Hares Creek and Metropolitan Special Areas based upon DECC (2007b)

3. Ability to withstand loss within the Hawkesbury Nepean Catchment (HNC) and associated threshold of special significance on the Woronora Plateau from DECCW 2011. Swamps supporting species of national significance are of special significance.

4. Status: V- vulnerable; E – endangered

5. * May be locally extinct (DECC 2007a), ** maternity sites a very high priority, *** of high interest to the community (DECC 2007a), # recorded within 10km of the Study Area

Table 3.2 Flora Species likely to occur within Southern Coalfields Habitats Vulnerable to Subsidence

Common name	Scientific name	EPBC Act status[2]	ROTAP status[3]	Habitats Vulnerable to Subsidence[1]		
				Habitat in upland swamps	**Habitat in creeks or rivers**	**Habitat on cliffs, rock benches or overhangs**
Small-flower Grevillea	*Grevillea parviflora* subsp. *parviflora*	V	-	**Yes**	No	No
Woronora Beard-heath	*Leucopogon exalasius*	V	2VC-	No	**Yes**	No
Deane's Paperbark	*Melaleuca deanei*	V	3RC-	**Yes**	No	No
Needle Geebung[5]	*Persoonia acerosa*	V	V	Fringing habitat	No	No
Brown Pomaderris	*Pomaderris brunnea* #	V	2VC-	No	**Yes**	No
Prickly Bush-pea	*Pultenaea aristata* #	V	2V	**Yes**	No	No

1. Vulnerability to Subsidence from DECC (2007a, 2008)
2. Status: V- vulnerable; E – endangered;
3. RoTAP status: 2 = geographic range in Australia less than 100 km, 3 = geographic range in Australia is less than 1000 km, R =- rare, V = vulnerable, C = conserved, a = 1000 plants or more known to occur within a conservation reserve, i = less than 1000 plants known to occur in a conservation reserve, - = reserve population size not accurately known
4. # - previously recorded within 10km of the Study Area.
5. Identified in determination of 'Alteration of habitat following subsidence due to longwall mining as a key threatening process' as susceptible to subsidence impacts.

3.4 *EPBC PROTECTED MATTERS SEARCH TOOL*

The EPBC Act Protected Matters Search Tool identified Endangered Ecological Communities (EECs), threatened species and migratory species listed under the EPBC Act that "*have the potential to occur, or rely on habitat that may potentially occur, within 10km of the study area*".

The output of the search is provided as *Annex A Table A.1. Annex A* also provides an assessment of the potential occurrence of each matter of NES within the Study Area.

Matters of NES identified in the Study Area in the terrestrial flora and assessment (ERM 2012a) and aquatic ecology surveys (Cardno Ecology Lab 2012) are listed in *Table 3.3*.

Table 3.3 Matters of NES Identified in the Study Area

Common Name	Scientific Name	Listing	Record	Vulnerable to Subsidence
Shale/Sandstone Transition Forest		EEC	Recorded in Wonga West	Yes
Macquarie Perch	*Macquaria australasica*	E	Present in Cataract Reservoir and in lower reaches of Cataract Creek.	Yes
Murray Cod	*Maccullochella peelii peelii*	V	Present in Cataract Reservoir. Tentatively recorded in Cataract Creek.	Yes
Trout Cod	*Maccullochella maquariensis*	E	Present in Cataract Reservoir. Tentatively recorded in Cataract Creek.	Yes
Giant Burrowing Frog	*Heleioporus australiacus*	V	Tadpoles identified in Wonga East (Nathan Garvey Biosis pers comm)	Yes
Hairy Geebung	*Persoonia hirsuta*	E	Recorded by Kevin Mills and Associates (1995)	No
Prickly Bush-pea	*Pultenaea aristata*	V	Previously recorded in site Study Area by Kevin Mills and Associates (1995). Recorded in Wonga East and Wonga West (ERM and Biosis).	Yes
Black-faced Monarch	*Monarcha melanopsis*	M	Recorded	-
Rufous Fantail	*Rhipidura rufifrons*	M	Recorded	-
Peregrine Falcon	*Falco peregrinus*	M	Recorded	-

Records are from ERM (2012a) or Cardno Ecology Lab (2011, 2012) unless otherwise acknowledged
Vulnerability to subsidence identified by DECC (2007a);
Migratory species were not discussed by DECC 2007a.

The terrestrial flora and fauna assessment (ERM 2012a), upland swamp assessment (Biosis 2012) and aquatic ecology surveys (Cardno Ecology Lab 2011, 2012) have considered all EECs, threatened species and migratory species listed by the search tool. Only those communities and species considered to have a moderate to high or high likelihood of occurrence and/or recorded, within the Study Area are highlighted. For communities and species not considered to have the potential to occur within the study area, information is provided in *Annex A.*

4 POTENTIAL FOR IMPACTS TO MATTERS OF NES

4.1 SUBSIDENCE IMPACTS

The most direct environmental impact of longwall mining is subsidence, which causes changes in the level of the ground surface overlying and adjacent to the area of extraction. As the first workings extraction methods in the Study Area are not expected to result in any subsidence greater than 20mm, and there will be no measurable surface deformations (Seedsman Geotechnics 2012), the only aspect of the proposed action that will cause subsidence is longwall mining.

The *Strategic Review of the Impacts of Underground Coal Mining on Natural Features in the Southern Coalfields of NSW* (DoP 2008) outlines subsidence impacts primarily as tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence, and subsidence depressions or troughs. As a depression or trough forms, the ground surface is subjected to tilts and strains depending on the geology, depth of cover, panel dimensions and position above the panel (DoP 2008).

The proposed action is expected to cause subsidence due to longwall mining, which has the potential to impact upon the EEC, threatened species and their habitats. Geographical features susceptible to the impacts of subsidence include aquatic ecosystems (streams and creeks), swamps (including upland swamps), and rocky environments (including caves and overhangs) (DECC 2007a, DoP 2008). It is generally recognised that the impacts of subsidence due to longwall mining on terrestrial ecosystems (including Shale Sandstone Transition Forest) are likely to be less significant than those experienced by aquatic-dependent ecosystems (DECC 2008), although rocky habitats are particularly vulnerable (DECC 2007a)..

Potential direct and indirect impacts from subsidence are outlined in *Table 4.1.*

Table 4.1 Potential Impacts to Flora and Fauna from Subsidence

Natural Feature	Subsidence Impact	Potential Consequence for Flora/Fauna
Terrestrial Vegetation	Tensile cracking of ground surface and shallow rock strata in particular on slopes and ridge tops. Surface cracking of gently undulating lands is not commonly observed	There have been no reported changes to ridge top and slope vegetation that have been attributed to mine subsidence (FloraSearch 2010). Changes in surface are likely to be small when compared to existing natural surface gradients.
	Depressurisation of groundwater due to development of the goaf and effects on overlying strata	Lowering of the water table beyond the reach of shallow rooted plants, causing degradation of vegetation communities.
Rivers (creeks, streams, tributaries).	Surface cracking due to subsidence	Reduction in surface flows into subsurface flow paths; increased frequency, duration and magnitude of drying aquatic habitats.
		Reduction in extent and/or duration of standing pools leading to reduction in aquatic or littoral habitats.
		Loss or reduction in connectivity between pools by riffles may reduce fauna migration opportunities.
		Potential changes to water quality (increased iron, manganese, sulphides and electrical conductivity, and lower dissolved oxygen).
		Reduced diversity of in-stream habitat due to the growth of iron-oxidising bacteria which can also be seen as a rusty-coloured mass in the water.
		Potential release of gas into the water column - oxidation of gas may lead to death of riparian vegetation and in-stream fauna.
	Water-rock chemical interactions along new flow pathways	Changes in water quality / quantity in streams and creeks including increased iron-oxidisation and bacteria flocculation.
	Tilting of stream beds	Stream bank and bed erosion altering aquatic and riparian habitat.
	Ponding in subsidence troughs	Inundation of vegetation.

Natural Feature	Subsidence Impact	Potential Consequence for Flora/Fauna
Upland Swamps	Draining of perched water table and loss of swamp soil moisture due to cracking of clay or shale seals which typically underlie upland swamps.	Reduction, change in composition or loss of swamp vegetation dependent on high soil moisture.
		Potential reduction in fauna abundance, including threatened species dependent on swamp ecosystems.
		Reduction of water purification and flow regulation function for downstream ecosystems.
		Gullying and erosion of swamps, exacerbating the draining of water from swamp soils.
		Increased fire frequency due to drying of swamps and their fringes.
		Draining/ drying of springs, soaks and dams.
Rocky Habitats	Surface cracking	Reduced health of riparian vegetation and in-stream habitats.
		Loss or creation of shelter sites for wintering reptiles and other animals.
	Decreased stability and increased probability of localised cliff collapse and rock falls.	Loss or creation of habitat for cave dependent species.
		Loss or creation of habitat for cliff dependent species including rock-orchids and cliff-nesting birds.
	Cracking and movement within rocks below swamps	Potential drop in perched water table leading to impacts on upland swamps as outlined above.
	Surface cracking	Alter and possibly destroy rock shelters and burrows for fauna.

Seedsman Geotechnics (2012) has predicted subsidence impacts from multiple seam assessment of the Study Area and provided visualisation of subsidence predictions. Seedsman provided subsidence value data for assessments undertaken in the EA (ERM 2012b) and specialist reports including GeoTerra (2012a and 2012b), Biosis (2012) and SCT (2012).

There is potential for a range of impacts associated with subsidence, including tilt, strain and surface cracking. The maximum values of subsidence for the Wonga East and Wonga West domains have been extracted from Seedsman (2012) and GeoTerra (2012a) and are provided in *Table 4.2* and *Table 4.3*.

Table 4.2 Maximum Predicted Subsidence in Wonga East

Domains	Subsidence (m)	Tilt (mm/m)	Strain (mm/m)	Upsidence (mm)	Valley Closure (mm)
Overall Wonga East Area 1 Mining Domain	1.20	17.0	-13 to 11	120	200
Overall Wonga East Area 2 Mining Domain	1.20	17.0	-14 to 15	120	200
Cataract Creek Main Channel	0.8	4.0	-2 to 8	120	200
Cataract River Main Channel	0	0	0	<60	<100
Bellambi Creek Main Channel	0	0	0	0	0

1. Seedsman 2012 and GeoTerra 2012a

Table 4.3 Maximum Predicted Subsidence in Wonga West

Domains	Subsidence (m)	Tilt (mm/m)	Strain (mm/m)	Upsidence (mm)	Valley Closure (mm)
Overall Wonga West Mining Domain					
Wongawilli Seam only	2.5	17.5	-12 to 14	-	-
Overall Wonga West Area 4 Mining Domain					
Wongawilli Seam only	1.5	12.5	-10.5 to 6.5	-	-
Lizard Creek Main Channel					
Wongawilli Seam only	0.25	3.0	5.0 to <-1.0	120	200
Wallandoola Creek Main Channel					
Wongawilli Seam only	0.5	3.0	6.0 to <-1.0	120	200

1. Seedsman 2012 and GeoTerra 2012a

4.2 *SUBSIDENCE IMPACTS ON FEATURES OF SPECIAL SIGNIFICANCE AND ECOLOGICAL SENSITIVITY*

Within each specialist report, natural features, including those of special significance, were assessed for potential subsidence impacts. Available predicted subsidence values for features of special significance are provided in *Table 4.4.* These values were extrapolated from predicted subsidence provided by Seedsman to Biosis and GeoTerra for specialist reports. For features in Wonga West subsidence values were provided in Seedsman (2010).

Table 4.4 Predicted Subsidence Impacts for Features of Special Significance and EECs

Habitat Feature	Subsidence (m)	Tensile strain mm/m)	Compressive strain (mm/m)	Max Tilt (mm/m)
Wonga East Area 1:				
Upland Swamp (CCUS1)	0.40	**2.65**	**-6.79**	**11.38**
Upland Swamp (CRUS3)	0	0	0	0
Wonga East Area 2:				
Upland Swamp (CRUS1)	0.89	**4.34**	**-7.2**	**17.51**
Upland Swamp (CRUS2)	0.0	0	0	0
Upland Swamp (CCUS4)	1.00	**4.63**	**-8.03**	**21.04**
Upland Swamp (CCUS5)	1.00	**4.74**	**-8.03**	**21.30**
Upland Swamp (CCUS10)	1.00	**4.60**	**-8.74**	**21.39**
Wonga West Area 3:				
Shale Sandstone Forest EEC over A3 LW4 and A3 LW5	2.3	13	11	16
Shale Sandstone Forest EEC over A3 LW2 and A3 LW1	2.3	5	5	10
Upland Swamp (WCUS1)	0.72	0	0	0
Upland Swamp (WCUS4 headwater)	3.35	**5.03**	**-6.97**	10.58
Upland Swamp (WCUS7)	2.19	**5.45**	-.0.1	10.70
Upland Swamp (WCUS11)	3.27	**5.35**	**-3.8**	8.02
Upland Swamps (LCUS1)	0.87	0	0	0
Upland Swamp (LCUS6)	0.96	0	0	1.93
Upland Swamp (LCUS8)	2.66	**2.75**	**-2.64**	9.15
Upland Swamp (LCUS27)	-	0.0	0	0
Wallandoola Creek Waterfall	<0.02	<1	<1	<1
Lizard Creek Waterfall	<0.12	<1	<1	<1
Wonga West Area 4:				
Caves and overhangs in Lizard Creek gorge	0.1	4	0	3

1. Subsidence values for upland swamps extrapolated by Biosis (2012), values for waterfalls from GeoTerra (2012a), from data provided by Seedsman. Subsidence values for Lizard Creek cliffs from Seedsman (2010).
2. Bold numbers indicate that values for subsidence exceed the criteria at which the upland swamp are considered to be at risk of negative environmental consequences as established by the PAC (2010) and OEH (2012)
3. Subsidence predictions for streams are provided in *Table 4.2*.

4.2.1 *Endangered Ecological Communities*

As noted above, it is generally recognised that the impacts of subsidence due to longwall mining on terrestrial ecosystems (including Shale Sandstone Transition Forest) are likely to be less significant than those experienced by aquatic-dependent ecosystems (DECC 2008).

Subsidence prediction values for the areas of Shale/Sandstone Transition Forest EEC are provided in *Table 4.4*. An assessment of the significance of the impact of the action of the EEC is provided in *Annex B.2*.

There is a maximum predicted subsidence of 2.3 m and maximum permanent predicted tilt of 15 mm/m under the EEC in the study area. This subsidence is considered unlikely to result in significant impacts on the EEC.

4.2.2 *Upland Swamps*

Both the Metropolitan (PAC 2009) and BSO PAC reports (PAC 2010) provided guidelines for determination of special significance of swamps and for assessment of the potential impacts from subsidence.

The SCI identified that the *subsidence impacts* for valley infill swamps were tensile cracking and movement of joint and bedding planes; and buckling and localized upsidence in the stream bed below the swamp. The primary *environmental consequences* for valley infill swamps are:

- draining of swamps leading to:
    - drying and potential erosion and scouring of dry swamp;
    - loss of standing pools within the swamp;
    - vulnerability to fire damage;
    - change to swamp vegetation communities; and
    - adverse water quality impacts eg iron bacterial matting; and
- loss of stream base flow (DoP 2008).

Secondary *environmental consequences* for valley infill swamps include:

- loss of terrestrial and aquatic habitats and associated fauna, including threatened species dependent on swamp ecosystems; and
- loss of water purification and flow regulation function for downstream ecosystems.

The SCI Panel upon review of available information at that time concluded that *undermining of valley infill swamps has or will cause drainage, water table drop and consequent degradation of swamp water quality and associated vegetation* (DoP 2008).

Headwater swamps are susceptible to *subsidence impacts* from tensile cracking and tensile/shear movement of joint and bedding planes in the rock below the swamp. The primary *environmental consequences* are potential drop in the perched water table leading to draining of the swamp (DoP 2008). The SCI noted that the impacts on headwater swamps are likely to be similar in character but less extensive and significant than for valley infill swamps (DoP 2008). Secondary consequences are the same as for valley infill swamps (DoP 2008).

GeoTerra (2012b) in their assessment of impacts on groundwater identified that, subsidence could affect swamps directly overlying the proposed longwalls due to either transient and/or spatial changes in porosity and permeability of a swamp or its underlying weathered sandstone substrate through generation of cracks or differential displacement of the perched aquifer.

If a swamp overlies an extracted longwall panel, it may undergo temporary extensional 'face line' cracking (perpendicular to the long axis of the panel) as a panel advances, followed by re-compression as the maximum subsidence occurs at any one location.

In addition, where a swamp overlies a longwall, it may also undergo both longer term extensional 'rib line' cracking (parallel to the long axis of the panel) along the outer edge of the panel, and compression within the central portion of a panel's subsidence trough. The more susceptible portions of a swamp to increased secondary porosity and/or permeability changes are where it undergoes 'rib line' cracking. Any adverse effects, if they occur, would be related to the extent and degree of cracking that occurs in the underlying weathered sandstone, as cracking is unlikely to manifest in a swamp due to its saturated, clayey, humic, plastic nature (GeoTerra 2012b).

It should be noted that, headwater swamps have undergone up to 1.0 m of subsidence, up to 1.5 mm/m of strain and up to 4.5 mm/m of tilt due to past longwall mining in the Bulli and Balgownie seams between 1979 and 1989, with no apparent adverse effects on their water holding capacity or ecology.

With the listing of the EEC Coastal Upland Swamp in the Sydney Basin Bioregion under the TSC Act, OEH developed draft assessment guidelines for the underground mining industry operating in the southern coalfields (OEH 2012). A risk assessment for the upland swamps of 'special significance' was undertaken in accordance with the OEH (2012) guidelines using the subsidence criteria identified in the PAC (2010). The predicted subsidence values for those upland swamps are provided in *Table 4.4.* Bold numbering in *Table 4.3* identifies when the investigation criteria may be exceeded as a result of subsidence impacts.

Based on an analysis of potential impacts to upland swamps of special significance Biosis (2012) concluded that:

- there is a negligible likelihood of negative environmental consequences for seven (7) upland swamps, including CRUS2, CRUS3, LCUS1, LCUS6, LCUS27, WCUS1 and WCUS4-valley infill swamp;

- there is a low likelihood of negative environmental consequences for five (5) upland swamps, including CCUS4, CCUS10, CRUS1, LCUS8 and WCUS11. It is recommended that NRE undertake monitoring and consider where possible minor changes to longwall layout to reduce potential impacts to these swamps. It is noted that CCUS4 is in the middle of A2 LW6;

- there is a moderate likelihood of negative environmental consequences for upland swamps WCUS4-headwater swamp and WCUS7. It is recommended that NRE revise mine plans for Area 3 Longwall panels 2, 3 and 4 to avoid, minimise and mitigate potential impacts to these swamps; and

- there is a significant likelihood of negative environmental consequences for upland swamps CCUS1 and CCUS5 in Wonga East. It is recommended that NRE revise the mine layout of Longwall panels A1 LW3, A2 LW7 and A2 LW8 to avoid, minimise and mitigate potential impacts to these swamps.

4.2.3 *Streams*

Surface water features within 600m of the proposed secondary workings consist of:

- 1st to 3rd order streams of Wallandoola Creek which drain into the Cataract River, downstream of the Cataract Dam wall at Wonga West;
- 1st to 4th order streams of Lizard Creek which drain into the Cataract River, downstream of the Cataract Dam wall at Wonga West;
- 1st to 4th order streams of Cataract Creek and Cataract River which flow into Cataract reservoir;
- 1st and 2nd order tributaries of Cataract River and Bellambi Creek (upstream of the reservoir) which will not be undermined by the Wonga East workings; and
- Cataract Reservoir, which will not be undermined by the Wonga East workings, although the western end of longwall WE-A2-LW10 extends into the reservoir high water mark in Cataract Creek.

No extraction is proposed under the 3rd order or higher channel of Lizard and Wallandoola Creeks, with the panel layout designed to avoid or minimise subsidence impacts on the bed of the creeks and Cataract reservoir.

A potential risk to the integrity of stream flow and connectivity in Wallandoola Creek could be present in the area that may potentially undergo up to 0.5 m of subsidence and 6 mm/m of tensile strain to the south of Longwalls A3 LW3 and A3 LW4.

There is a low potential risk to the integrity of stream flow and connectivity in Lizard Creek in the area that may potentially undergo 6 to 7mm/m of tensile strain to the north of Longwall A3 LW2 and south of the northern end of Longwall A4 LW5.

The 1st, 2nd and 3rd order tributaries, in particular LCT1 (over Longwall A3 LW3) and LCT2 (near the northern end of Longwall A3 LW5) which overly the proposed 20mm subsidence zone are at risk of subsidence related stream bed cracking, enhancement of stream bed underflow, discharge of ferruginous springs and reduced stream water quality at their confluence with Lizard Creek. It is not anticipated however, that the total volume of water entering Lizard Creek will be adversely affected. It is noted, that all of these aspects of LCT1 are currently adversely affected by existing Bulli workings subsidence (GeoTerra 2012a).

No extraction is proposed under the 3rd order or higher channels of Cataract River (upstream of the reservoir) or Bellambi Creek at Wonga East. Negligible stream flow effects, impacts or consequences are anticipated to occur in Cataract River or Bellambi Creek, upstream of Cataract Reservoir, due to the low to absent levels of predicted strains and subsidence (GeoTerra 2012a).

Cataract Creek is proposed to be undermined by longwalls in Wonga East (Area 2), with a predicted maximum subsidence of 0.8m, along with up to 10mm/m compressive and 5mm/m tensile strains over A2 LW8 (GeoTerra 2012a). Potential subsidence impacts include potential cracking of the 4th order stream bed due to subsidence near or over A2 LW7, A2 LW8, A2 LW9 and A2 LW10.

Environmental consequences are potential impact on stream flow, with downstream flow re-emergence; potential effect on pool holding capacity of rock bars and potential iron hydroxide seepage. It is noted, that iron hydroxide seepage is currently occurring (GeoTerra 2012a).

4.2.4 *Cliffs*

Rocky habitats that occur along valley sides and cliffs are vulnerable to subsidence impacts, particularly where they occur directly above a mined area and resulting goaf. Consequences of subsidence impacts for rocky habitats are primarily associated with overhang collapse, rock falls and surface cracking (DoP 2008). Plant and animal species dependent upon rocky environments during some part of their lifecycle are most likely to be impacted by subsidence due to longwall mining. Broad-headed Snake and Large-eared Pied Bat (*Chalinolobus dwyeri*) are of primary ecological concern in these areas (DECC 2007a).

Caves and overhangs in Lizard Creek gorge may provide habitat for threatened species. Predicted subsidence values for these features are provided in *Table 4.4.*

4.3 *MATTERS OF NES*

Matters of NES that occur within the Study Area or have the potential to occur within the Study Area include threatened species, EECs and migratory species. These matters are discussed in this section.

Assessment of impact has been refined further to address those species and communities that have been identified in the Southern Coalfields Inquiry as vulnerable to the impacts of subsidence (DECC 2007a, DoP 2008).

4.3.1 *Threatened Species and EECS*

The ecological assessment (ERM 2012a) identified a number of EECs and threatened species that are both likely to occur within the study area, and that are vulnerable to the impacts of subsidence.

These include:

- Shale / Sandstone Transition Forest EEC;
- Macquarie Perch (*Macquaria australasica*);
- Murray Cod (*Maccullochella peeli peeli*;
- Trout Cod (*Maccullochella maquariensis*);
- Large-eared Pied Bat *(Chalinolobus dwyeri)*;
- Broad-headed Snake (*Hoplocephalus bungaroides*);
- Giant Burrowing Frog (*Heleioporus australiacus*);
- Heath Frog (*Litoria littlejohni*);

- Stuttering Barred Frog (*Mixophyes balbus*);
- Spotted-tailed Quoll (*Dasyurus maculatus maculatus*);
- Woronora Beard Heath (*Leucopogon exolasius*);
- Prickly Bush-pea (*Pultenaea aristata);*
- Deane's Paperbark (*Melaleuca deanei*);
- Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*); and
- Bargo Geebung (*Persoonia bargoensis*).

Impact assessments for these species and communities have been undertaken in accordance with the EPBC Act *Significant Impact Guidelines 1.1* (DEWHA 2009a) and are summarised in *Section 4.4.1*. The detailed assessments are provided in *Annex B*.

4.3.2 Migratory Species

Listed in *Table 3.3* are a number of terrestrial migratory species that have been recorded in the Study Area. A number of other migratory species may occur in the Study Area. *A* full list of the migratory species with the potential to occur is provided in *Annex A.*

None of these species have been identified as likely to be vulnerable to the effects of subsidence impacts. None of these species are dependent upon habitat that have a potential for adverse negative environmental consequences, in particular upland swamps or streams in particular the lower reach of Cataract Creek or the 3rd order tributaries of Lizard Creek. Given that predicted levels of subsidence are not anticipated to alter structure of terrestrial vegetation such that habitat elements for these species may be altered an assessment of the impact of the proposal on these species has not been undertaken.

4.3.3 Ramsar Wetlands

The Study Area does not occur within the catchment of any Ramsar listed Wetlands of International Importance. The nearest Ramsar listed wetland is Towra Point Nature Reserve on the southern shores of Botany Bay.

4.4 ASSESSMENT OF SIGNIFICANT IMPACTS

Assessment in accordance with the EPBC Act *Significant Impact Guidelines 1.1* (DEWHA 2009a) were undertaken for 16 species, including one EEC, nine fauna species and six flora species. The full assessments are provided in *Annex B*.

The assessments found that impacts could be significant for the Large-eared Pied Bat and for the Giant Burrowing Frog, and that disruption to the breeding cycle of the Heath Frog could occur. No other species were considered to have the potential to be significantly impacted by the proposed action.

4.4.1 *Summary of Assessments*

The impact assessment for the Large-eared Pied Bat (*Chalinolobus dwyeri*) concluded that there is a negligible to low risk that the action could modify, destroy, remove or isolate or decrease the availability or quality of habitat associated with the cliffs and/or steep slopes in Wonga West to the extent that the species is likely to decline. The species was not recorded in the microbat surveys of the Study Area, and no suitable roosting caves were recorded. However, it cannot be ruled out that suitable roosting caves potentially occur in or near the Study Area. Should a local population occur, there is a negligible to low risk that the proposal may impact on potential roosting habitat for individuals, however the proposal is not predicted to interfere substantially with the recovery of a population that may occur throughout the Woronora Plateau.

The impact assessment for the Giant Burrowing Frog concluded that potentially the proposed action may modify, destroy, remove of isolate habitat within the tributaries of Lizard Creek over the Wonga West Area 3 longwalls. The proposed action is likely to fragment an existing population into two or more populations, disrupt the breeding cycle of the population within that area. The assessment also found that although the local population may be impacted, the proposal is not predicted to interfere substantially with the recovery of the population within the Woronora Plateau.

The Heath Frog is likely to occur within the Wallandoola Creek drainage, and suitable habitat for breeding occurs within the valley infill swamp WCUS7. This swamp is likely to be subject to subsidence impacts and cracking of substrate may occur (GeoTerra 2012b). If cracking of pond bars or substrate were to occur, habitat condition may become degraded to a point such that the Heath Frog could no longer successfully breed there. The assessment found that if that were the case, the proposed action may disrupt the breeding cycle of that population. However, it is noted that a large portion of habitat for this species is associated with valley infill upland swamps in the upper reaches of Wallandoola Creek and Lizard Creek and these areas are predicted to have a negligible risk of negative environmental consequences. Accordingly, the proposal is unlikely to interfere substantially with the recovery of the population within the Woronora Plateau.

The threatened Macquarie Perch (*Macquaria australasica*) and a hybrid of the freshwater cod species Murray Cod (*Maccullochella peelii peelii*) and Trout Cod (*Maccullochella macquariensis*) are known from the waters of Cataract Dam and have been recorded periodically in the waters of Cataract Creek. Due to barriers downstream, none of these species are expected to occur in Lizard Creek and Wallandoola Creek. The worst case subsidence predictions identify that extraction of the longwall panels in this reach of Cataract Creek may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage (GeoTerra 2012a). Accordingly, the proposed action may affect habitat values required for spawning should spawning occur in this reach of Cataract Creek. The proposed action will not impact the main habitat for all of these species in Cataract Dam. NRE have made a commitment to monitor actual subsidence of longwall panels to validate the predictions about the consequences of subsidence on aquatic habitats and biota and assess any unexpected impacts on these that may occur and terminate mining beneath Cataract Creek if subsidence and ground movements exceed 250 mm and the creek experience greater than minimal impact. With adaptive management, the action is unlikely to affect the population of these species (Cardno Ecology Lab 2012).

Suitable habitat and good quality breeding habitat for the Stuttering Barred Frog (*Mixophyes balbus*) has been identified in the reaches of Cataract Creek upstream of proposed Longwall A2 LW8 in Wonga East. Based on worse case subsidence predictions habitat for the Stuttering Barred Frog above A2 LW8 and A2 LW7 will be adversely affected by the proposed action. A large section of habitat for this species occurs upstream of the affected reach of Cataract Creek and is predicted to have negligible environmental consequences.

Prickly Bush-pea has previously been recorded in Wonga West near Shaft No 5 (Kevin Mills and Associates 1995) and was recorded during surveys by ERM and Biosis in Wonga East in September 2011 and Wonga West in 2012. It may be present in a range of vegetation types, from heath in upland swamps to dry sclerophyll woodlands such as Exposed Sandstone Scribbly Gum Woodland and Upland Swamp Fringing Eucalypt Woodland and Upland Swamp: Restioid Heath that are widespread in the Study Area. While the action will not clear potential habitat or directly decrease the size of the population in the Study Area there is potential impact to the drier edges of the Upland Swamps that are favoured by this species.

The majority of the upland swamp CRUS1 will not be undermined but is anticipated to have low risk of negative environmental consequences from mining under the northern extent of the swamp. The upland swamp CCUS3 will be undermined by Longwall A2 LW5. Subsidence predictions for CCUS3 are less than the swamp gradient, and as a result subsidence induced erosion is not anticipated, nor is any significant changes in the potential for ponding, scouring or erosion (GeoTerra 2012c). Cracking in the sandstone may occur resulting in changes to hydrology in this wetland however there is a low likelihood that this will alter the headwater swamp.

For other areas of potential upland swamp habitat, GeoTerra (2012a) and Biosis (2012) reported possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking. The changes to hydrology in these areas have been generally reported to be 'potential and minor'. Given that Prickly Bush-pea is associated with drier vegetation on the fringes of the upland swamps, it is considered unlikely that the proposed action will lead to an impact on an important population of the Prickly Bush-pea.

The Woronora Beard-heath (*Leucopogon exolasius*), Deane's Paperbark (*Melaleuca deanei*), Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*) and Bargo Geebung (*Persoonia bargoensis*) may occur in the Study Area. All of these species are reliant upon the 'terrestrial' sandstone woodland, forest or dry heath habitats. While maximum subsidence predictions in these potential habitat areas is approximately 2.3 m and maximum predicted tilt of 15 mm/m, he mine design approach has recognised that the majority of the surface can be safely subsided (Seedsman 2012) and this level of subsidence is unlikely to impact on terrestrial vegetation communities and the species within them. It is unlikely that the changes in conditions would cause significant damage to vegetation communities and subsequently a long-term decrease in the size of an important population of these species. This finding also holds for the Shale/Sandstone Transitional Forest that occurs in Wonga West, as discussed in *Section 4.2.1*

5 PROPOSED SAFEGUARDS AND MITIGATION MEASURES

5.1 AVOIDANCE

The proposed mining will be in the Wongawilli seam in an area where the Bulli seam and in some places, the Balgownie seam have already been extracted (Olsen, 2009). In order to manage environmental risks, the mining proposal incorporated a risk assessment methodology and applied a hierarchy of risk management strategies during planning. Details of the strategies and the projected outcomes are included in a report prepared by Seedsman Geotechnics Pty Ltd (Seedsman, 2010).

As the baseline surveys of the Study Area progressed, NRE used an iterative mine planning process to avoid and mitigate impacts to the values identified by ERM and associated consultants. The progressive mine plans that were considered and altered throughout the iterative mine planning process are described in Seedsman (2012). In 2007 a map of 'ecological risk management zones' was provided to NRE for consideration and these areas included upland swamp communities, creek lines and riparian zones, significant fauna habitats and endangered ecological communities and an additional risk management zone of 250m around swamps (as identified at that time), and 50m around creeks. These risk management zones provided the subsidence engineers and mine managers with an understanding of the locations of sites of ecological significance within the Study Area. It also provided an opportunity to refine the mine plans based upon this information.

Areas of ecological significance including upland swamps, streams and sensitive habitat areas for threatened fauna, flora and ecological communities were identified during the ecological assessment in 2009. In order to avoid impacts to surface features, the design of longwall panel layouts has been such that potential for impacts to third and fourth order creeks are reduced (Seedsman, 2012).

Impacts to habitat associated with Cataract River, Lizard Creek and Wallandoola Creek have largely been avoided from mine planning and there is a negligible risk of negative environmental consequences for the large upland swamp complexes associated with the upper reaches of Lizard Creek and Wallandoola Creek and the large upland swamps associated with Cataract River.

5.2 MITIGATION

NRE has provided an undertaking that the mining operations will be modified as required through adaptive management measures informed through monitoring of actual subsidence impacts, to reduce negative outcomes.

An adaptive management plan will be developed to use the monitoring program to detect the need for adjustment to the mining operations so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences do not occur in upland swamps, streams and rocky habitats associated with cliffs and steep slopes.

Recommendations provided by Biosis (2012) in their assessment of upland swamps and by Cardno Ecology Lab (2012) in their assessment of aquatic habitat, will be considered in development of the adaptive management plan and future mining plans.

Measures to mitigate potential small scale effects of subsidence are recommended within the Study Area, in order to assist in amelioration of impacts. These include:

- if fracturing does occur, remediation should be implemented as soon as possible. Methods could include grouting, although the success of this measure is variable with different circumstances. All remediation works undertaken should be controlled and implemented in accordance with an Environmental Management Plan (EMP);

- if fracturing occurs leading to loss of surface water these areas should be prioritised for remediation, and extraction should be ceased in areas with similar fracture risks;

- if significant cracking occurs in vegetated areas then measures such as temporary fencing should be implemented. This will ensure that fauna are not injured or trapped; and

- prior to any remediation works, advice should be sought from an ecologist regarding the potential impacts of such remediation works to plant and animal populations within the area.

The proposed mine plan involves progressive extraction of longwalls starting in the Wonga East domain, before moving to extraction from the wider longwalls of Wonga West (Seedsman Geotechnics 2012). In order to mitigate the impacts at the scale of the entire Study Area, ongoing monitoring of sensitive habitats needs to be implemented in accordance with an EMP.

5.3 *MONITORING*

Although not a mitigation tool, monitoring of the important habitat areas (such as the upland swamps, creeks and rocky habitats) should occur pre and post mining, to allow early detection of impacts as a result of the proposed action. This would enable mobilisation of mitigation and remediation works to be undertaken in accordance with Environmental Management Plans.

A Failure Modes and Effects Analysis (FMEA) workshop was held as a means of determining ecological risks, and determining management controls for these risks (Olsen Consulting 2009). The FMEA approach was undertaken for ecological features that were not eliminated from the impact zone through the mine planning process. The primary objective of the FMEA was to identify:

- environmental effects (system failures) that would require additional study in order to quantify and minimise potential impact; and

- any relevant environmental effects that had not as yet been considered in the FMEA process (Olsen Consulting 2010).

Four ecological values were determined to have a medium or high risk of system failure, as shown in *Table 5.1*. The planned responses and recommended actions for each of the identified risks involve monitoring to evaluate level of impacts to these features over time. This monitoring will inform the ongoing development of longwall panels over time as part of the current proposed mine plan, in accordance with an EMP.

Table 5.1 Terrestrial Ecological Values Assessed in the FMEA

Identified Effect	Risk	Proposed Response and Recommended Action.
Loss of maternity and roost sites for a local cave-roosting population of the state listed threatened Eastern Bentwing-bat.	Medium	Design monitoring activity to enable better prediction of the effects of mine subsidence on potential roost sites.
Potential adverse subsidence effects on specific highly significant upland swamp and associated creek (LCT2) resulting in loss of breeding habitat for the Giant Burrowing Frog.	High	ERM to undertake field studies to ascertain extent and condition of species habitat (actions are provided in this report.)
Disturbance to tributary standing pools in tributaries to Wallandoola Creek above Wongawilli West Area	Medium	Implement appropriate monitoring program to confirm subsidence predictions. Mine plan has already been modified to minimise effects on major structures.
Disturbance to tributary standing pools in first to third order tributaries of Lizard Creek above Wongawilli West.	Medium	Ensure appropriate monitoring program is in place prior to mining in these areas.

1. Source: Olsen Consulting (2009)

The objective of the monitoring should be to identify subsidence impacts as early as possible, identify other areas that are vulnerable to similar impacts, and provide recommendations to the proponent to alter the mine plan to reduce the risk of subsidence impacts affecting similar values. In this case, the mitigation measure would be to alter the extraction plans to minimise risk to sensitive features, based on the knowledge gained through ongoing monitoring.

Implementation of any management measures should be considered with regard to the specific circumstances of the subsidence impact, such as the location, nature and extent of the impact and the assessment of the potential environmental consequences of the remediation technique used.

It is noted that in respect to upland swamps the OEH (2012) guidelines require offsets to be negotiated where impacts are not able to be remediated to the level of no negative environmental outcomes. Further, offsets are not an alternative to taking actions to avoid impacts in particular impacts to swamps of special significance.

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Annex A

EPBC Protected Matters Search Database Results

This Annex provides and assessment of the likelihood of occurrence for EPBC Act listed threatened ecological communities and threatened species within the Study Area, as presented in *Table A.1*. The species considered in this table were identified in the PMST search for the locality (see Annex C) and the NSW database outputs as provided in Annex C of *Annex S*.

Table A.1 EPBC Protected Matters Search Database Results

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Threatened Ecological Communities						
Cumberland Plain Shale Woodlands		CE	Community likely to occur within area.	The Cumberland Plain Shale Woodlands lies in a coastal valley rain shadow that occupies the driest part of the Cumberland Plain. It typically occurs on flat to undulating or hilly terrain, at elevations up to about 350 m above sea level, and on clay soils (derived from Wianamatta Group shales), with some occurrences on other soils. Annual rainfall in the region typically lies within the range of 700–900 mm.	Does not occur in Study Area.	No
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia		CE	Community likely to occur within area.	Rainforest and coastal vine thickets typically occurring: within two kilometres of the coast; or adjacent to a large body of salt water; or on offshore islands. Not associated with a particular soil type, but usually found on headlands and dunes. Encompasses warm temperate, sub-tropical and tropical climatic zones. Canopy species are well adapted to coastal exposure and protect less tolerant species in the understorey.	Does not occur in Study Area.	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Shale/Sandstone Transition Forest		E	Community likely to occur within area.	Occurs on areas transitional between the clay soils derived from Wianamatta Shale and the sandy soils derived from Hawkesbury Sandstone on the margins of the Cumberland Plain. All sites are within the Sydney Basin Bioregion.	Two stands in Wonga West. Transitional Shale Open Blue Gum Forest spanning over Longwalls A3 LW1 and A3 LW2; and Transitional Shale Stringybark Forest over Longwalls A3 LW4 and A3 LW5. Covers approximately 149.8ha	Yes
Turpentine-Ironbark Forest in the Sydney Basin Bioregion		CE	Community likely to occur within area.	Originally existed as a forest with either a shrubby or grassy understorey. Occurs primarily on clay soils derived from Wianamatta shale, including clay lenses of Wianamatta shale within Hawkesbury sandstone. The ecological community less commonly occurs on transitional areas between soils derived from the Wianamatta shale and Hawkesbury sandstone, or on soils derived from Holocene alluvium, or the Mittagong formation. Parent geology is confined to the Sydney Basin Bioregion.	Does not occur in Study Area.	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Temperate Highland Peat Swamps on Sandstone		E	Community identified by NSW Office of Environment and Heritage Not identified on PMST.	The Temperate Highland Peat Swamps on Sandstone are temporary or permanent swamps in the Blue Mountains, Lithgow, Southern Highlands and Bombala regions. They include the Blue Mountains Swamps, Butler's Swamp, Jackson's Bog (also known as Mila Swamp), Newnes Plateau Swamps, Paddy's River Swamps, Wildes Meadow Swamp and Wingecarribee Swamp. The Temperate Highland Peat Swamps all occur on sandstone and share similar vegetation. Sphagnum bogs and fens occupy the wetter parts while sedge and shrub associations occur in the drier parts of the swamps. Some, like the Blue Mountains Swamps, are hanging swamps that are prominent on steep valley sides, where water exits the ground between sandstone and claystone layers of rock. Other swamps, like Wingecarribee Swamp, occur in natural depressions or along watercourses.	Does not occur in Study Area. Swamps on Woronora Plateau occur at lower altitude and only some generate peat (Biosis 2012). Upland swamps in study area are representative of TSC Act listed Coastal Upland Swamps EEC.	No
Threatened Birds						
Anthochaera phrygia	Regent Honeyeater	E & M	Species or species habitat likely to occur within area.	Widespread but very sparsely scattered, mostly on the inland slopes of the Great Dividing Range (Higgins *et al* 2001). Nomadic species mostly occur in dry box-ironbark eucalypt woodland and dry sclerophyll forest associations, wherein they prefer the most fertile sites available, eg along creek flats, or in broad river valleys and foothills.	Not expected. No records in Metropolitan SA (DECC 2007b)	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Botaurus poiciloptilus	Australasian Bittern	E	Species or species habitat known to occur within area.	In NSW, they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleoacharis* spp.). Hides during the day amongst dense reeds or rushes and feeds mainly at night on frogs, fish, yabbies, spiders, insects and snails. Nests are built in secluded places in densely-vegetated wetlands on a platform of reeds.	No preferred habitat. Low number of records in Metropolitan SA, rare visitor Illawarra (DECC 2007b, c)	No
Dasyornis brachypterus	Eastern Bristlebird	E	Not identified in PMST. Recorded in locality on state database.	Dense, low vegetation including heath and open woodland with heathy understorey in communities not burnt for at least 15 years. Nests on or near ground. Recorded in locality on state database.	There is only a remote possibility that it still exists in Southern Sydney (DECC 2007c). Habitat in Study Area is not as dense as areas of known habitat in Jervis Bay and Holsworthy. Low likelihood of occurrence in Study Area.	No
Diomedea exulans (sensu lato)	Wandering Albatross	V & Ma	Species of species habitat may occur within area.	Marine. Recorded in locality on state database.	Not expected	No
Diomedea exulans amsterdamensis	Amsterdam Albatross	E & Ma	Species of species habitat may occur within area.	Marine.	Not expected	No
Diomedea exulans antipodensis	Antipodean Albatross	V & Ma	Species of species habitat may occur within area.	Marine.	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Diomedea exulans exulans syn *D. dabbenea*	Tristan Albatross	E & Ma	Foraging may occur within area.	Marine.	Not expected	No
Diomedea exulans gibsoni	Gibson's Albatross	V & Ma	Species of species habitat may occur within area.	Marine. Recorded in locality on state database.	Not expected	No
Fregetta grallaria grallaria	White-bellied Storm Petrel	V	Species of species habitat may occur within area.	Marine.	Not expected	No
Lathamus discolor	Swift Parrot	E	Species or species habitat likely to occur within area.	Found in NSW over winter (May to August) predominantly along the western inland slopes of the Great Dividing Range but are also patchily distributed along the North and South coasts of NSW and around Sydney. Prefer box-ironbark forests (dominated by Grey Box, *Eucalyptus microcarpa*, and Mulga Ironbark, *E. sideroxylon*) and grassy woodlands (dominated by White Box (*E. albens*) Grey Box and Grey Box/Yellow Gum) in NSW. Feeds, preferably in large trees associated with drainage lines on eucalypt nectar, pollen and associated insects (Swift Parrot Recovery Program, DPI, Hobart).	Extremely rare autumn/winter visitor, declining. No preferred feed trees.	No
Macronectus giganteus	Southern Giant-Petrel	E &Ma	Species or species habitat may occur within area.	Marine.	Not expected	No
Macronectus halli	Northern Giant-Petrel	V & Ma	Species or species habitat may occur within area.	Marine. Recorded in locality on state database.	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Neophema chrysogaster	Orange-bellied Parrot	CE & M	Species or species habitat may occur within area.	Breeds in the south-west of Tasmania and migrates in autumn to spend winter on the mainland coast of south-eastern South Australia and southern Victoria. Occasional reports from NSW, with the most recent records from Shellharbour and Maroubra in May 2003. Typical winter habitat is saltmarsh and strandline/foredune vegetation communities either on coastlines or coastal lagoons. Spits and islands are favoured but they will turn up anywhere within these coastal regions. The species can be found foraging in weedy areas associated with these coastal habitats or even in totally modified landscapes such as pastures, seed crops and golf courses.	No preferred habitat, not expected.	No
Phoebetria fusca	Sooty Albatross	V	Not identified on PMST search	Marine. Recorded in locality on state database.	Not expected	No
Pterodroma leucoptera leucoptera	Gould's Petrel	E & Ma	Species or species habitat may occur within area.	Marine. Breeds on Cabbage Tree Island off Port Stephens on mid-north coast of NSW.	Not expected	No
Pterodroma neglecta neglecta (western)	Kermadec Petrel	V	Species or species habitat may occur within area.	Marine.	Not expected	No
Rostratula australis	Australian Painted Snipe	V & M	Species or species habitat may occur within area.	Shallow inland terrestrial freshwater (occasionally brackish) wetlands with exposed wet mud and dense low vegetation, including temporary and permanent lakes, swamps and claypans, particularly in the Murray-Darling Basin. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains.	Wetland habitat on site not suitable, not expected.	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Sternula nereis nereis	Fairy Tern (Australian)	V	Species or species habitat may occur within area.	Marine.	Not expected	No
Thalassarche bulleri	Buller's Albatross	V & Ma	Species or species habitat may occur within area.	Marine.	Not expected	No
Thalassarche cauta cauta	Shy Albatross	V & Ma	Species or species habitat may occur within area.	Marine. Recorded in locality on state database.	Not expected	No
Thalassarche cauta salvini	Salvin's Albatross	V & Ma	Species or species habitat may occur within area.	Marine.	Not expected	No
Thalassarche cauti steadi	White-capped Albatross	V & Ma	Species or species habitat may occur within area.	Marine.	Not expected	No
Thalassarche melanophris	Black-browed Albatross	V & Ma	Species or species habitat may occur within area.	Marine.	Not expected	No
Thalassarche melanophris impavida	Campbell Albatross	V & Ma	Species or species habitat may occur within area.	Marine. Recorded in locality on state database.	Not expected	No
Threatened Ray-finned Fish						
Macquaria australasica	Macquarie Perch	E	Species or species habitat may occur within area.	A riverine, schooling species of the Murray-Darling Basin and parts of south-eastern coastal NSW and the ACT. Known from Cataract Dam (translocated) and one record in Georges River in Sydney region. It prefers deep, rocky holes with considerable cover from rocks, overhanging banks, logs, branches and vegetation. Spawning occurs just above riffles (shallow running	Recorded Cataract Creek downstream of rock bar over A2 LW7 and A2 LW8. Not expected in Wallandoola Ck or Lizard Ck due to waterfalls downstream. Known from Cataract Dam	**Yes**

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
				water). Populations may survive in impoundments if able to access suitable spawning sites.	and Cataract River between dam and Broughtons Pass Weir (near Appin)	
Maccullochella macquariensis	Trout Cod	E	Species or species habitat likely to occur within area.	A large riverine species, inhabiting a variety of flowing waters in the mid to upper reaches of rivers and streams with large amount of cover in the form of woody debris or boulders. Only naturally occurring population restricted to Murray River between Yarrawonga Weir and Strathmerton. Since mid 1980s released into former distribution in Murray-Darling River system. Translocated to Cataract Dam (outside of species range) in the early 1900s. Population in Cataract Dam is thought to have hybridised with the Murray Cod (DPI 2006). *Maccullochella* sp captured in Cataract Creek near the dam tentatively identified as this species or the Murray Cod.	Juvenile freshwater cod recorded Cataract Creek downstream of rock bar over A2 LW7 and A2 LW8. Not expected in Wallandoola Ck or Lizard Ck due to waterfalls downstream. Translocated to Cataract Dam.	**Yes**
Maccullochella peelii peelii	Murray Cod	V	Not identified on PMST	Largest freshwater fish in Australia. Found throughout Murray-Darling basin with some local extinctions. Inhabits warm water habitats from clear rocky streams through to slow flowing turbid rivers and billabongs with woody debris for cover. Translocated to Cataract Dam. Population in dam is composed largely of hybrids of Murray Cod and Trout Cod. *Maccullochella* sp captured in Cataract Creek near the dam tentatively identified as this species or the Trout Cod.	Juvenile freshwater cod recorded Cataract Creek downstream of rock bar over A2 LW7 and A2 LW8. Not expected in Wallandoola Ck or Lizard Ck due to waterfalls downstream. Translocated to Cataract Dam.	**Yes**

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Prototroctes maraena	Australian Grayling	V	Species or species habitat likely to occur within area.	Spends part of its lifecycle in freshwater usually in cool, clear waters with a gravel substrate and pool and riffle zones. Recorded from Shoalhaven River in NSW and in Victoria from rivers flowing E and S of the main dividing ranges. Grayling migrate between freshwater streams and the ocean. The upstream migration of this species has been effectively terminated in some rivers by dams.	Not expected	No
Threatened Frogs						
Heleioporus australiacus	Giant Burrowing Frog	V	Species or species habitat likely to occur within area.	Preference for sandstone ridgetop habitat associated with small headwater creek lines. Vegetation typically woodland, open woodland and heath. Recorded in locality on state database.	Known to inhabit upland swamps and small creek lines in Wonga West. Tadpoles identified in habitat downstream from upland swamp CRUS2 in 2012 (Nathan Garvey, Biosis pers comm).	**Yes**
Litoria aurea	Green and Golden Bell Frog	V	Species or species habitat may occur within area.	Marshes, dams and stream sides, particularly those containing *Typha* spp. Optimum habitat includes waterbodies which are unshaded, have a grassy area nearby and diurnal sheltering sites. Recorded in locality on state database.	No preferred habitat in Study Area	No
Litoria littlejohni	Littlejohn's Tree Frog/Heath Frog	V	Species or species habitat may occur within area.	Occurs along permanent and semi-permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone crops. Breeding occurs in slow flowing pools that receive extended exposure to sunlight, but will also use temporary isolated pools. Inhabits the tree canopy and the ground, and shelters under rocks on high exposed ridges during summer.	Habitat in upland swamps. Breeding habitat identified in Wonga East in 1st order streams associated with upland swamps in Cataract River catchment.	**Yes**

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
				Recorded in locality on state database.		
Litoria raniformis	Growling Grass Frog	V	Species or species habitat may occur within area.	This species is found mostly amongst emergent vegetation (Robinson 1993), including *Typha sp.* (bullrush), *Phragmites sp.* (reeds) and *Eleocharis sp.* (sedges), in or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds and farm dams (DEC 2005a). The Growling Grass Frog can be found floating in warmer waters in temperatures between 18–25°C.	Not expected	No
Mixophyes balbus	Stuttering Barred Frog	V	Species or species habitat likely to occur within area.	Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range. The Hunter Valley separates the southern portion of the Stuttering Frog's range from the northern portion. The species depends on freshwater streams and riparian vegetation for breeding and habitation. Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor.	Potential breeding habitat identified along Cataract Creek.	**Yes**

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Threatened Mammals						
Balaenoptera musculus	Blue Whale	E & Ma	Species or species habitat may occur within area.	Marine	Not expected	No
Chalinolobus dwyeri	Large-eared Pied Bat	V	Species or species habitat may occur within area.	Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (*Hirundo ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features. Found in well-timbered areas containing gullies.	Uncommon resident, probably declining in region however habitat available along gorges in particular in Wonga West.	**Yes**
Dasyurus maculatus maculatus (SE mainland population)	Spotted-tail Quoll	E	Species or species habitat may occur within area.	Found on the east coast of NSW and is recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites	Rare resident in region however recently seen in Cataract Catchment. Habitat throughout Study Area including potential den sites	**Yes**
Eubalaena australis	Southern Right Whale	E & Ma	Species or species habitat known to occur within area.	Marine	Not expected	No
Isoodon obesulus obesulus	Southern Brown Bandicoot	E	Species or species habitat may occur within area.	Heathy forest, shrubland and woodland which on well-drained soils. A mosaic of post-fire vegetation is an important component of the habitat.	Considered locally extinct. Not expected in area	No
Megaptera novaeangliae	Humpback Whale	V & Ma	Species or species habitat known to occur within area.	Marine	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Petrogale pencillata	Brush-tailed Rock-wallaby	V	Species or species habitat may occur within area.	In NSW, occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. Occupies rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. Browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees and shelters or basks during the day in rock crevices, caves and overhangs.	Potential sub-optimal habitat associated with gorges along Lizard Creek which tends to be south facing. May be locally extinct in Southern Coalfields (DECC 2007).	No
Potorous tridactylus tridactylus (SE mainland)	Long-nosed Potoroo	V	Species or species habitat may occur within area.	Dense grassland or low thick scrub, its main food source is fungi, it may also take insects, grasses, roots and other types of vegetation to supplement its diet. May be locally extinct in Southern Coalfields (DECC 2007).	Extremely rare in region, possibly locally extinct. Low likelihood of occurrence in upland swamp habitat.	No
Pseudomys novaehollandiae	New Holland Mouse	V	Species or species habitat may occur within area.	Known from coastal areas and up to 100 km inland on sandstone country up to 900 m above sea level. Preferred habitat open heathland, woodland with heath understorey or vegetated sand dunes. Needs deep top soils and soft substrate for burrowing.	Preferred habitat not available	No
Pteropus poliocephalus	Grey-headed Flying-fox	V	Roosting known to occur within area.	Found within 200km of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Feed on the nectar and pollen of native trees, in particular *Eucalyptus*	Locally common. Expect will forage throughout area however habitats not anticipated to be vulnerable to subsidence.	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
				spp., *Melaleuca* spp. and *Banksia* spp., and fruits of rainforest trees and vines.		
Threatened Plants						
Acacia bynoeana	Bynoe's Wattle	V	Not identified in PMST. Recorded in locality on state database.	Occurs in heath and dry sclerophyll forest typically on sand and sandy clay, often with ironstone gravels, usually very infertile and well drained. Often grows among rock platforms. Recorded in locality on state database.	May occur in sandstone plateau heath/woodland. Habitat not vulnerable to subsidence impacts.	No
Astrotricha crassifolia	Thick-leaf Star-hair	V	Not identified in PMST.	Shrub to 2.4 m high which occurs in sclerophyll woodland on sandstone. Known from the Woronora Plateau in coastal heaths and Red Bloodwood-Scribbly Gum heathy woodland on sandstone. Recorded at Metropolitan Colliery (Bangalay 2009)	Low likelihood of occur in sandstone woodland. Habitat not vulnerable to subsidence impacts.	No
Caladenia tessellata	Thick-lipped Spider-orchid	V	Species or species habitat likely to occur within area.	Perennial terrestrial orchid found in grassy sclerophyll woodland on clay loam or sandy soils though has been record on stony soils. It is often seen after fire. Known from Sydney, Wyong, Ulladulla and Braidwood in NSW and Victoria. Populations in Kiama and Queanbeyan are presumed extinct. Only known from Pittwater sub-region of the Hawkesbury Nepean CMA.	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Cryptostylis hunteriana	Leafless Tongue-orchid	V	Species or species habitat may occur within area.	Does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum (*Eucalyptus sclerophylla*), Silvertop Ash (*E. sieberi*), Red Bloodwood (*Corymbia gummifera*) and Black Sheoak (*Allocasuarina littoralis*); appears to prefer open areas in the understorey of this community and is often found in association with the Large Tongue Orchid (*C. subulata*) and the Tartan Tongue Orchid (*C. erecta*). Little is known about the ecology of the species; being leafless it is expected to have limited photosynthetic capability and probably depends upon a fungal associate to meet its nutritional requirements from either living or dead organic material. In addition to reproducing from seed, it is also capable of vegetative reproduction and thus forms colonies which can become more or less permanent at a site.	Not known from Woronora Plateau. Not expected	No
Cynanchum elegans	White-flowered Wax Plant	E	Species or species habitat likely to occur within area.	Climber or twiner occurring mainly at the ecotone between dry subtropical rainforest and sclerophyll forest / woodland communities. Recorded in locality on state database.	Not expected in Study Area	No
Daphnandra johnsonii	a tree	E	Species or species habitat likely to occur within area.	Usually found in subtropical rainforest, less frequently on the margins and in disturbed areas, to 150 m alt., mostly on rocky sites along gullies near creeks. Recorded in locality on state database on Illawarra lowlands extending onto upper escarpment slopes on soils derived from volcanic and sedimentary rocks.	Not expected in Study Area	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V	Species or species habitat likely to occur within area.	Crests or upper slopes in lightly clayey soils in woodlands, often with laterite soils. It has been recorded in a range of ecological communities from heath and shrubby woodland to open forest (including Shale Sandstone Transitional Forest (EEC)). Recorded in locality on state database.	May occur in Shale Sandstone Transitional Forest EEC in Wonga West	**Yes**
Leucopogon exolasius	Woronora Beard-heath	V	Species or species habitat likely to occur within area.	Occurs in woodland on sandstone and is often associated with rocky hillsides and creek lines. Recorded in locality on state database.	May occur in woodland habitat along Lizard Creek and Wallandoola Creek.	**Yes**
Melaleuca biconvexa	Biconvex Paperbark	V	Species or species habitat may occur within area.	Associated with damp habitats, often near streams and rivers or low-lying areas on alluvial soils in the Hawkesbury-Nepean, Northern Rivers and Hunter-Central Rivers and Southern Rivers natural resource management areas. May occur in dense stands in association with other *Melaleuca* species or as an understorey species in wet forest types. Flowering occurs over just three to four weeks in September and October.	Not expected in Study Area.	No
Melaleuca deanei	Deane's Melaleuca	V	Species or species habitat likely to occur within area.	Species occurs on wet heath on sandstone. Mostly occupies broad flat ridgetops, dry ridges and slopes, strongly associated with sandy loam soils that are low in nutrients, sometimes with ironstone present. Recorded at Metropolitan Colliery (WRI 2009)	May occur in wet heath.	**Yes**
Persoonia acerosa	Needle Geebung	V	Not identified in PMST. Recorded in locality on state database.	Grows in heath, low woodland or dry sclerophyll forest on sandstone, in well drained soils. Prefers ridgetops and plateau.	May occur in sandstone woodland communities in particular in Wonga West. Habitat not vulnerable to subsidence impacts.	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Persoonia bargoensis	Bargo Geebung	V	Species or species habitat likely to occur within area.	Restricted to a small area on the western edge of the Woronora Plateau. Grows in woodland to dry sclerophyll forest on sandstone and clayey laterite or heavier, well drained, loamy, gravelly soils of the Hawkesbury Sandstone and Wianamatta Shale in catchments of the Cataract, Cordeaux and Bargo River. Recorded in locality on state database.	May occur in sandstone woodland communities	**Yes**
Persoonia hirsuta	Hairy Geebung	E	Not identified in PMST. Recorded in locality on state database.	Occur in woodland and dry sclerophyll forest or very rarely on shale. Patchy distribution on central coast and central tablelands of NSW around Sydney. Recorded in locality on state database.	While previously recorded in Wonga West (1995) it is not considered susceptible to subsidence impacts.	No
Persoonia nutans	Nodding Geebung	E	Species or species habitat likely to occur within area.	Woodland and dry sclerophyll forest on laterite and alluvial soils of the Cumberland Plain (Harden, 2002)	Not expected in Study Area	No
Pimelea spicata		E	Species or species habitat may occur within area.	In Western Sydney known from undulating topography of substrates derived from Winamatta Shale in areas supporting Cumberland Plain Woodland Ecological Community. In the Illawarra also found in coastal headland grassland communities with *Themeda australis*, *Lomandra longifolia*, *Imperata cylindrica*, *Acacia sophorae*, *Banksia integrifolia* and *Westringa fruiticosa* (DEC 2005).	Not expected in Study Area	No
Pomaderris brunnea	Brown Pomaderris	V	Species or species habitat likely to occur within area.	In open forest in association with *Eucalyptus amplifolia*, *Angophora floribunda*, *Acacia parramattensis*, *Bursaria spinosa* and *Kunzea ambigua*. It is often found on sandstone, clay and alluvial soils of floodplains and creek lines. Habitat in riparian and floodplain habitats of the Cumberland Plain and associated Sydney hinterland forest to the west of the PAA. Recorded in locality on state database. Recovery plan	Limited alluvial soils along creeks and preferred open forest habitat is to west of PAA. Not expected in Study Area.	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
				notes that this is an old record (1957) with low accuracy (Sutter 2010). Other known populations near Camden, Tahmoor, Douglas Park, Bargo and Elizabeth Macarthur Agricultural Institute (Sutter 2010).		
Pterostylis gibbosa	Illawarra Greenhood	E	Species or species habitat likely to occur within area.	Open forest or woodland on flat or gently sloping land with poor drainage. In Illawarra region grows in *Eucalyptus tereticornis*, *E. longifolia* and *Melaleuca decora* woodland with grassy understorey on coastal lowlands at Albion Park and Yallah.	No preferred habitat	No
Pterostylis saxicola	Sydney Plains Greenhood	E	Species or species habitat likely to occur within area.	Prefers shallow sandy soils in depressions on sandstone rock shelves above cliff lines in sclerophyll forest or woodlands on shale/ sandstone transition soils or shale soils. Known from only five localities including Georges River National Park, Ingleburn, Holsworthy, Peter Meadows Creek and near Douglas Park.	Not expected to occur.	No
Pultenaea aristata	Prickly Bush-pea	V	Species or species habitat likely to occur within area.	Known from Upland Swamp Banksia Thicket and Restoid Heath Complex and in areas where drainage is poor in sandstone forest communities (TSSC 2008). Occurs in moist or dry sclerophyll woodland to wet heath on sandstone. Recorded in locality on state database.	Previously recorded (1995). Recorded in upland swamps in Wonga East and Wonga West in 2011 and 2012.	**Yes**
Thelymitra sp. Kangaloon (D.L.Jones 18108)	Kangaloon Sun-orchid	CE	Species or species habitat may occur within area.	The Kangaloon Sun-orchid is endemic to the Central Coast/Tablelands of NSW, in the Fitzroy Falls/Robertson/Kangaloon area. The species grows in seasonally swampy sedgeland on grey silty clay loam at 600–700 m above sea level.	Not expected to occur	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Threatened Reptiles						
Caretta carretta	Loggerhead Turtle	E & Ma	Species or species habitat likely to occur within area.	Marine, nesting occurs on sandy beaches.	Not expected	No
Chelonia mydas	Green Turtle	V & Ma	Species or species habitat may occur within area.	Marine, nesting on islands and coastal beaches in northern Australia. Forage in subtropical waters of southern NSW.	Not expected	No
Dermochelys coriacea	Leatherback Turtle	E & Ma	Species or species habitat may occur within area.	Marine, nesting rarely recorded in Australia.	Not expected	No
Eretmochelys imbricata	Hawksbill Turtle	V	Species or species habitat known to occur within area.	Marine, nesting occurs in tropical regions of Australia.	Not expected	No
Hoplocephalus bungaroides	Broad-headed Snake	V	Species or species habitat likely to occur within area.	Woodland, open woodland/ heath communities on Sandstone within the Sydney Basin. They utilise rock crevices and exfoliating sheets of weathered sandstone on exposed cliff edges in the cooler months, and shelter in hollows in large trees near the escarpment in the warmer months (NPWS Threatened Species Information 2005).	Expected to occur in rocky plate and or overhang habitats, in particular in Wonga West.	**Yes**
Natator depressus	Flatback Turtle	V	Species or species habitat likely to occur within area.	Marine, nesting occurs in tropical regions of Australia.	Not expected	No
Threatened Sharks						
Carcharias taurus (east coast population)	Grey Nurse Shark	CE	Species or species habitat may occur within area.	Marine.	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Caracharodon carcharias	Great White Shark	V & Ma	Species or species habitat may occur within area.	Marine.	Not expected	No
Pristis zijsron	Green Sawfish	V	Species or species habitat may occur within area.	Marine.	Not expected	No
Rhincodon typus	Whale Shark	V & Ma	Species or species habitat may occur within area.	Marine.	Not expected	No
Migratory Terrestrial Species						
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	Species or species habitat likely to occur within area.	Usually seen perched high in a tree, or soaring over waterways and adjacent land. Common in coastal and near coastal areas of Australia.	May overfly Study Area. Habitat not vulnerable to subsidence impacts.	No
Hirundapus caudacutus	White-throated Needletail	M	Species or species habitat may occur within area.	The species is almost exclusively aerial feeding on flying insects, from heights of less than one metre up to more than 1000 m above the ground. Occur over most types of habitat, they are probably recorded most often above wooded areas, including open forest and rainforest.	Not expected	No
Merops ornatus	Rainbow Bee-eater	M	Species or species habitat may occur within area.	The species occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in close proximity to permanent water.	Not expected.	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Monarcha melanopsis	Black-faced Monarch	M	Breeding may occur within area.	The species is found in rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating.	Recorded	**Yes**
Myiagra cyanoleuca	Satin Flycatcher	M	Breeding likely to occur within area.	The species is found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	May occur. Habitat not vulnerable to subsidence impacts.	No
Rhipidura rufifrons	Rufous Fantail	M	Breeding may occur within area.	The species is found in rainforest, dense wet forests, swamp woodlands and mangroves, preferring deep shade, and is often seen close to the ground. During migration, it may be found in more open habitats or urban areas.	Recorded	**Yes**
Migratory Wetland Species						
Ardea abla	Great Egret	M	Species or species habitat may occur within area.	Prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands. Great Egrets can be seen alone or in small flocks, often with other egret species, and roost at night in groups.	Not expected	
Ardea ibis	Cattle Egret	M	Species or species habitat may occur within area.	Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. It has occasionally been seen in arid and semi-arid regions however this is extremely rare. High numbers have been observed in moist, low-lying poorly drained pastures with an abundance of high grass; it avoids low grass pastures.	Not expected	No
Arenaria interpres	Ruddy Turnstone	M	Species or species habitat known to occur within area.	Migrates to rocky coasts, sandy beaches with seaweed, saltmarsh, mangroves, reefs and mudlfats	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Calidris alba	Sanderling	M	Species or species habitat known to occur within area.	Ocean beaches, occasionally intertidal mudflats.	Not expected	No
Calidris canutus	Red Knot	M	Species or species habitat known to occur within area.	Intertidal mudflats and sandflats, estuaries, bays and inlets.	Not expected	No
Charadrius bicinctus	Double-banded Plover	M	Species or species habitat known to occur within area.	Interdidal sand and mudflats, ocean beaches, sub-coastal fresh and saltwater lakes.	Not expected	No
Gallinago hardwickii	Latham's Snipe	M	Species or species habitat may occur within area.	Occurs in permanent and ephemeral wetlands up to 2000 m above sea-level (Chapman 1969; Naarding 1981). They usually inhabit open, freshwater wetlands with low, dense vegetation (eg open swamps, flooded grasslands or heathlands, around bogs and other water bodies) (Frith *et al* 1977; Naarding 1983; Weston 2006). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (Frith *et al* 1977; Naarding 1983).	Not expected. Swamp habitats in the Study Area are considered unsuitable for the species given their dense vegetation assemblages and lack of open habitat.	No
Limosa laponica	Bar-tailed Godwit	M	Species or species habitat known to occur within area.	Intertidal mudflats, rarely far from the coast	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Migratory Marine Birds						
Ardea alba	White Egret	M	Species or species habitat may occur within area.	Prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands. Great Egrets can be seen alone or in small flocks, often with other egret species, and roost at night in groups.	Not expected	No
Ardea ibis	Cattle Egret	M	Species or species habitat may occur within area.	Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. It has occasionally been seen in arid and semi-arid regions however this is extremely rare. High numbers have been observed in moist, low-lying poorly drained pastures with an abundance of high grass; it avoids low grass pastures.	Not expected	No
Apus pacificus	Fork-tailed Swift	M	Species or species habitat may occur within area.	Never settle voluntarily on the ground, spending most of their lives in the air, living on the insects they catch in their beaks.	Not expected	No
Calonectris leucomelas syn *Puffinus leucomelas*	Streaked Shearwater	M & Ma	Species or species habitat may occur within area.	Marine	Not expected	No
Sterna albifrons	Little Tern	Ma	Species or species habitat may occur within area.	Almost exclusively coastal, preferring sheltered environments. Nests in small scattered colonies on sandy beaches.	Not expected	No
Thalassarche chlororhynchos	Yellow-nosed Albatross	Ma	Species or species habitat may occur within area.	Marine.	Not expected	No

Species/Community Scientific Name	Common Name	EPBC listing	Type of presence (PMST)	Preferred habitat	Likelihood of Occurrence in Study Area	Assessment required?[1]
Other Migratory Marine Species						
Balaenoptera edeni	Bryde's Whale	Ma	Species or species habitat may occur within area.	Marine	Not expected	No
Caperea marginate	Pygmy Right Whale	Ma	Species or species habitat may occur within area.	Marine	Not expected	No
Lagenorhynchus obscurus	Dusky Dolphin	Ma	Species or species habitat may occur within area.	Marine	Not expected	No
Lamna nasus	Mackeral Shark	Ma	Species or species habitat likely to occur within area.	Marine	Not expected	No
Orcinus orca	Killer Whale	Ma	Species or species habitat may occur within area.	Marine	Not expected	No
Rhincodon typus	Whale Shark	Ma	Species or species habitat may occur within area.	Marine	Not expected	No

EPBC Act Listing: CE = Critically Endangered; E = Endangered; V = Vulnerable; M = Migratory; Ma = Migratory Marine

1. Assessment required for species identified on site or identified in the Southern Coalfields Inquiry as species that would be impacted if subsidence had an adverse impact on their habitats (DECC 2007).

Annex B

EPBC Act Significant Impact Assessments

B.1 INTRODUCTION

This section provides Impact Assessments for threatened species and ecological communities listed under the EPBC Act, following the Commonwealth *Significant Impact Guidelines 1.1* (DEWHA 2009) by using its detailed criteria (as shown in italicised phrases in section B.2 below).

Species and ecological communities identified here have been selected for inclusion following the analysis process outlined in *Chapter 3* and *reported in Annex A.*

B.2 SIGNIFICANT IMPACT ASSESSMENT

Shale/Sandstone Transition Forest (EEC EPBC Act; EEC TSC Act)

Shale Sandstone Transition Forest is listed as an Endangered Ecological Community under the EPBC Act and the NSW TSC Act. This community occurs at the edges of the Cumberland Plain in Western Sydney, where clay soils derived from shale rock intergrades with sandstone derived soils or where shale caps overlay sandstone (DECCW 2010).

This community was recorded as two stands in Wonga West within the Study Area. The EEC occurs as Transitional Shale Open Blue Gum Forest between Lizard Creek and Wallandoola Creek spanning over Longwalls A3 LW1 and A3 LW2 and as Transitional Shale Stringybark Forest in the west of the Study Area over Longwalls A3 LW4 and A3 LW5. This community is identified as vulnerable to impacts associated with subsidence (DECC 2007a).

Shale Sandstone Transition Forest is represented by two recorded vegetation communities in the study area:

- Transitional Shale Stringybark Forest; and
- Transitional Shale Tall Open Blue Gum Forest.

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

reduce the extent of an ecological community

Transitional Shale Stringybark Forest and Transitional Shale Tall Open Blue Gum Forest communities are listed under Shale Sandstone Transition Forest EEC; and are present in areas above Wonga West domains. No surface works are associated with the action and therefore potential impacts are related to subsidence and include cracking of surface and sub-surface, lowering of the water table beyond the reach of plants. There is a maximum predicted subsidence of 2.3m and maximum predicted tilt of 15mm/m under the EEC. This subsidence is considered unlikely to result in significant impacts on the EEC.

fragment or increase fragmentation of an ecological community

No clearing of vegetation is involved in the proposed action. It is unlikely that subsidence will cause significant impacts on the community and therefore no fragmentation is predicted.

adversely affect habitat critical to the survival of an ecological community

Shale Sandstone Transition Forest occurs at the edges of the Cumberland Plain where shale rock and clay soils gradually change to sandstone and this requirement limits the distribution of the community. The predicted subsidence related impacts associated with the proposed action are unlikely to adversely affect this habitat.

modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns

There is a maximum predicted subsidence of 2.3 m under the EEC in the Study Area (Seedsman 2012) and this subsidence is unlikely to modify the soil to the extent that would impact the community. There is potential for temporary soil cracking to occur within the area of the EEC in Wonga West, and there is potential for altered groundwater flows within the soils and Hawkesbury Sandstone following mining (GeoTerra 2012b). This community is not a groundwater dependent ecosystem and any changes are not likely to modify or destroy factors necessary for the survival of the EEC.

cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting

Subsidence impacts may include temporary soil cracking and altered groundwater flows. Given that, this community is not a groundwater dependent ecosystem the proposal is unlikely to cause a substantial change in species composition or an increased susceptibility to bushfire.

cause a substantial reduction in the quality or integrity of an occurrence of an ecological community

The FMEA (Olsen Consulting 2010) identified potential impact on the Shale Sandstone Transition Forest EEC as low risk and it is considered unlikely that the community will be impacted as a result of the proposed action. Therefore, a substantial reduction in the quality or integrity of the EEC's occurrence is not predicted.

interfere with the recovery of an ecological community.

A recovery plan has not been prepared for this community specifically; however, the Cumberland Plain Recovery Plan (DECCW 2010) addresses Shale Sandstone Transition Forest EEC and other communities and species within the Cumberland Plain area. The overall objective of the recovery plan is to provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. The Cumberland Plain Recovery Plan seeks to focus recovery efforts on those lands that represent the best opportunities to secure viable, long-term conservation outcomes in the region (priority conservation lands). The Study Area does occur at the edge of the Cumberland Plain, but is not mapped in the recovery plan as part of the Cumberland Plain, therefore no priority conservation lands are mapped in the Study Area. Subsidence impacts are not mentioned in the plan.

The proposed action is not likely to interfere with the recovery of the ecological community as a whole.

Macquarie Perch (*Macquaria australasica*) (E EPBC Act).

The Macquarie Perch is a riverine, schooling species. It prefers clear water and deep, rocky holes with lots of cover. As well as aquatic vegetation, cover may comprise large boulders, debris and overhanging banks (Cadwallader & Eden 1979). Spawning occurs from October to December at the foot of pools, in shallow water just above riffles (shallow running water). Populations may survive in impoundments if able to access suitable spawning sites (DSEWPC 2011; Wager and Jackson 1993).

The Murray-Darling form of the Macquarie Perch is found in the upper reaches of the Murray-Darling Basin in NSW, Victoria and the ACT and the eastern form is confined to the Hawkesbury-Nepean and Shoalhaven river systems (DSEWPC 2011). Known from: Cataract Dam (translocated), the Nepean River, and one record in the Georges River near Campbelltown (DSEWPC 2011). There is a viable population of Macquarie Perch in the reach of the Cataract River between the dam and Broughtons Pass Weir, near Appin (Cardno Ecology Lab 2011b).

The species is known to occur in Cataract Dam and baseline surveys by Cardno Ecology Lab (2011) have confirmed that the Macquarie Perch occurs in Cataract Creek up to the rock bar over A2 LW08 and A2 LW07 in Wonga East (Cardno Ecology Lab 2012). Waterfalls act as a physical barrier to prevent the species reaching Lizard Creek and Wallandoola Creek in Wonga West (Cardno Ecology Lab 2012).

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:
lead to a long-term decrease in the size of a population
The Macquarie Perch is known from Cataract Dam (DSEWPC 2011) and a viable population of Macquarie Perch is known from the reach of the Cataract River between the dam and Broughtons Pass Weir, near Appin. Field investigations have identified individuals in Cataract Creek up to the rock bar over LW07 (Cardno Ecology Lab 2011). The fish caught in summer 2011 were of a size that may have been migrating from the dam to spawn upstream (Cardno Ecology Lab 2011). GeoTerra (2012a) concluded that the worst case prediction of the longwall panels in this reach may reduce stream flows, pool holding capacity of the rock bars and potential changed water chemistry. Implementation of adaptive management measures would minimise potential adverse environmental consequences. Without implementation of the adaptive mine plan, the proposed action may effect habitat values required for spawning should spawning occur in this reach of Cataract Creek. Without adaptive management to minimise environmental consequences, the action may impact on life cycle and population numbers. With adaptive management, the action is unlikely to affect the population (Cardno Ecology Lab 2012).
reduce the area of occupancy of the species
Cataract Creek presents the only potential habitat for the Macquarie Perch in the Study Area. Extraction of the longwall panels in this reach may have an adverse impact on stream conditions as previously described. With implementation of adaptive management measures, the area available for occupancy by the species in Cataract Creek will not be reduced (Cardno Ecology Lab 2012). The action is unlikely to reduce area of occupancy in waters of Cataract Dam or other tributaries in the Wonga East area.
fragment an existing population into two or more populations
The population is concentrated in the waters of Cataract Dam and tributaries. The proposed action will not fragment the existing population.
adversely affect habitat critical to the survival of a species
The Macquarie Perch is known to occur in Cataract Dam and Cataract Creek up to A2 LW07 in Wonga East (Cardno Ecology Lab 2011) where it reported the species could potentially spawn in the riffle habitats of Cataract Creek. The Macquarie Perch will survive in impoundments where there are suitable feeder streams in which to breed. In this instance, the breeding habitat represented in Cataract Creek and other creeks feeding into Cataract Dam may be critical to the survival of the species in the dam. Extraction of the longwall panels in this reach may have an adverse impact on stream conditions as previously described. Implementation of adaptive management measures would minimise this such that the action is unlikely to adversely affect the species use of this habitat. The habitat in Cataract Reservoir and downstream is outside of the predicted subsidence impact area.
disrupt the breeding cycle of a population
Macquarie Perch is known to migrate from impoundments into rivers to spawn in areas with small boulders, pebbles and gravel. Newly hatched larvae shelter amongst the pebbles, but move back downstream to lake habitat. Cardno Ecology Lab (2011) reports that the Macquarie Perch periodically occupy the reach of Cataract Creek in Wonga East up to LW07 and may spawn in the riffle habitats of Cataract Creek. Extraction from the longwall panels under this section may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential changed water chemistry. Implementation of adaptive management measures would minimise the risk of impacts and the avoid disruption to breeding cycle (Cardno Ecology Lab 2012).

modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Cataract Creek represents the only suitable habitat for the species in the Study Area (Cardno Ecology Lab 2012). GeoTerra (2012a) concluded that extraction of the longwall panels in this reach may have an adverse impact on stream conditions as previously described. With adaptive management measures, the proposed action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat (Cardno Ecology Lab 2012) to the extent that the species is likely to decline.

result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

Macquarie Perch compete with exotic fish species particularly European Carp, Redfin Perch, Rainbow Trout and Brown Trout (DSEWPC 2011). It is unlikely that any invasive species will be introduced or become more established in the Study Area as a result of the proposed action.

introduce disease that may cause the species to decline

Macquarie Perch are susceptible to the waterborne Epizootic Haematopoietic Necrosis Virus (EHNV) (DSEWPC 2011). It is unlikely that disease will be introduced or become more established in the Study Area as a result of the proposed action.

interfere with the recovery of the species.

At present, there is no recovery plan for the Macquarie Perch. With implementation of adaptive management measures, no impacts to potential Macquarie Perch habitat in Cataract Creek are anticipated as a result of the proposed action. Therefore, it is unlikely that the proposed action will interfere with the recovery of the species.

Murray Cod (*Maccullochella peelii peelii*) (V EPBC Act).

The Murray Cod is the largest freshwater fish in Australia. Found throughout Murray-Darling basin except for the upper reach of some tributaries, with some local extinctions. It inhabits a diverse range of habitats including warm water habitats, clear rocky streams through to slow flowing turbid rivers and billabongs with woody debris, large rocks or overhanging vegetation for cover.

Translocated populations have been established in NSW and Victoria, including within Cataract Dam. Population in dam is composed largely of hybrids of Murray Cod and Trout Cod (Cardno Ecology Lab 2012). Unidentified juvenile and adult freshwater cod caught recently in the Cataract Creek arm of Cataract Dam may be a Murray Cod, Trout Cod or a hybrid of these species (Cardno Ecology Lab 2011a, 2012).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

Cataract Dam supports an introduced population of the Murray Cod. An unidentified freshwater cod that may be a Murray Cod, Trout Cod or a hybrid of these species was identified in the Cataract Creek arm of Cataract Dam (Cardno Ecology Lab 2011, 2012). The absence of any significant barriers to fish passage within this section of the creek means that individuals occurring downstream could potentially migrate upstream and periodically utilise habitats overlying the proposed longwalls 8, 9 and 10 in Wonga East (Cardno Ecology Lab 2011a, 2012).

GeoTerra (2012) concluded that extraction of the longwall panels in this reach may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. Implementation of adaptive management measures would minimise this such that there is no adverse impact on flow and water quality and habitat values.

The habitat in Cataract Dam and downstream is outside of the predicted subsidence impact area. It is unlikely that there would be any adverse effects on the life cycle of this species and accordingly a long-term decrease in the size of the population is considered highly unlikely (Cardno Ecology Lab 2012).

reduce the area of occupancy of an important population

Cataract Creek presents the only potential habitat for the Murray Cod in the Study Area with the main area of known habitat is in the waters of Cataract Dam. Extraction of the longwall panels in this reach may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. Without implementation of adaptive management measures the action may reduce the area of occupancy of the population in the Study Area.

The habitat in Cataract Dam and downstream is outside of the predicted subsidence impact area.

fragment an existing important population into two or more populations

Given that the population is hybridised it may not be an 'important population' for the survival of the Murray Cod. Notwithstanding this, the main population of Murray Cod is in the waters of Cataract Dam and the action is unlikely to fragment this population.

adversely affect habitat critical to the survival of a species

The Murray Cod was introduced in Cataract Dam and there is no barrier to this species dispersing upstream into Cataract Creek in Wonga East. Subsidence predictions indicate that there may be physico-chemical impacts on the aquatic habitat that Murray Cod may periodically occupy in Cataract Creek. With implementation of adaptive management measures, the action has been assessed as unlikely to affect habitat in Cataract Creek (Cardno Ecology Lab 2012).

The existing Murray Cod habitat in Cataract Dam is well outside of the predicted subsidence impact area and the proposed action is unlikely to adversely affect this habitat.

disrupt the breeding cycle of an important population

Cardno Ecology Lab (2011a, b) reports that the Murray Cod may occur in Cataract Creek in Wonga East. Murray Cod migrates upstream in late spring early summer in response to water warming, to spawn in the vicinity of submerged rocks. The hatched larvae drift downstream to settle out in suitable habitat.

The subsidence predictions indicate that extraction of the proposed longwalls within Wonga East may alter stream flow, ponding or water quality in the overlying reach of Cataract Creek. The proposed action may disrupt the breeding cycle of individuals that periodically use Cataract Creek.

With implementation of adaptive management measures, the action has been assessed as unlikely to affect the breeding cycle in Cataract Creek (Cardno Ecology Lab 2012).

The proposed action will not alter habitat value of Cataract Dam or other tributaries of the dam. The population in the dam is not a naturally occurring population and is likely to have hybridised with the Trout Cod that was also translocated accordingly the population in dam is unlikely to be considered an 'important population' for the Murray Cod.

modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Cataract Creek represents the only suitable habitat for the species in the Study Area. GeoTerra (2012) concluded that adverse effects on stream water quality anticipated in Cataract Creek may occur. Subsequently the proposed action may modify, destroy, remove, isolate or decrease the availability or quality of habitat for the hybrid freshwater cod that use the creek periodically.

With implementation of adaptive management measures, the action has been assessed as unlikely to impact on habitat to the extent that the species in Cataract Creek is likely to decline (Cardno Ecology Lab 2012).

The existing Murray Cod habitat in Cataract Dam is well outside of the predicted subsidence impact area and the proposed action is unlikely to adversely affect this habitat.

result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

There a number of introduced fish species recognised as competitive, predatory or that alter habitat for the Murray Cod (National Murray Cod Recovery Team 2010). The proposed action is unlikely to introduce or establish any invasive species in the study area.

Introduce disease that may cause the species to decline

Little is known of the impact of diseases on Murray Cod (National Murray Cod Recovery Team 2010).

interfere with the recovery of the species.

There is a national recovery plan for the Murray Cod. The overall objective of the plan is to have self-sustaining Murray Cod populations managed for conservation, fishing and culture (National Murray Cod Recovery Team 2010). The proposed action will not affect the objectives or actions of the Murray Cod Recovery Plan.

Trout Cod (*Maccullochella macquariensis*) (E EPBC Act).

The Trout Cod occupies stream positions characterised by a high abundance of large woody debris (or 'snags') in water that is comparatively deep and close to riverbanks, though midstream snags are also an important habitat component (NSW Fisheries 2001). As a large proportion of the streams that the Trout Cod originally inhabited are now degraded, it is difficult to accurately determine the habitat requirements of the species (Reed 1995).

The Trout Cod is native to the southern Murray-Darling drainage system but was translocated into areas outside of their natural range including Cataract Dam before 1915. The Trout Cod is still known to occur in the dam and the Trout Cod Recovery Team (2008) indicates that the cod population within Cataract Dam is composed largely of hybrids of Trout Cod and Murray Cod. In the absence of any significant barriers to movement, the Trout Cod may occur in Cataract Creek.

Unidentified juvenile and adult freshwater cod caught recently in the Cataract Creek arm of Cataract Dam may be a Trout Cod, Murray Cod or a hybrid of these species (Cardno Ecology Lab 2011, 2012).

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of a population

The Trout Cod has been previously recorded in Cataract Dam. The absence of any significant barriers to fish passage within this section of Cataract Creek means that individuals occurring in the dam periodically utilise habitats overlying the proposed longwalls in Wonga East (Cardno Ecology Lab 2011, 2012).

GeoTerra (2012) concluded that extraction of the longwall panels in this reach may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. While the biology and ecology of the Trout Cod is poorly understood alterations to habitat values in Cataract Creek may disrupt the life cycle of the proportion of the hybrid freshwater cod population that periodically frequent Cataract Creek.

Cardno Ecology Lab (2012) assessed that implementation of adaptive management measures would minimise this impact such that alteration to habitat (stream flow, ponding, water quality) would not be anticipated.

The habitat in Cataract Dam and other tributaries of the dam are outside of the predicted subsidence impact area. The action will not alter habitat value of Cataract River or Bellambi Creek that may also be used by the hybrid species.

reduce the area of occupancy of the species

Cataract Creek presents the only habitat for the Trout Cod in the Study Area with the main area of known habitat in the waters of Cataract Dam. Extraction of the longwall panels in this reach may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. Without implementation of adaptive management measures, the action may reduce the area of occupancy of the population in the Study Area.

The habitat in Cataract Dam and downstream is outside of the predicted subsidence impact area.

fragment an existing population into two or more populations

The main population of the hybridised Trout Cod is in the waters of Cataract Dam. The proposed action will not alter habitat in Cataract Dam and therefore fragmentation of an existing population is highly unlikely.

adversely affect habitat critical to the survival of a species

A hybrid Trout Cod occurs in Cataract Dam and Cardno Ecology Lab (2011, 2012) reported that the species occurs in Cataract Creek in Wonga East downstream of Mount Ousley Road. Trout Cod utilise several types of habitat with critical habitat requirements being sites with large woody debris or snags, particularly those located in deeper water and high surface velocity, away from the stream bank (Trout Cod Recovery Team 2008).

Subsidence predictions indicate that there may be an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage and thereby reduce habitat values in this reach of Cataract Creek. Cardno Ecology Lab (2012) assess that with implementation of adaptive management measures, the action is not expected to reduce the area of occupancy of the population in the Study Area.

The habitat in Cataract Dam and downstream is outside of the predicted subsidence impact area.

disrupt the breeding cycle of a population

The Trout Cod Recovery Team identifies that the translocated population of Trout Cod in Cataract Dam is a breeding population though likely to be hybridised with the Murray Cod (Trout Cod Recovery Team 2008). Cardno Ecology Lab (2011, 2012) reports that a hybrid of the Trout Cod occurs in Cataract Creek.

Little is known of the biology and ecology of the Trout Cod in the wild. They are known to spawn in spring though it is thought that they do not migrate spawning within their home range. Impacts to hydrology are predicted in Cataract Creek and without implementation of an adaptive management plan, the action may disrupt the breeding cycle of the species.

modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Cataract Creek represents the only suitable habitat for the Trout Cod in the Study Area (Cardno Ecology Lab 2012). GeoTerra (2012) concluded adverse effects on stream water quality are anticipated in Cataract Creek. Subsequently the proposed action is likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

With implementation of adaptive management measures, the action has been assessed as unlikely to impact on habitat to the extent that the species in Cataract Creek is likely to decline (Cardno Ecology Lab 2012).

The existing Trout Cod habitat in Cataract Dam is well outside of the predicted subsidence impact area and the proposed action is unlikely to adversely affect this habitat.

result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

Several introduced species including Carp, Redfin Perch and Brown Trout co-occur with the Trout Cod and it is unclear what their impact is on the Trout Cod (Trout Cod Recovery Team 2008). It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.

introduce disease that may cause the species to decline

There are a variety of parasites reported to infect Trout Cod and introduced fish carry diseases though the impact on wild populations is unclear (Trout Cod Recovery Team 2008). It is unclear whether disease will become more established as a result of the proposed action.

interfere with the recovery of the species.

There is a National Recovery Plan for the Trout Cod (Trout Cod Recovery Team 2008). The overall objective is to minimise the probability of extinction of the Trout Cod in the wild and to increase the probability of important populations becoming self-sustaining in the long term. The proposed action will not affect the objectives or actions of the Trout Cod Recovery Plan.

Large-eared Pied Bat (*Chalinolobus dwyeri*) (V EPBC Act; V TSC Act)

The current distribution of Large-eared Pied Bat (*Chalinolobus dwyeri*) is poorly known. Records exist from Shoalwater Bay, north of Rockhampton, Queensland, through to the vicinity of Ulladulla, NSW in the south (Hoye 2005). In NSW, this species has been recorded from a large range of vegetation types including: dry and wet sclerophyll forest; Cypress-pine dominated forest; tall open eucalypt forest with a rainforest sub-canopy; sub-alpine woodland; and sandstone outcrop country (Duncan, 1999).

Little is known about the roosting requirements of the Large-eared Pied Bat, but natural roosts may depend heavily on sandstone outcrops. It has also been found roosting in disused mine shafts, caves, overhangs and disused Fairy Martin (*Hirundo ariel*) nests for shelter and to raise young (Hoye & Dwyer 1995; Schulz 1998).

In the Southern Sydney region most records of this species were found in the Greater Blue Mountains (DECC 2007c). Despite considerable survey effort there are no records of this species in sandstone woodlands and open forests of the Woronora Plateau records are concentrated on the Grassy Box Woodlands and Red-Gum Ironbark communities of the wider fertile valley floors, coastal plains and some easterly rivers (DECC 2007c).

This species was not recorded within the Study Area during field investigations, and no suitable roost caves were recorded though. However, it cannot be ruled out that suitable roosting sites for the species may occur within the Study Area and the tall forests along creek lines through the east of the sandstone plateau have been highlighted as habitat in the regional study by DECC (2007c, 2007b). The species is considered to be vulnerable to impacts associated with subsidence (DECC 2007a).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

Cave roost dependent bats such as the Large-eared Pied Bat are susceptible to loss of roost sites, changes in micro-climate of roost sites and reduction in foraging habitat. The Large-eared Pied Bat is considered to have a moderate likelihood of occurring in the Study Area. No roosts were observed during field surveys however, the Study Area contains some sandstone outcropping in Wonga West that may be suitable, and tall forests along creek lines in Wonga East may provide foraging habitat for the species.

The majority of sandstone outcropping and benching is located around Lizard Creek, Wallandoola Creek and their tributaries with the most likely location for caves and overhangs to support these bats within the deeply incised valley of Lizard Creek, above the fully supported underground driveage in Wonga West. Damage to caves and cracks used as roost sites may occur within the Wonga West domains of the Study Area, specifically caves and overhangs in Lizard Creek gorge are predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012). Those habitat features that are located over the longwall panels in Area 4 may be subject to minor and negligible environmental consequences (SCT Operations 2012). Negligible environmental consequences are predicted for cliff formations not directly above the proposed longwall panels (SCT 2012).

For the low height rock formations in Wonga East, rock falls are expected to be limited in extent (SCT 2012).

Minor to negligible damage to Large-eared Pied Bat roosting habitat may occur over Area 4 within the Study Area and negligible impact to other areas of suitable habitat as a result of the proposed action. Accordingly, it is unlikely that a viable local population of the species would be placed at risk of extinction.

reduce the area of occupancy of an important population
A reduction in foraging habitat for the Large-eared Pied Bat is not predicted to occur as a result of the proposed action. Minor to negligible damage to caves and overhangs used as roost sites by the species may potentially occur within the Wonga West domains. Due to the mobility of the species it is not considered that the area of occupancy of the population would be reduced.
fragment an existing important population into two or more populations
Should this species occur in the Study Area, minor to negligible damage to caves and overhangs (which may provide roost sites) may displace individuals to alternative roost sites. It is not likely that the impacts on potential roost sites in Lizard Creek gorge would cause fragmentation of an important population, as the species is mobile.
adversely affect habitat critical to the survival of a species
Foraging habitat is unlikely to be affected by the proposed action. Subsidence in the area of Lizard Creek gorge may have negligible and minor environmental consequences on caves and overhangs and accordingly roost sites, which may be important to the survival of the local population of Large-eared Pied Bats. However no habitat critical to the survival of the species has been identified in or near the Study Area.
disrupt the breeding cycle of an important population
Maternity roost sites are important for the survival of all cave roosting bat species. No maternity roosts have been identified in the vicinity of Lizard Creek gorge. The likelihood of a maternity cave occurring within the Study Area is considered to be low, given that the species requires deep, dark caves for breeding and such caves are rarely formed within sandstone geology (Brad Law, Forests NSW, pers. comm.). It is predicted that there will be negligible to minor impacts on features (SCT 2012) that may provide the habitat roost habitat and given that the likelihood of a suitable maternity site is low, the action is unlikely to disrupt the breeding cycle of an important population.
modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
There is negligible to minor environmental consequences predicted to cliff formations (SCT Operations 2012) that may provide roosting habitat. Modification, destruction and/or a reduction in the availability of suitable roost sites may result from the proposed action. If suitable roost sites are impacted, there is the potential for any individuals that occur in the locality to be affected. Given that Southern Sydney region records are concentrated to the west of the PAA and in the Blue Mountains this is unlikely to cause the further decline of the species in the locality.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
It is considered unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.
introduce disease that may cause the species to decline
It is considered unlikely that disease will be introduced or become more established in the study area as a result of the proposed action.
interfere substantially with the recovery of the species.
There is negligible to minor environmental consequences predicted to cliff formations (SCT 2012) that may provide roosting habitat. If roosting habitat is impacted a local population may be affected however, it is not considered likely that this would substantially impact the recovery of the species.

Broad-headed Snake (*Hoplocephalus bungaroides*) (V EPBC Act; E TSC Act)

The Broad-headed Snake (*Hoplocephalus bungaroides*) is known from the coast and ranges of NSW, within an area approximately 250 km from Sydney (DECCW, 2010). Largely confined to Triassic and Permian sandstones (including the Hawkesbury, Narrabeen and Shoalhaven groups), this species shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring and hollows in large trees during summer (DECCW, 2010).

On a regional scale the Broad-headed Snake has been classified as an extremely rare resident, possibly declining in the Southern Sydney region (DECC 2007c). The Woronora Plateau is identified as likely ot be core to the species survival (DECC 2007c). This species was not recorded within the Study Area during field investigations although was considered to have a high likelihood of occurrence based on the availability of suitable habitat. This species is considered to be vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

The Broad-headed Snake is expected to occur in suitable wintering habitat on north-west facing rock benches and outcrops with exfoliating rock, recorded in the Study Area particularly along Lizard Creek and Wallandoola Creek and their tributaries. The Study Area is not expected to provide habitat for a significant proportion of a population of this species, as extensive outcropping of rock benches, which would provide critical wintering habitat, was not recorded (Eco Logical 2009).

Rocky habitats that occur along valley sides and cliffs are vulnerable to subsidence impacts, particularly where they occur directly above a mined area and resulting goaf. The FMEA (Olsen Consulting 2010) identified adverse subsidence impacts resulting in loss of wintering habitat for threatened rock-dwelling reptiles as low risk. Rocky overhangs in Lizard Creek gorge are predicted to have a maximum vertical subsidence of 100mm and maximum tilt of 3mm/m (SCT Operations 2012). Those habitat features that are located over the longwall panels in Area 4 may be subject to minor and negligible environmental consequences (SCT Operations 2012). Negligible environmental consequences are predicted for cliff formations not directly above the proposed longwall panels (SCT 2012).

For the low height rock formations in Wonga East, rock falls are expected to be limited in extent (SCT 2012).

Due to the topography of the study area and the location of the proposed longwalls, it appears that conflicts between the proposed action and the habitat requirements of this threatened species have been avoided (Eco Logical 2009). It is unlikely that the proposed action would lead to a long-term decrease in the size of an important population of a species.

reduce the area of occupancy of an important population

The FMEA (Olsen Consulting 2010) identified adverse subsidence impacts resulting in loss of wintering habitat for threatened rock-dwelling reptiles as low risk and Eco Logical (2009) reports that conflicts between the proposed action and habitat requirements of the Broad-headed Snake have been avoided. It is therefore unlikely that the proposed action would result in a reduction in the area of occupancy of an important population of the species.

fragment an existing important population into two or more populations

The main habitat areas for the Broad-headed Snake in the Study Area include wintering habitat on north-west facing rock benches and outcrops with exfoliating rock and summer habitat of hollow bearing trees within 200m of escarpments. The FMEA (Olsen Consulting 2010) identified adverse subsidence impacts resulting in loss of wintering habitat for threatened rock-dwelling reptiles as low risk. Therefore, it is unlikely that significant modification of rocky habitat will occur.

The potential areas of hollow bearing tree habitat occur in forest and woodland communities around ridgelines in the vicinity of the rocky outcrops along Lizard Creek and Wallandoola Creek and their tributaries. These habitat areas are expected have a maximum subsidence of 2 m (Seedsman 2012). This level is unlikely to result in significant modification of habitat that would result in loss of hollow bearing trees. As no significant impacts to habitat for the species are expected it is unlikely that fragmentation would occur.

	adversely affect habitat critical to the survival of a species
	As stated above, both wintering habitat on north-west facing rock benches and outcrops with exfoliating rock and summer habitat of hollow bearing trees within 200m of escarpments are not expected to be significantly impacted as a result of the proposed action.
	disrupt the breeding cycle of an important population
	No significant impacts to habitat are likely and subsequently the breeding cycle of the Broad-headed Snake is unlikely to be impacted.
	modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
	Modification of suitable wintering habitat may result from the proposed action. This would occur via minor to negligible impacts to rocky outcrops in Wonga West. It is not anticipated that the degree of modification would modify habitat to a degree that would cause the species to decline.
	result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
	It is considered unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.
	introduce disease that may cause the species to decline
	The action is unlikely to alter processes that provide for spread or establishment of any disease in the Study Area.
	interfere substantially with the recovery of the species.
	It is possible that potential wintering habitat for the Broad-headed Snake will be impacted as a result of the proposed action. Both the FMEA (Olsen Consulting 2010) and Eco Logical (2009) predict that significant impacts to habitat and the species are unlikely to occur. Therefore, it is unlikely that the proposed action will interfere substantially with the recovery of the species.

Giant Burrowing Frog (*Heleioporus australiacus*) (V EPBC Act; V TSC Act)

The Giant Burrowing Frog (*Heleioporous australiacus*) is known from two distinct areas within south eastern NSW and Victoria; the northern population being largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla and the southern population occurring from near Narooma through to Walhalla in Victoria (DECCW, 2010).

In the Southern Sydney Region the Giant Burrowing Frog is assessed as an uncommon resident stable population with the Woronora plateau containing the greatest density of records (DECC 2007c).

The Giant Burrowing Frog spends approximately 95% of its time in foraging habitat which includes heath, woodland and open dry sclerophyll forest on a variety of soil types (except those that are clay based) although not generally where there is a grassy ground layer. Highest quality habitat is identified in the vicinity of upland swamps.

Preference for upland swamps is because these areas are associated with preferred breeding habitat in first or second order semi-permanent streams and soaks that are fish free with nearby burrowing habitat in deep, sandy soil. Giant Burrowing Frog may breed throughout the year though mainly in autumn immediately before or following heavy rain.

This species was recorded within the Study Area during field investigations in Lizard Creek Tributary 1 and Lizard Creek Tributary 2 in Wonga West. Potential habitat for the Giant Burrowing Frog occurs in the majority of the upland swamps and associated 1st or 2nd order streams in the Study Area. Tadpoles were identified in the 1st order stream to the south of CRUS2 in Wonga East in 2012 (Biosis pers comm).

The Giant Burrowing Frog is identified by DECC (2007a) as vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:
lead to a long-term decrease in the size of an important population of a species
The Giant Burrowing Frog was recorded within Lizard Creek Tributary 1 (LCT1) and Lizard Creek Tributary 2 (LCT2) in Wonga West; and in a 1st order stream downstream of upland swamp CRUS2. Potential habitat occurs in most of the 84 upland swamps recorded in the Study Area. The individuals recorded in the Study Area may form part of an 'important population' as they may aid maintenance of genetic diversity and be a key source population for either for breeding or dispersal. As a result the population in the Study Area is considered to constitute part of an important population. The FMEA (Olsen Consulting 2010) identified a high risk for subsidence related impacts to result in the loss of breeding habitat for the Giant Burrowing frog. It is likely that surface cracking as a result of mine subsidence will lead to a reduction in surface water availability including standing pools in creeks and tributaries (within the LCT1 and LCT2) where this species was recorded. This is expected to have direct consequences for the availability of breeding habitat for Giant Burrowing Frog. Some of the upland swamps may represent better quality habitat in that they are larger and/or support a diversity of vegetation communities including moisture dependent communities. A risk assessment of the upland swamps has identified that this subset of the upland swamps within the two Study Areas are predicted to experience negligible through to significant environmental consequences across the the footprint area of proposed action. However, for the breeding habitat confirmed associated with CRUS2, it is predicted that the proposed action will have negligible environmental consequences as not directly undermined. It is likely that the proposed action will have an adverse effect on the life cycle of the species, in particular within Wonga West area, such that it may lead to a long-term decrease in the size of the local important population, within the Study Area.
reduce the area of occupancy of an important population
The proposed action is likely to result in losses of breeding habitat for the species and subsequently reduce the area of occupancy of the population.
fragment an existing important population into two or more populations
Breeding habitat of the Giant Burrowing Frog is likely to be impacted as a result of the proposed action. The breeding habitat is within mainly 1st and 2nd order streams in Wonga West and upland swamps throughout the Study Area. Due to the unpredictable nature of subsidence some bed sections of streams may be impacted and others not. As a result, many sections of the streams would provide suitable breeding habitat, and other nearby sections may become less suitable. Tadpoles may be washed out of suitable habitat and into unsuitable downgradient habitat, reducing the likelihood of their survival to maturity. In this case, upstream breeding frogs in LCT2 may become isolated from other frogs in nearby catchments, as connectivity of tadpole habitat is potentially constrained due to surface cracking and reduction in surface water volume. The same scenario exists for the population in LCT1 downstream of LCUS18. It is likely that the existing population may become fragmented as a result of the proposed action.
adversely affect habitat critical to the survival of a species
The proposed action will not involve any surface works within the study area; as a result the direct removal of habitat would not occur. Breeding habitat for the Giant Burrowing Frog occurs within streams and pools free of fish, and upland swamp areas with pooling water. Subsidence related impacts as a result of the proposed action are likely to result in modification of Giant Burrowing Frog breeding habitat to an extent that it would reduce breeding success. The proposed action is therefore likely to adversely affect habitat critical to the survival of the species in the locality, however this habitat is not considered critical to the survival of the population on the Woronora Plateau as a whole.

	disrupt the breeding cycle of an important population
	Breeding habitat for the Giant Burrowing Frog occurs within streams and pools, and upland swamp areas with pooling water. Disruption to breeding cycle of the population could occur if impacts resulted in loss of breeding habitat, loss of breeding individuals, or loss of extensive areas of over-wintering habitat. It is likely that surface cracking as a result of mine subsidence will lead to a reduction in surface water availability including standing pools within creeks where the species was recorded (Andrew Dawkins, GeoTerra *pers. comm.*). Giant Burrowing Frog breeding habitat may be modified to an extent that it would disrupt the breeding cycle and likely reduce breeding success.
	modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
	Modification of breeding habitat is likely to result from the proposed action. This would occur via subsidence induced cracking of streambeds leading to changes in flow. It is likely that the loss of this breeding habitat would cause the species to decline in the locality.
	result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
	It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.
	Introduce disease that may cause the species to decline
	It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action. Access of personnel for monitoring should implement measures to limit spread of disease.
	interfere substantially with the recovery of the species.
	The local population of Giant Burrowing Frogs are likely to be impacted by the proposed action. It is not thought that the local impacts to habitat within the Study Area will lead to substantial interference of the recovery of the species as a whole.

Heath Frog (*Litoria littlejohni*) (V EPBC Act; V TSC Act)

The Heath Frog (*Litoria littlejohni*) has a distribution range that includes the plateaus and eastern slopes of the Great Dividing Range from the Watagan State Forest south to Buchan in Victoria, with the majority of records from within the Sydney Basin Bioregion (DECCW, 2010). Non-breeding habitat is heath based forests and woodlands where it shelters under leaf litter and low vegetation. Breeding habitat includes the upper reaches of permanent streams and perched swamps (DECCW, 2010).

In the Southern Sydney Region Littlejohn's Tree Frog is assessed as extremely rare resident; with the Woronora Plateau recognised as one of two important areas, key to the survival of the species in the region (DECC 2007c). The majority of records of this species in the water catchment area occur in the Woronora Special Area to the north of the PAA with few records in in the Metropolitan SA DECC (200b).

This species was not recorded within the Study Area during field investigations although was considered to have a moderate to high likelihood of occurrence based on the availability of suitable habitat. The Heath Frog is considered to be vulnerable to impacts associated with subsidence

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
	lead to a long-term decrease in the size of an important population of a species
	Suitable habitat for Heath Frog was recorded within Wonga West during field surveys by both Eco Logical (2009) and Biosis (2009) in the 3rd order reaches of Wallandoola Creek and Lizard Creek. Biosis have also identified marginal breeding habitat in 1st order streams associated with upland swamps CRUS1, CRUS2, CCUS4 and CCUS5 in Wonga East (N. Garvey Biosis, pers comm). There is also potential habitat in the majority of upland swamps within the Study Areas. Subsidence and related disturbance including cracking of creek beds has the potential to reduce water quality in these areas and limit the breeding potential of the species. GeoTerra (2012a) predicts that there is potential for cracking of the stream bed of LCT1 impacting on stream flow and

ponding. There is only limited potential for cracking of the stream bed of LCT2. GeoTerra (2012a) predicts no change in the creek bed of the upper reaches of Lizard Creek and Wallandoola Creek. However, there is potential for cracking of the 3rd order reach of Wallandoola Creek immediately to the south of the longwalls in Area 3 Wonga West (GeoTerra 2012a) that may impact on stream flow, ponding and habitat condition.

Upland swamps of special significance may represent better quality habitat in that they are larger and/or support a diversity of vegetation communities including more moisture dependent communities. A risk assessment of the upland swamps of special significance has identified that this subset of the upland swamps within the two Study Areas are predicted to experience negligible through to significant environmental consequences from the proposed action. Upland swamps of special significance that may experience moderate or significant environmental risk are WCUS4, WCUS7, CCUS4, CCUS5 and CCUS1. Habitat values of these swamps and associated 1st order streams may be adversely affected such that it may affect individuals dependent upon these habitats.

However, a number of the larger upland swamps will experience negligible environmental consequences and will provide alternative habitat for the population in the Study Areas. For the breeding habitat downstream of CRUS2 and CRUS1 it is predicted that the proposed action will have negligible to low environmental consequences.

Overall there is a low risk that the proposed action will lead to a long-term decrease in the size of an important population of the species.

reduce the area of occupancy of an important population

Potential habitat varied from good to poor condition, with some stream and pools being affected by iron-oxidising bacteria scum. The greatest extent of suitable habitat was recorded within the upper reaches of Lizard Creek, the Lizard Creek swamp complex, and within the pooled sections of Wallandoola Creek within the associated swamp complex (Biosis 2009, Eco Logical 2009). In Wallandoola Creek suitable breeding habitat for Heath Frog is generally restricted to the upper reaches where the water column did not appear to be affected by iron-oxidising bacteria flocculate (Eco Logical 2009). There is potential for impacts to potential breeding pools in the northern section of WCUS7. The overall area of occupancy is not likely to be altered as the species forages widely within heath habitats which are not likely to be altered.

fragment an existing important population into two or more populations

Due to the frogs ability to disperse and travel in wet heath environments, it is anticipated that fragmentation of populations will not occur.

adversely affect habitat critical to the survival of a species

As noted above suitable habitat for Heath Frog was recorded in the Study Area in a range of conditions, including areas, which were impacted by iron-oxidising bacteria scum. The largest tracts of habitat are associated with the reaches of Wallandoola Creek and Lizard Creek that will not be undermined and may experience negligible impacts. In these areas the proposed action is unlikely to adversely affect breeding habitat that may be critical to the survival of the species in the Study Area.

Moderate or higher risk of adverse environmental consequences is predicted for upland swamps WCUS7, WCUS4, CCUS4, CCUS5 and CCUS1. Should the population be reliant upon these swamps, the action may affect survival of the species.

disrupt the breeding cycle of an important population

Disruption to breeding cycle of the population could occur if impacts resulted in loss of breeding habitat, loss of breeding individuals, or loss of extensive areas of over-wintering habitat. Potential breeding pools for Heath Frog occur in WCUS7. These pools may be impacts by subsidence at the southern end of longwalls in Area 3. If these pools become degraded to the point where breeding of Heath Frogs is no longer successful, then the breeding cycle of the population may be disrupted. This is not anticipated to occur in habitat in the upper reaches of Lizard Creek and Wallandoola Creek.

Breeding habitat identified in Wonga East downstream of CRUS2 and CRUS1 are unlikely to be adversely affected such that the breeding cycle is disrupted.

modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Modification of some areas of potential habitat is likely to result from the proposed action. This would occur via subsidence induced cracking of 1st order streambeds associated with upland swamps. Though it is noted that large tracts of upland swamp habitat associated with main channel of Wallandoola Creek and Lizard Creek are unlikely to be modified, removed or isolated or decrease the available or quality of habitat to the extent that the species if present it likely to decline across the two Study Areas.

result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.

introduce disease that may cause the species to decline

It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action. Access of monitoring personnel should implement measures to limit spread of disease.

interfere substantially with the recovery of the species.

It has been established that the local population of Heath Frogs may be disrupted if the potential breeding habitat for the species is altered by surface cracking. It is not anticipated that this disruption is likely to interfere with the recovery of the species as a whole, given the wide distribution of the species, and the extensive suitable habitat present within the Study Area and surrounding SCA Special Areas.

Stuttering Barred Frog (*Mixophyes balbus*) (V EPBC Act; E TSC Act)

In NSW The Stuttering Barred Frog or Stuttering Frog (*Mixophyes balbus*) is found in rainforest and wet, tall open forest on the foothills and escarpment of the eastern side of the Great Dividing Range, where the Dorrigo appears to be a stronghold for the species (DECCW, 2010). This species breeds in streams and shelters in deep leaf litter and thick understorey vegetation outside of the breeding season (DECCW, 2010).

In the Southern Sydney Region Stuttering Barred Frog is assessed as extremely rare resident; known from Macquarie Pass National Park, Mt Werong in the Blue Mountains National Park and near Helensburgh (DECC 2007c). Based on surveys in Metropolitan SA, DECC (2000b) assess Stuttering Barred Frog as probably locally extinct with habitat in rainforests and moist forest.

Stuttering Barred Frog was not recorded within the Study Area during field investigations, although was considered to have a moderate to high likelihood of occurrence based on the availability of suitable habitat and identification of good quality breeding habitat in the reaches of Cataract Creek upstream of proposed Longwall A2 LW8 in Wonga East. Stuttering Barred Frog is considered to be vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

Habitat searches identified suitable foraging and breeding habitat for the Stuttering Barred Frog within the upper reaches of Cataract Creek in the Wonga East area (Eco Logical 2009), however no individuals have been recorded during surveys.

GeoTerra (2012a) concluded that the worst case predictions extraction of the longwall panels in this reach (between surface water monitoring sites CC5 and CC9) may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. Implementation of adaptive management measures would minimise potential adverse environmental consequences. Without implementation of the adaptive mine plan, the proposed action may effect habitat values in this reach of Cataract Creek. Without adaptive management to minimise environmental consequences, the action may impact on life cycle and population numbers. With adaptive management, the action is unlikely to affect the population.

Habitat for Stuttering Barred Frog extends upstream of Mount Ousley Road. There is negligible potential for negative environmental consequences on the stream (GeoTerra 2021a) and accordingly habitat value in this section of Cataract Creek.

With implementation of an adaptive mine plan it is unlikely that the proposed action will lead to a long-term decrease in habitat and therefore unlikely to result in a decrease in the size of an important population of the species.

reduce the area of occupancy of an important population
Extraction of the longwall panels under Cataract Creek between A2 LW8 and Mount Ousley Road may have an adverse impact on stream flow, pool holding capacity of the rock bars and potential iron hydroxide seepage. With implementation of adaptive management measures, the area of occupancy for Stuttering Barred Frog in Cataract Creek will not be reduced. No adverse effects on stream water quality are anticipated in Cataract Creek upstream of Mount Ousley Road. Due to the predicted lack of impacts a reduction in the area of occupancy for the species is not predicted.
fragment an existing important population into two or more populations
Potential habitat for Stuttering Barred Frog occurs upstream of proposed Longwall A2LW8 either side of Mount Ousley Road. Predicted subsidence impacts are anticipated to be mainly associated with A2 LW8 and to a lesser degree with A2 LW7. There is no habitat identified downstream of these panels. The proposed action is not anticipated to fragment an existing population into two or more populations.
adversely affect habitat critical to the survival of a species
The areas of suitable habitat for the Stuttering Barred Frog within the Study Area that were recorded in good condition would be considered critical habitat for the local population of the species. This habitat area is mainly upstream of A2 LW7 and the majority of it is not anticipated to be adversely affected by the proposed action.
disrupt the breeding cycle of an important population
Disruption to breeding cycle of the population could occur if impacts resulted in loss of breeding habitat, loss of breeding individuals, or loss of extensive areas of over-wintering habitat. Given that a large portion of the potential habitat will not be adversely affected by the proposed action, the breeding cycle of the species is not expected to be disrupted.
modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
Modification, destruction or removal of habitat will occur in the habitat closest to A2 LW7 and A2 LW8. However, there is negligible potential for environmental consequences upstream of A2 LW6, and a subsequent decline in the species is not expected.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.
introduce disease that may cause the species to decline
It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action. Access of monitoring personnel should implement measures to limit spread of disease.
interfere substantially with the recovery of the species.
A local population of Stuttering Barred Frogs is unlikely to be impacted by the proposed action. Therefore, substantial interference with the recovery of the species is considered unlikely.

Spotted-tailed Quoll (*Dasyurus maculatus*) (E EPBC Act; V TSC Act).

The Spotted-tailed Quoll (*Dasyurus maculatus*) is known to occur from the sub-alpine zone to the coastline within a range of habitat types including rainforest, open forest, woodland, coastal heath and inland riparian forest (DECCW, 2010). Hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky cliff faces are used as den sites (DECCW, 2010).

This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat, recent nearby sighting (DECC 2007b). Spotted-tailed Quoll is also considered to be vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of a population

The Spotted-tailed Quoll inhabits a variety of habitats, with extensive suitable habitat for the species occurring in the Wonga West area. The home range of a male Spotted-tailed Quoll is very large and could contain the entire Wonga West domain. Rocky outcrops and caves would be critical sheltering habitat as well as densely vegetated creek lines which the Spotted-tailed Quoll would use for traversing its home range. In Lizard Creek gorge, where suitable habitat may be impacted, maximum vertical subsidence of 100mm and maximum tilt of 3mm/m is predicted (SCT Operations 2012). There is a negligible to low potential that this amount of subsidence will damage caves and latrine sites located above the proposed longwall panels and a negligible potential where these features do not occur over longwall panels. It is unlikely that this level of disturbance would lead to a long-term decrease in the size of the population.

reduce the area of occupancy of the species

The Spotted-tailed Quoll inhabits a wide range of habitats and the home range of a male is very large and could contain the entire Wonga West domain. Potential impacts associated with the proposed action centre on damage to caves around Lizard Creek gorge, which may provide shelter sites for the species. It is considered that any impacts to these features would not be significant to the degree that they would limit the ability of the species to survive in the locality. Therefore, it is unlikely that the proposed action would result in a reduction in the area of occupancy of the species.

fragment an existing population into two or more populations

Caves may be impacted by the proposed action however it is unlikely that the potential minor changes in habitat would significantly limit the ability of a generalist species such as the Spotted-tailed Quoll to the degree that a local population would be fragmented.

adversely affect habitat critical to the survival of a species

Caves utilised for shelter by the Spotted-tailed Quoll are considered critical to the species survival. In Lizard Creek gorge maximum vertical subsidence of 300mm and maximum tilt of 10mm/m is predicted (Seedsman 2012) over longwall panels. Negligible environmental consequences are predicted for cliff formations not directly above the proposed longwall panels (SCT 2012)

Localised habitat critical to the survival of the species may be adversely affected while other sections of the cliff may not be adversely affected.

disrupt the breeding cycle of a population

There is potential, however it is considered unlikely that the proposed action will impact the breeding cycle of the species. The potential to impact the breeding cycle exists by impacts occurring on a maternal den site, especially if one is containing young at the time of subsidence.

modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Caves around Lizard Creek gorge may be impacted due to subsidence. However the impacts to these habitat features are considered unlikely to impact availability or quality of habitat to the extent that the species is likely to decline.

result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.

introduce disease that may cause the species to decline

It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action.

interfere with the recovery of the species.

Habitat for the Spotted-tailed Quoll may be impacted by the proposed action, however the degree of habitat modification is not considered significant for the species. Therefore, it is highly unlikely that the proposed action will interfere with the recovery of the species.

Woronora Beard-heath (*Leucopogon exolasius*) (V EPBC Act; V TSC Act)

The Woronora Beard-heath (*Leucopogon exolasius*) is known from the upper Georges River area and Heathcote National Park where it is found growing in woodland on sandstone and is often associated with rocky hillsides and creek lines (DECCW, 2010).

This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat and is also considered to be vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

The Tall Open Peppermint-Blue Gum Forest, Sandstone Gully Peppermint Forest and Exposed Sandstone Scribbly Gum Forest within the study area provide potential habitat for Woronora Beard-heath. Areas of all of these communities are located within the subsidence impact zone. Maximum predicted subsidence within these areas is 2.5 m (Seedsman 2012); this level of subsidence is unlikely to significantly impact vegetation communities.
It is therefore considered that a long-term decrease in a population, if present, would not occur as a result of the proposed action.

reduce the area of occupancy of an important population

The level of subsidence predicted in suitable habitat areas for Woronora Beard-heath is not anticipated to have significant impacts on vegetation communities. Therefore, it is unlikely that the proposed action will result in a reduction in the area of occupancy of the species.

fragment an existing important population into two or more populations

The level of subsidence predicted in suitable habitat areas for Woronora Beard-heath is not anticipated to have significant impacts on vegetation communities. Therefore, it is unlikely that the proposed action will result in fragmentation of an existing population, if present.

adversely affect habitat critical to the survival of a species

The level of subsidence predicted in suitable habitat areas for Woronora Beard-heath is not anticipated to have significant impacts on vegetation communities, which may provide habitat for the species. Therefore, it is unlikely that the proposed action will adversely affect habitat critical to the species survival.

disrupt the breeding cycle of an important population

Woronora Beard-heath produces a fruit (drupe) which is most likely distributed by ants. Pollination is most likely by bees or other small insects. The potential impacts of the action are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. Therefore, it is unlikely that the proposed action will disrupt this cycle.

	modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
	The level of subsidence predicted in suitable habitat areas for Woronora Beard-heath may modify the vegetation communities, however the modification is not anticipated to be significant or result in any changes to ecology or result in the species decline.
	result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
	It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.
	introduce disease that may cause the species to decline
	It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action.
	interfere substantially with the recovery of the species.
	Due to the lack of predicted impacts on potential habitat for the Woronora Beard-heath it is unlikely that the proposed action will interfere substantially with the recovery of the species.

Prickly Bush-Pea (*Pultenaea aristata*) (V EPBC Act; V TSC Act)

The Prickly Bush-pea (*Pultenaea aristata*) is restricted to the Woronora Plateau where it is found growing within dry sclerophyll woodland or wet heath on sandstone (OEH online profile). Known from Upland Swamp Banksia Thicket and Restoid Heath Complex and in areas where drainage is poor in sandstone forest communities (TSSC 2008).

This species has previously been recorded within Wonga West near Shaft No 5 (Kevin Mills and Associates, 1995). Field investigations by ERM and Biosis have identified the species in upland swamps CRUS1, CCUS3, CCUS10, CCUS8 and BCUS7 in the Wonga East area and upland swamps LCUS27, WCUS5, WCUS1, WCUS4, LCUS14, LCUS13, LCUS15, LCUS16, LCUS33, LCUS17 in the Wonga West area.In the majority of these swamps, the Prickly Bush-pea was recorded at the drier edge of the swamp communities. In the Bulli Seam Operation Area, Prickly Bush-pea occurred primarily in Restioid Heath and Fringing Eucalypt Woodland (FloraSearch 2009).

The Prickly Bush-pea is considered to be vulnerable to impacts associated with subsidence (DECC 2007). Prickly Bush-pea is identified as a species that is not able to withstand loss of individuals (greater than five) within the Hawkesbury Nepean Catchment and is considered to have national special significance (DECCW 2011). Swamps supporting this species (CRHS1 and CCUS3) are considered to have national special significance

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
	lead to a long-term decrease in the size of an important population of a species
	Prickly Bush-pea has previously been recorded in Wonga West near Shaft No 5 (Kevin Mills and Associates 1995) and by ERM and Biosis in upland swamps CRUS1, CCUS3, CCUS10, CCUS8 and BCUS7 in the Wonga East area and upland swamps LCUS27, WCUS5, WCUS1, WCUS4, LCUS14, LCUS13, LCUS15, LCUS16, LCUS33, LCUS17 in the Wonga West area. It may be present in a range of vegetation types, from heath in upland swamps to dry sclerophyll woodlands such as Exposed Sandstone Scribbly Gum Woodland and Fringing Eucalypt Woodland that are widespread in the Study Area. The action will not clear potential habitat or directly decrease the size of the population in the Study Area. The maximum predicted subsidence in potential woodland habitat areas is approximately 2.5 m (GeoTerra 2012a) and this level of subsidence is unlikely to result in significant impacts to terrestrial vegetation communities. Therefore, it is unlikely that the proposed action will have an adverse effect on species within this community. Potential habitat for the Prickly Bush-pea also exists within the upland swamp areas of the Study Area. GeoTerra (2012a) and Biosis (2012) reported possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking is predicted in some of the

upland swamp areas. In an upland swamp risk assessment, Biosis (2012) have identified those upland swamps of 'special significance' that are at a greater than negligible risk of negative environmental consequence (based on subsidence criteria).

Those upland swamps containing suitable habitat and identified as at a greater than negligible risk of negative environmental consequence include CCUS10 and CRUS1 in Wonga East and WCUS4 in Wonga West (Biosis 2012a). One other upland swamp (CCUS3) habitat is at a greater than negligible risk of negative environmental consequences and this swamp will be undermined by A2 LW5, and was the subject to separate approval.

For other areas of potential upland swamp habitat, GeoTerra (2012a) and Biosis (2012) reported possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking. The changes to hydrology in these areas have been predicted to be negligible. Given that Prickly Bush-pea is associated with drier vegetation on the fringes of the upland swamps, it is unlikely that the proposed action will lead to a long term decrease in the size of an important population of the Prickly Bush-pea.

reduce the area of occupancy of an important population

Prickly Bush-pea has been recorded in 15 of the 84 upland swamps in the Study Area. This equates to approximately 65ha or 25% of the available upland swamp habitat in the Study Area.

The proposed action will not involve any surface works or direct removal of habitat within the Study Area. GeoTerra (2012a) and Biosis (2012) predicted possible changes to swamp water level, water storage, stream seepage and water quality due to substrate cracking in some of the upland swamp areas. Of the 65ha of confirmed upland swamp habitat in the Study Area approximately 23ha (35%) is at a greater than negligible risk of negative environmental consequences. Given that this species is associated with drier vegetation on the fringes of the upland swamps, it is unlikely that the habitat for this species will be modified.

Terrestrial habitat for this species will be not removed and is unlikely to be modified by the proposed subsidence.

Therefore, a reduction in the known area of occupancy of an important population of the species is not expected.

fragment an existing important population into two or more populations

The level of subsidence predicted in suitable habitat areas for Prickly Bush-pea is not anticipated to have significant impacts on vegetation communities. Therefore, it is unlikely that the proposed action will result in fragmentation of an existing population, if present.

adversely affect habitat critical to the survival of a species

The level of subsidence predicted in areas of known habitat for Prickly Bush-pea is not anticipated to have significant impacts on vegetation communities, which provide critical habitat for the species. Therefore, it is unlikely that the proposed action will adversely affect habitat critical to the species survival.

disrupt the breeding cycle of an important population

Prickly Bush-pea produces a hard coated seed, with recruitment of individuals occurring after fire. The potential impacts of the action are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. Therefore, it is unlikely that the proposed action will disrupt this cycle.

modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The level of subsidence predicted in suitable habitat areas for Prickly Bush-pea may modify the vegetation communities, however the modification is not anticipated to be significant or result in any changes to ecology or result in the species decline.

result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.

introduce disease that may cause the species to decline

It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action.

interfere substantially with the recovery of the species.

Due to the lack of predicted significant impacts on potential habitat for the Prickly Bush-pea it is unlikely that the proposed action will interfere substantially with the recovery of the species.

Deane's Paperbark (*Melaleuca deanei*) (V EPBC Act; V TSC Act)

Deane's Paperbark (*Melaleuca deanei*) occurs within two distinct areas in the Ku-ring-gai/Berowra and Holsworthy/Wedderburn areas (either side of Sydney metropolitan area), although more isolated occurrences are also known from the Blue Mountains, Wollemi National Park, the Nowra region and the Hawkesbury River (DECCW, 2010). It is known from two large populations in the Nepean and Avon Dam catchment (DECCW 2010) to the south of the PAA.

Within this distribution range, Deane's Paperbark grows in heath communities on broad flat sandstone ridge tops, dry ridges and slopes, strongly associated with sandy loam soils low in nutrients sometimes with ironstone present (DECCW, 2010). This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence in sandstone dry woodland community based on the availability of suitable habitat and is also considered to be vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

Deane's Paperbark grows in heath on sandstone ridges and plateaus. The action will not clear potential habitat or directly decrease the size of the population in the study area.

No surface works are associated with the action and therefore potential impacts are related to subsidence and include cracking of surface and sub-surface, lowering of the water table beyond the reach of plants. There is a maximum predicted subsidence of 2.5 m and maximum predicted tilt of 15 mm/m under terrestrial vegetation communities on the sandstone plateau in Wonga West. This subsidence is unlikely to result in significant impacts on the vegetation community structure.

It is therefore, unlikely that the proposed works will lead to a long term decrease in the size of an important population of Deane's Paperbark.

reduce the area of occupancy of an important population

Deane's Paperbark has a limited distribution and any population could be considered important. The proposed action is unlikely to significantly modify potential habitat for the species within the study area. Therefore, a reduction in the area of occupancy of an important population of the species is not expected.

fragment an existing important population into two or more populations

The level of subsidence predicted in suitable habitat areas for Deane's Paperbark is not anticipated to have significant impacts on vegetation communities. Therefore, it is considered unlikely that the proposed action will result in fragmentation of an existing population, if present.

adversely affect habitat critical to the survival of a species

The level of subsidence predicted in suitable habitat areas for Deane's Paperbark is not anticipated to have significant impacts on vegetation communities, which provide habitat critical for the species. Therefore it is considered unlikely that the proposed action will adversely affect habitat critical to the species survival.

disrupt the breeding cycle of an important population

Deane's Paperbark is an infrequent flowering shrub that is most likely to be pollinated by insects (DECCW 2010). It is a clonal species, that has the ability of re-sprout and this may be the main mechanism for recruitment (DECCW 2010). Seeds are produced in woody capsules held on the plant for several years with release triggered by dehydration (DECCW 2010). The potential impacts of the action are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. Therefore, it is unlikely that the proposed action will disrupt this cycle.

modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The level of subsidence predicted in suitable habitat areas for Deane's Paperbark may modify the vegetation communities, however the modification is not anticipated to be significant or result in any changes to ecology or result in the species decline.

result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

It is unlikely that any invasive species will be introduced or become more established in the study area as a result of the proposed action.

introduce disease that may cause the species to decline

It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action.

interfere substantially with the recovery of the species.

There is a state recovery plan for Deane's Paperbark (DECCW 2010). Due to the lack of predicted significant impacts on potential habitat for Deane's Paperbark it is unlikely that the proposed action will interfere substantially with the recovery of the species.

Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*) (V EPBC Act; V TSC Act)

The Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*) shrub occurs sporadically throughout the Sydney Basin with the main occurrences centred on Picton, Appin and Bargo (DECCW, 2010). It grows in sandy or light clay soils, usually over thin shales, within a range of vegetation types from heath and shrubby woodland to open forest, and has often been recorded in slightly disturbed areas (e.g. on the edges of tracks) (DECCW, 2010). Also occurs across a range of altitudes and landforms, from flat, low-lying areas to upper slopes and ridge crests (DECCW, 2010).

This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat and was also considered to be vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

Small-flower Grevillea is considered to have a moderate likelihood of occurrence within the Study Area. It has been recorded in a range of vegetation types, from heath and shrubby woodland to open forest including Shale-Sandstone Transition Forest EEC identified in the Study Area. The action will not clear potential habitat or directly decrease the size of the population in the study area.

The FMEA (Olsen Consulting 2010) identified potential impacts in the Shale Sandstone Transition Forest EEC as low risk. Therefore, it is unlikely that the proposed action will have an adverse effect on species within this community. Further, the maximum predicted subsidence in this potential habitat area is approximately 2.3m (Seedsman 2012) and is not predicted to impact vegetation communities. It is therefore unlikely that the proposed action will lead to a long-term decrease in the size of an important population of the Small-flower Grevillea.

reduce the area of occupancy of an important population

Small-flower Grevillea has a limited distribution and any population may be considered important. As described above, the proposed action is unlikely to significantly modify potential habitat for the species within the Study Area. Therefore, a reduction in the area of occupancy of an important population of the species is not expected.

fragment an existing important population into two or more populations

The level of subsidence predicted in suitable habitat for Small-flower Grevillea is not anticipated to have significant impacts on vegetation communities. Therefore, it is considered unlikely that the proposed action will result in fragmentation of an existing population, if present.

adversely affect habitat critical to the survival of a species

The level of subsidence predicted in suitable habitat for Small-flower Grevillea is not anticipated to have significant impacts on vegetation communities, which provide critical habitat for the species. Therefore, it is unlikely that the proposed action will adversely affect habitat critical to the species survival.

disrupt the breeding cycle of an important population

Flowering of Small-flower Grevillea has been recorded from July to December and in April to May. Flowers are insect pollinated and seeds are released at maturity probably with minimal local dispersal of seed. Small-flower Grevillea can regenerate from rhizomes. The potential impacts of the action are not anticipated to have an adverse effect on these processes or the ability of this species to reproduce, germinate or disperse its seed. Therefore, it is unlikely that the proposed action will disrupt this cycle.

modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The level of subsidence predicted in suitable habitat areas for Small-flower Grevillea may result in minor modifications of the vegetation communities, however the modification is not anticipated to be significant or result in any changes to ecology or result in the species decline.

result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

It is unlikely that any invasive species will be introduced or become more established in the Study Area as a result of the proposed action.

introduce disease that may cause the species to decline

It is unlikely that disease will be introduced or become more established in the Study Area as a result of the proposed action.

interfere substantially with the recovery of the species.

Due to prediction that the subsidence impacts may result in negligible to minor environmental consequences on potential habitat for Small-flower Grevillea it is unlikely that the proposed action will interfere substantially with the recovery of the species.

Bargo Geebung (*Persoonia bargoensis*) (V EPBC Act; E TSC Act)

Bargo Geebung (*Persoonia bargoensis*) grows in dry sclerophyll eucalypt woodland or forest. It occurs on heavier, well drained, loamy, gravelly soils of Hawkesbury Sandstone & Wianamatta Shale, between 100 and 300 m altitude (Weston & Johnson 1991; Harden 1991; Blombery & Maloney 1992; Weston 1995b).

This species was not recorded within the Study Area during field investigations although was considered to have a moderate likelihood of occurrence based on the availability of suitable habitat and was also considered to be vulnerable to impacts associated with subsidence.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

lead to a long-term decrease in the size of an important population of a species

Suitable habitat for Bargo Geebung occurs in the Study Area in Shale Sandstone Forest in Wonga West. No vegetation clearance is associated with the action and therefore potential impacts are related to subsidence and include cracking of surface and sub-surface, lowering of the water table beyond the reach of plants.

The maximum predicted subsidence in these potential habitat areas is approximately 2.3 m and maximum predicted tilt of 15 mm/m under the EEC. The mine design approach has recognised that the majority of the surface can be safely subsided (Seedsman 2012) and this level of subsidence is unlikely to impact on terrestrial vegetation communities and the species within them. It is unlikely that the changes in conditions would cause significant damage to vegetation communities and subsequently a long-term decrease in the size of an important population of the species is not expected to result from the proposed action.

reduce the area of occupancy of an important population

The proposed action is unlikely to significantly modify potential terrestrial habitat for Bargo Geebung within the Study Area. Therefore a reduction in the area of occupancy of an important population of the species is not expected to occur as a result of the proposed action.

fragment an existing important population into two or more populations

The level of subsidence predicted in suitable habitat areas for Bargo Geebung is not anticipated to have significant impacts on vegetation communities. Therefore, it is unlikely that the proposed action will result in fragmentation of an existing population, if present.

adversely affect habitat critical to the survival of a species

The level of subsidence predicted in suitable habitat areas for Bargo Geebung is not anticipated to have significant impacts on vegetation communities, which provide critical habitat for the species, such dry sclerophyll eucalypt woodland or forest. Therefore, it is unlikely that the proposed action will adversely affect habitat critical to the species survival.

disrupt the breeding cycle of an important population

Bargo Geebung is likely to be pollinated by bees. The potential impacts of the action are not anticipated to have an adverse effect on flowering or dispersal of pollinators and subsequently the breeding cycle of the species. Therefore, it is unlikely that the proposed action will disrupt this cycle.

modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The level of subsidence predicted in suitable habitat areas for Bargo Geebung is unlikely to modify the soil to the extent that would affect the community. There is potential for temporary soil cracking to occur within the area of the Shale/Sandstone Transition Forest in Wonga West, and there is potential for altered groundwater flows within the soils and Hawkesbury Sandstone following mining (GeoTerra 2012b). This community is not a groundwater dependent ecosystem and any changes are not likely to modify or destroy factors necessary for the survival of the

result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

It is unlikely that any invasive species will be introduced or become more established in the Study Area as a result of the proposed action.

introduce disease that may cause the species to decline

It is unlikely that disease will be introduced or become more established in the study area as a result of the proposed action.

interfere substantially with the recovery of the species.

Due to the lack of predicted significant impacts on potential habitat for Bargo Geebung it is unlikely that the proposed action will interfere substantially with the recovery of the species.

Annex C

PMST Report

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

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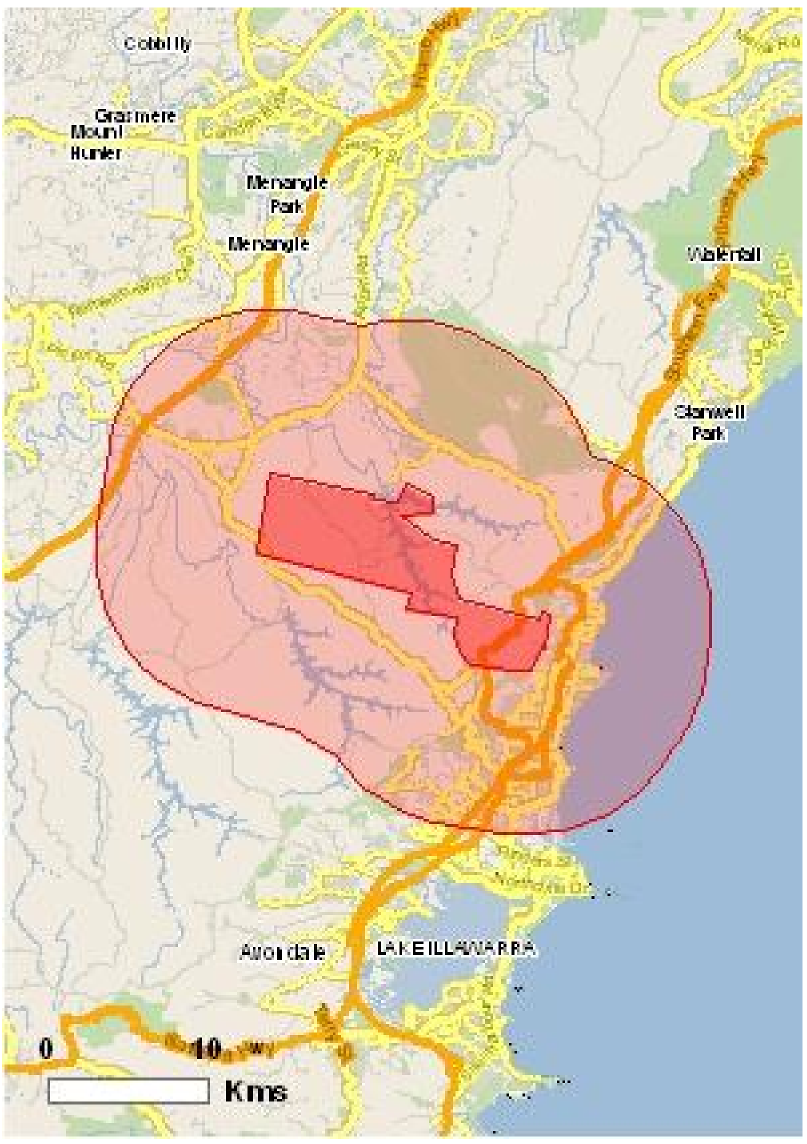

Coordinates

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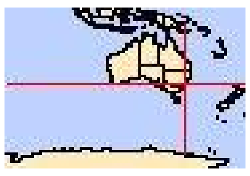

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	4
Threatened Species:	65
Migratory Species:	52

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.

Commonwealth Lands:	12
Commonwealth Heritage Places:	None
Listed Marine Species:	64
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

Place on the RNE:	44
State and Territory Reserves:	4
Regional Forest Agreements:	None
Invasive Species:	17
Nationally Important Wetlands:	1

Details

Matters of National Environmental Significance

Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered	Community likely to occur within area
Littoral Rainforest and Coastal Vine Thickets of	Critically Endangered	Community likely to

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Eastern Australia		occur within area
Shale/Sandstone Transition Forest	Endangered	Community likely to occur within area
Turpentine-Ironbark Forest in the Sydney Basin Bioregion	Critically Endangered	Community likely to occur within area

Threatened Species

[Resource Information]

Name	Status	Type of Presence
BIRDS		
Anthochaera phrygia Regent Honeyeater [82338]	Endangered	Species or species habitat likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Diomedea exulans amsterdamensis Amsterdam Albatross [82330]	Endangered	Species or species habitat may occur within area
Diomedea exulans antipodensis Antipodean Albatross [82269]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans exulans Tristan Albatross [82337]	Endangered	Foraging, feeding or related behaviour may occur within area
Diomedea exulans gibsoni Gibson's Albatross [82271]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Vulnerable	Species or species habitat may occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Sternula nereis nereis Fairy Tern (Australian) [82950]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta salvini Salvin's Albatross [82343]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris impavida Campbell Albatross [82449]	Vulnerable	Species or species habitat may occur within area
FISH		
Maccullochella macquariensis Trout Cod [26171]	Endangered	Species or species habitat likely to occur within area
Macquaria australasica Macquarie Perch [66632]	Endangered	Species or species habitat may occur within area
Prototroctes maraena Australian Grayling [26179]	Vulnerable	Species or species habitat likely to occur within area
FROGS		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat likely to occur within area
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat likely to occur within area
Litoria littlejohni Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat may occur within area
Litoria raniformis Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog [1828]	Vulnerable	Species or species habitat may occur within area
Mixophyes balbus Stuttering Frog, Southern Barred Frog (in Victoria) [1942]	Vulnerable	Species or species habitat likely to occur within area
MAMMALS		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Isoodon obesulus obesulus		
Southern Brown Bandicoot [68050]	Endangered	Species or species habitat known to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petrogale penicillata		
Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat may occur within area
Potorous tridactylus tridactylus		
Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat may occur within area
Pseudomys novaehollandiae		
New Holland Mouse [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
PLANTS		
Caladenia tessellata		
Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana		
Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Cynanchum elegans		
White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area
Daphnandra johnsonii		
a tree [67186]	Endangered	Species or species habitat likely to occur within area
Grevillea parviflora subsp. parviflora		
Small-flower Grevillea [64910]	Vulnerable	Species or species habitat likely to occur within area
Leucopogon exolasius		
[14251]	Vulnerable	Species or species habitat likely to occur within area
Melaleuca biconvexa		
Biconvex Paperbark [5583]	Vulnerable	Species or species habitat may occur within area
Melaleuca deanei		
Deane's Melaleuca [5818]	Vulnerable	Species or species habitat likely to occur within area
Persoonia bargoensis		
[56267]	Vulnerable	Species or species habitat likely to occur within area
Persoonia nutans		
[18119]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Pomaderris brunnea		
Rufous Pomaderris [16845]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis gibbosa		
Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood [4562]	Endangered	Species or species habitat likely to occur within area
Pterostylis saxicola		
Sydney Plains Greenhood [64537]	Endangered	Species or species habitat known to occur within area
Pultenaea aristata		
[18062]	Vulnerable	Species or species habitat likely to occur within area
Thelymitra sp. Kangaloon (D.L.Jones 18108)		
Kangaloon Sun-orchid [81971]	Critically Endangered	Species or species habitat likely to occur within area
REPTILES		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hoplocephalus bungaroides		
Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
SHARKS		
Carcharias taurus (east coast population)		
Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat may occur within area
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered*	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable*	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered*	Foraging, feeding or related behaviour may occur within area
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Puffinus leucomelas Streaked Shearwater [66541]		Species or species habitat may occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross [64697]	Vulnerable*	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross [64459]	Vulnerable*	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable*	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable*	Species or species habitat may occur within area
Migratory Marine Species		
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Caperea marginata		
Pygmy Right Whale [39]		Species or species habitat may occur within area
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Lagenorhynchus obscurus		
Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus		
Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Breeding may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding likely to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Breeding may occur within area
Xanthomyza phrygia Regent Honeyeater [430]	Endangered*	Species or species habitat likely to occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Rostratula benghalensis s. lat. Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Postal Corporation
Commonwealth Land - Australian Telecommunications Commission

Name		
Commonwealth Land - Commonwealth Trading Bank of Australia		
Commonwealth Land - Defence Housing Authority		
Commonwealth Land - Director of War Service Homes		
Commonwealth Land - Telstra Corporation Limited		
Defence - AIRTC WOLLONGONG		
Defence - Graovac House		
Defence - HYDROGRAPHIC OFFICE		
Defence - TS ALBATROSS-WOLLONGONG		
Defence - WOLLONGONG MULTI-USER DEPOT		

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]		Species or species habitat known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered*	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable*	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered*	Foraging, feeding or related behaviour may occur within area
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat likely to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Breeding may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding likely to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Breeding may occur within area
Rostratula benghalensis s. lat. Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross [64697]	Vulnerable*	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross [64459]	Vulnerable*	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable*	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Species or species habitat may occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus abdominalis Bigbelly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Stigmatopora argus Spotted Pipefish, Gulf Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area

Whales and other Cetaceans

[Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Species or species habitat may occur within

Name	Status	Type of Presence
		area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Loddens Creek Catcment	NSW	Indicative Place
Upper Nepean Water Catchment	NSW	Indicative Place
Austinmer Beach Geological Site	NSW	Registered
O'Hares Creek Catchment	NSW	Registered
Indigenous		
East Cordeaux Area (relocation)	NSW	Indicative Place
Breakfast Creek Area	NSW	Registered
Bulli Area	NSW	Registered
Cobbong Creek Area	NSW	Registered
East Cordeaux Area	NSW	Registered
Loddon Area Loddon Site 8	NSW	Registered
Sandy Creek Road Area	NSW	Registered
Stokes Creek Area	NSW	Registered
Wilton Art Site	NSW	Registered
Historic		
Austinmer Railway Station Group	NSW	Indicative Place
Austinmer War Memorial	NSW	Indicative Place
Barracks Headquarters and Quartermasters Building	NSW	Indicative Place
Cataract Dam & Reservoir	NSW	Indicative Place
Corrimal Colliery Ruins and Shaft	NSW	Indicative Place
Glastonbury Gardens	NSW	Indicative Place
Gleniffer Brae Manor House and Garden	NSW	Indicative Place
Greenhill Garden	NSW	Indicative Place
Hillside Garden	NSW	Indicative Place
Illawarra Escarpment	NSW	Indicative Place

Name	State	Status
Morton Park Bakery	NSW	Indicative Place
Morton Park Circular Brick Garden Structure	NSW	Indicative Place
Morton Park Early Dwelling	NSW	Indicative Place
Morton Park Group	NSW	Indicative Place
Morton Park Homestead	NSW	Indicative Place
Morton Park Stone Stable	NSW	Indicative Place
Mount Keira Summit Park	NSW	Indicative Place
Thirroul Soldiers Memorial	NSW	Indicative Place
Trooper Andrews Memorial Drinking Fountain	NSW	Indicative Place
Village of Mount Kembla	NSW	Indicative Place
Wollongong Memorial Arch	NSW	Indicative Place
Belmore Basin Lighthouse	NSW	Registered
Bulli Family Hotel	NSW	Registered
Courthouse (former)	NSW	Registered
Illawarra Historical Museum	NSW	Registered
Little Milton	NSW	Registered
St Bedes Catholic Church and Graveyard	NSW	Registered
St Mark the Evangelist Anglican Church	NSW	Registered
St Marys Towers	NSW	Registered
Wollongong Courthouse	NSW	Registered
Wollongong Harbour (part)	NSW	Registered

State and Territory Reserves [Resource Information]

Name	State
Dharawal	NSW
Dharawal	NSW
Illawarra Escarpment	NSW
Upper Nepean	NSW

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit,

Name	Status	Type of Presence
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides		
Alligator Weed [11620]		Species or species habitat likely to occur within area
Asparagus asparagoides		
Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum		
African Boxthorn, Boxthorn [19235]		Species or species habitat may occur within area
Nassella neesiana		
Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Nassella trichotoma		
Serrated Tussock, Yass River Tussock, Yass Tussock, Nassella Tussock (NZ) [18884]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtiji		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Ulex europaeus		
Gorse, Furze [7693]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
O'Hares Creek Catchment	NSW

Coordinates

-34.33812 150.89005,-34.33394 150.89096,-34.33454 150.89477,-34.35427 150.89263,
-34.35335 150.89043,-34.36664 150.88445,-34.36588 150.87683,-34.36687 150.87585,
-34.36306 150.85117,-34.35552 150.84508,-34.34692 150.8412,-34.33649 150.84326,
-34.33268 150.81539,-34.32274 150.81714,-34.2999 150.73174,-34.25533 150.73848,
-34.26752 150.79648,-34.27139 150.79648,-34.27258 150.81075,-34.26128 150.81462,
-34.26961 150.83038,-34.27794 150.82919,-34.27972 150.81105,-34.2931 150.83009,
-34.29548 150.84258,-34.31236 150.8397,-34.32637 150.84488,-34.3381 150.89003,
-34.33812 150.89005

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787

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Environmental Resources Management

PO Box 71
Thornton NSW 2322
53 Bonville Avenue
Thornton NSW 2322

T: +61 2 4964 2150
F: +61 2 4964 2152
www.erm.com

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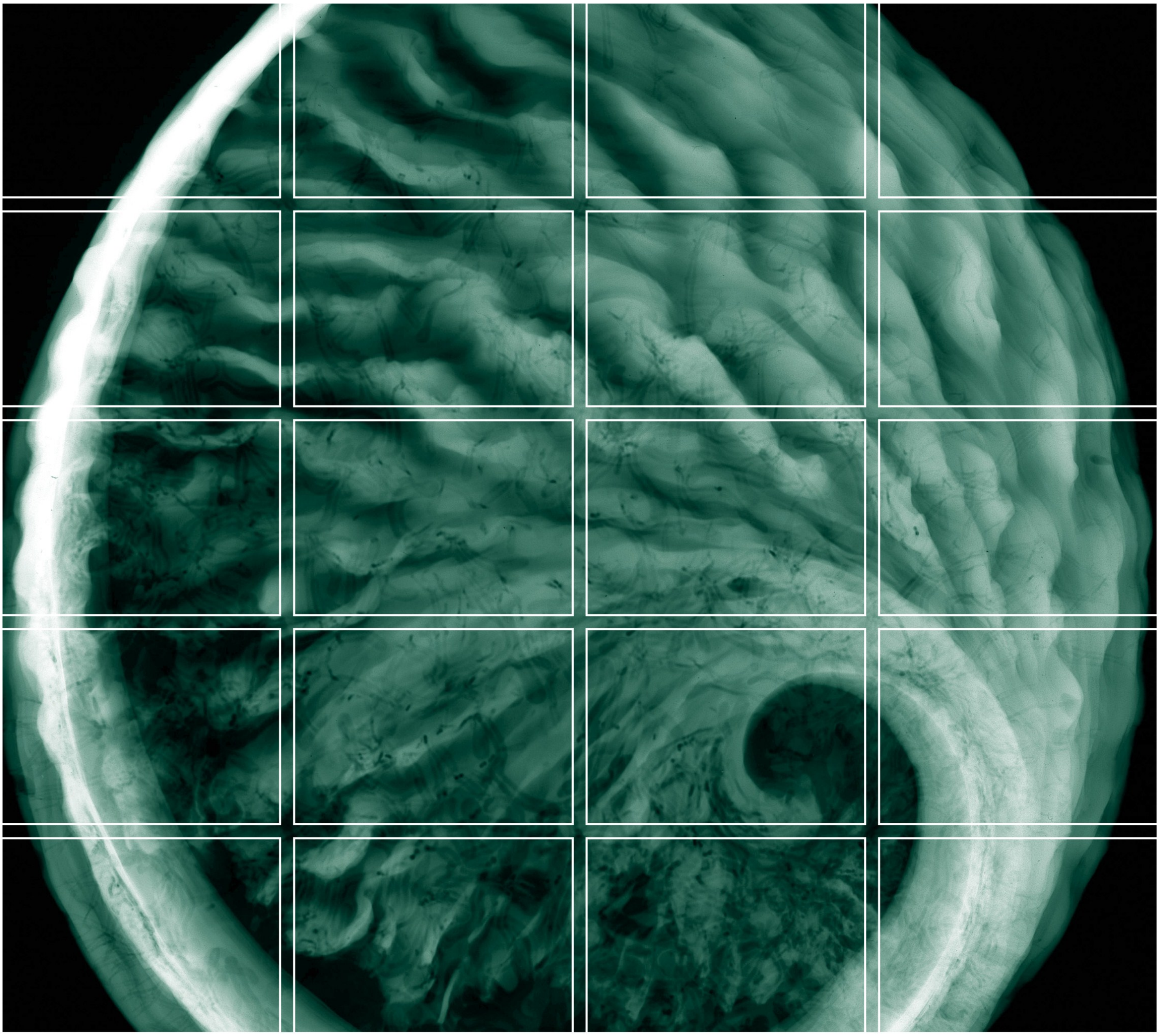
Annex U

Aboriginal Heritage Assessment



NRE No.1 Colliery

Aboriginal Heritage Assessment

NOT FOR PUBLIC DISTRIBUTION

Gujarat NRE Coking Coal Pty Ltd

November 2012

0079383 Aboriginal Heritage - FINAL

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NRE No.1 Colliery

Aboriginal Heritage Assessment

Gujarat NRE Coking Coal Pty Ltd

November 2012

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Approved by:	*Thomas Muddle*
Position:	Project Manager
Signed:	
Date:	*30 November 2012*
Approved by:	*Steve O'Connor*
Position:	Principle
Signed:	
Date:	*30 November 2012*

Environmental Resources Management Australia Pty Ltd Quality System

Certified System
Quality
ISO 9001
SAI GLOBAL

Quality-ISO-9001-PMS302

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EXECUTIVE SUMMARY

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Gujarat NRE Coking Coal Pty Ltd (NRE), to prepare an Aboriginal Heritage Assessment for the consolidation and continuation of mining operations at NRE No.1 Colliery.

The Study Area for this assessment focuses on areas with the potential for surface disturbance resulting from mine related subsidence. The Study Area is divided into two geographically separate areas. The eastern Study Area, referred to as the 'Wonga East Study Area', encompasses the proposed Wonga East mining area and adjacent land. The western Study Area, referred to as the 'Wonga West Study Area', encompasses the Wonga West and V Mains mining areas and adjacent land, as shown in Figure 1.2. A search of AHIMs database revealed 50 recorded Aboriginal sites within the Study Areas. Fifteen of these sites are within the potential subsidence footprint.

The iterative mine planning process involved consideration of longwall options in light of archaeological constraints, in order to avoid impact to areas of high conservation value. The proposed mine plans have avoided or modified longwall extraction directly under third and fourth order creeks (Seedsman Geotechnics 2012), with the exception of Central Creek in Wonga West and within proximity to Cataract Dam. This approach has enabled a large number of significant Aboriginal sites to be avoided, particularly those sites located adjacent to Cataract Dam. The avoidance strategy has ensured that thirty five sites within the Study Area are not within the potential subsidence footprint.

The Study Area was surveyed on foot by the study team and Aboriginal representatives. Owing to the difficult terrain and low ground surface visibility in much of the Study Area, the survey targeted the location of the previously recorded archaeological site and creek lines.

A total of 56 sites have been identified within the study area, of these six new sites were identified through field survey within the potential subsidence footprint. Fifteen AHIMS registered sites were relocated including 13 rock shelters, one grinding groove site and one artefact scatter.

All sites within the potential subsidence footprint were assessed for significance and potential risk and given an impact assessment score. Four sites are of high archaeological significance and five sites are of moderate archaeological significance. Where high or moderately significant sites are at moderate or high impact risk they will be actively managed. There are five site types present within the potential subsidence footprint. These are axe grinding grooves, artefact scatters, scarred trees, water holes and rock shelters. These will be managed in different ways as the subsidence may impact these sites in different ways. The enclosed sites may collapse, while the open sites may crack or be impacted by tilt. Monitoring and archival recording will be undertaken at these sites. There are four sites with moderate significance and moderate risk including one shelter with art and three shelters with deposits. These sites will be relocated where possible and there AHIMs cards updated.

1 INTRODUCTION

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Gujarat NRE Coking Coal Pty Ltd (NRE), to prepare an Aboriginal Heritage Assessment for the consolidation and continuation of mining operations at NRE No.1 Colliery in the Southern Coalfields (the 'Project'). The Project Application Area (PAA) comprises Consolidated Coal Lease (CCL) 745, Mining Purposes Lease (MPL) 271 and Mining Lease (ML) 1575. A locality map showing the PAA and the extent of the relevant lease areas is presented as *Figure 1.1*.

Extensive underground mining has been undertaken within the PAA, dating from the early twentieth century; however a substantial volume of high quality coking coal resource remains, along with some thermal coal.

The proposal is a Major Project under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and relevant Director General's Requirements (DGRs) were issued on 18 August 2009. Supplementary to the DGRs, the Office of Environment and Heritage (OEH), (formerly Department of Environment, Climate Change and Water (DECCW)) provided specific requirements for the Project on 1 September 2009.

In regards to Aboriginal Heritage the DGRs include the assessment of:

Heritage – including the potential Aboriginal and non-Aboriginal heritage impacts of the project, both within the surface infrastructure areas and proposed mining area;

ERM's approach to the preparation of the detailed site assessment was based on the following requirements and current best practice guidelines:

- the DGRs;
- OEH correspondence and subsequent discussions with OEH to clarify requirements;
- National Parks and Wildlife Service (NPWS) Aboriginal Cultural Heritage: Standards and Guidelines Kit (draft 1997);
- Department of the Environment and Climate Change (DECC) Interim Community Consultation Requirements for Applicants (2005);
- DECC Guide to Determining and Issuing Aboriginal Heritage Impact Permits (2009);
- DECC Operational Policy: Protecting Aboriginal Cultural Heritage (2009); and
- the Australia ICOMOS Burra Charter 1999 (Burra Charter).

1.1 NRE NO.1 STUDY AREA

The Study Area for this assessment focuses on areas with the potential for surface disturbance resulting from mine related subsidence. In accordance with the Southern Coalfields Inquiry, land within 600 m of the underground extraction area and associated potential subsidence footprint have been included in the Study Area. The Study Area is divided into two geographically separate areas. The eastern Study Area, referred to as the 'Wonga East Study Area', encompasses the proposed Wonga East mining area and adjacent land. The western Study Area, referred to as the 'Wonga West Study Area', encompasses the Wonga West and V Mains mining areas and adjacent land, as shown in *Figure 1.2.*

The Russell Vale Site contains the coal handling facilities. An Aboriginal Heritage assessment of this site has also been prepared. This is presented in *Annex A.*

1.2 AUTHORSHIP

Dr. Tim Owen (ERM archaeologists) prepared the environmental and archaeological background reviews (Chapters 3 and 4). Dr. Luke Kirkwood (ERM archaeologist) undertook the Aboriginal heritage field survey and prepared Chapters 5. Dr. Diana Neuweger (ERM Heritage Consultant) undertook fieldwork and authored Chapters 6 to 8.

1.3 REPORT STRUCTURE

This report is structured in the following way:

Chapter 2 Aboriginal community consultation;

Chapter 3 Environmental background relating to the Study Area;

Chapter 4 Archaeological context, including known and potential heritage sites within and near the Study Area;

Chapter 5 Survey methodology, results of the field survey and significance assessment of heritage sites located within the Study Area;

Chapter 6 The impact assessment;

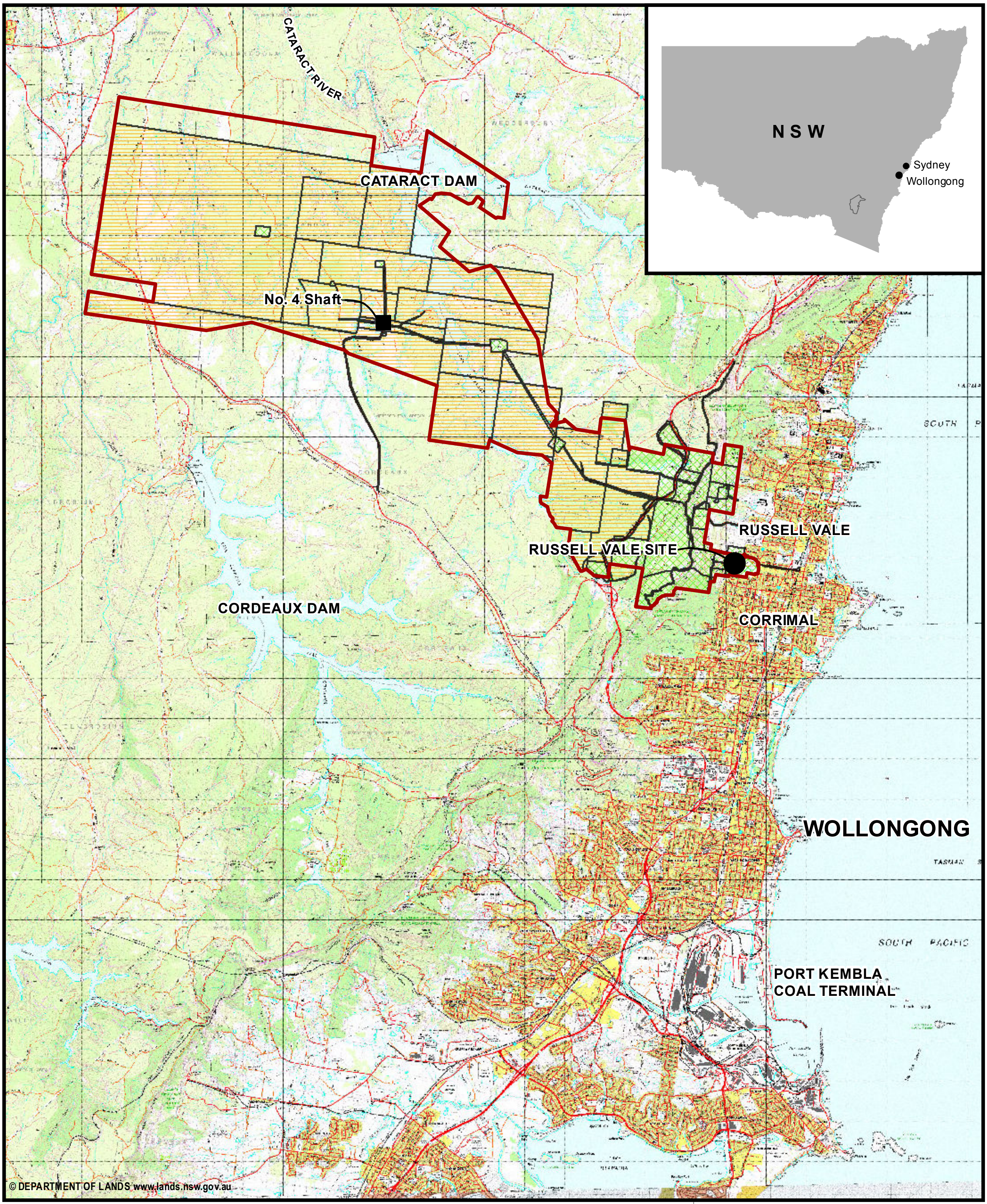
Chapter 7 NSW legislative framework and statutory requirements; and

Chapter 8 Heritage management and impact mitigation recommendations.

Annex A Russell Vale Site Aboriginal Heritage Assessment; and

Annex B Log of the stakeholder consultation undertaken for the project.

Annex C Legislation



Legend

- Project Application Area
- Surface Lease
- Underground Lease

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No. 1 Colliery EAR Post Adequacy 2012 Aboriginal Heritage Assessment
Drawing No:	0079383s_AHA_GIS009_R0.mxd
Date:	26/03/2010 — Drawing size: A4
Drawn by:	JF — Reviewed by: MK
Scale:	Refer to Scale Bar

N

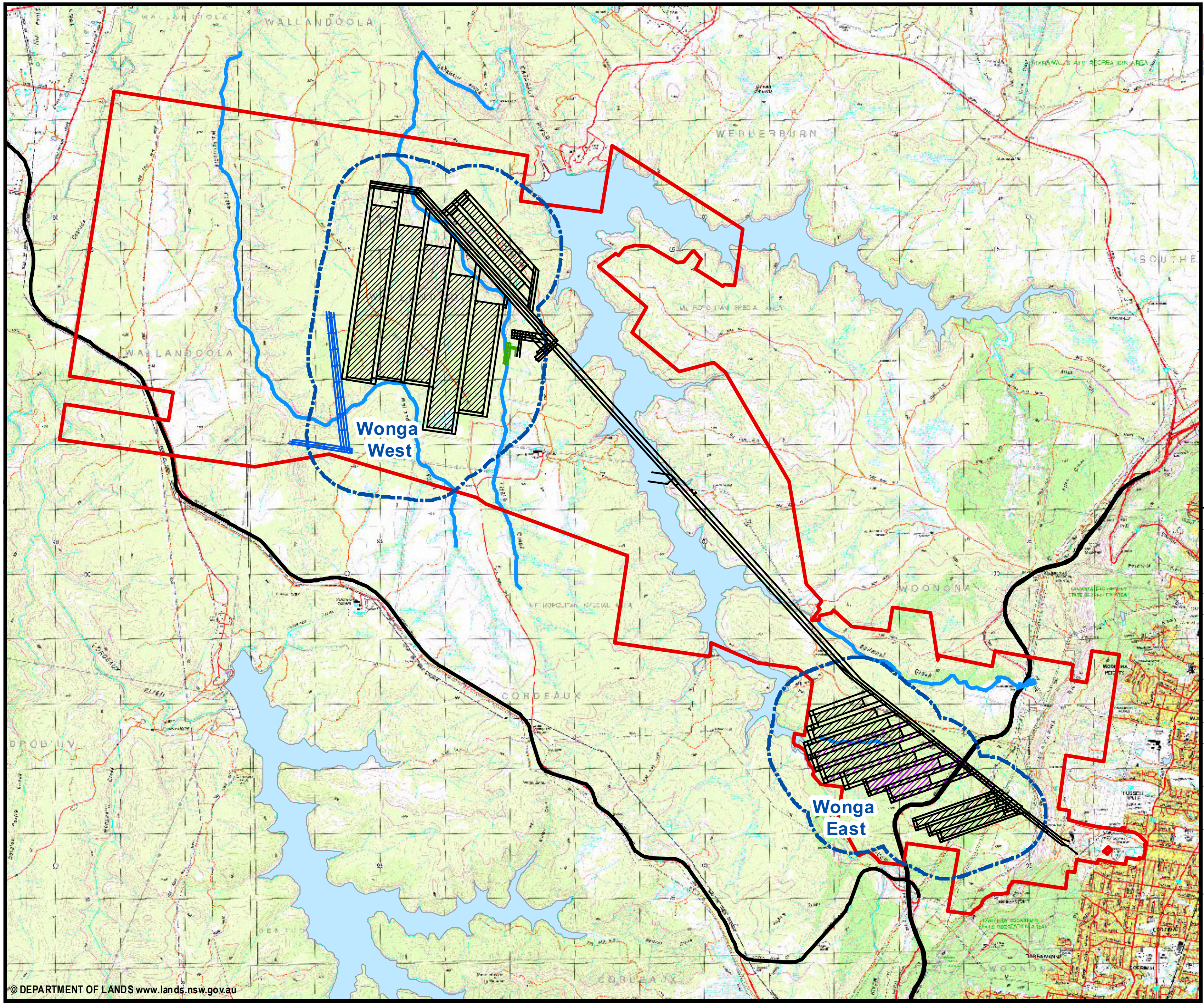
0 1 2 3km

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Figure 1.1
Locality Map

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie,



Legend

- Project Application Area
- Study Areas
- Proposed Longwalls
- Subject to separate application (MP 10_0046_MOD 1)
- Proposed Bulli Seam first workings
- Proposed Balgownie Seam first workings
- Major Road
- Creek/River

Figure 1.2
Study Areas

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No. 1 Colliery EAR Post Adequacy 2012 Aboriginal Heritage Assessment
Drawing No:	0079383s_AHA_GIS007_R2.mxd
Date:	12/09/2012 — Drawing size: A4
Drawn by:	SQW — Reviewed by: MK
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2 ABORIGINAL COMMUNITY CONSULTATION

This chapter contains details of Aboriginal community consultation with regard to ERM's heritage assessment of the project.

Aboriginal consultation is required for any assessment of Aboriginal heritage. The OEH requires consultation to be undertaken in accordance with the 'Interim Community Consultation Requirements Guideline' (2005).

The interim guideline sets out a process for inviting Aboriginal groups to register interest as a party to consultation (including the placing of local press advertisements), seeking responses on the proposed assessment methodology and seeking comment on proposed assessments and mitigation measures. The interim guidelines require proponents to allow ten working days for Aboriginal groups to respond to invitations to register, and then 21 days for registered Aboriginal parties to respond to a proposed assessment methodology. Additional time should be allowed for groups to review a draft report and comment on the results and management recommendations.

The Aboriginal community consultation for this project has been carried out in accordance with the OEH guideline. The complete log of all communications between ERM and local Aboriginal stakeholders is presented in *Annex B*.

2.1 CONSULTATION FOR FIELD SURVEY

Letters requesting advice on Aboriginal organisations to consult, and any known heritage issues to be taken into consideration in the area, were emailed on 3 October 2008 to:

- OEH;
- Registrar, *Aboriginal Land Rights Act 1983* (NSW);
- Illawarra Local Aboriginal Land Council (ILALC); and
- Wollongong City Council.

A local press advertisement requesting local Aboriginal stakeholders interested in being consulted, was run in the Illawarra Mercury newspaper on 10 October 2008. Responses to the advertisement and advice on consultation suggested that five Aboriginal groups were interested in the assessment process.

These five groups were:

- Illawarra Local Aboriginal Land Council (ILALC);
- D'harawal Knowledge Holders (DKH);
- Northern Illawarra Aboriginal Collective (NIAC);

- Wodi Wodi Elders Corporation; and
- Kullila Welfare and Housing Aboriginal Corporation.

Each group was provided with a written survey methodology, by post and email, between 6 and 11 November 2008. Comments and fieldwork registration were received from the ILALC, DKH and NIAC. All other stakeholders agreed to the proposed methodology, but did not provide the requested information and insurances.

ILALC provided a letter to ERM stating that NIAC are not recognised as representing the Illawarra Aboriginal community, and that NIAC therefore cannot speak on behalf of 'country' and do not represent the views of the local Aboriginal community. The letter is provided in *Annex B.*

NRE representative Dr Chris Harvey was provided with a list of Aboriginal stakeholders and information forwarded by the community groups. Aboriginal group selection and engagement was undertaken by NRE.

Further details of the Aboriginal consultation are provided in *Annex B*.

The field survey aimed to target areas of Aboriginal archaeological potential based upon the initial desktop assessment, particularly within 100 m of any drainage lines and previously recorded sites.

During the surveys, ERM archaeologists discussed the local Aboriginal heritage values and patterning with the community representatives. This provided an understanding of the local perspective for Aboriginal habitation and subsistence patterns; as well as understanding some local intangible values. When Aboriginal sites were identified, all participants were involved in recording the site, determining its extent and archaeological potential. At the completion of the survey an open discussion was held regarding the sites, the archaeological potential and required investigations in the future. The outcomes of the discussions were agreed upon by all present. The outcomes of this consultation underwrite this heritage assessment.

2.2 *FUTURE ABORIGINAL CONSULTATION*

Copies of the draft report will be sent to all registered Aboriginal groups and Wollondilly Council's Indigenous Heritage Officer and committee for comment and feedback on the content, assessment and recommendations. All comments received from these groups will be appended to this report when received (the appended report will be titled Final 2). Any future work relating to the Aboriginal archaeological mitigation should include consultation with the relevant Aboriginal stakeholders.

3 ENVIRONMENTAL BACKGROUND

The purpose of this chapter is to provide the environmental context that was used in developing a predictive model of potential Aboriginal site locations. Interactions between people and their surroundings are of integral importance in both the initial formation and the subsequent preservation of the archaeological record. The nature and availability of resources including water, flora and fauna and suitable raw materials for the manufacture of stone tools and other items had (and continues to have) a significant influence over the way in which people use the landscape.

Alterations to the natural environment also impact upon the preservation and integrity of any cultural materials that may have been deposited, whilst current vegetation and erosional regimes affect the visibility and detectability of Aboriginal sites and objects. For these reasons, it is essential to consider the environmental context as a component of any heritage assessment.

3.1 ENVIRONMENTAL CONTEXT

3.1.1 Physical Description and Geology

The Study Area is located within the Southern Coalfield of the Sydney basin. The stratigraphical series in the area is formed by a near-horizontal to gently folded succession of sandstones, shales, claystones and coal, of Permian to Triassic age. The north westerly plunging South Bulli Syncline is the dominant geological structure at NRE No. 1 Colliery. Major faults are characteristic of the Southern Coalfield.

East of the Illawarra Escarpment, the geology of the PAA comprises Permian age Illawarra Coal Measures, underlain by units of the Shoalhaven Group. Typically the rock types which make up the Illawarra Coal Measures are lithic sandstone, shale, siltstone, tuffs and associated carbonaceous sediments (Geological Survey NSW 1966). The coal seams comprise the Bulli, Balgownie, Cape Horn, Hargraves and Wongawilli seams, in descending stratigraphical order. The Cape Horn and Hargraves seams are too thin to be of economic interest for mining.

West of the escarpment, the Permian deposits are overlain by units of the Triassic Narrabeen Group, comprising sandstone, siltstone, claystone, shale and tuffaceous claystone. Further west and extending across the majority of the PAA, these deposits are overlain by Hawkesbury Sandstone, characterised by quartz sandstone with some shale. There are some relatively small areas where the Hawkesbury Sandstone is overlain by the Liverpool sub group which comprises predominantly shale with some sandstone beds (Geological Survey NSW 1966).

3.1.2 *Landforms*

The PAA extends from the coastal slopes near Russell Vale, west across the Illawarra escarpment and the Woronora plateau. The land above the proposed mining area ranges in elevation from 260 to 400 m above the Australian Height Datum (AHD). The area contains north-western sloping drainage depressions and uplands swamps, plateau surfaces, narrow to gently undulating crests and ridges, and rugged steep slopes and sandstone gorges incised by the deep valleys of the Cataract River and its tributaries (Hazelton and Tille 1990). The PAA is typical of lands flanking the Illawarra Escarpment in the Wollongong region (Land Information Centre 2000).

The major landforms in the south west of the Study Area consist of gentle slopes rising to the south from the various open depressions created by Wallandoola Creek and its tributaries. On the western side of the Study Area, the land slopes more rapidly down to Lizard Creek in the north.

3.1.3 *Soils*

The Russell Vale site is on the Illawarra Escarpment soil landscape, while the majority of the PAA occur west of the escarpment on the Lucas Heights and Maddens Plains soil landscapes (Hazelton and Tille 1990). A small area of the Gymea soil landscape occurs along the north eastern edge of Cataract Dam. The Bundeena soil landscape is present along Bellambi Creek (west from the escarpment).

The diversity of soil landscapes and landforms in the Study Area means that the soil has variable properties. Soil types within the Study Area include podzolic soils (yellow, red, lateritic and gleyed podzolic soils), lithosols, yellow soloths, yellow earths, brown earths, earthy sands, siliceous sands and leached sands (Hazelton and Tille, 1990). Acid peats are present in swamps and areas of poor drainage (Hazelton and Tille, 1990). Soils of the PAA commonly developed from Hawkesbury Sandstone and are typically infertile and acidic with a high erosion hazard (DoP, 2008). Mass movement and rock fall hazards are characteristic of the Illawarra Escarpment, Warragamba and Hawkesbury landscapes.

The NSW Soil and Land Information System was accessed to determine whether any soil technical reports existed for the Study Area. No reports were available within the Study Area. However, two reports were available for the area, within two km of the southern boundary. A summary of the data contained within these reports is shown in *Table 3.1*.

Table 3.1 Soil Technical Reports Relevant to the Study Area

Sample Location #	1	2
Survey/Profile	Wollongong II NHT, Profile No: 17	Soil Landscapes of the Wollongong-Port Hacking 1:100 000 Sheet Survey, Profile 93
Site morphology	Flat on summit surface	Shallow valley floor
Elevation	363 m	Not stated
Lithology	Shale, Sandstone-quartz	Sandstone-quartz
Vegetation	Dry sclerophyll forest	Native vegetation also swamp complex
Layer 1 (m)	A1 0-0.30 - fine light sandy clay loam	0-0.35 – silty loam
Layer 2 (m)	B2 0.3-0.5 - fine sandy loam	0.35-0.62 – sandy loam
Layer 3 (m)		0.62-1.1 – loamy sand

Soil profiles in the area suggest that the upper soil horizons could be relatively deep, especially in lower areas (e.g. adjacent to Lizard Creek). The thick vegetation cover in much of the area is likely to have helped prevent erosion, which if it occurred could cause disturbance to Aboriginal archaeological sites in the upper horizons.

3.1.4 Hydrology

The availability of water has significant implications for the range of resources available and the suitability of the area for human occupation. The Study Area is adjacent to the Cataract River, which even prior to damming would have been the major reliable water source for the immediate area. Watercourses of third order and above (according to the Strahler classification scheme) over the proposed underground mining areas include the old Cataract River and Bellambi, Lizard and Wallandoola Creeks. Two additional unnamed third-order drainage lines occur within Wonga West and feed into Lizard Creek.

Near the headwaters, the streams are generally shallow with poorly defined channels, a low bed gradient and upland swamps are present. Downstream, bed gradients increase, elongated pools are present and creeks flow over exposed sandstone bed rock and rock shelves. Deeply incised sandstone gorges flank the creeks at some points, this is most noticeable at Lizard Creek and these conditions have led to the formation of a number of sandstone overhangs. Cataract, Bellambi, Lizard and Wallandoola Creeks have been undermined by past coal mining, within and/ or upstream of the PAA. Land east of the Illawarra Escarpment, including the Russell Vale site, drains to Bellambi Gully which flows through the Russell Vale site and the suburb of Bellambi before discharging into the South Pacific Ocean at Bellambi Beach.

Upland swamps occur along the drainage lines, in flat sections and can form sediment deposition behind choke points in the stream. Swamps have a major role in regulating the flow and water quality of perennial streams.

Upland swamps in this region are diverse and are key habitats for a wide variety of fauna that are unique to swamps. Swamps were a key resource zone for Aboriginal peoples, providing a wide variety of edible plants and fauna species.

3.1.5 Flora and Fauna

The Study Area is on the Illawarra plateau elevated 400 m above the coastal plain, foothills and the lower and upper slopes of the escarpment. The plateau is incised with deep valleys and covered with dense native vegetation. The plateau consists predominantly of Hawkesbury sandstone some of which has eroded to reveal the underlying Narrabeen sandstone.

Fertile pockets of clay and shale have allowed rainforests to develop; other vegetation communities include dry and wet sclerophyll forest and upland swamps. The upland swamps are able to support moorland species such as sedges, melaleuca and banksia.

Some of the animal species present across the plateau include: large brown hawk sugar gliders, quail, brown snake, red wallaby, echidna, brush bronze wing, pheasant coucal, platypus, currawong, red bellied black snake, dove, death adder, crow, magpie lark, white throated swift, heath monitor, white cockatoo and pied currawong (after DEC Undated B: 80-104).

Plant species included: maiden's blush, three-veined myrtle, dog wood, water gum, mopoke, silvertop ash, blackbutt, smooth-barked apple, Sydney golden wattle, blackwood, Port Jackson pine, white maple, prickly current bush, rough tree fern, soft tree-fern, prickly tree-fern, giant lily, Gymea lily, blueberry ash, messmate, native cherry, native geranium, native mulberry, red devil, mountain devil, paper bark, bracelet honey-myrtle, broad leaved and narrow leaved geebung, five corners, waratah, grass tree (after DEC Undated B: 80-104).

It has been recorded that local Aboriginal peoples used these plants and animals as part of their economy. The DEC (Undated B) also provides the seasonal availability, part of the plant used and possible uses, i.e. medicine, food, indicators of insects or animals etc.

3.2 *SYNOPSIS OF ENVIRONMENTAL BACKGROUND*

The environmental assessment of the site indicates that the underlying geology presents a context that was favourable for the creation of Aboriginal sites. Outcrops of sandstone on hill slopes can form overhangs that were favourable camping locations and used as art sites, the aspect of which, often presented views of water resources. The horizontal outcrops of sandstone revealed by water erosion caused by the creeks and tributaries would have provided useful locations to sharpen stone axes and thus lead to the formation of grinding grooves over time.

The numerous water resources in the area, including Wallandoola and Lizard Creeks and their associated swamplands, would have provided habitat for numerous species of fauna and flora which would have been exploited by Aboriginal peoples for food, medicines and implement making.

Within the majority of the PAA (outside of surface lease areas), soils in the area are likely to be relatively deep and undisturbed and only minor disturbance has occurred in relation to the construction of access roads, mining infrastructure and bushfires. As a result, any archaeological sites are likely to be well preserved.

4 ABORIGINAL HERITAGE BACKGROUND

4.1 ARCHAEOLOGICAL BACKGROUND

4.1.1 *Regional Ethno-History*

Archaeological studies have confirmed that Aboriginal people have occupied the Australian sub-continent for at least 40,000 years (c.f. Allen and O'Connell 2003). This date is frequently challenged however, with tentative indications that occupation may extend back into the early Pleistocene.

However, such early dates for the Sydney basin and surrounds have not been established. The earliest proven occupation dates in the Illawarra area are around 20,000 BP. Scientifically verified dates have been obtained from rock shelters near the Nepean River (14,700 BP; cited in Attenbrow 2002 and Flood 1999); from sites along the current Shellharbour coast (17,000 BP; cited in Attenbrow 2002 and Flood 1999); a rock shelter on Burrill Lake (20,760 BP; Lampert 1971 cited in Flood 1999), and a date of 17,000 BP has been returned from a shell midden site at Bass Point (Steele 2006).

Late Pleistocene dates, obtained from Holocene 'coastal' locations, represent Aboriginal Pleistocene occupation of hinterland locations (sea levels during the Pleistocene were lower than today, with the sea positioned around 16 km further east).

These early dates confirm a long history of Aboriginal occupation across the Illawarra region. Aboriginal occupation in the region has created an enduring and rich archaeological record; see the discussion relating to the archaeological record below. However, historical records relating to Aboriginal culture, at the time of European colonisation, are limited. Individuals, such as Tench (1793) and Matthews (1901) recorded facets of Aboriginal culture and language; albeit often as a secondary component to their primary research or objectives. Others, such as Tindale (1940; 1974), whilst aiming to record Aboriginal culture, could unfortunately, only record a social system which had been greatly altered during the preceding 150 years. Coupled with the inherent biases of western culture and society, the historical accounts are sometimes incorrect and/or lacking in detail.

However, coupling the available written documents with the archaeological record and oral histories (from descendents of the original inhabitants); allows a picture of Aboriginal society, demography and economy to be developed. The consequential account can be used to assist with interpreting and deciphering Aboriginal sites and their ancient landscape context.

4.1.2 *Local Ethno-History*

The regional social organisation of the Illawarra Aboriginal groups has been understood from oral histories, early historical accounts and linguistic studies. The tribal group in the Illawarra area, prior to European occupation, was the

Wodi Wodi (DEC Undated B; 2005 and Tindale 1974) who spoke a variant of the Dharawal language (*Tharawal* across the current Study Area [Mathews 1901:127]). The Dharawal name derives from traditional stories, which tell of the people's arrival in the mouth of Lake Illawarra bringing the Cabbage Tree Palm (Dharawal) with them from the north (DEC Undated B: 5).

Groups of Dharawal inhabiting the Illawarra were probably composed of small units (also referred to in the literature as bands/tribes/clans or named groups), comprising individuals who spoke a similar language. A group may have been composed of one or two adult males and their 'wives' and dependants (McDonald 1992). The groups of people undertook localised social interaction between themselves (such as marriage); whilst numerous groups formed larger units (bands or clans) that gathered resources, traded and held regional gatherings (Attenbrow 2002).

Local Aboriginal population density prior to European settlement is not clearly understood (as for most of Australia) and it is believed that Illawarra local groups were decimated early in European history from introduced diseases (Organ 1997). Official European settlement in the Illawarra began in 1816 once a government land survey had been conducted (DEC 2005). DEC states that 'Dr. Charles Throsby moved cattle into the area in 1815 via the Bulli Pass with the assistance of stockman Joseph Wild and two Aboriginal guides (possibly Bundle and Broughton). The first five land grants for the Illawarra were issued in late December 1817' (2005:14).

Settlement in the Illawarra by Europeans had a profound effect on Aboriginal society and economy. Land grants adjacent to the larger fresh water resources, clearance of forests and the commencement of agriculture would have restricted Aboriginal access to food and land. The introduction of exotic plants and animals resulted in a significant alteration to (and prevention of) traditional land care practices (such as bush burning). This impacted the social, political and cultural balance which existed between the Aboriginal groups. The result was enmities between the Illawarra Dharawal speakers and the Bong Bong, Broughton Creek, Kiama and Shoalhaven Dharawal speakers (DEC 2005:16).

The pattern of pre-European Aboriginal society and economy across the Illawarra is far different from that recorded during the nineteenth century. Aboriginal economy across the Illawarra was split with people referring to themselves as 'fresh water' or 'salt water' people; depending on whether they occupied the coastal or plateaus and inland river valleys (DEC Undated B: 5). The Study Area is located within a landscape defined as plateau. Environmental conditions on the plateau are described on the following pages.

Water, stone, clay, plant and animal resources were the raw materials utilised, collected and mined by the Illawarra Dharawal people. These materials (such as ochre, silcrete and basalt), were traded with neighbouring groups. Water was a key resource, and whilst plentiful within the flatter landscape adjacent to the coast, could be scarce on the higher plateau. To allow habitation within the inland areas, the Dharawal incised sandstone platforms with channels to drain water into carved wells (DEC Undated B: 11).

Resource gathering and patterns of habitation were influenced by the season. Knowledge of food resources influenced the timing for journeys, gatherings and festivals. An intricate knowledge of edible plants, their medicinal uses and practical applications was held by the Dharawal. Artefacts such as spears, shields and canoes were made from timbers, gums and resins. Nuts, feathers, teeth, ochres, animal skins and plant fibres were used to create decorative clothing, cloaks and ornamentation (DEC Undated B: 12).

Extensive use of resources created a visible symbology across a group's landscape (some of which may still remain today). For instance, the Dharawal identified distinct landforms from a distance by the colouring and form of trees (which were sometimes assigned uses by gender); ceremonial areas were defined spatially through carved trees; burials were also marked in such a way. During gatherings, trees were marked to designate camping areas for visiting groups (who may stay for weeks or months) (DEC Undated B: 13). Many uses of natural materials will not have resulted in an archaeological signature, e.g. smoke from leaves was used for communication over long distances; or annual indicators observed in plants or animals told people when they were in season or available. These cultural aspects would have resulted in use of resources, or actions of people, for which there may be a physical record (such as the resulting sites).

4.1.3 Local Archaeological Context

A literature review of the OEH library (and additional reports held by ERM) was undertaken to understand the broader region's archaeological patterning. This review was targeted to those reports relevant to the Study Area. Key word searches were used to find reports for the locality in AHIMS.

The majority of South Coast, Illawarra based, heritage studies have concentrated on the coastal and estuarine zones (discussed in Navin Officer 2006). These studies have either been compiled as heritage or impact studies for the development sector or as local studies by an interest group.

Previous archaeological research in the Illawarra area suggests that Aboriginal sites are very common along the coastal plain. More recent research, triggered principally by mining environmental assessments, has started to identify and record Aboriginal sites across the Illawarra's hinterland. Aboriginal sites in this landscape context have been associated with resources, such as food and fresh water.

Archaeological models for Aboriginal Holocene occupation in the Illawarra region have been developed by a number of researchers. Most models suggested ridgelines were used as they provide access routes through the difficult hinterland terrain. Flat areas and saddles were favoured for repeat visits and would have been a focus for occupation activities, possibly resulting in an archaeological signature in these areas.

A brief overview of Aboriginal sites types (from the wider recorded pattern in the OEH's AHIMS) suggests that most Aboriginal sites are lithic sites, rock shelters with art and deposits and grinding grooves. A general connection appears to exist with shallow shelves of sandstone located on the upper reaches of ridgelines, which create small overhangs that were attractive locations to Holocene Aboriginal people.

Of direct relevance to the current assessment (in terms of archaeological content and proximity) are two academic studies (Sefton 1998; McDonald 1994) and five consultants' studies (Saunders 1997, 1998; Biosis 2005, 2007a, 2008a). A further two studies define the observed impacts on Aboriginal heritage sites resulting from long-wall mining (Biosis 2007b, 2008b). A review of these reports is provided in *Table 4.1*.

Table 4.1 Previous Studies within the immediate region

Author	Type of archaeological work	Locality	Details of sites recorded
Sefton (1988)	Masters thesis (Unpublished)	Illawarra Escarpment	Focused on data collected by the Illawarra Prehistory Group, who between 1970 and 1988 recorded hundreds of Aboriginal shelter sites. Sefton's study area comprised 351 km^2 from the Illawarra escarpment (east) to the Woronora River (north), Cataract Catchment (south) and Wallandoola River (west). The outcomes of the work were a high incident of recorded grinding grooves in the Georges River Basin than the Cataract River Basin; suggesting a higher population density in the former. It was noted that rock engravings were found in the same locations as grinding grooves, although a higher incident of engravings were noted in coastal locations.
Sefton (1993a)	Aboriginal Heritage Assessment	North of Mount Keira Rd	The study area consisted of 600 hectares on the northern side Mt Keira Road. Four sites were noted as occurring in the area: two axe grinding grooves, a shelter with deposit and axe grinding groove, and a shelter with art and axe grinding groove.
Sefton (1993b)	Aboriginal Heritage Assessment	Cordeaux Colliery	The study area consisted of 500 hectares mainly on the northern side of Mt Keira Road (with a small part on the southern). Sixteen sites were recorded: seven axe grinding grooves, six shelters with art, two shelters with deposit and one shelter with art and deposit.

Author	Type of archaeological work	Locality	Details of sites recorded
McDonald (1994)	PhD Thesis (Published)	The Hawkesbury sandstone formation within the Sydney Basin	PhD thesis focusing on prehistoric rock art across the Sydney region. A number of points relevant to the current study area were drawn including: only 7% shelters with art contained deposits; 28% of shelter sites with deposits also contained grinding grooves; the majority of the art is depictive (66%), stencilled (33%) and only two of the sites (from 181) contained rock engravings; around half (41%) of motifs were unidentifiable (because of rock preservation); of the identifiable motifs, 49% were hand stencils or variants therein, 9% were macropods, 7% anthropomorphs, 6% other land animals. The majority of art was created by charcoal (or other dry pigment) stencilling, a few were painted; barely any used both techniques. The overall findings suggested that there was a major variation between the rock art techniques and motif types between the Woronora plateau and the central and northern areas of the Sydney basin.
Navin Officer (1995)	Aboriginal Heritage Assessment	Lake Cataract	The survey area consisted of three subsidence lines on the eastern and western sides of Lake Cataract: 42% of Line 1 was surveyed, as was 88% of Line 2 and 51% of Line 3. No sites were recorded.
Navin Officer (1999a)	Aboriginal Heritage Assessment	Lake Cataract	The survey area consisted of land on the eastern and western sides of Lake Cataract, with attention focussed on rock exposures along watercourses, and mature trees. Particularly focus was on landform features most at risk of subsidence (sandstone rock shelters, overhangs and platforms). One previously recorded site (a shelter with art) was relocated during the survey. No additional sites were found.
Navin Officer (1999b)	Aboriginal Heritage Assessment	Cordeaux Colliery	Survey of 366 ha on the northern and southern sides of Mount Keira Road, and further south east for a pipeline and borehole. Five previously recorded sites existed in this area (three axe grinding grooves, a shelter with art and an isolated find). Five additional sites were found: three shelters with art and two axe grinding grooves.
Navin Officer (2000)	Aboriginal Heritage Assessment	Cordeaux Colliery	The survey area consisted of land on the western side of Lake Cataract, with attention focussed on rock exposures along watercourses, and mature trees. Twelve recorded sites existed in this area: seven shelters with art; four shelters with art and deposit; and one axe grinding groove site. Two additional sites were recorded: a shelter with art and deposit, and a shelter with art.

Author	Type of archaeological work	Locality	Details of sites recorded
Sefton C. 2000	Monitoring study of effects of subsidence to archaeological sites	Woronora plateau	51 overhangs were monitored to determine effects of underground mining. Five showed changes. Four showed evidence of movement (crack or opening) as well as flaking, block fall and cracking of associated surfaces. One had water damage to the rear wall of the cave. There was no indication of deposits being affected by subsidence. It was noted that the main threat to panels containing the art was the effects of cracking or flaking.
Navin Officer (2001a)	Aboriginal Heritage Assessment	Wallandoola Creek	The survey area consisted of land north and east of Wallandoola Creek, with attention focused on rock exposures along watercourses, and mature trees. Particular focus was on landform features most at risk of subsidence (sandstone rock shelters, overhangs and platforms). Four previously recorded sites were within the survey area (two shelters with art, one axe grinding groove site and one shelter with art and deposit and axe grinding grooves). Five additional sites were found (two shelters with art, one shelter with art and deposit, one axe grinding groove site and one isolated find). Ten PADs were also identified.
Navin Officer (2001b)	Aboriginal Heritage Assessment	Cordeaux Colliery	The survey area consisted of land on the western side of Lake Cataract, with attention focused on rock exposures along watercourses, and mature trees. Particularly focus was on landform features most at risk of subsidence (sandstone rock shelters, overhangs and platforms). Two shelters with PADs and one shelter with art were found.
Dallas, M. 2002	Archaeological Test Excavation	Stuart Park	116 stone artefacts recovered from three pits. The site was small and was therefore of low significance as it did not hold the potential to contain a statistically strong sample to gain new information.
Navin Officer (2003)	Aboriginal Heritage Assessment	Cordeaux Colliery	No sites were recorded.
Navin Officer 2006	Aboriginal Heritage Assessment	Mt Ousley	No Aboriginal sites were located during survey. Recommended that Aboriginal groups be invited to monitor.
Steele D. 2006	Aboriginal Heritage Assessment	Wollongong	No new sites identified during survey.
Roberts. A 2007	Aboriginal & European Heritage Assessment	Darkes Forest	Two Aboriginal sites identified a scarred tree and an ochre/gypsum quarry with associated artefact scatter and PAD. Minimisation of impact to sites recommended, no disturbance of the PAD and monitoring of the excavation works of the development.

Author	Type of archaeological work	Locality	Details of sites recorded
ERM (2009)	Aboriginal Heritage Assessment	V Mains – NRE No.1 Colliery	Four Aboriginal heritage sites were identified through a OEH) search of the AHIMS) . Two of these sites were able to be relocated during archaeological survey. One site, Wollondoola 2 lies within the subsidence impact zone of the V Mains. This is a rock shelter with grinding grooves and artefacts, considered to have moderate archaeological potential.

4.1.4 *Recent Mining Subsidence Impact Assessments*

Of direct relevance to the current study are the potential impacts from longwall mining subsidence. A number of key reports, by consultants and the NSW Government, have recently been written on the subject. The following review provides a discussion of long wall mining subsidence. This review will be used to underpin the impact assessment portions of this assessment.

Sefton (2000)

Sefton (2000) prepared a ten year monitoring program assessing the impacts of longwall coal mining in the Southern Coal Fields on sandstone overhang Aboriginal archaeological sites. Sefton inspected and monitored a total of 52 sites, prior to, during and after long wall mining (2000:15). The results of the assessment program (and a principle component analysis using 16 variables) were:

- five of the 52 sites had evidence of impacts resulting from mining (2000: 17-18);
- the impacts from longwall mining could be grouped into four categories: cracking, movement along existing joints/bedding planes, block falls and change to the pattern of water seepage through the rock;
- the components associated with most change were: overhang size (especially length); wetness of the overhang; location near the valley bottom; location above the goaf [that part of a mine from which the mineral has been partially or wholly removed]; and block-fall type shelters;
- no monitored overhang collapsed during the study;
- no monitored shelter with an area of less than 50 m^3 has suffered subsidence impacts (irrespective of other risks);
- not all shelters larger than 50 m^3 suffer impacts (only five of the 23 large shelters [>50 m^3]suffered an impact);

- the 'over-riding factor which appears to be significant is overhang size where large overhangs are at greater risk' (2000:38); and
- the impacts caused by subsidence were not observed until at least three months post mining.

Biosis (2007b)

Biosis (2007b) reviewed the potential impacts to cultural heritage sites in the Dendrobium Area 2 Subsidence Management Plan (SMP) area. A single Aboriginal site (a sandstone shelter with art, AHIMS# 52-2-2252) was located, which had moderate significance and was to be subject to a number of subsidence related movement impacts. Site 2252 was located two km south of the current Study Area. The aim of the study was to 'assess the impacts of predicted subsidence on identified heritage sites and recommend management and mitigation measures' (2007b:3).

An assessment of potential impacts to Site 2252 was made. The site was judged to be at some risk because of its large size (>50 m^3), the block fall shelter formation, bedding and jointing planes present, dampness and location directly over a longwall goaf. It was predicted that the site was at some risk from potential impact, because of the compressive and tensile strains were enough to deform the rock and the cliff formation containing the site was in an advanced stage of natural erosion (2007b:32).

Biosis (2008b) provides the results from the assessment, post long wall mining subsidence on Aboriginal Site 2252 undertaken six months post mining.

The results of the assessment showed that the site had suffered some damage attributable to subsidence movement. This damage included: the opening of a pre-existing crack at the base of the back wall; and the down slope slumping of talus and boulders adjacent to the site. Twenty monitoring points were observed; only one of which had changed. The observed change was minor additional opening of a pre-existing crack to a width of 10 mm. Soil cracking and displacement of boulders was observed in the front of the shelter (2008b:7).

Southern Coalfields Inquiry Report

In 2008 an independent inquiry (Southern Coalfields Inquiry (SCI) Report) was established because of concerns held by the Government over both past and potential future impacts of mine subsidence on significant natural features in the Southern Coalfield (NSW 2008). The objectives of the report were threefold:

1. to undertake a strategic review of the impacts of underground mining in the Southern Coalfield on significant natural features (ie rivers and significant streams, swamps and cliff lines), with particular emphasis on risks to water flows, water quality and aquatic ecosystems;

2. to provide advice on best practice in regard to:

    a) assessment of subsidence impacts;

    b) avoiding and/or minimising adverse impacts on significant natural features; and

    c) management, monitoring and remediation of subsidence and subsidence-related impacts; and

3. to report on the social and economic significance to the region and the State of the coal resources in the Southern Coalfield.

This report is of importance to Aboriginal heritage as it provides a basic assessment of potential environmental consequences resulting from subsidence impacts on Aboriginal heritage sites.

The summary of the report stated that:

> *"Aboriginal heritage sites are most at risk of subsidence impacts where they are located in cliff lines and/or rock overhangs. The Panel was not made aware of any significant impacts having occurred on Aboriginal heritage features in the Southern Coalfield since the 1980s (2008: 2)."*

Chapter 4 of the report (*Subsidence impacts on natural features*) includes a review of the type of impacts that can be expected from mining related subsidence. Several types of subsidence impacts were judged to be relevant to archaeological sites:

- rock falls and cliff collapses;
- surface cracking and exfoliation; and
- water table and/or seepage changes (2008: 77).

It was reported that Aboriginal rock shelter and painted art sites in valleys and on cliff lines had the potential to be damaged by cliff falls or rock falls. Axe grinding grooves and engraved art sites were likely to be exposed to cracking of bedrock or creek side strata.

The Inquiry (2008: 84) determined that the *"prediction of the impacts on features of Aboriginal heritage significance is determined, first, by adequate surveys to determine the existence and significance of archaeological or cultural significance… the archaeological sites which are most susceptible to subsidence-induced damage are rock shelters in caves or overhangs, generally associated with cliff lines."*

The impacts on cliff lines (watercourses and valleys) were viewed primarily as being associated with 'non-conventional' subsidence (2008: 82). Therefore the measures of predicting valley closure and upsidence were judged to be the most valuable when determining impacts on these landforms.

The Inquiry determined that predicted valley closure was the most useful subsidence parameter [2008: 83]. It should be noted that current scientific understanding of nonconventional surface subsidence effects (far-field horizontal movements, valley closure, upsidence and other topographical effects) are not as advanced as effects resulting from conventional subsidence [an opinion reflected in NSW 2009].)

Management of impacts to Aboriginal sites arising from subsidence was discussed with OEH (2008: 109). The outcomes of this discussion were a proposed risk based decision model that was 'outcome-based and designed to avoid overly-prescriptive requirements' (2008: 109):

> *"DECC has instead proposed an ecological risk-based standard that addresses threatened species, Aboriginal heritage, upland swamps and other features, in addition to rivers and streams. This model is based on both risk management and risk avoidance. High risks are to be avoided; lesser risks are to be managed. DECC considers that clear and objective criteria with defined 'acceptable limits of change' are needed.*
>
> *It proposes that this be made operational via a decision model that identifies limits of risk acceptability for identified ecological features and potential subsidence outcomes. The model is based on an ecological risk assessment approach that identifies risk values of 'High', 'Medium' and 'Low' and stipulates management measures of 'Prevent', 'Minimise' and 'Proceed with Caution'. In essence, the model establishes qualitative risk standards by ensuring impacts do not exceed a qualitative impact rating. DECC argues that mining companies would then have the flexibility to determine solutions to comply with the required outcomes. DECC stresses that its model is still in infancy and remains 'conceptual' until it can be trialled with mining companies and stakeholders."*

At the time of writing, OEH had not published the risk based decision making tool.

The Inquiry recommended that Risk Management Zones (RMZs) should be identified to focus assessment and management of potential impacts on natural features. In particular they should be identified for all significant environmental features which are sensitive to non-conventional subsidence effects.

Metropolitan Planning and Assessment Commission

The Metropolitan Planning Assessment Commission Report 2009 (MPAC) (NSW 2009) report was prepared for the Metropolitan Coal Project, which was the first mining proposal in the Southern Coalfield to be assessed under Part 3A since the release of the SCI report (NSW 2008). The Aboriginal Cultural Heritage Assessment (prepared for the Part 3A project application) identified 188 Aboriginal heritage sites within the Project Area, of which 142 sites were sandstone overhangs; the remainder were open sites.

The summary presented in NSW 2009 noted that:

> *"the subsidence assessments for the [Aboriginal] sites presented in the EA are based on conventional subsidence. There is no analysis of the non-conventional subsidence effects, albeit that some open sites are located in or close to drainage lines and a number of sites are associated with watercourses. The Panel considers that this does not constitute an adequate degree of assessment for an EA.*
>
> *It appears likely that some sites of Aboriginal heritage and cultural significance will be impacted by the Project and approval conditions will therefore need to incorporate provisions for monitoring all highly significant sites for the purpose of comparing predictions of effects and impacts against measured effects and impacts and implementing mitigation and remediation measures where practical. (NSW 2009:v)*
>
> *Monitoring of predicted versus measured effects, impacts and consequences of both conventional and non–conventional subsidence on a range of significant features including watercourses, groundwater, upland swamps, Aboriginal heritage sites and cliff lines (2009: vi)."*

A detailed review of the Aboriginal Cultural Heritage Assessment (ACHA) report is presented in NSW 2009: Chapter 11. The review included a discussion relating to scientific archaeological versus Aboriginal cultural significance assessment and conventional versus non-convention subsidence impacts on Aboriginal heritage sites.

The review found the impact assessment to be insufficient, and recommended the following be implemented for the future studies (after NSW 2009: 99-101):

- a high level of quantification of Aboriginal sites, with detailed descriptions of a site's shape, dimensions, structure and composition, especially those of higher significance;

- a site specific assessment of high significance sites, having regard to assessment criteria recently adopted in another mining approval (Biosis 2007a,);

- an analysis of conventional and non-conventional subsidence effects, impacts and consequences on Aboriginal sites (subsidence prediction should use the prediction of effects to then predict what impact these effects will have on features of interest [NSW 2008: 78]), using terms that are quantified (not terms such as negligible, very low or low risk); and
- a quantitative link between subsidence impacts and consequences to Aboriginal sites and to the 'back analysis' of actual versus predicted effects and impacts on recorded Aboriginal sites (i.e. the possible inclusion of a monitoring program for all sites of high significance; for the purpose of comparing predictions of effects and impacts against measured effects and impacts and implementing mitigation and remediation measures where practical).

4.1.5 *Study Area AHIMS Data*

A search of the DECC AIHMS database for an area 12 km by 12 km, with the proposed NRE No.1 longwalls at the centre of the search, was undertaken on 17 October 2008. The search identified 254 recorded Aboriginal sites, the substantial majority of which were shelter sites containing a combination of art, archaeological deposits and grinding grooves. This search was refined focussing on the Wonga East and Wonga West Study Areas. Fifty recorded Aboriginal sites are located within the Study Areas with 21 of these sites within the potential subsidence footprint *(Table 4.2)*. The potential subsidence footprint is defined as the area where subsidence is predicted to be greater than 20 mm. *Table 4.3* and *Figure 4.1* and identify the locations of AHIMs listed sites.

Table 4.2 Number of Aboriginal sites within the Study Area

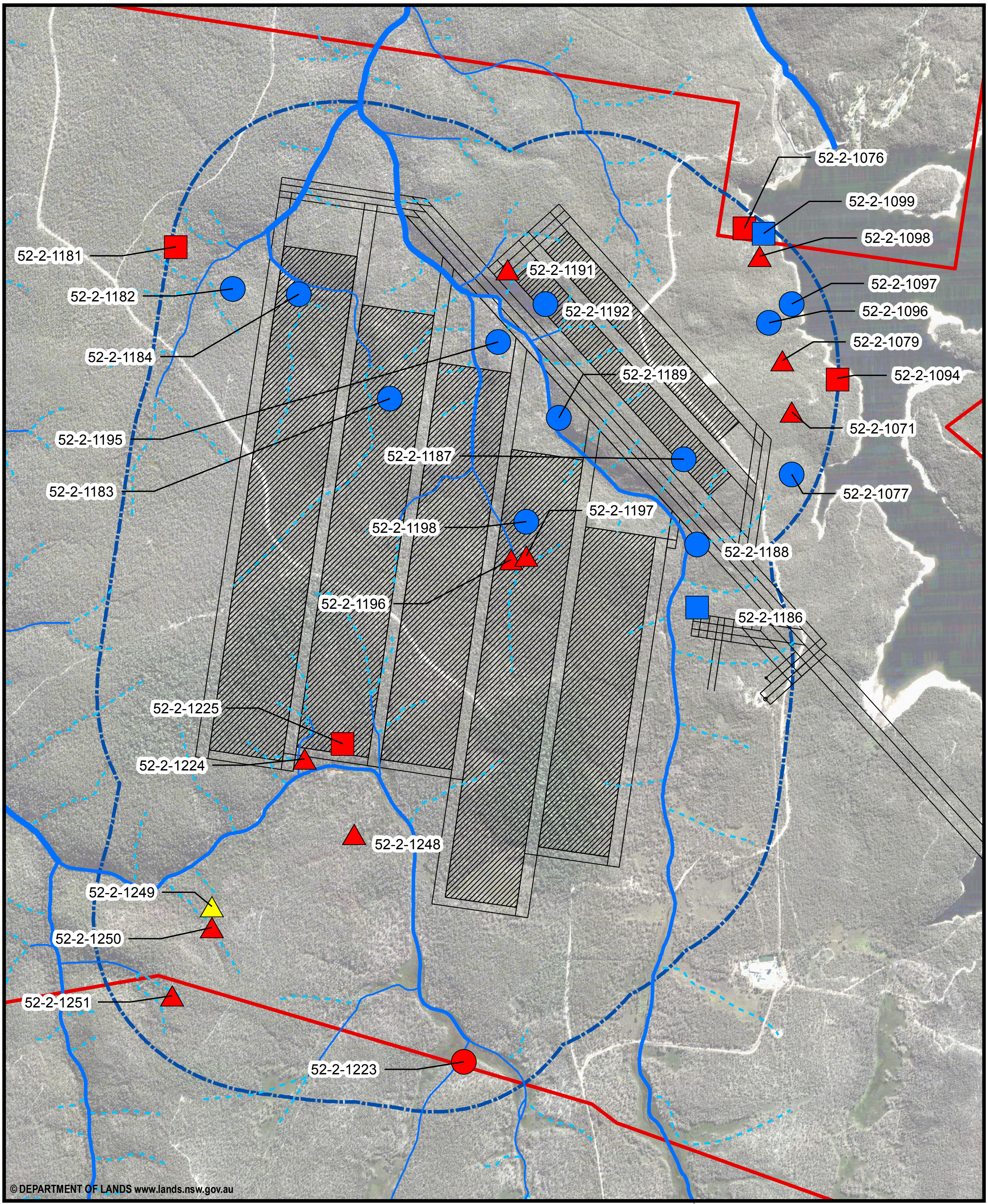
Site Type	Count	Frequency
Artefact Scatter	1	2%
Axe Grinding Groove	14	28%
Shelter with Art and/or Artefacts, Grinding Grooves	35	70%
Total	**50**	**100%**

Table 4.3 AIHMS registered sites within the Study Area

AHIMS Site Id[1,]	AHIMS Site Name	Context	Site Type
Wonga West			
52-2-1071	Gillbird Site 47	Open site	Axe grinding grooves
52-2-1076	Gillbird Site 56	Enclosed Shelter	Shelter with Art and Deposit
52-2-1077	Gillbird Site 48	Enclosed Shelter	Shelter with Art
52-2-1079	Gillbird Site 51	Open site	Axe grinding groove
52-2-1094	Gillbird Site 50	Enclosed Shelter	Shelter with Art and Deposit
52-2-1096	Gillbird Site 52	Enclosed Shelter	Shelter with Art
52-2-1097	Gillbird Site 53	Enclosed Shelter	Shelter with Art

AHIMS Site Id[1,]	AHIMS Site Name	Context	Site Type
52-2-1098	Gillbird Site 54	Open site	Axe grinding groove
52-2-1099	Gillbird Site 55	Enclosed Shelter	Shelter with Deposit
52-2-1181	Lizard Creek Site 17	Enclosed Shelter	Shelter with Art and Deposit
52-2-1182	Lizard Creek Site 16	Enclosed Shelter	Shelter with Art
52-2-1183	Lizard Creek Site 14	Enclosed Shelter	Shelter with Art
52-2-1184	Lizard Creek Site 15	Enclosed Shelter	Shelter with Art
52-2-1186	Lizard Creek Site 1	Enclosed Shelter	Shelter with Deposit
52-2-1187	Lizard Creek Site 3	Enclosed Shelter	Shelter with Art
52-2-1188	Lizard Creek Site 2	Enclosed Shelter	Shelter with Art
52-2-1189	Lizard Creek Site 4	Enclosed Shelter	Shelter with Art
52-2-1191	Lizard Creek Site 6	Open Site	Axe grinding grooves
52-2-1192	Lizard Creek Site 5	Enclosed Shelter	Shelter with Art
52-2-1195	Lizard Creek Site 10	Enclosed Shelter	Shelter with Art
52-2-1196	Lizard Creek Site 11	Open Site	Axe grinding grooves
52-2-1197	Lizard Creek Site 12	Open Site	Axe grinding grooves
52-2-1198	Lizard Creek Site 13	Enclosed Shelter	Shelter with Art
52-2-1223	Wallandoola Site 2	Enclosed Shelter	Shelter with Deposit, and Axe grinding grooves
52-2-1224	Wallandoola Site 4	Open Site	Axe grinding grooves
52-2-1225	Wallandoola Site 3	Enclosed Shelter	Shelter with Art and Deposit
52-2-1248	Wallandoola Site 12	Open Site	Axe grinding grooves
52-2-1249	Wallandoola Site 13	Enclosed Shelter	Shelter with Art, and Axe grinding grooves
52-2-1250	Wallandoola Site 14	Open Site	Axe grinding grooves
52-2-1251	Wallandoola Site 15	Open Site	Axe grinding grooves
Wonga East			
52-2-0083	Bulli Mine Shaft Site 7	Enclosed Shelter	Shelter with Deposit
52-2-0099	Bulli Mine Shaft Site 8	Enclosed Shelter	Shelter with Art and Deposit and axe grinding grooves
52-2-0229	Bulli Mine Shaft Site 12	Open site	Axe grinding grooves
52-2-0233	Bulli Mine Shaft Site 13	Open site	Axe grinding grooves
52-2-0603	Bulli Mine Shaft Site 19	Enclosed Shelter	Shelter with Art
52-2-1081	Gillbird Site 2	Enclosed Shelter	Shelter with Art and Deposit and axe grinding grooves
52-2-1082	Gillbird Site 3	Enclosed Shelter	Shelter with Art
52-2-1095	Gillbird Site 1	Enclosed Shelter	Shelter with Art
52-3-0310	Bulli Mine Shaft Site 18	Enclosed Shelter	Shelter with Art and Deposit and axe grinding grooves
52-3-0311	Bulli Mine Shaft Site 20	Enclosed Shelter	Shelter with Deposit
52-3-0312	Bulli Mine Shaft Site 23	Enclosed Shelter	Shelter with Deposit
52-3-0313	Bulli Mine Shaft Site 29	Open Site	Artefact Scatter
52-3-0314	Bulli Mine Shaft Site 21	Enclosed Shelter	Shelter with Art
52-3-0317	Bulli Mine Shaft Site 22	Enclosed Shelter	Shelter with Deposit
52-3-0318	Bulli Mine Shaft Site 30	Enclosed Shelter	Shelter with Art
52-3-0319	Bulli Mine Shaft Site 24	Enclosed Shelter	Shelter with Deposit
52-3-0320	Bulli Mine Shaft Site 25	Open Site	Axe grinding grooves
52-3-0322	Bulli Mine Shaft Site 31	Open Site	Axe grinding grooves
52-3-0323	Bulli Mine Shaft Site 26	Enclosed Shelter	Shelter with Deposit
52-3-0325	Bulli Mine Shaft Site 27	Enclosed Shelter	Shelter with Art

1. Co-ordinates for sites were estimated off topographical maps by the Illawarra Prehistory Group in the early 1980s. When sites are re-recorded with modern GPS equipment, errors in the original co-ordinates of up to 400 m are not uncommon.



Legend

- Project Application Area
- Study Area - Wonga West
- Proposed Longwalls
- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order and above stream

AHIMS Site Type

- Axe Grinding Groove
- Axe Grinding Groove, Shelter with Art
- Axe Grinding Groove, Shelter with Deposit
- Shelter with Art
- Shelter with Art, Shelter with Deposit
- Shelter with Deposit

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No. 1 Colliery EAR Post Adequacy 2012 Aboriginal Heritage Assessment
Drawing No:	0079383s_AHA_GIS001_R2.mxd
Date:	18/10/2012 Drawing size: A4
Drawn by:	SQW Reviewed by: NB
Scale:	Refer to Scale Bar

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Figure 4.1
AHIMS Sites within the Wonga West Study Area

Environmental Resources Management ANZ

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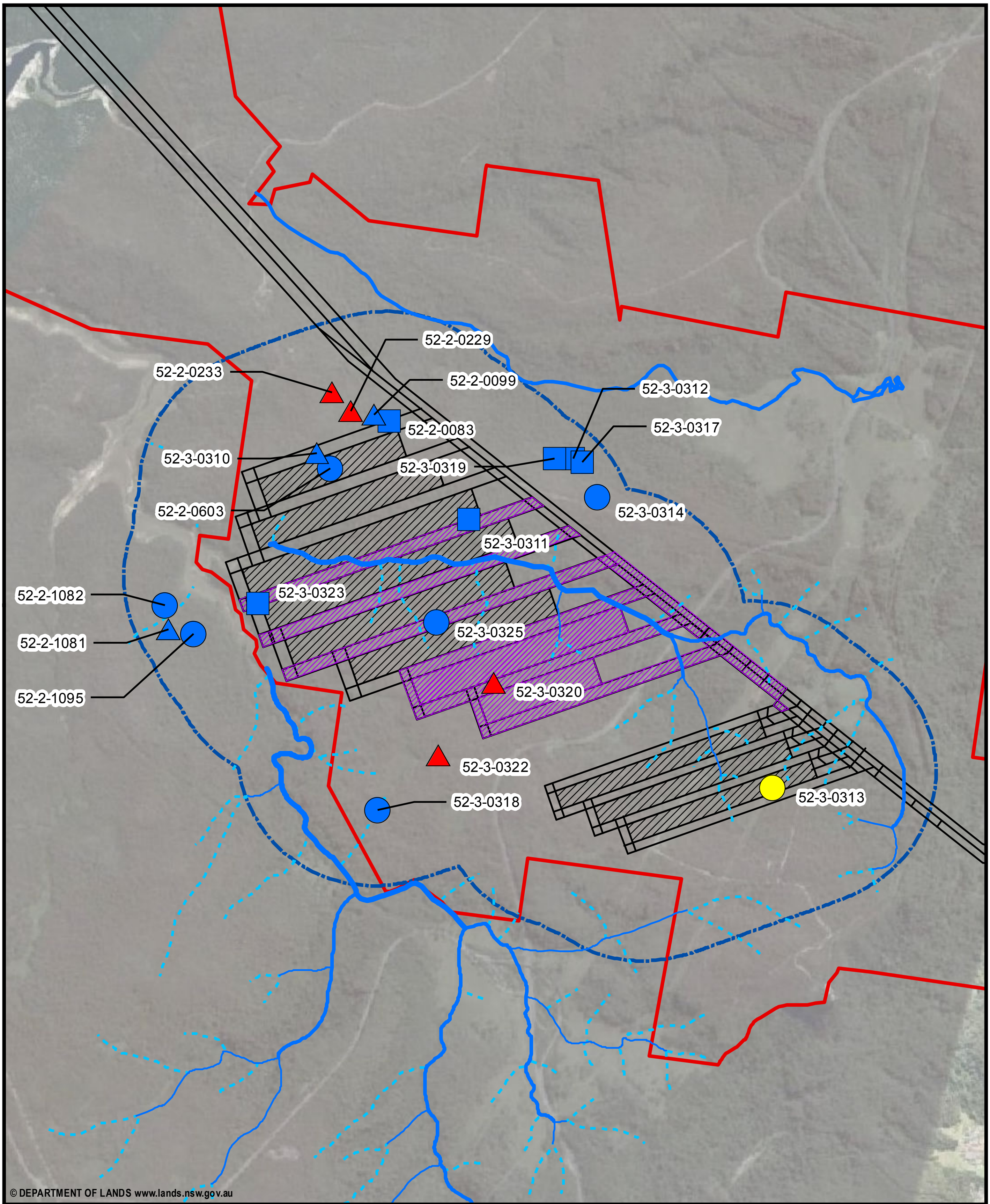

Legend

- Project Application Area
- Study Area - Wonga East
- Proposed Longwalls
- Subject to separate application (MP 10_0046_MOD 1)
- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order and above stream

AHIMS Site Type

- Axe Grinding Groove
- Axe Grinding Groove, Shelter with Art, Shelter with Deposit
- Open Camp Site
- Shelter with Art
- Shelter with Deposit

Client: Gujarat NRE Coking Coal Limited

Project: NRE No. 1 Colliery EAR Post Adequacy 2012 Aboriginal Heritage Assessment

Drawing No: 0079383s_AHA_GIS011_R1.mxd

Date: 09/11/2012 Drawing size: A4

Drawn by: SQW Reviewed by: MK

Scale: Refer to Scale Bar

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Figure 4.2

AHIMS Sites within the Wonga East Study Area

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4.2 *PREDICTIVE ABORIGINAL HERITAGE STATEMENT*

Table 4.4 provides an overview of the most likely site types which could be found within the Study Area.

Table 4.4 Aboriginal sites commonly found in the local area

Site types	Definitions
Stone artefact concentration	Stone artefact concentrations are collections of stone, frequently brought from other areas, which demonstrate evidence for Aboriginal working, use and/or discard of the stone at a single location. Stone artefact concentrations may be associated with any of the site types listed in the table. Where such sites are buried by sediment they may not be noticeable unless exposed by erosion or disturbed by modern activities. These sites may be found in any landform, but are most likely to be associated with waterways, flat landforms and ridgeline. It is expected that some stone artefact concentrations will be present.
Isolated finds	Sites consisting of only one identified stone artefact, isolated from any other artefacts or archaeological evidence (and defined by an arbitrary separation distance of 50 m). They are generally indicative of sporadic past Aboriginal use of a location. A distinction should be drawn between isolated finds which are a component of the background distribution and objects such as axes, hammer stones, grinding dishes etc. which would have been used repeatedly. These sites could be recorded anywhere within the Study Area.
Background distribution	Represents the low density of Aboriginal objects that have been discarded but cannot be associated with concentrations of objects. The background distribution is a record of Aboriginal occupation of an area. The density that defines the background scatter needs to be defined through local comparisons. It is recognised that regionally there is a low density count of background objects recorded across the escarpment.
Shelter sites	Sandstone shelters and overhangs were used by Aboriginal people to provide habitation areas sheltered from the rain and sun. The deposits in such sites are commonly very important because they often contain clearly stratified material in a good state of preservation. These sites are expected to be located within the Study Area.
Grinding grooves	Grooves resulting from the grinding of stone axes or other implements are found on flat areas of suitable sandstone. They are often located near waterholes or creek beds as water is necessary in the sharpening process. In areas where suitable outcrops of rock were not available, transportable pieces of sandstone were used. These sites are expected to be located within the Study Area.
Quarries	These are areas where stone was obtained for flaked artefacts or ground-edge artefacts, or where ochre was obtained for rock paintings, body decoration or decorating wooden artefacts. These sites have a low chance of being located within the Study Area, due to the sandstone geology.

Site types	Definitions
Art sites	Aboriginal paintings, drawings and stencils are commonly to be found where suitable surfaces occur in sandstone shelters and overhangs. These sites are often referred to as rock shelters with painted art. Rock engravings, carvings or peckings are also to be found on sandstone surfaces both in the open and in shelters. These are referred to as rock engraving sites. These sites are expected to be located within the Study Area.
Scarred trees	Scarred trees bear the marks of bark and wood removal for utilisation as canoes, shields, boomerangs or containers. It is commonly very difficult to confidently distinguish between Aboriginal scars and natural scars or those made by Europeans. Scars may also originate as 'foot-marks', small pockets cut into the bark of a tree enabling the tree to be climbed. These sites have a moderate chance of being recorded within the Study Area, but only in areas with old growth trees.
Burial sites	Burials may be of isolated individuals, or they may form complex burial grounds. Often associated with other site types such as middens, or mounds. These sites are not expected to be located within the Study Area.
Stone arrangements, carved trees and ceremonial grounds	These site types are often interrelated. Stone arrangements vary from simple cairns or piles of rocks to more elaborate arrangements; patterns of stone laid out to form circles and other designs, or standing slabs of rock held upright by stones around the base. Carved trees may have intricate geometric or linear patterns or representations of animals carved into their trunks. Ceremonial grounds and graves were often marked by such trees. Bora grounds are a common type of ceremonial site and they are generally associated with initiation ceremonies. They comprise two circles, generally edged with low banks of earth but sometimes of stone, a short distance apart and connected by a path. It cannot be predicted whether these sites will be located within the Study Area.
Resource areas	Resource gathering areas represent landforms that contain a high number of fauna and flora species, which were known Aboriginal resources. Resource areas are frequently associated with permanent water resources, often swamps or marshes, and frequently have recorded sites such as middens nearby. Landforms associated with these sites are often flats with a favourable outlook. These sites are not expected to be located within the Study Area.

5 FIELDWORK RESULTS

5.1 FIELD SURVEY METHODOLOGY

The Study Area was surveyed in two field trips. The initial survey was held on 9-10 February 2009 and involved ERM Heritage consultant Dr Diana Neuweger and ERM Archaeologist James Shepherd. ILALC representative Peter Henry and Veronica Falk of DKH also participated in the survey. A second survey was conducted on 9-19 November 2009 (exclusive of weekends). The second survey team included ERM Archaeologist Luke Kirkwood and ERM Environmental Consultant Melissa Karam with the ILALC represented by Michael Pixton, Allan Walker, Craig Tungai and Richard Campbell and DKH being represented by Peter Falk.

The survey methodology was prepared in light of the archaeological background undertaken for this study, the guidelines provided by NPWS and by the DGRs.

The surveys took the form of a pedestrian survey. Owing to the difficult nature of the terrain and low ground surface visibility in much of the Study Area, conventional survey transects were not able to be walked. The survey targeted locations of previously recorded archaeological sites, ridgelines, areas associated with sandstone overhangs, large sandstone platforms associated with water and creeklines, where unregistered sites may have been present. Ground surface visibility was variable; however it was generally low, ranging between 0% to 10%. Survey transects are shown on *Figure 5.1*.

Previously recorded sites were targeted to determine their current condition. Sites that were relocated were assessed against the original detail on the site cards to determine any changes.

The co-ordinates for previously recorded sites documented by the Illawarra Prehistory Group in the mid-1980s were at the time estimated from topographic maps. This created difficulties in accurately relocating sites in extremely difficult terrain with dense vegetation hindering visibility. A multi-step methodology for relocating these sites was developed and involved:

1. surveying a 100 m radius around a given co-ordinate in an effort to identify the archaeological site and/or features described in the site card relocation instructions;

2. identifying key landform features mentioned in site card relocation instructions and possible candidate areas for further inspection; and

3. surveying natural features such as sandstone overhang ridgelines and sandstone platforms.

This methodology helped to increase the chances of relocating sites, and enabled targeted survey of potential culturally sensitive landforms (overhangs etc) in a systematic fashion.

When heritage sites were identified, they were recorded by the survey team for content, GPS location and digitally photographed.

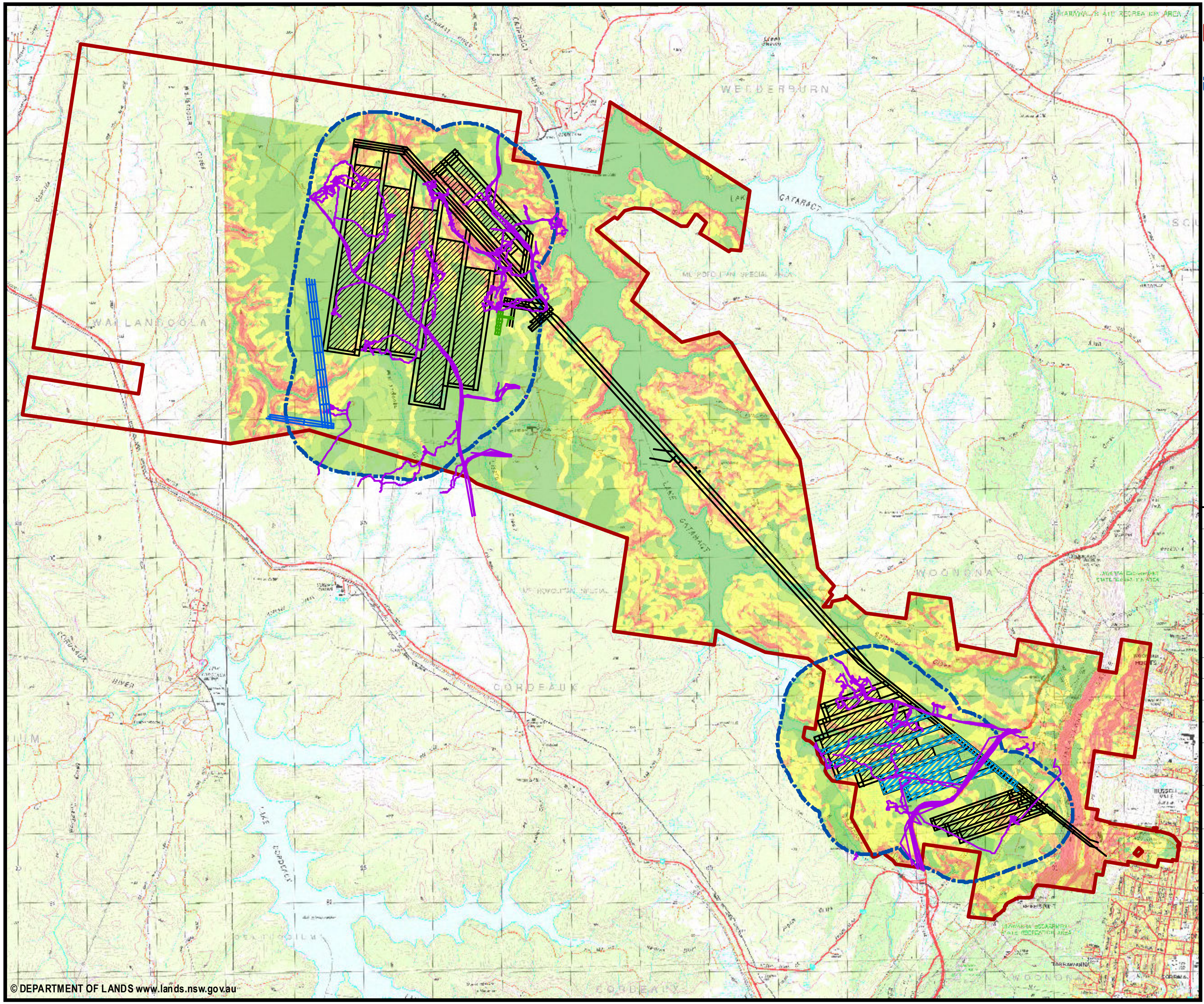
5.2 FIELDWORK CONSTRAINTS AND LIMITATIONS

The survey was limited by a number of factors including restricted access to the survey area following wet weather; imprecise co-ordinates for previously recorded archaeological sites; dense vegetation cover coupled with low ground surface visibility and weather conditions.

A large part of the PAA is designated as a Schedule 1 Restricted Access Area (Metropolitan Special Area) under the *Sydney Water Catchment Management Act 1998*. It is managed by the Sydney Catchment Authority (SCA) and access into and through the area is restricted following wet weather.

The archaeological sites previously recorded in the Study Area were recorded by the Illawarra Prehistory Group during voluntary surveys in the mid to late 1980s. The co-ordinates of the sites were estimated using topographic map series available at the time. The inaccuracy of recorded co-ordinates coupled with the dense vegetation and low visibility, made locating previously recorded sites difficult. In some cases, sites were over 350 m from their recorded position. As a result, a methodology of multiple relocation techniques was adopted, although not all sites were able to be relocated.

The Study Area contains few fire access trails and large areas of bushland over dissected plateaux terrain, much of which has not been burnt for some years. The density of vegetation restricts movement and poses a health and safety risk, especially in terms of concealing cliffs, drops and dangerous wildlife. Hot weather conditions during the time of the field survey also presented additional risks to surveying in remote bushland. While all precautions were taken, excessive heat, bushfire risk and the potential for electrical storms during the field survey limited the distances that could be safely surveyed. The survey team therefore only accessed areas which did not pose a high level of risk to safety and could easily be evacuated in the event of an emergency.



Legend

- Project Application Area
- Proposed Longwalls
- Study Areas
- Subject to separate application (MP 10_0046_MOD 1)
- Proposed Bulli Seam first workings
- Proposed Balgownie Seam first workings
- Survey Transects

Slope %Rise

- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 45

Figure 5.1

Survey Data

Client: Gujarat NRE Coking Coal Limited

Project: NRE No. 1 Colliery EAR Post Adequacy 2012 Aboriginal Heritage Assessment

Drawing No: 0079383s_AHA_GIS008_R2.mxd

Date: 18/10/2012 Drawing size: A4

Drawn by: SQW Reviewed by: MK

Scale: Refer to Scale Bar

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5.3 *FIELDWORK RESULTS*

Three new sites were identified during fieldwork, all within the potential subsidence footprint.

Fifteen AHIMS registered sites were relocated including thirteen rock shelters, one grinding groove site and one artefact scatter.

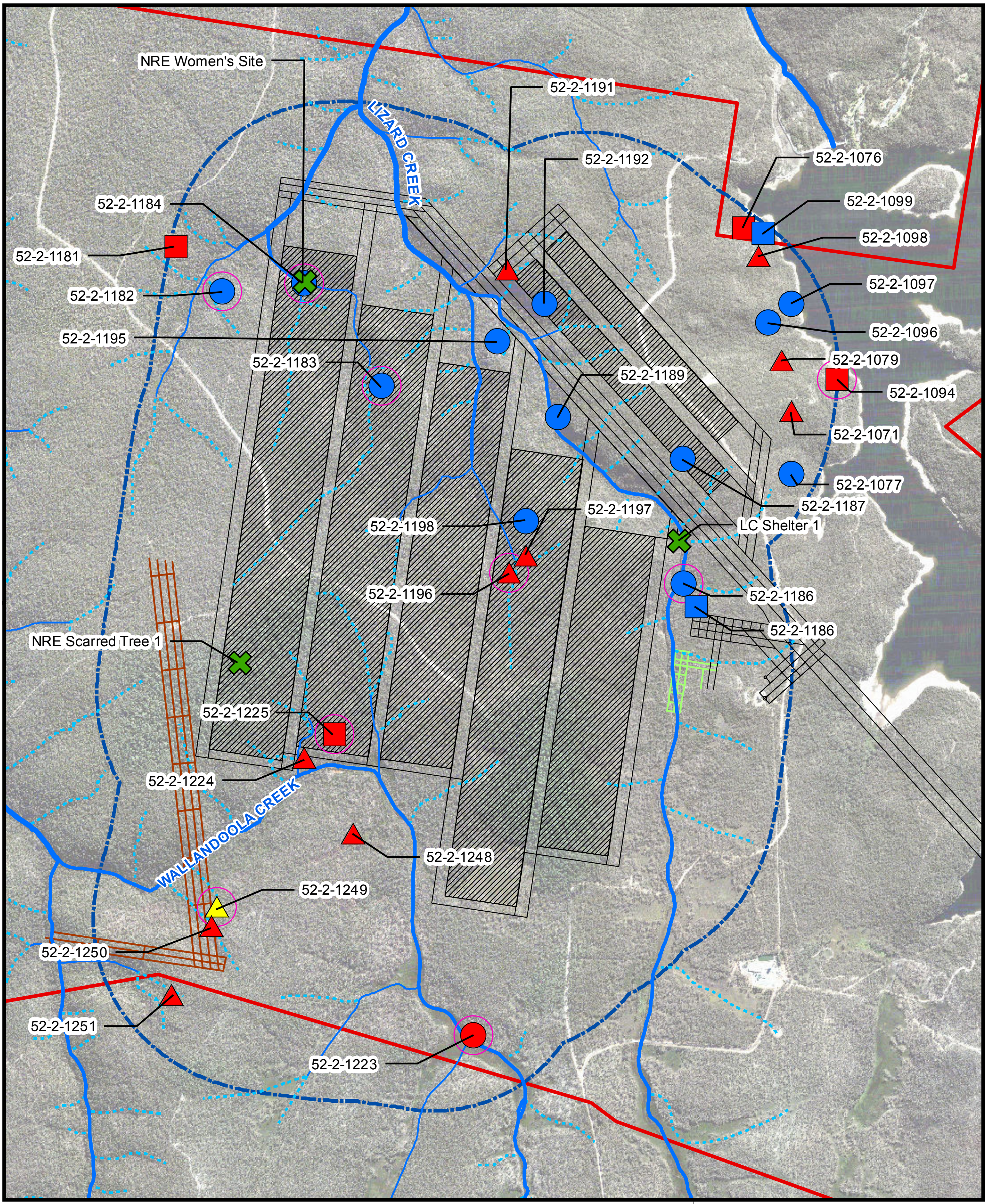
Three additional sites referred to as Wonga East 1, 2 and 3 were also identified by Biosis while undertaking fieldwork associated with a separate application to modify the Preliminary Work Project (MP 10_0046). These sites were not visited by ERM. Details of these new sites were provided to ERM by Biosis to ensure consistency in reporting.

A summary of the survey results is provided in *Table 5.1*, the location of the sites is shown in *Figure 5.2*and *Figure 5.3*.

The re-located sites are discussed in the following pages.

Table 5.1 Aboriginal sites new and relocated

AHIMS Site Number	AHIMS Site Name	AHIMS Site Type
Wonga West		
52-2-1223	Wallandoola Site 2	Shelter with Deposit and Axe grinding groove
52-2-1094	Gillbird Site 50	Shelter with Art and Deposit
52-2-1182	Lizard Creek Site 16	Shelter with Art
52-2-1183	Lizard Creek Site 14	Shelter with Art
52-2-1184	Lizard Creek Site 15	Shelter with Art
52-2-1188	Lizard Creek Site 2	Shelter with Art
52-2-1196	Lizard Creek Site 11	Axe Grinding Grooves
52-2-1225	Wallandoola Site 3	Shelter with Art and Deposit
52-2-1249	Wallandoola Site 13	Shelter with Art and axe grinding grooves
New NRE Womens Site	NRE Women's Site	Water Hole with Aboriginal Ceremony & Dreaming
New NRE Scarred Tree	NRE Scarred Tree 1	Scarred Tree
New LC Shelter 1	Lizard Creek Shelter 1	Shelter with Art
Wonga East		
52-2-0312	Bulli Mine Shaft Site 23	Shelter with Deposit
52-2-0314	Bulli Mine Shaft Site 21	Shelter with Art
52-2-0319	Bulli Mine Shaft Site 24	Shelter with Deposit
52-2-0603	Bulli Mine Shaft Site 19	Shelter with Art
52-3-0310	Bulli Mine Shaft Site 18	Shelter with Art and Deposit and Axe grinding Grooves
52-3-0313	Bulli Mine Shaft Site 29	Artefact scatter
Biosis	Wonga East 1	Shelter with Deposit
Biosis	Wonga East 2	Shelter with Deposit
Biosis	Wonga East 3	Shelter with Deposit



Legend

- Project Application Area
- Study Area - Wonga West
- Proposed Longwalls
- Proposed Bulli Seam first workings
- Proposed Balgownie Seam first workings
- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order and above stream
- Identified Heritage Site (ERM 2009)
- Relocated AHIMS Site (ERM 2009)

AHIMS Site Type

- Axe Grinding Groove
- Axe Grinding Groove, Shelter with Art
- Axe Grinding Groove, Shelter with Deposit
- Shelter with Art
- Shelter with Art, Shelter with Deposit
- Shelter with Deposit

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No. 1 Colliery EAR Post Adequacy 2012 Aboriginal Heritage Assessment
Drawing No:	0079383s_AHA_GIS014_R1.mxd
Date:	13/09/2012 Drawing size: A4
Drawn by:	SQW Reviewed by: MK
Scale:	Refer to Scale Bar

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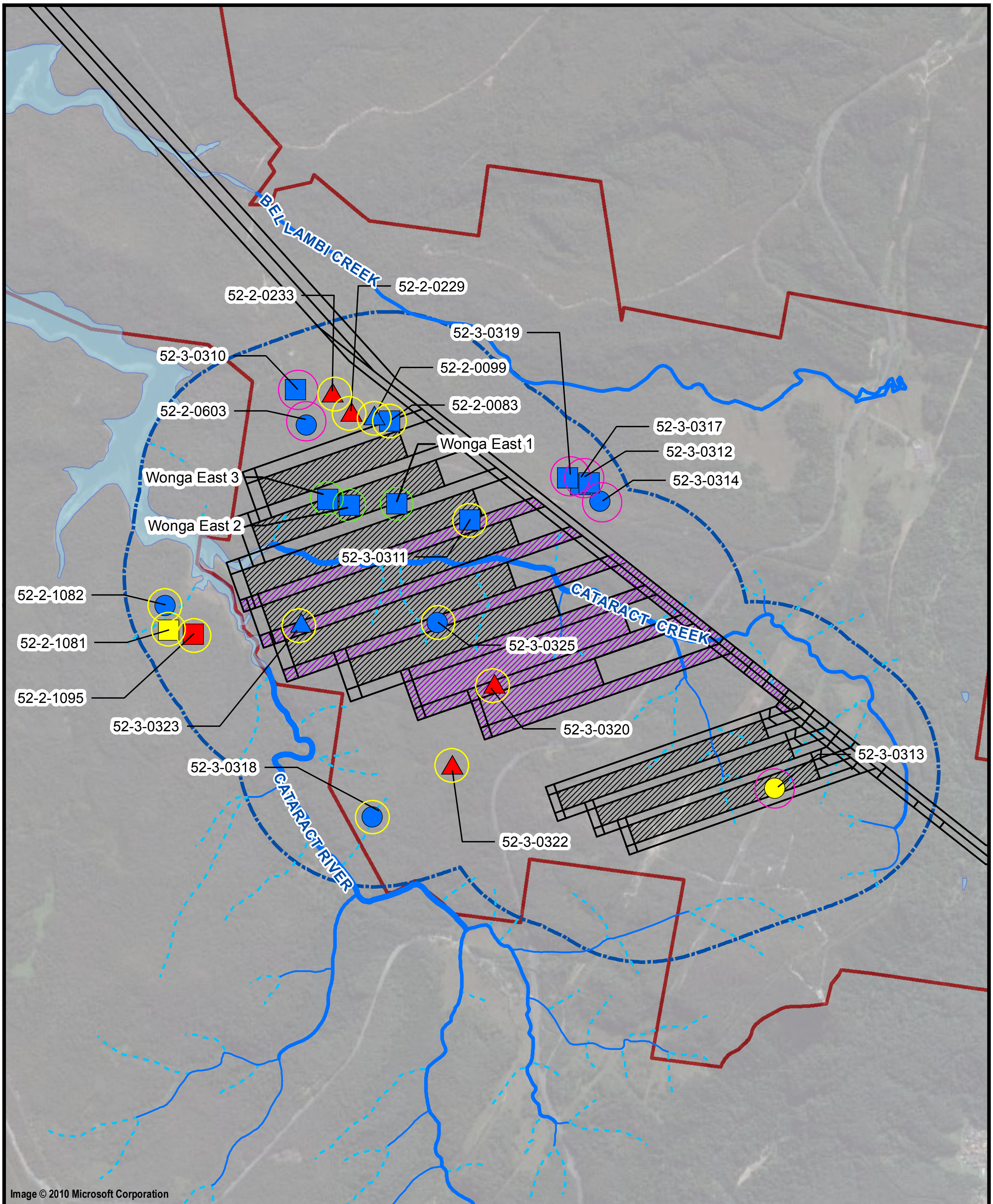
Figure 5.2

Archaeological sites relocated and identified in the Wonga West study area

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM



Legend

- Project Application Area
- Study Area - Wonga East
- Proposed Longwalls
- Subject to separate application (MP 10_0046_MOD 1)
- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order and above stream

AHIMS Site Type

- Axe Grinding Groove
- Axe Grinding Groove, Shelter with Art, Shelter with Deposit
- Open Camp Site
- Shelter with Art
- Shelter with Deposit
- Relocated AHIMS Site (Biosis 2012)
- Relocated AHIMS Site (ERM 2009)
- New AHIMS Site (Biosis 2012)

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery Aboriginal Heritage Assessment
Drawing No:	0079383s_AHA_GIS015_R1.mxd
Date:	09/11/2012 Drawing size: A4
Drawn by:	KB Reviewed by: MK
Scale:	Refer to Scale Bar

N

0 250 500 750m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Figure 5.3

Archaeological sites relocated and identified in the Wonga East study area

Environmental Resources Management Australia Pty Ltd

Brisbane, Canberra, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM

5.4 *WONGA WEST*

5.4.1 *Relocated Archaeological Sites*

52-2-1223 Wallandoola Site 2

Wallandoola Site 2 is a rock shelter facing west over a tributary of Wallandoola Creek. A tree has grown up in front of the shelter and the tree trunk rest against the rock overhang. There were reportedly 19 grinding grooves associated with shelter and a deposit of greater than 30 cm depth consisting of grey loamy sand. One red jasper flake and one grey quartzite flake were also recorded at the site. No art was recorded in the shelter.

A follow up condition assessment was undertaken by Caryll Sefton (year of assessment not provided). This identified two wombat burrows, fresh fungal growth and chemical weathering. Sefton also speculated that the presence of a 'stone wall' hinted at recent European occupation.

Photograph 5.1 52-2-1223 Wallandoola Site 2 – Sandstone overhang.

Photograph 5.2 52-2-1223 Wallandoola Site 2 – Grinding grooves within the overhang.

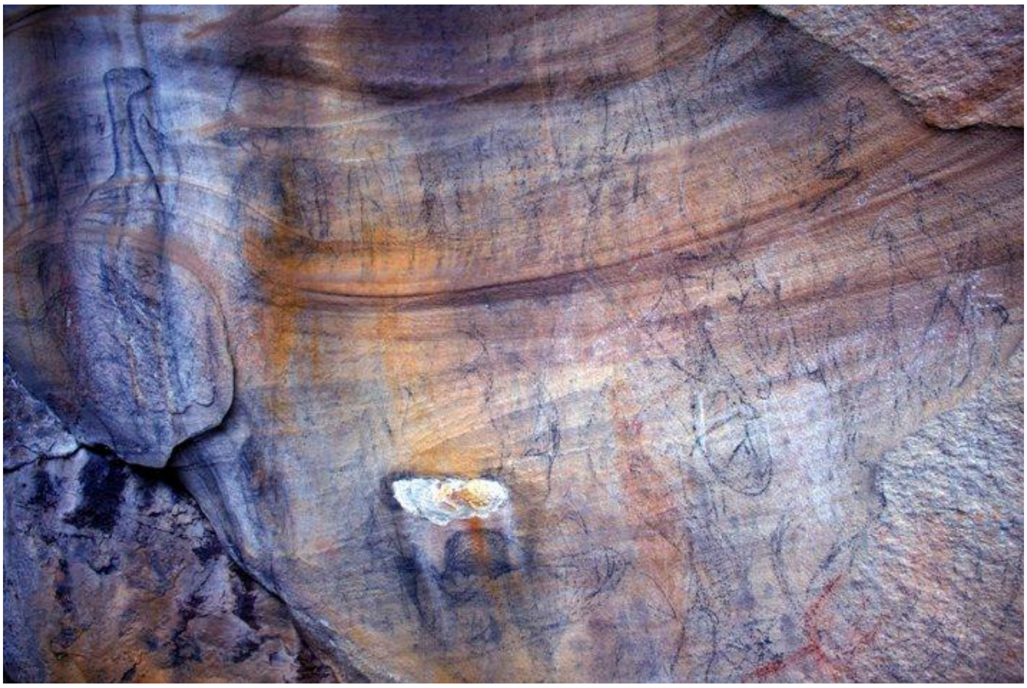
52-2-1094 Gillbird Site 50

Gillbird Site 50 is a rock shelter with art and potential archaeological deposit. The Illawarra Prehistory Group noted in their 1984 survey that this site represents one of the largest and best rock art sites within the Cataract catchment area. This site is accessible via a small access track off Fire Road No. 8H and is located on the first major sandstone ridge up from Lake Cataract, 80 m from the current water's edge. Estimates of the original Cataract River's course situate the rock art site approximately 300-500 m from the nearest permanent water source at that time. The sandstone overhang is 17 m in length, 5.7 m wide and 6 m high with an easterly aspect. The living area, measures 8 m by 3 m and was formed through block fall and cavernous weathering. The archaeological deposit is an orangey to cream sand of varying depth with no visible surface artefacts.

The bulk of the art is located in the extreme left of the shelter which is also protected from the elements by large sandstone boulders. The original recording identified thirty six motifs which included: 18 macropods; 3 snakes;

3 birds; 2 echidnas; 1 bat; 3 fish; 3 frontal human figures; 3 profile human figures; 70 indeterminates; and 18 abstract outlines in red ochre (probably bird tracks). The current survey identified many of these motifs including what may be a fishing scene involving a number of previously recorded motifs. However, this rock art panel has suffered extensive weathering and some vandalism, and not all of the motifs previously recorded could be confirmed.

Water from the roof has seeped down the back wall leaving a white mineralized deposit. In some areas, spalling has occurred with the largest area impacted being approximately 30 by 25 cm. It is unclear whether the spalling is natural or the result of vandalism, however in places where spalling has occurred, there is evidence of further mineralization. Vandalism has also occurred to this rock panel in the form of arrows, dates and letters which are presumably initials (16/9/83, FN, RA etc). Most of the vandalism is superimposed on the rock art using either charcoal or having been scratched into the rock. A 20 cm long charcoal 'pencil' made from a small tree branch was found at the base of one of the rock art panels that had suffered vandalism. While it is possible that attempts have been made to add motifs to the rock art, the majority of motifs are thought to be authentic and are typical of the style found in the surrounding area.



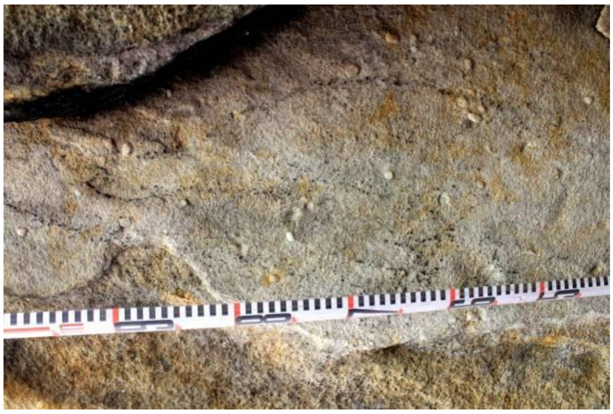
Photograph 5.3 52-2-1094 Gillbird Site 50 – Left section of extensive rock art panel

Depicted here are several motifs including a possible depiction of at least two people fishing (top centre), a stylized watercourse, macropods, several types of fish and turtle and a large emu motif (far left). Note spalling (centre) and mineralization (white patches) caused through water seepage from the roof. There is also evidence of vandalism across the panel in the form of arrows, dates and letters presumably initials.

52-2-1182 Lizard Creek Site 16

Lizard Creek Site 16 is a small rock shelter with art and potential archaeological deposits overlooking an ephemeral tributary of Lizard Creek. The sandstone overhang is approximately 6 m in length by 2.7 m wide and 1.5 m in height. The living area of the shelter is 3 m by 2 m and the aspect is north-west. The deposit in the shelter is grey sandy loam up to 20 cm deep, although no surface artefacts were observed. Two outline charcoal motifs have been recorded for this shelter by the Illawarra Prehistory Group in 1984. The first smaller motif is that of a lizard, while the second much larger motif has been interpreted as being also a lizard however not complete. Both motifs occur on small flat panels on the roof of the rock shelter. A reinspection of the site in 1991 did not identify any new motifs but noted the site as being disturbed.

Photograph 5.4 52-2-1182 Lizard Creek Site 16 – Facing north east highlighting the sandstone overhang.



Photograph 5.5 52-2-1182 Lizard Creek Site 16 – Charcoal outline of the large incomplete 'lizard' motif present on roof of rock shelter.

52-2-1183 Lizard Creek Site 14

Lizard Creek Site 14 is a rock shelter with art, artefacts and potential archaeological deposit on an ephemeral tributary of Lizard Creek. The overhang is 8 m in length by 3.3 m in width and 3.0 m in height. The living area of the shelter is 5 m by 2 m and the aspect of the shelter is north-west. The deposit in the shelter is creamy grey sandy loam up to 30 cm deep. Over 50 artefacts were originally recorded by the Illawarra Prehistory Group including chert, quartz, silcrete and fossilized wood. The current survey was able to record 19 stone artefacts without disturbing the archaeological deposit. This assemblage represented both flakes and cores of the variety of raw material previously recorded. The art in the shelter is a white-painted stencil of a child's left hand, one white-painted adult hand stencil on the right of the shelter and one faded red-painted adult right hand stencil on the roof of the left of the shelter. The shelter is disturbed by wombat burrows and the art is generally faded. The site has been investigated by the Illawarra Prehistory Group in 1984, and subsequently re-examined in 1991.

Photograph 5.6 52-2-1183 Lizard Creek Site 14 – Facing south east highlighting the sandstone overhang and rock fall in front of shelter.

Photograph 5.7 52-2-1183 Lizard Creek Site 14 – Selection of stone artefacts recovered from the floor of the shelter.

52-2-1184 Lizard Creek Site 15

Lizard Creek Site 15 is a rock shelter with art and deposit at the confluence of two small ephemeral tributaries of Lizard Creek. The site was originally recorded by the Illawarra Prehistory Group in 1984 and reinspected in 1991. The sandstone overhang is 4 m in length, and only 1 metre in width and 1 metre in height and the living area inside the shelter is 4 m by 1 m. The aspect of the shelter is north-west. The floor of the shelter is yellow sandy loam with a potential depth of 40 cm deep. The art includes a charcoal outline of a macropod with some portions of it faded and three undetermined outline charcoal motifs.

Photograph 5.8 52-2-1184 Lizard Creek Site 15 – Facing south east showing the sandstone overhang.

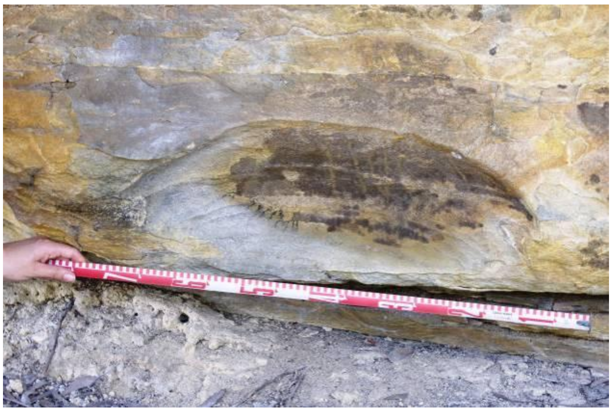
Photograph 5.9 52-2-1184 Lizard Creek Site 15 – Charcoal outline of an indeterminate motif present on back wall of rock shelter.

52-2-1188 Lizard Creek Site 2

Lizard Creek Site 2 is a rock shelter with art and a potential archaeological deposit overlooking Lizard Creek approximately 300 m north of a large waterfall. The sandstone overhang is 4 m in length, 2.2 m in width and 1.6 m in height. The living area is 4 m long and 0.5 m deep and faces to the west.

The deposit is cream sandy loam and is approximately 40 cm deep. The art in the shelter is one indeterminate charcoal outline drawing on a small concave panel in the centre of the back wall. The art is in poor condition having the lower portion of it rubbed away, most likely by sheltering animals, as evidenced by recent scats deposited in the shelter.

Photograph 5.10 52-2-1188 Lizard Creek Site 2 – Facing east highlighting the sandstone overhang.



Photograph 5.11 52-2-1188 Lizard Creek Site 2 – Very faint weathered charcoal outline (bottom left) present on small concave at base of rock shelter.

52-2-1196 Lizard Creek Site 11

Lizard Creek Site 11 is composed of three grinding grooves cut into a 24 m by 6m sandstone exposure approximately 20 m from a small waterfall. The largest grinding groove measures 380 mm long, 80 mm wide and 10 mm deep. Originally recorded by the Illawarra Prehistory Group in 1985 the site was revisited again in 1991 and was recorded as being in good condition.

Photograph 5.12 52-2-1196 Lizard Creek Site 11 – Rock platform and rock pools where grinding grooves are located. Facing south.

Photograph 5.13 52-2-1196 Lizard Creek Site 11 – Three grinding grooves.

52-2-1225 Wallandoola Site 3

Wallandoola Site 3 is a rock shelter with art and limited potential for archaeological deposits. Located approximately 150 m north of a waterfall and natural waterhole on Wallandoola Creek, the overhang and living space is 8 m in length, 6 m wide and 1.5 m high.

Very faint weathered rock art exists on the roof (charcoal outlines) and on the wall (white adult hand stencils) of the shelter. However at some point between the 1950s and the present, the shelter was re-occupied by campers who extensively modified the shelter through removing any potential archaeological deposits, creating a stone platform at the back of the shelter and creating walls out of rock falls. No stone artefacts were observed. A number of pieces of wooden furniture, tin plates and glass bottles with dates of manufacture remain within the shelter, enabling the reoccupation to be dated to at least the 1950s.

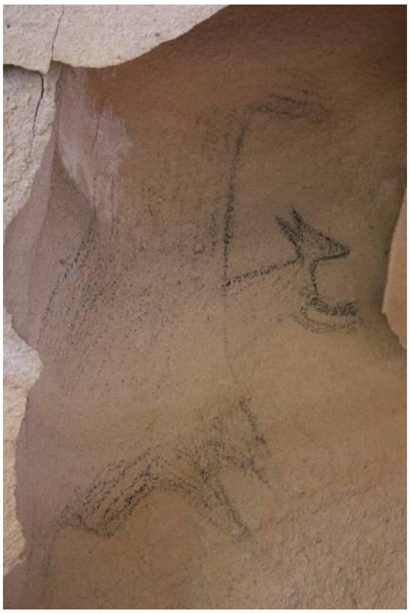
Photograph 5.14 52-2-1225 Wallandoola Site 3 – Mid 20th century artefacts (table, plates, bottles) indicating habitation of rock shelter within the last 60 years.

Photograph 5.15 52-2-1225 Wallandoola Site 3 – The very faint weathered outline of a charcoal motif (right) present on roof of rock shelter.

52-2-1249 Wallandoola Site 13

Wallandoola Site 13 is a rock overhang formed by a block fall and cavernous weathering. A number of painted images were recorded on the wall of the shelter. The art includes two charcoal outline and infill macropods (one with a joey), 1 profile human figure, 1 charcoal front human figure, three red stencils and three indeterminate charcoal drawings.

Field inspection on February 2009 noted the same features as recorded in the site card. The rock art and condition of the rock shelter are identical to the description and photographs in the site card. The grinding groove was still obvious and the shelter contains a loose sandy deposit that has the potential to be of some depth and to contain archaeological artefacts and indicators of occupation.



Photograph 5.16 52-2-1249 Wallandoola Site 13 – Sandstone overhang.

Photograph 5.17 52-2-1249 Wallandoola Site 13 – Charcoal outline of macropod and joey.

5.4.2 New Sites

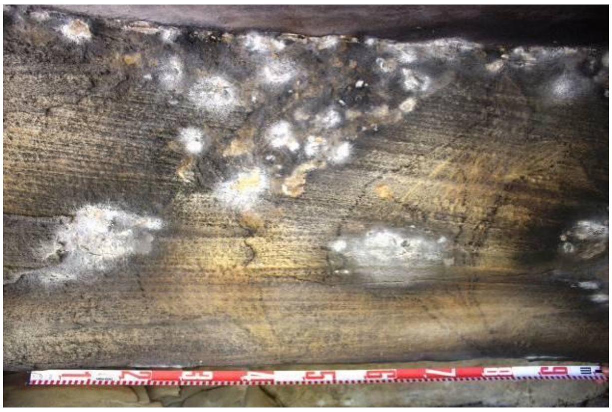
New Site Lizard Creek Rock Shelter (LC Shelter 1)

The new Lizard Creek Site (LC Shelter 1) is a previously unrecorded rock shelter with art and deposit located on the western bend of Lizard Creek immediately opposite a gully on the eastern side of the creek. The sandstone overhang is 27 m in length, and 2 m in width and 1.5 m in height and is composed of two distinct sandstone layers differing in their hardness, with the harder more robust layer forming the overhang and sitting on top of a softer, more easily weathered layer. The living area inside the shelter is 10 m by 2 m. The aspect of the shelter is east north east and it is located 100 m from Lizard Creek on a moderate slope. The vegetation immediately outside the shelter is composed of banksias and bloodwoods. The floor of the shelter is yellow/white sandy loam with a potential depth of 50 cm. No surface artefacts were identified.

The rock art within the shelter is divided into two panels with three charcoal outline motifs present in total. The first panel is 8.8 m from the left edge of the shelter and is composed of two charcoal outline drawings of fish. The inside of the two motifs has been scratched in a top to bottom fashion and with one of the fish partly superimposed on the other. Soot is present on the walls and roof of the shelter and there is peeling as the result of mineralized accretions which are roughly 3 cm across. The motifs of the fish are similar in shape and design and both measure 37 cm wide and 23 cm high.

The second motif is an unidentifiable charcoal outline with some infill also of charcoal. The figure possibly represents a macropod or lizard. The motif is in a concave cavity immediately to the right of the first motif. Some peeling has occurred in the extreme right of the motif and some possible rubbing weathering from animals has occurred along the top of the motif. There is no obvious cracking and apart from some minor mineralization, both motifs are in good condition.

Photograph 5.18 New Lizard Creek Site XX – Facing south west highlighting the sandstone overhang.



Photograph 5.19 New Lizard Creek Site XX – Rock Art panel showing charcoal outline of two fish and white mineralization.

NRE Women's Site

The NRE Women's Site was identified by Veronica Falk of DKH is located within a tributary of Lizard Creek and is made up of naturally formed holes in the sandstone creek bed. The sandstone platform is a natural creek bed and the holes in the sandstone are permanently filled with water. The local Aboriginal knowledge suggests that these holes in the sandstone were used for birthing.

This site contains three birthing holes and is located within 750 m of a rock shelter site (52-2-1183) that contains hand stencils of children.

Photograph 5.20 New NRE Women's Site – Creek bed of Lizard Creek looking up stream.

Photograph 5.21 New NRE Women's Site – Example of one of the water holes present within the creek bed.

NRE Scarred Tree 1

The NRE Scarred Tree 1 is located adjacent to a track leading of the western side of the No.8 Fire Trail, in dense bushland. The hardwood tree contains a four metre long and two meter wide scar. The scar is an oval shape and may be for small shield. The scar is located above head height.

Photograph 5.22 NRE Scarred Tree 1.

5.4.3 Non-Relocated Sites

Although every effort was made to relocate all sites, this was not possible. Incorrect site co-ordinates, vague site descriptions and difficult terrain have meant that some sites were unable to be relocated. Descriptions of AHIMS archaeological sites that were unable to be relocated have been summarized from their site card descriptions.

52-2-1071 Gillbird Site 47

Gillbird Site 47 is recorded as being a grinding groove site. The nature and extent of the site is not recorded on the site card. The condition of site is considered to be reasonable and it is noted that it is located in a small gully close to a creek. The site was originally recorded in 1984 by Illawarra Prehistory Group.

52-2-1076 Gillbird Site 56

Gillbird Site 56 is a rock shelter with grinding grooves, art and artefacts. The art is faint and in fairly poor condition due to fretting on the sandstone surface. The site card is incomplete and does not provide the number and location of grinding grooves. The art is described to include three macropods and two pieces of in determinant art. There is also an adult right hand stencil under one of the macropods. All of the motifs are in charcoal and there is some evidence of ochre spray and white clay drawings in patches. Seven artefacts were recorded at the site including silcrete, chert and quartzite flakes. The aspect of the shelter is north north east. The site was originally recorded in 1984 by Illawarra Prehistory Group.

52-2-1077 Gillbird Site 48

Gillbird Site 48 is a rock shelter with grinding grooves and art. The art is faint due to fretting on the sandstone surface. The site card is incomplete and does not include full details of the rock art or number and location of grinding grooves. The attached drawings of the rock art show at least three macropods, one human (male) figure and three pieces of indeterminate art. All of the motifs are in charcoal and there is some evidence of ochre spray in patches. The aspect of the shelter is east. The site was originally recorded in 1984 by Illawarra Prehistory Group.

52-2-1079 Gillbird Site 51

Gillbird Site 51 is an extensive grinding groove site. There are 54 grinding grooves recorded on two large sandstone outcrops measuring approximately 13 m by 10 m and 22 by 10 m. The site is located near a small creek and was originally recorded by the Illawarra Prehistory Group in 1984.

52-2-1096 Gillbird Site 52

Gillbird Site 52 is a rock shelter with art, grinding grooves and an archaeological deposit. The sandstone overhang is approximately 6 m in length, 2.1 m wide and 1.6 m high. The living area measures 6 m by 2 m. The shelter has a south east aspect. Deposit in the rock shelter is a light grey sandy loam approximately 45 cm deep. The recorded art is of a charcoal outlined echidna and five indeterminate figures. The art is recorded as being of good condition. Originally recorded by the Illawarra Prehistory Group in 1984.

52-2-1097 Gillbird Site 53

Gillbird Site 53 is a rock shelter with art and an archaeological deposit. The sandstone overhang is approximately 17 m in length, 2.1 m wide, and 2.3 m in height. The living area of shelter measures 6 m by 1.5 m. The aspect of the shelter is east. Deposit within the shelter yellow clayey loam up to 25 cm in depth. The art consist of two charcoal human figures in profile with spear in hand and a third human frontal view and three indeterminate charcoal drawings. Recorded by the Illawarra Prehistory Group 1984.

52-2-1098 Gillbird Site 54

Gillbird Site 54 is a series of 19 grinding grooves located near a small creek. The sandstone exposure measures 18 m long by 2.5 m wide. The largest groove is recorded as being 340 by 85 by 16 millimetres. Some of these grooves are hard to distinguish. Recorded by the Illawarra Prehistory Group 1984.

52-2-1099 Gillbird Site 55

Gillbird Site 55 is a rock shelter with grinding grooves and artefacts. The site card is incomplete and does not provide the number and location of grinding grooves. The shelter walls are unsuitable for art and some erosion of the deposit was observed. The shelter aspect is north east and four artefacts were recorded. The site was originally recorded in 1984 by Illawarra Prehistory Group.

52-2-1181 Lizard Creek Site 17

Lizard Creek Site 17 is a rock shelter with art, grinding grooves and an archaeological deposit. The sandstone overhang is 16 m in length, 1.9 m in width, 2.8 m in height. The living area of the shelter is 14 m by 2m and the aspect of the shelter is north east. The deposit in the shelter is grey sandy loam approximately 25 cm deep. The art in the shelter is 17 hand stencils, 14 indeterminate charcoal and ochre drawings and 1 outlined macropod ~1.5 m long. Most of the art in is poor condition. Some stone artefacts were also recorded including 3 dark chert chips and 5 quartz flakes. Recorded by the Illawarra Prehistory Group in 1984.

52-2-1186 Lizard Creek Site 1

Lizard Creek Site 1 is a rock shelter with an archaeological deposit. The shelter is disturbed by wombat burrows. The site was originally recorded by the Illawarra Prehistory Group. The second page of site card is missing.

52-2-1187 Lizard Creek Site 3

Lizard Creek Site 3 is a rock shelter with art and an archaeological deposit. The sandstone overhang is 6 m in length, 2.6 m in width and 1.3 m in height. The living area measures 4 m by 2 m and the aspect of shelter is south-west. The deposit is yellow clayey loam approximately 20 cm deep. The art includes a charcoal frontal outline of a human and 1 charcoal indeterminate. The art is in poor condition but the deposit is undisturbed. The site was originally recorded by the Illawarra Prehistory Group in 1984 and re-examined in 1991 which stated that the condition was disturbed.

52-2-1189 Lizard Creek Site 4

Lizard Creek Site 4 is a rock shelter with art. The sandstone overhang is 6.5 m in length, 2.5 m in width and 2.2 m in height. The shelter has no living area and has a westerly aspect. The only art in the shelter is one indeterminate charcoal draining on the centre of the back wall. The art is recorded as very poor condition. Originally recorded by the Illawarra Prehistory Group in 1985 the site was revisited in 1991 and recorded as disturbed.

52-2-1191 Lizard Creek Site 6

Lizard Creek Site 6 is one grinding groove located near a pothole in the nearby creek. The creek is a metre wide and the groove is in the flow of water. Originally recorded by the Illawarra Prehistory Group in 1985 the site was revisited in 1991 and recorded as being in good condition.

52-2-1192 Lizard Creek Site 5

Lizard Creek Site 5 is a rock shelter with art. The sandstone overhang is 7 m in length, 2.2 m in width and 1.2 m in height. The living area of the shelter is 4 by 1.5 m and the aspect of the shelter is west-southwest. The deposit in the shelter is grey sandy loam approximately 10 cm in depth. The art in the shelter is 2 indeterminate charcoal drawings. The art is in poor condition and water staining had impacted most of the drawings in the shelter. Originally recorded by the Illawarra Prehistory Group in 1985, the site was revisited in 1991 and recorded as being very disturbed.

52-2-1195 Lizard Creek Site 10

Lizard Creek Site 10 is a rock shelter with art and deposit. The sandstone overhang is 12 m in length, 3 m in width, 1.5 m in height. The living area of the shelter is 2 m by 2 m and the aspect of the shelter is east-northeast. The deposit in the shelter is brown yellow sandy loam approximately 15 cm in depth. The art in the shelter consists of two figures and three indeterminate charcoal drawings. The art is in poor condition. Originally recorded by the Illawarra Prehistory Group in 1985, the site was revisited in 1991 and recorded as being disturbed.

52-2-1197 Lizard Creek Site 12

Lizard Creek Site 12 is a series of 23 grinding groove located on a 7 m by 2 m surface of sandstone along a creek bed. There are 10 grooves at the bottom edge of a small pothole and with the remainder located near the edge of 1.5 m drop. Originally recorded by the Illawarra Prehistory Group in 1985, the site was revisited in 1991 and recorded as being in good condition.

52-2-1198 Lizard Creek Site 13

Lizard Creek Site 13 is a rock shelter with art, grinding groove and an archaeological deposit. The sandstone overhang is 2 m in length, 3.3 m wide and 2.3 m in height. The aspect of the shelter is south west and the living area is 12 m by 2 m. The deposit is brown-grey sandy loam approximately 15 cm in depth. At least 25 stone artefacts of chert, silcrete, jasper and quartz are located on the dripline. There are two indeterminate charcoal drawings. Recorded by the Illawarra Prehistory Group in 1987.

52-2-1224 Wallandoola Site 4

Wallandoola Site 4 is recorded as being a grinding groove site. The details of second page of the site card are illegible, although the site is recorded as in reasonable condition. Originally recorded by the Illawarra Prehistory Group in 1985.

52-2-1248 Wallandoola Site 12

Wallandoola Site 12 is a series of eight grinding grooves located on a sandstone outcrop that runs east to west and has an area of 4 by 1.5 m. Six of the grooves are found in one area of the sandstone outcrop with the two largest grooves found immediately east of them. The site is recorded as in reasonable condition. Originally recorded by the Illawarra Prehistory Group in 1985.

52-2-1250 Wallandoola Site 14

Wallandoola Site 14 is a series of 10 grinding grooves. 5 grooves are located 30 cm back from the ledge in water flow in an area measuring approximately 20 m x 3 m. The largest groove measures 360 cm x 70 cm x 10 cm. Another groove is located upstream on edge of water flow, 3 grooves are located a further 12 m upstream, with another 1 found 10 m up from that the final groove located other 36 m further up. The overall area is estimated to be 50 m x 40 m. The whole area is below a small swamp.

52-2-1251 Wallandoola Site 15

Wallandoola Site 15 is recorded as being an extensive collection of 52 grinding grooves. The axe groove site is upstream from the edge of a 2.5 m high waterfall. 5 grooves are located on the lower edge of the first pothole 1.5 m from the edge; 12 on the lower edge of the second pothole with one other 20 cm west of them. The area is on the creek bed and measures 10 m x 8 m, 3 m upstream another 4 grooves below a pothole with 3 others above at top of the 7 m upstream on an area 10 x 9 m just above another small drop. 13 grooves around a small pothole with a water channel 2 m long x 40 mm wide x 5 mm deep leading from above the pothole with the 13 grooves near the top of this is a short parallel water channel. 10 m south west is an area of sandstone 16 m x 4 m, 8 m from the top of the area are 3 grooves, 4 m lower down are 8 more grooves, 2 m southwest of this unit are 3 more.

5.5 WONGA EAST

5.5.1 *Relocated Archaeological Sites*

52-2-0312 Bulli Mine Shaft Site 23

Rock shelter Bulli Mine Shaft 23 is in the same condition as described on the site card. There was evidence on the floor of the shelter of long term disturbance, broken glass bottles of the 1920s and 1930s present.

The living area of the rock shelter shows no structural damage to the sandstone faces. There were lichens and mosses growing on the rock shelter walls and ferns growing out of the cracks and crevices.

Photograph 5.23 52-2-0312 Bulli Mine Shaft Site 23 –showing the sandstone overhang.

Photograph 5.24 52-2-0312 Bulli Mine Shaft Site 23 – Glass bottle found in shelter.

52-2-0314 Bulli Mine Shaft Site 21

Bulli Mine shaft Site 21 is a sandstone overhang that contains art. The ceiling of the rock shelter has fallen, and this is likely to have collapse long ago. The description given by the site card indicates that the living area is still the same as recorded in the 1980s. The art is of a lizard and shows two figures overlapping. The rock shelter still contains a sandy deposit.

Photograph 5.25 52-2-0314 Bulli Mine Shaft Site 21 –showing the sandstone overhang.

Photograph 5.26 52-2-0314 Bulli Mine Shaft Site 21– Charcoal outline of a lizard present on ceiling of rock shelter.

52-2-0319 Bulli Mine Shaft Site 24

This site was found to be in the same condition as it was when recorded in the 1980s. There are ferns growing in the cracks and crevices of the rock shelter. The shelter contains a sandy deposit.

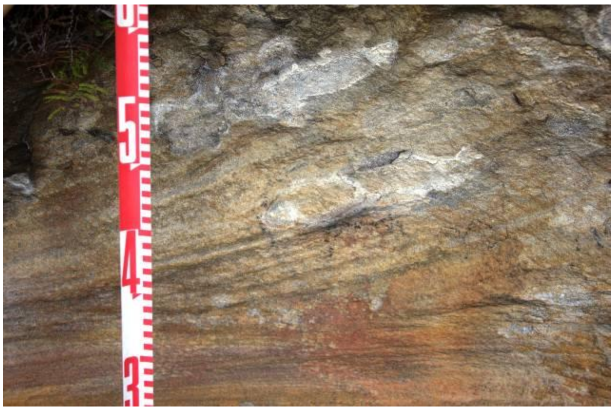
Photograph 5.27 52-2-0319 Bulli Mine Shaft Site 24 –showing the sandstone overhang.

Photograph 5.28 52-2-0319 Bulli Mine Shaft Site 24 – Evidence of deposit.

52-2-0603 Bulli Mine Shaft 19

Bulli Mine Shaft 19 is a sandstone overhang with art and an artefact. The shelter is approximately 7 m long, 3 m wide and 3 m in height, while the living space is 4 by 3 m. The shelter faces west towards the Cataract River which is approximately 800 m away. A single silcrete core artefact has been recorded for this site. In the shelter, there is a weathered red hand stencil and faint charcoal outline drawing on the back wall. Despite the large size of the living space, the shelter is quite exposed and shows evidence of block fall and weathering. The site was originally recorded in 1983 by the Illawarra Prehistory Group and its position recorded using topographic maps. The current survey relocated the site approximately 280 m to the northwest of its recorded position putting it outside of the potential subsidence footprint.

Photograph 5.29 52-2-0603 Bulli Mine Shaft 19 – Facing East Highlighting The Sandstone Overhang.



Photograph 5.30 52-2-0603 Bulli Mine Shaft 19 – Very Faint Weathered Charcoal Outline (Centre) Present On Wall Of Rock Shelter.

52-3-0310 Bulli Mine Shaft 18

Bulli Mine Shaft 18 is a large rock shelter with art, grinding grooves, artefacts and deposit. Located on the south side of Fire Trail 7D, the shelter is between the Cataract River in the west and a large swamp associated with a tributary of the Cataract in the east. The sandstone overhang and living space is 9.6 m in length, 8.5 m in width, 1.6 m in height. The aspect of the shelter is west. The deposit in the shelter is a fine brown dust to medium grey ashy sand over 45 cm deep. Over 100 artefacts have been recorded within the shelter, which includes flakes of silcrete, quartz, jasper, chert, fossilized wood, a broken blade, fabricators, cores and blades. Three grinding grooves are found at the south end of the shelter. The art includes twelve identified motifs including a human figure, macropods, fish and geometric lines and dots. Originally recorded by the Illawarra Prehistory Group in 1985, the site was revisited in 1991 and recorded as having deposits disturbed by animal movement.

Photograph 5.31 52-3-0310 Bulli Mine Shaft 18 – Facing east highlighting the sandstone overhang.

Photograph 5.32 52-3-0310 Bulli Mine Shaft 18 – Selection of stone artefacts recovered from the floor of the rock shelter.

52-3-0313 Bulli Mine Shaft 29

Bulli Mine Shaft 29 is an open artefact scatter measuring approximately 25 by 5m with the deposit being shallow white sand over yellow clay. The site is located in open eucalypt forest and is 100m back from a sharp drop leading down to a rainforest ecotone. The site is recorded as being composed of 9 stone artefacts made of materials such as silcrete, chert and fossilized wood. Originally recorded by the Illawarra Prehistory Group in 1984, the exposed areas today suffer from extensive erosion of the topsoil through water movement and fire trail upgrades. While the location of the site was able to be accurately relocated, no stone artefacts were observed.

Photograph 5.33 52-3-0313 Bulli Mine Shaft 29 – Access track to Brokers Nose Ridge highlighting the level of erosion along this track.

Photograph 5.34 52-3-0313 Bulli Mine Shaft 29 –Access track to Brokers Nose Ridge underneath the transmission lines which is the recorded location for this site.

5.5.2 *Non-Relocated Sites*

52-2-0083 Bulli Mine Shaft Site 7

Bulli Mine Shaft 7 is a rock shelter with an archaeological deposit. The sandstone overhang is approximately 2.5 m in length, 1.5 m wide and 1.5 m in height. The deposit extends outside the shelter to a depth of 30 cm, with a number of artefacts being noted including chert flakes, a silcrete flake and 2 pieces of quartz. The site was originally recorded in 1984 by Illawarra Prehistory Group with the site having been revisited in 1991.

52-2-0099 Bulli Mine Shaft 8

Bulli Mine Shaft 8 is a series grinding grooves located in an exposed sandstone outcrop measuring approximately 8 m by 4 m. There are 6 grinding grooves in total. The site was originally recorded in 1984 by Illawarra Prehistory Group with the site having been revisited in 1991.

52-2-0229 Bulli Mine Shaft 12

Bulli Mine Shaft 12 is recorded as being 1 grinding groove in a sandstone outcrop measuring approximately 18 by 2 m wide. The site was originally recorded in 1984 by Illawarra Prehistory Group with the site having been revisited in 1991.

52-2-0233 Bulli Mine Shaft 13

Bulli Mine Shaft 13 is recorded as being 2 grinding grooves in a sandstone outcrop measuring approximately 18 by 4 m wide. The site lies of the north of the road to Shaft #1. The site was originally recorded in 1984 by Illawarra Prehistory Group with the site having been revisited in 1991.

52-2-1081 Gillbird Site 2

Gillbird Site 2 is a rock shelter with art, grinding grooves and an archaeological deposit. The rock shelter is described as "the worst damaged shelter" having been vandalized by modern graffiti including names and dates. This graffiti is of a similar nature to 52-2-1094 and was possibly vandalized at the same time. The sandstone overhang is 9 m in length, 2.8 m in width and 3.3 m in height. The aspect of the shelter is north west. The deposit in the shelter is a grey brown loam approximately 20 cm deep with 3 silcrete flakes being found on shelter floor. Six grinding grooves are found within the shelter. The art includes 9 red hand stencils and a number of indeterminate figures. Originally recorded by the Illawarra Prehistory Group in 1985.

52-2-1082 Gillbird Site 3

Gillbird Site 3 is a rock shelter with art. The sandstone overhang is 3.7 m in length, 2.2 m in width and 1.4 m in height. The living area of the shelter is 3m by 1m and the aspect of the shelter is north east. The deposit in the shelter is grey sandy loam approximately 30 cm in depth. The art in the shelter are a number of indeterminate charcoal drawings on the roof. Originally recorded by the Illawarra Prehistory Group in 1985.

52-2-1095 Gillbird Site 1

Gillbird Site 1 is a rock shelter with art. The rock shelter is vandalized by modern graffiti – names, dates and animal figures. This graffiti is of a similar nature to that at 52-2-1094 and was possibly vandalized at the same time. The sandstone overhang measures approximately 6m in length, 1.8 m in width, and 2.3 m in height. The living area is 4 m x 2 m. The aspect of the shelter is north-northeast. The deposit in the shelter is a brown sandy loam approximately 15 cm in depth. The art includes a number of red hand stencils (adult and children), eleven identified motifs including macropods, echidnas, lizards, snakes, eels and fish and a number of indeterminate figures. Originally recorded by the Illawarra Prehistory Group in 1985.

52-3-0311 Bulli Mine Shaft Site 20

Bulli Mine Shaft Site 20 is a rock shelter with an archaeological deposit. The sandstone overhang is 7.5 m in length, 6.9 m in width and 1.2 m in height. The aspect of the shelter is southwest. Surface artefacts identified include 5 quartz chips, 1 red silcrete chips and black chert flake and 1 quartz pebble. The deposit in the cave has been disturbed by wombat diggings and there is also evidence on the shelter roof of burning. Originally recorded by the Illawarra Prehistory Group in 1984.

52-3-0317 Bulli Mine Shaft Site 22

Bulli Mine Shaft Site 22 is a rock shelter with an archaeological deposit. The sandstone overhang is 20 m in length, 4 m in width and 4 m in height. The aspect of the shelter is northwest. The floor of the shelter is mostly a stone floor with brown sandy loam at either end of the shelter. The living area of the shelter is estimated to be approximately 5 m by 2 m. The estimated deposit depth is 15 cm. Large sandstone block fill most of the shelter. One fine grained light grey split pebble has been identified. Original site card was recorded in 1984 by the Illawarra Prehistory Group.

52-3-0318 Bulli Mine Shaft Site 30

Bulli Mine Shaft Site 30 is a rock shelter with art. The sandstone overhang measures approximately 10 m long, 3.7 m wide and 4.5 m high. The living area is 9 m by 3 m. The site in recorded as being located in a canyon and is well protected with the shelter having a westerly aspect. One human figure, an indeterminate charcoal drawing and six other drawings are recorded for this shelter.

52-3-0320 Bulli Mine Shaft Site 25

Bulli Mine Shaft Site 25 is one grinding groove recorded on a sandstone outcrop measuring 22 m by 2.5 m. The site is recorded as in reasonable condition. Originally recorded by the Illawarra Prehistory Group in 1984.

52-3-0322 Bulli Mine Shaft Site 31

Bulli Mine Shaft Site 31 is a series of two grinding grooves recorded on a sandstone outcrop measuring approximately 11 m by 20 m. The site is recorded as being in reasonable condition. Originally recorded by the Illawarra Prehistory Group in 1985.

52-3-0323 Bulli Mine Shaft Site 26

Bulli Mine Shaft Site 26 is a rock shelter with an archaeological deposit. The aspect of the shelter is south west. The sandstone overhang is 6 m in length, 3.5 m in width, 3 m in height. The deposit in the shelter is sand to a depth of 20 cm. Three stone artefacts were located on the dripline of the shelter which included 1 grey chert, 1 coarse grained silcrete flake and 1 quartzite flake. Originally recorded by the Illawarra Prehistory Group in 1985.

52-3-0325 Bulli Mine Shaft Site 27

Bulli Mine Shaft Site 27 is a rock shelter with artefacts and deposit. The sandstone overhang is 3 m in length, 2.5 m in width and 1.2 m in height. The aspect of the shelter is north. The deposit is recorded as being approximately 45 cm in depth.

There are 5 artefacts recorded in the shelter including: one red silcrete chip, one quartz flake, one fossilised wood, one quartz chip and one quartz core. The original site card was recorded in 1984 by Illawarra Prehistory Group.

Wonga East 1

Wonga East 1 is a west facing rock shelter with artefacts and deposit, recorded by Biosis in September 2012 (Asher Ford *pers. com*). The shelter is located within open woodland on an upper ridgeline approximately 280 metres north of Cataract Creek. The sandstone overhang is 8 m in length, 8 m in width and 1.5 m in height. The shelter deposit consists of yellowish grey sand that has gone through limited surface disturbance due to animals and extensive leaf and dried wood deposit. There are 5 artefacts recorded within the shelter including: two quartz flakes, one chert flake, one chert distal fragment and one silcrete flake. A potential archaeological deposit was identified as being associated with the artefacts.

Wonga East 2

Wonga East 2 is a south to south-west facing rock shelter with artefacts and deposit, recorded by Biosis in September 2012 (Asher Ford *pers. com*). The shelter is located within open woodland on an upper ridgeline approximately 300 metres north of Cataract Creek. The sandstone overhang is 25 m in length, 4 m in width and 4 m in height. The floor area of the shelter measures 10 m by 2 m and is divided into three living areas within the shelter that are separated by rock boulders. The shelter deposit consists of yellowish grey sand that has gone through limited surface disturbance due to animals. There are 6 artefacts recorded within the shelter including: two silcrete bipolar flakes, two quartz angular fragments, one quartz bipolar flake and a sandstone hammer stone. The artefacts were located within all three living areas and a potential archaeological deposit was identified as being associated with the artefacts.

Wonga East 3

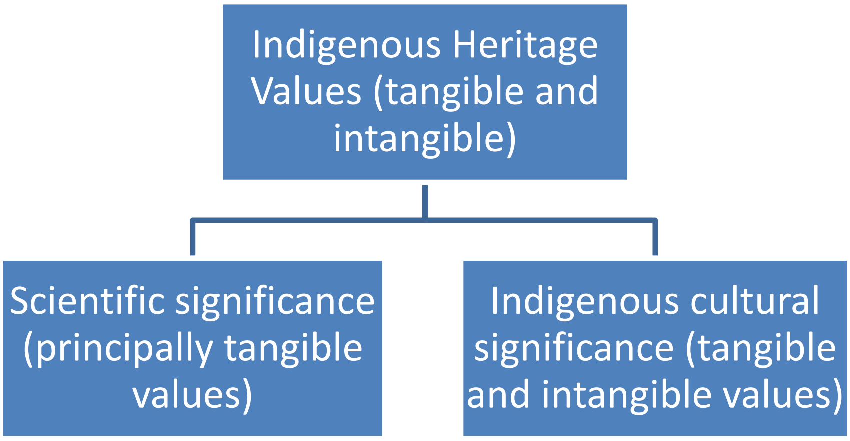
Wonga East 3 is a south facing rock shelter with artefacts and deposit, recorded by Biosis in September 2012 (Asher Ford *pers. com*). The shelter is located within open woodland on an upper ridgeline approximately 330 metres north of Cataract Creek. The sandstone overhang is 8 m in length, 2 m in width and 1 m in height. The floor area of the shelter measures 6 by 1 m and is covered in a deposit consisting of yellowish grey sand that has gone through limited surface disturbance due to animals. There are 4 artefacts recorded within the shelter including: three quartz bi-polar flakes and one silcrete flake was located at the eastern part of the shelter floor, adjacent to the boulder, approximately 60cm from the drip line. A potential archaeological deposit was identified as being associated with the artefacts.

6 SIGNIFICANCE ASSESSMENT

6.1 PREAMBLE

Aboriginal heritage sites, objects and places hold value for communities in many different ways. The nature of those heritage values is an important consideration when deciding how to manage a heritage site, object or place and balance competing land-use options.

ERM's approach to the Aboriginal heritage assessment is based upon identifying the key Aboriginal heritage values; values that are likely to be both tangible and intangible. This approach needs to consider the values assessment from the scientific and Aboriginal community perspectives, in accordance with Australian best practice documents.



The NPWS Aboriginal Cultural Heritage Standards and Guidelines Kit (1997) states:

> *While Aboriginal sites and places may have educational, tourism, and other values to groups in society their two principal values are likely to be in terms of their cultural/social significance to Aboriginal people and their scientific significance to archaeologists. It is thus possible to identify two main streams in the overall significance assessment process: the assessment of cultural/social significance to Aboriginal people and the assessment of scientific significance to archaeologists… (1997: PDF page 92)*

This assessment focuses upon the scientific significance assessment of the sites observed and recorded during the survey, and the AHIMs sites located within the Study Area. The Aboriginal community has provided input into the survey and assessment and has been afforded the opportunity to comment on this report for a cultural and social significance assessment of the sites recorded.

6.1.1 *Archaeological Potential*

Archaeological site formation is a combination of scientific factors, such as bioturbation, and environmental factors, such as erosion or burial through soil movement. Once discarded on the ground surface, artefacts are often readily incorporated into the topsoil horizons through the process of bioturbation. Most commonly, dense artefact deposits exist hidden beneath the upper surface (c.f. Wandsnider and Camilli 1992; Fanning and Holdaway 2001). Most frequently, the eroded component of a larger subsurface deposit is detected and recorded as a site. Where soils are sandy, artefacts can occur at greater depths and erosion may frequently expose artefacts. Therefore it is crucial that soils, sands and geomorphology of an area are defined in an archaeological assessment and the archaeological implications defined. An understanding of these factors, linked further to the notions of site integrity and condition, yield an understanding of an area or site's archaeological potential.

It is important to note that the level of archaeological potential relates to the likelihood of discovering an Aboriginal object or site, within a location. Further description should then be made as to the potential condition and integrity of the soil matrix and potential site itself. Only after all these factors have been considered, can scientific value start to be assessed for an area with potential. Therefore, whilst scientific value and potential are linked, it must be noted that these values and potentials are not the same and can differ substantially for any single site or area with potential.

Areas with archaeological potential were identified according to the definitions in *Table 6.1.*

Table 6.1 Definitions of Archaeological Potential

Rank	Definition	Example
No potential	Artefacts cannot occur in-situ.	Eroded landforms, reconstructed landscapes, hazardous landscape, developed areas.
Low potential	Artefacts are not normally found in comparable contexts but could occur in low densities making detection unlikely.	Landforms with no specific focus for use, i.e. with no water sources or undifferentiated slopes.
Moderate potential	Artefacts are known to occur in comparable landforms in detectable densities (~1 artefact/m^2) and there is an unknown possibility for detection.	Landforms with an environmental focus which may have seen seasonal visitation.
High potential	Artefacts are consistently found in comparable landforms or similar environmental contexts and thus will certainly be found in any ground breaking works.	Landforms with known environmental focus encouraging repeat visitation to specific locale, i.e. margins of swamp or near high order creeks.

6.1.2 *Scientific Significance Assessment*

The primary guide to management of heritage places is the Australia ICOMOS Burra Charter 1999. The Burra Charter defines cultural significance as:

> *Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations.*
>
> *Cultural significance is embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects.*
>
> *Places may have a range of values for different individuals or groups.*

This assessment has sought to identify Aboriginal heritage objects and sites within the Study Area and obtain sufficient information to allow the values of those objects and sites to be determined. NPWS (1997:93) has stated that 'while various criteria for archaeological significance assessment have been advanced over the years, most of them fall under the heading of archaeological research potential'. As such, seven key criteria may be used to examine the scientific value/significance of a site. These are:

- Rarity: whether any or all aspects of a site (type, location, integrity, content and archaeological potential) can be considered common or rare within a local, regional or national context;

- Representativeness: the comparative rarity of the site when considered and contrasted against other similar sites conserved at the local and/or regional level;

- Archaeological landscapes: the study of the cultural sites relating to Aboriginal peoples within the context of their interactions in the wider social and natural environment they inhabited. Landscapes can be large or small depending upon specific contexts (i.e. local or regional conditions); they may also may be influenced by Aboriginal social and demographic factors (which may no longer be apparent);

- Connectedness: whether the site can be connected to other sites at the local or regional level through aspects such as type, chronology, content (i.e. materials present, manufacturing processes), spatial patterning or ethno-historical information;

- Integrity and condition: integrity refers to the level of modification a site has been subject to (the cultural and natural formation process) and whether the site could yield intact archaeological deposits, which could be spatially meaningful. Condition takes into account the state of the material, which is especially relevant for organic materials;

- Complexity: the demonstrated or potential ability of a site to yield a complex assemblage (stone, bone and/or shell) and/or features (hearths, fire pits, activity areas); and

- Archaeological potential: the potential to yield information (from sub-surface materials which retain integrity, stratigraphical or not) that will contribute to an understanding of contemporary archaeological interest, or which could be saved for future research potential.

6.1.3 *Aboriginal Heritage Values*

The survey was conducted according to the methodology discussed with all Aboriginal stakeholders and focused on the identification of Aboriginal heritage values relating to archaeological sites, although discussion also included intangible values and the importance of sites to the local community. Field survey methods were adopted to discover new archaeological sites, to ensure their accurate recording and to provide sufficient information to provide an assessment of cultural significance to the extent that surface survey allowed.

6.2 *STATEMENT OF HERITAGE SIGNIFICANCE*

Fifty AHIMS listed sites and six new Aboriginal cultural heritage sites have been identified as occurring within the Study Area. These include: one artefact scatter; 14 axe grinding grooves; 39 rock shelters with art, deposits and/or axe grinding grooves; one scared tree; and one water hole with Aboriginal Ceremony and Dreaming. Of the rock shelters 25 contain art, 18 contain archaeological deposit and 5 have associated axe grinding grooves.

A statement of heritage significance is provided for each archaeological site. *Table 6.2* provides an overview of the scientific and cultural significance assessment for all sites within the Study Area.

No significant and no moderate changes were observed to the re-located sites during the survey. All relocated sites were in generally the same condition as described on the original site card. The only apparent difference was the addition of lichen and fern growth for the shelters found in the damper areas. It has therefore been assumed that non relocated sites will be in generally the same condition as described on the original site card. The significance and impact assessment for the non-relocated sites are therefore based on the information recoded on the AHIMS site cards.

6.2.1 *Significance Assessment for Relocated sites in Wonga West*

52-2-1223 Wallandoola 2

Shelter sites in the Illawarra escarpment are not rare. Wallandoola 2 contains deposits and artefacts that were noted on a previous visit to the site. There has been little excavation of rock shelter deposits in the Illawarra and this makes Wallandoola 2 potentially interesting on scientific grounds. A wombat burrow was noted in the cave on the site card and therefore the integrity of the deposit is not expected to be good.

The shelter is in good condition and the grinding grooves illustrate that the rock shelter was occupied in the past. There is a moderate archaeological potential for artefacts to be present in the floor deposits.

Therefore Wallandoola site 2 is of moderate scientific significance.

52-2-1094 Gillbird Site 50

This site is a shelter with art, and is located on a large ridgeline within a short walking distance to the original course of the Cataract River. The large flat panel on the back wall of the shelter contains 36 easily identifiable motifs with a further 88 motifs being either indeterminate or abstract in nature. The art is in a mixed condition with varying degrees of preservation due to different levels of exposure to natural weathering processes and vandalism. While rock art is a common site type for the area, the scale and variety of motifs in this rock shelter make this site highly significant.

52-2-1182 Lizard Creek Site 16

This site is a shelter with two outline charcoal motif of lizards marked on the roof. The site is part of a ridgeline of eroding sandstone looking over a dry minor tributary of Lizard Creek. No stone artefacts were observed, although the floor of the shelter may possess archaeological deposits. The art is in a relatively poor condition and is difficult to discern. Rock art shelters with charcoal outline figures are a common archaeological site type for the region and coupled with the poor preservation of the motifs this site is rated as being of low scientific significance.

52-2-1183 Lizard Creek Site 14

This site is a shelter with three hand stencils, a number of surface artefacts and the potential for archaeological deposits. The site is on a ridgeline looking over an ephemeral minor tributary of Lizard Creek.

Nineteen stone artefacts of various raw materials and types were readily identifiable on the surface living space of the shelter, suggesting the potential for archaeological deposits. The art is in a poor condition being faded, with the red hand stencil being much harder to identify than the white stencils. Rock art is a common site type for the area, however the potential for extensive archaeological deposits and the presence of a child's hand stencil make this site high scientifically and culturally significant.

52-2-1184 Lizard Creek Site 15

This site is a shelter with one outline charcoal motif of a partial macropod and three indeterminate charcoal outline motifs. The site is a small sandstone overhang with a limited living space. No stone artefacts were observed, although the floor of the shelter may possess archaeological deposits. The art is in a very poor condition and is difficult to discern. Rock art shelters with charcoal outline figures are a common archaeological site type for the geographical region and coupled with the poor preservation of the motifs this site has low scientific significance.

52-2-1188 Lizard Creek Site 2

The site is a small rock shelter with one motif of a small indistinguishable charcoal outline at the base of the shelter. The motif has suffered extensive weathering. Rock shelter sites with art are common in the geographic region and given the size of the shelter and the poorly preserved nature of the single motif warrant a low scientific significance.

52-2-1196 Lizard Creek Site 11

Grinding groove sites are common within the region, especially in areas with sandstone outcrops and surface water. Lizard Creek Site 11 is not significant in terms of representativeness or rarity. The significance of this site is low.

52-2-1225 Wallandoola Site 3

Rock shelters with art are a common archaeological site type within the geographic region. Although the shelter contains both stencils and charcoal outlines, their weathered damaged nature caused by reoccupation of the site post 1950s and the limited nature of the archaeological deposits reduces the scientific significance (as it relates to Aboriginal cultural heritage) of this site to low.

52-2-1249 Wallandoola 13

The Illawarra has a large number of rock shelter sites with art that form a complex of site types that not only are scientifically significant but are also spiritually significance to Aboriginal individuals.

The shelter is in good condition and the art is faded but has survived well. There is also the moderate archaeological potential for artefacts to be present in the floor deposits.

Therefore Wallandoola site 13 is of high scientific significance as the floor deposits are not obviously disturbed by animals.

6.2.2 *Significance Assessment for New Sites Identified in Wonga West*

New Site LC Shelter 1

LC Shelter 1 is a rock shelter with three charcoal outline motifs (two fish and one indeterminate) located just above Lizard Creek on the western bank. Apart from some mineralization, the art is in generally good condition. No stone artefacts were observed, although the floor of the shelter may possess archaeological deposits. Rock art shelters with charcoal outline figures are a common archaeological site type for the geographical region therefore this site has moderate scientific significance.

NRE Women's Site

The NRE Women's Site is made up of naturally formed water holes in the sandstone creek bed which the local Aboriginal knowledge suggests were used for birthing. The site is important as it can be used to show women's sites in the area. It is also closely associated with the 52-2-1183 which is found in close proximity and has stencils of childrens' hands.

The women's site contains natural features in a sandstone creek bed. The condition of this site is good. This site contains no potential to provide scientific data. This site type is rare and is therefore of high archaeological significance. The site is of high significance to the Aboriginal community.

NRE Scarred Tree 1

The NRE Scarred Tree 1 is a tree that contains a four metre long and two metre wide scar.

The condition of the tree is good. There is no potential for further scientific information to be obtained from this site. The site itself is not of a rare type. Therefore the site is of low scientific significance but contains high Aboriginal cultural significance.

6.2.3 *Significance Assessment for Relocated sites in Wonga East*

52-2-0312 Bulli Mine Shaft Site 23

This rock shelter contains deposit and therefore has potential for artefacts to be found. There is no art on the shelter walls and the site type itself is not rare. As this site like all the other shelter sites in the Study Area are part of a greater complex showing occupation in the Study Area the significance of the site is moderate.

52-2-0314 Bulli Mine Shaft Site 21

This site contains shallow archaeological deposit and therefore has some potential to yield further archaeological information and artefacts. The site also contains two figures, most likely lizards in the shelters. These art motifs are not common in the area and therefore this site has high archaeological significance.

52-2-0319 Bulli Mine Shaft Site 24

This shelter contains potentially deep sandy deposit on the floor. There is potential to contain further archaeological information within the shelter. There is no art on the rock shelter walls. The site type is again not uncommon in the area, but as part of the complex of sites within the region it contains a moderate archaeological significance.

52-2-0603 Bulli Mine Shaft 19

The site is a rock shelter with two motifs: a small indistinguishable charcoal outline at the base of the shelter and a red hand stencil. The two motifs have suffered extensive weathering through exposure to the elements and are barely visible. While a single silcrete core artefact had been previously located, the shelter does not possess an extensive deposit as the floor of the shelter is predominately bedrock. Rock shelter sites with art are common in the geographic region and the poorly preserved nature of the motifs warrant a low scientific significance. This site is outside the potential subsidence footprint.

52-3-0310 Bulli Mine Shaft 18

This site is a large shelter with over 100 surface artefacts and 12 motifs of various designs including a human figure, macropods, fish and a number of simple non-figurative geometric designs and dots.

Comprehensive surveys on rock art in the Sydney basin by McDonald (1994) determined that non-figurative designs such as dots and other geometric designs occur relatively infrequent in rock shelter art, representing only 6% of the 14,242 surveyed sites. Although rock shelters are a relatively common site type for the region, the extent of the living space of this shelter combined with the nature of the motifs and large numbers of surface artefacts makes this shelter of high significance for further scientific investigation.

52-3-0313 Bulli Mine Shaft 29

Bulli Mine Shaft 29 is an open artefact scatter recorded as being located on a heavily disturbed access track. There is the potential for this site to extend into undisturbed deposits. Although open stone artefact scatters are relatively uncommon on the Illawarra Escarpment, the number of artefacts identified coupled with the heavily disturbed nature of the site and lack of any visible cultural remains today means that this site only has low scientific value.

6.2.4 Significance Assessment for New Sites in Wonga East (Not Visited By ERM)

Wonga East 1

This shelter contains sandy deposit on the floor. There is potential to contain further archaeological information within the shelter. There is no art on the rock shelter walls. The site card records a potential archaeological deposit as being associated with the artefacts. The site type is not uncommon in the area, but as part of the complex of sites within the region it contains a moderate archaeological significance.

Wonga East 2

This shelter contains sandy deposit on the floor. There is potential to contain further archaeological information within the shelter. There is no art on the rock shelter walls. The site card records a potential archaeological deposit as being associated with the artefacts. The site type is not uncommon in the area, but as part of the complex of sites within the region it contains a moderate archaeological significance.

Wonga East 3

This shelter contains sandy deposit on the floor. There is potential to contain further archaeological information within the shelter. There is no art on the rock shelter walls. The site card records a potential archaeological deposit as being associated with the artefacts. The site type is not uncommon in the area, but as part of the complex of sites within the region it contains a moderate archaeological significance. Significance of Non-Relocated Sites.

As no significant or moderate changes were detected at the relocated sites, the condition of non-relocated sites also is assumed to be the same as when they were originally recorded.

6.2.5 *Summary*

Table 6.2 summarises the significance of the sites within the Study Area.

Table 6.2 Summary of Significance Assessment

AHIMS Site Number	Context	Archaeological potential	Scientific significance[1]	Aboriginal social significance[2]
Wong West				
52-2-1071	Open site	None	Low	High
52-2-1076	Enclosed Shelter	Moderate	High	High
52-2-1077	Enclosed Shelter	Moderate	High	High
52-2-1079	Open site	None	Moderate	High
52-2-1094	Enclosed Shelter	High	High	High
52-2-1096	Enclosed Shelter	High	High	High
52-2-1097	Enclosed Shelter	High	High	High
52-2-1098	Open site	Moderate	Moderate	High
52-2-1099	Enclosed Shelter	Low	Moderate	High
52-2-1181	Enclosed Shelter	Moderate	Moderate	High
52-2-1182	Enclosed Shelter	Moderate	Low	High
52-2-1183	Enclosed Shelter	High	High	High
52-2-1184	Enclosed Shelter	Low	Low	High
52-2-1186	Enclosed Shelter	Moderate	Moderate	High
52-2-1187	Enclosed Shelter	Moderate	High	High
52-2-1188	Enclosed Shelter	Low	Low	High
52-2-1189	Enclosed Shelter	Low	Low	High
52-2-1191	Open Site	Low	Low	High
52-2-1192	Enclosed Shelter	Low	Low	High
52-2-1195	Enclosed Shelter	Low	Low	High
52-2-1196	Open Site	Low	Low	High
52-2-1197	Open Site	None	Low	High
52-2-1198	Enclosed Shelter	High	High	High
52-2-1224	Open Site	None	Low	High
52-2-1225	Enclosed Shelter	Low	Low	High
52-2-1248	Open Site	None	Low	High
52-2-1223	Enclosed Shelter	Moderate	Moderate	High
52-2-1249	Enclosed Shelter	Moderate	High	High
52-2-1250	Open Site	None	Low	High
52-2-1251	Open Site	None	Low	High
New LC1	Enclosed Shelter	Moderate	Moderate	High
New NRE Women's Site	Open Site	None	High	High
New NRE Scarred Tree	Open Site	None	Low	High
Wonga East				
52-2-0083	Enclosed Shelter	Moderate	Moderate	High
52-2-0099	Enclosed Shelter	None	Low	High
52-2-0229	Open site	None	Low	High
52-2-0233	Open site	None	Low	High
52-2-0603	Enclosed Shelter	Low	Low	High
52-2-1081	Enclosed Shelter	Moderate	Moderate	High
52-2-1082	Enclosed Shelter	Moderate	Moderate	High

AHIMS Site Number	Context	Archaeological potential	Scientific significance[1]	Aboriginal social significance[2]
52-2-1095	Enclosed Shelter	High	High	High
52-3-0310	Enclosed Shelter	High	High	High
52-3-0311	Enclosed Shelter	High	Moderate	High
52-3-0312	Enclosed Shelter	High	Moderate	High
52-3-0313	Open Site	Low	Low	High
52-3-0314	Enclosed Shelter	Moderate	High	High
52-3-0317	Enclosed Shelter	Moderate	Moderate	High
52-3-0318	Enclosed Shelter	Moderate	Moderate	High
52-3-0319	Enclosed Shelter	Moderate	Moderate	High
52-3-0320	Open Site	None	Low	High
52-3-0322	Open Site	None	Low	High
52-3-0323	Enclosed Shelter	Moderate	Moderate	High
52-3-0325	Enclosed Shelter	Moderate	Moderate	High
Wonga East 1	Enclosed Shelter	High	Moderate	High
Wonga East 2	Enclosed Shelter	High	Moderate	High
Wonga East 3	Enclosed Shelter	High	Moderate	High

1. For non- relocated sites the scientific significance was determined from the condition described in the AHIMs site card (see *Section 6.2)*.
2. Derived from discussion with local Aboriginal community representatives in relation to site types identified.

7 IMPACT ASSESSMENT

7.1 POTENTIAL SUBSIDENCE IMPACTS

7.1.1 Introduction

NRE commissioned Seedsman Geotechnics Pty Ltd (Seedman) to prepare a subsidence assessment for the Project. The following impact assessment is based on the predications made by Seedsman. A copy of the full report *Gujarat NRE No.1 Colliery Management of Subsidence Risks Associated with Wongawilli Seam Extraction* (Seedsman 2012) is provided as *Annex M* of the Environmental Assessment Report.

7.1.2 Impact Types

The method of mining to be undertaken at the Wonga East and Wonga West mining areas is longwall extraction. Longwall extraction results in the remaining unsupported strata collapsing into the resulting void which is known as a goaf.

Collapse of overlying strata into the goaf results in surface subsidence. Subsidence causes a number of different potential impacts to the surface geology. The potential impacts are described in the following sections.

Subsidence

Subsidence is the vertical displacement occurring over the goaf. There is a horizontal component of this displacement both across the width of the panel and along the panel (NSW DoP 2008). Subsidence is expressed in terms of millimetres of displacement. The level of displacement has been assessed based upon the predictions provided by Seedsman (2012) for sites within the potential subsidence footprint.

Tilt

Tilt is created when two adjacent points undergo differing amounts of vertical displacement. Tilt is expressed in terms of millimetre per metre; this is the change in vertical orientation per meter of height above ground (NSW DoP 2008). Tilt has been predicted for each Aboriginal archaeological site within the potential subsidence footprint. The impact risk results, predicted by Seedsman, are shown in *Table 7.3*.

Strain

Strain is the change of horizontal distance between two points. This occurs as extension or compression (NSW DoP 2008). It is expressed in terms of millimetre per metre, where positive strain is tensile strain, and negative strain is compressive strain.

The strain has been predicted for each Aboriginal archaeological site within the potential subsidence footprint. The impact risk results, predicted by Seedsman, are shown in *Table 7.3*.

Valley Closure

Valley closure is where two sides of a valley move horizontally toward the centre line of the valley (NSW DoP 2008). Seedsman (2012: 40) has stated that Valley closure has been measured to within about 700m in-line of extraction or about a 45^{o} draw angle to the side. At the position of presumed negligible vertical subsidence the range of horizontal movement is less than 20mm to 150mm (at 35o draw angle) or 70mm (at 300m offset from extraction edge). It should be noted that Seedsman (2012:41) also states that due to an inadequate understanding of the variables there is great difficulty in accurately assessing valley closure in this instance.

Upsidence

Upsidence is the uplift of valley floor strata causing bulging, buckling and shearing of the near surface strata. This can cause the valley floor to 'rise' relative to its position prior to mining (NSW DoP 2008). For upsidence, the range of values at the negligible vertical subsidence limit are less than 20mm to a maximum of 60mm (Seedsman 2012: 40).

Far Field Horizontal Movement

Far-field horizontal movements involve the *en masse* horizontal displacement of the surface which has been detected in the Southern Coalfield over the past 15 years up to several km from the limits of mining. Far field horizontal movements involved are usually in the of the order of tens of millimetres. These movements give rise to induced tensile strains that are typically less than 0.01 mm/m. As such, they are immeasurable and their associated impacts are of little significance (DoP, 2008b). This impact is not predicted by the geotechnical report (Seedsman 2012).

7.1.3 Cliffs and Slopes

An assessment of the likely impacts to cliffs and steep slopes within Wonga East and Wonga West indicates that:

- within long wall areas there is a potential for rock fall to occur on 5% of the length of cliffs in Wonga East and most of Wonga West;
- rock falls are likely along 15% of Lizard creek located of Longwall A4-6;
- there are likely to be further subsidence impacts associated with waterfalls on Lizard Creek and Wallandoola Creek should proposed long walls be fully extracted; and

- surface cracking is considered possible in areas of steep slopes, particularly when mining is being conducted in the same direction as the slope. Cracking is anticipated in Long wall A4-6 and in areas of Hawkesbury sandstone in the south of Wonga East.

One site is located within A4-6 (52-2-1187), impacts to this sites has been assessed according to the subsidence estimates provided by Seedsman (2012).

7.1.4 *Consequences and Effects on Aboriginal Sites*

The following discussion (*Section 7.4*) provides an assessment of the potential impacts of mining on Aboriginal heritage site types recorded within the Study Area. It should be noted that different effects of subsidence have the potential to impact on heritage sites different ways.

Rock shelters may be adversely affected by cracking, movement along joints or bedding planes, by block fall and by water seepage. All these impacts may directly affect the stability of the shelter and consequentially any rock art within a shelter.

Impacts arising from valley closure can put additional strain on the cliff tops, which may cause consequential strain on any rock shelters present beneath the upper most landforms. Grinding grooves can be affected by upsidence only where they are located at or near the valley floor and thereby causing cracking as well as cracking from strain. Upsidence and valley closure have not been predicted (Seedsman 2012).

Artefact scatters can be indirectly impacted by tilt, causing rain water to run off in differing ways resulting in increased levels of erosion. Artefact scatters are least likely Aboriginal site type to be impacted by mining subsidence (DoP 2008b).

7.2 BACK ANALYSIS AND IMPACT GUIDELINES

Previous studies have monitored changes to rock shelters in areas where mining has occurred. However there is insufficient data recorded on the actual impacts versus predicted impacts of subsidence (i.e. amount of movement, subsidence, tilt and stain) to Aboriginal heritage sites to predict what the effects of various levels of subsidence, tilt or strain with any certainty. The available data is from monitoring of sites pre and post mining, but this data does not provide actual versus predicted measurements.

Sefton's monitoring work is summarised in *Section 4.1.4*. The key risk for rock shelters was found to be the size of the overhang. 52 rock shelter sites were monitored over ten years. No rock shelter smaller than 50m ^{3} was impacted by mining subsidence.

Kayandel (2009) describes monitoring of 103 rock shelters (including Seftons' 2000 work) and shows that eleven sites had been impacted; Aboriginal heritage was impacted at only one of the sites.

Biosis (2009) report found that rock shelter collapse in a conservation area not impacted by mining. That site was over 1.5 km away from the nearest mining activity. The Biosis study also reported a collapse of an overhang located 550 m outside the longwall panel, after heavy rain. It was reported that the collapse of this overhang was not mining related.

Previous monitoring programs (Sefton 2000, Kayandel 2008) have assessed rock overhangs where the predicted tensile strain was greater than or equal to 0.5 mm/m and where the predicted compressive strain was greater than or equal to 2 mm/m.

The results of previous monitoring indicate that the following should be considered in undertaking the impact assessment:

- the predicted amount of subsidence/strain/ tilt;
- the size of the overhang (where known);
- the location of the site in relation to the longwalls. If the site is directly over a goaf it is more likely to be impacted; and
- the data available which indicated that only 10%of sites with predicted impacts have shown actual impact from mining subsidence.

7.3 SITES WITHIN THE POTENTIAL SUBSIDENCE FOOTPRINT

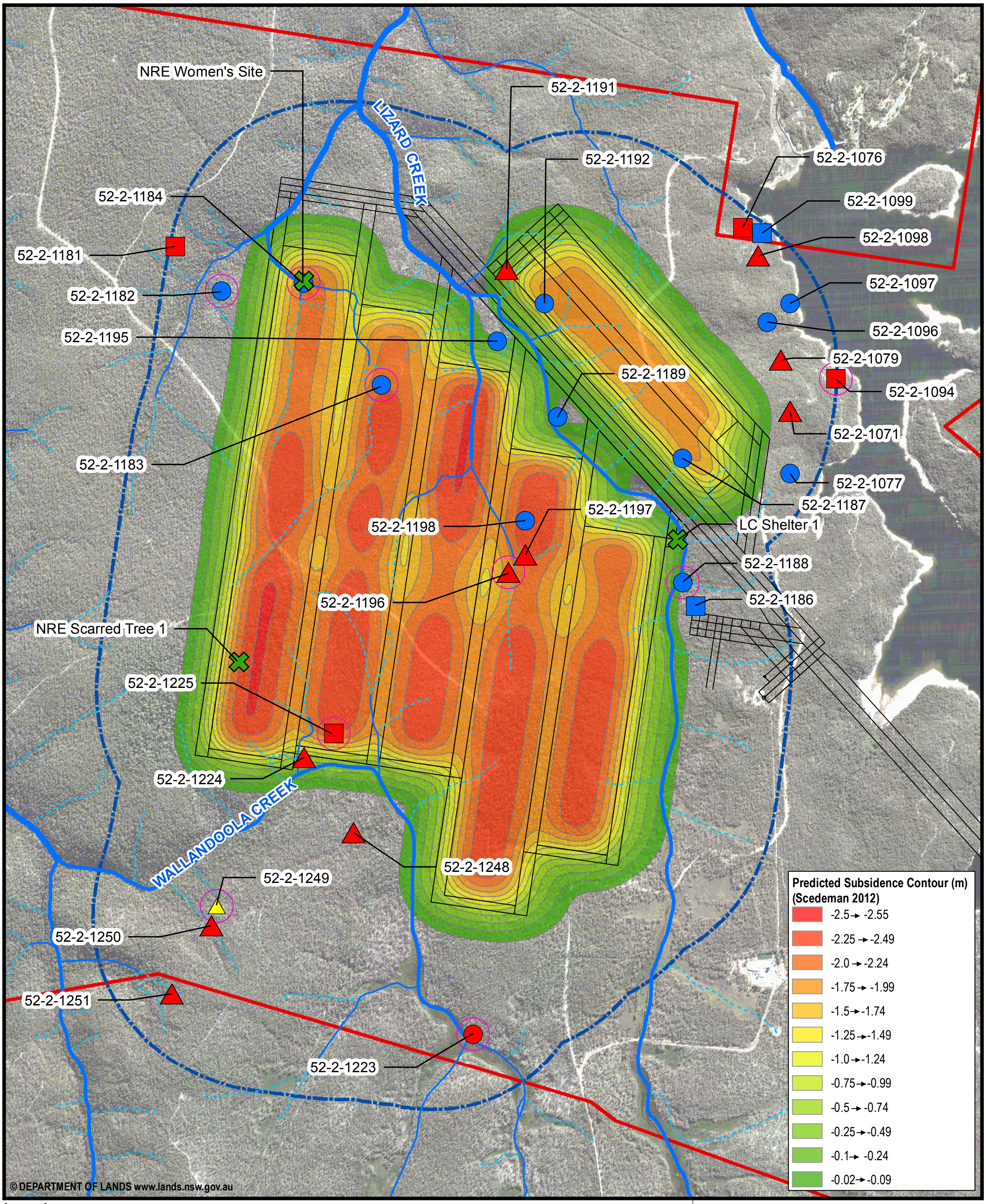
All sites within the Study Area have been considered in this assessment. However, not all of these sites are within the potential subsidence footprint.

Table 7.1 identifies which sites are located within the potential subsidence footprint (as predicted by Seedsman 2012). These are illustrated on *Figure 7.1* and *Figure 7.2.*

Table 7.1 Sites within the Potential Subsidence Footprint

AHIMS Site Number	Scientific Significance	Site Type	Within potential subsidence footprint
Wonga West			
52-2-1071	Low	Axe grinding grooves	No
52-2-1076	High	Shelter with Art and Deposit	No
52-2-1077	High	Shelter with Art	No
52-2-1079	Moderate	Axe grinding groove	No
52-2-1094	High	Shelter with Art and Deposit	No
52-2-1096	High	Shelter with Art	No
52-2-1097	High	Shelter with Art	No
52-2-1098	Moderate	Axe grinding groove	No
52-2-1099	Moderate	Shelter with Deposit	No
52-2-1181	Moderate	Shelter with Art and Deposit	No
52-2-1182	Low	Shelter with Art	No
52-2-1183	High	**Shelter with Art**	**Yes**
52-2-1184	Low	**Shelter with Art**	**Yes**
52-2-1186	Moderate	Shelter with Deposit	No
52-2-1187	High	**Shelter with Art**	**Yes**
52-2-1188	Low	Shelter with Art	No
52-2-1189	Low	**Shelter with Art**	**Yes**
52-2-1191	Low	**Axe grinding grooves**	**Yes**
52-2-1192	Low	**Shelter with Art**	**Yes**
52-2-1195	Low	**Shelter with Art**	**Yes**
52-2-1196	Low	**Axe grinding grooves**	**Yes**
52-2-1197	Low	**Axe grinding grooves**	**Yes**
52-2-1198	High	**Shelter with Art**	**Yes**
52-2-1223	Low	Shelter with Deposit, and Axe grinding grooves	No
52-2-1224	Low	**Axe grinding grooves**	**Yes**
52-2-1225	Low	**Shelter with Art and Deposit**	**Yes**
52-2-1248	Moderate	Axe grinding grooves	No
52-2-1249	High	Shelter with Art, and Axe grinding grooves	No
52-2-1250	Low	Axe grinding grooves	No
52-2-1251	Low	Axe grinding grooves	No
New NRE Rock shelter 1	Moderate	**Shelter with Art**	**Yes**
New NRE Women's Site	High	**Water Hole with Aboriginal Ceremony and Dreaming**	**Yes**
New NRE Scarred Tree	Low	**Scarred Tree**	**Yes**
Total In			***15***
Total Out			***18***

AHIMS Site Number	Scientific Significance	Site Type	Within potential subsidence footprint
Wonga East			
52-2-0083	Moderate	Shelter with Deposit	No
52-2-0099	Low	Shelter with Art and Deposit and axe grinding grooves	No
52-2-0229	Low	Axe grinding grooves	No
52-2-0233	Low	Axe grinding grooves	No
52-2-0603	Low	Shelter with Art	No
52-2-1081	Moderate	Shelter with Art and Deposit and axe grinding grooves	No
52-2-1082	Moderate	Shelter with Art	No
52-2-1095	High	Shelter with Art	No
52-3-0310	High	Shelter with Art and Deposit and axe grinding grooves	No
52-3-0311	Moderate	**Shelter with Deposit**	**Yes**
52-3-0312	Moderate	Shelter with Deposit	No
52-3-0313	Low	Artefact Scatter	**Yes**
52-3-0314	High	Shelter with Art	No
52-3-0317	Moderate	Shelter with Deposit	No
52-3-0318	Moderate	Shelter with Art	No
52-3-0319	Moderate	Shelter with Deposit	No
52-3-0320	Low	**Axe grinding grooves**	**Yes**
52-3-0322	Low	Axe grinding grooves	No
52-3-0323	Moderate	Shelter with Deposit	No
52-3-0325	Moderate	Shelter with Art	No
Wonga East 1	Moderate	**Shelter with Deposit**	**Yes**
Wonga East 2	Moderate	Shelter with Deposit	**Yes**
Wonga East 3	Moderate	**Shelter with Deposit**	**Yes**
Total In			***6***
Total Out			***17***



Legend

Project Application Area

Study Area - Wonga West

Stream_Order_Nov2012

Order_

- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order and above stream

Identified Heritage Site (ERM 2009)

Relocated AHIMS Site (ERM 2009)

AHIMS Site Type

- Axe Grinding Groove
- Axe Grinding Groove, Shelter with Art
- Axe Grinding Groove, Shelter with Deposit
- Shelter with Art
- Shelter with Art, Shelter with Deposit
- Shelter with Deposit

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery Aboriginal Heritage Assessment		
Drawing No:	0079383s_AHA_G016_R0.mxd		
Date:	15/11/2012	Drawing size:	A4
Drawn by:	SQW	Reviewed by:	MK
Scale:	Refer to Scale Bar		

N

0 250 500 750m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

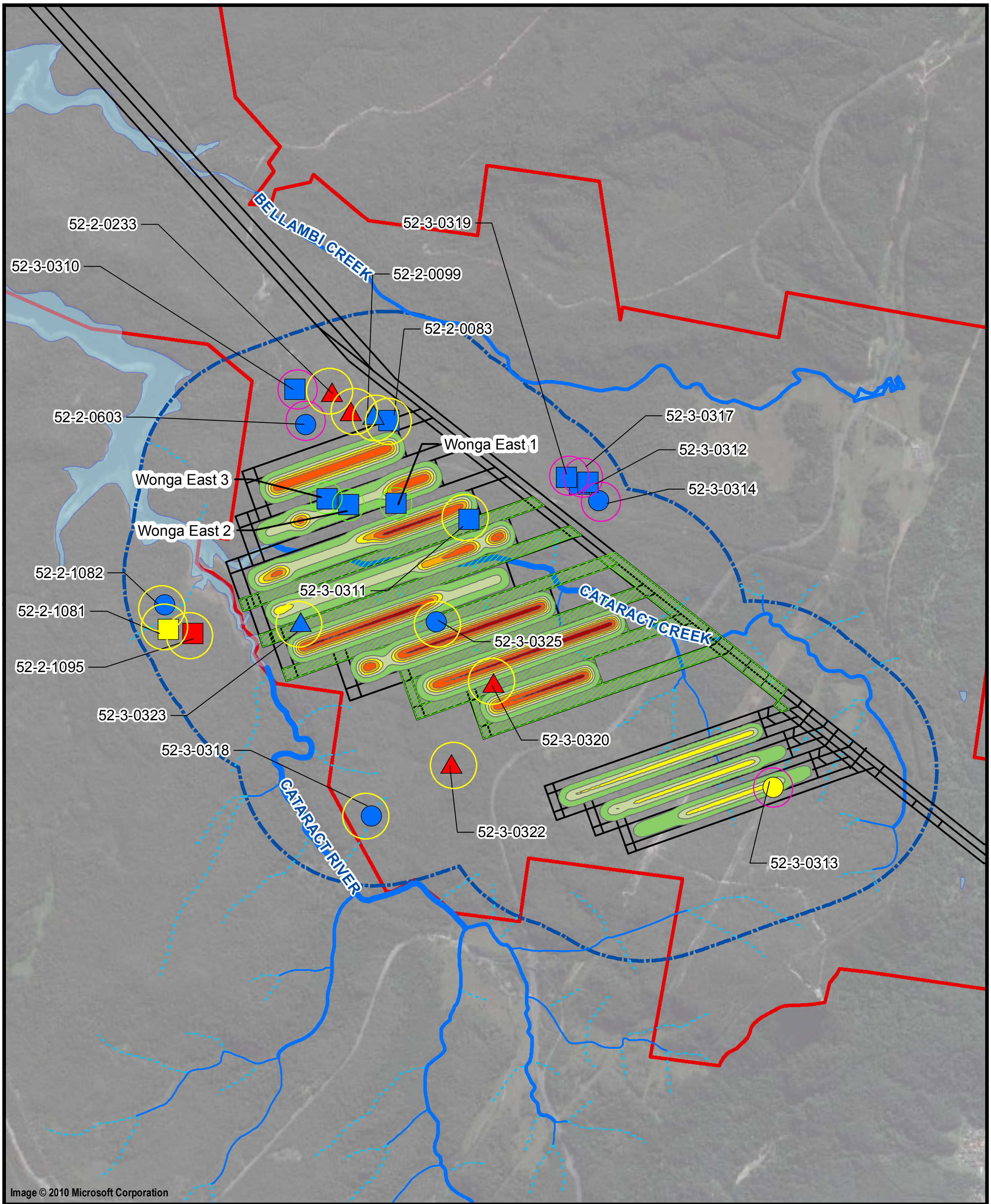
Figure 7.1

Archaeological sites located within the Wonga West subsidence footprint

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM



Legend

- Project Application Area
- Study Area - Wonga East
- Subject to separate application (MP 10_0046_MOD 1)

AHIMS Site Type

- Axe Grinding Groove
- Axe Grinding Groove, Shelter with Art, Shelter with Deposit
- Open Camp Site
- Shelter with Art
- Shelter with Deposit
- Relocated AHIMS Site (Biosis 2012)
- Relocated AHIMS Site (ERM 2009)
- New AHIMS Site (Biosis 2012)

- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order and above stream

Predicted Subsidence Contour (m) (Seedsman 2012)

- -0.02 -0.19
- -0.2 -0.39
- -0.4 -0.59
- -0.6 -0.79
- -0.8 -0.99
- -1.0 -1.2

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery Aboriginal Heritage Assessment
Drawing No:	0079383s_AHA_GIS013_R2.mxd
Date:	28/11/2012 Drawing size: A4
Drawn by:	KB Reviewed by: MK
Scale:	Refer to Scale Bar

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0 250 500 750m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Figure 7.2

Archaeological sites located within the Wonga East subsidence footprint

Environmental Resources Management Australia Pty Ltd

Brisbane, Canberra, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM

The impact assessment has focused on the sites within the potential subsidence footprint. Seedsman (2012) notes that sites outside the potential subsidence footprint are unlikely to be impacted by the longwall mining.

7.4 PREDICTED IMPACTS TO SITES

Seedsman (2012) provided an indication of the predicted subsidence, strain and tilt in relation to the potential subsidence footprint. This information along with the size of the rock shelter and the placement of the site in relation to the goaf (factors identified as relevant by Sefton 2000) have been allocated a scaling in order to quantify potential likelihood of impact to the affected sites. The scaling is presented in *Table 7.2*.

Table 7.2 Risk factor Scaling

Risk Factor	Low	Medium	High
Subsidence	0-1000mm	1001-2000mm	2001+mm
Tilt (+ or -)	0-9mm/m	10-19mm/m	20+mm/m
Strain (+ or -)	0-9mm/m	10-19mm/m	20+mm/m
Size of Shelter	less 50m³		Over 50m³
Over Goaf	No		Yes

Three levels of likelihood have been allocated to each risk factor. This information has been applied to each site within the predicted subsidence footprint to determine the impact likelihood. The results are presented in *Table 7.3*.

Note that not all factors have been given the same weight. A higher weight has been applied to sites located over the goaf. As there is no precise way to predict actual impact and previous monitoring programs have indicated that only 10 % of the recorded sites are likely to be impacted (Sefton 2000), this approach is considered reasonable.

There are five levels of impact risk:

- high, where the potential impact risk to the site is likely;
- moderate, where the potential impact risk to the site is possible;
- low, where there is limited potential impact risk;
- very low, where potential impact risk is unlikely; and
- negligible, where potential impacts are not predicted to affect the site.

A moderate impact likelihood was the highest recorded in this assessment and was applied to 15 sites. The remaining six sites within the predicted subsidence footprint recording impact likelihood of very low or negligible.

Table 7.3 Impact Likelihood

AHIMS Site Number	Relocated	Subsidence (mm)	Final Tilt (mm/m)	Final Strain (mm/m)	Size of overhang	Over Goaf[1]	Impact Risk
Wonga West							
52-2-1183	Yes	2200 (H)	2 (L)	-3 (L)	$79m^3$ (H)	Yes (H)	Moderate
52-2-1184	Yes	1920 (M)	3 (L)	-4 (L)	$4m^3$ (L)	Yes (H)	Moderate
52-2-1187	No	1500 (M)	8 (L)	-6 (L)	$20m^3$ (L)	Yes (H)	Moderate
52-2-1189	No	20 (L)	0.9 (L)	1 (L)	$16.m^2$ (L)	No (L)	Negligible
52-2-1191	No	400 (L)	6 (L)	3.5 (L)	NA (L)	No (L)	Negligible
52-2-1192	No	1700 (M)	8 (L)	-5(L)	$18m^3$ (L)	Yes (H)	Moderate
52-2-1195	No	500 (L)	1.5 (L)	3 (L)	$54m^3$ (H)	No (L)	Very Low
52-2-1196	Yes	1800 (M)	4 (L)	-2(L)	NA (L)	Yes (H)	Moderate
52-2-1197	No	2250 (H)	3 (L)	-2.5(L)	NA (L)	Yes (H)	Moderate
52-2-1198	No	2300 (H)	2 (L)	-2.5(L)	$15m^3$(L)	Yes (H)	Moderate
52-2-1224	No	700 (L)	8 (L)	4(L)	NA(L)	No (L)	Negligible
52-2-1225	Yes	2200 (H)	6 (L)	-6(L)	$72m^3$(H)	Yes (H)	Moderate
New LC1	Yes	25 (L)	1.5 (L)	2 (L)	$81m^3$ (H)	No (L)	Very Low
New NRE Women's Site	Yes	500 (L)	16 (M)	5 (L)	NA(L)	Yes (H)	Moderate
New NRE Scarred Tree	Yes	2250 (H)	8 (M)	-8 (L)	NA(L)	Yes(H)	Moderate
Wonga East							
52-3-0311	No	20 (L)	2 (L)	5 (L)	$62m^3$(H)	Yes (H)	Moderate
52-3-0313	Yes	20 (L)	10 (M)	0 (L)	NA (L)	Yes (H)	Moderate
52-3-0320	No	20 (L)	5 (L)	2 (L)	NA (L)	Yes (H)	Moderate
Wonga East 1	No	20 (L)	5 (L)	-2 (L)	NA (L)	Yes (H)	Moderate
Wonga East 2	No	200 (L)	0 (L)	2 (L)	NA (L)	Yes (H)	Moderate
Wonga East 3	No	20 (L)	NA (L)	NA (L)	NA (L)	No (L)	Very Low

1. For sites that have not been relocated the location has been determined using the co-ordinates provided on the AHIMs site card which may be inaccurate. The location of re-located sites can be accurately stated.

7.4.1 *Rating the Impact Assessment*

In order to rank the level of potential impact to each Aboriginal site, an impact assessment score has been prepared. The impact assessment score combines, by summation, impact likelihood (as determined in *Table 7.3*) and the scientific significance of the site (as summarised in *Table 6.2*). The lower the final score, the higher the risk.

Table 7.4 Impact Assessment Score

Impact risk	Score	Scientific significance	Score
High	1	High	1
Moderate	2	High/moderate	2
Low	3	Moderate	3
Very low	4	low	4
Negligible	5		

The results for reach site are summarised in *Table 7.5*.

Table 7.5 Impact Assessment Score

AHIMS Site Number	Site Type	Impact Risk	Scientific significance	Impact Assessment Score
Wonga West				
2-2-1183	Shelter with Art	Moderate	High	3
52-2-1184	Shelter with Art	Moderate	Low	6
52-2-1187	Shelter with Art	Moderate	High	3
52-2-1189	Shelter with Art	Negligible	Low	9
52-2-1191	Axe grinding grooves	Negligible	Low	9
52-2-1192	Shelter with Art	Moderate	Low	6
52-2-1195	Shelter with Art	Very Low	Low	8
52-2-1196	Axe grinding grooves	Moderate	Low	6
52-2-1197	Axe grinding grooves	Moderate	Low	6
52-2-1198	Shelter with Art	Moderate	High	3
52-2-1224	Axe grinding grooves	Negligible	Low	9
52-2-1225	Shelter with Art and Deposit	Moderate	Low	6
New LC1	Shelter with Art	Very Low	Moderate	7
New NRE Women's Site	Water Hole with Aboriginal Ceremony and Dreaming	Moderate	High	3
New NRE Scarred Tree	Scarred Tree	Moderate	Low	6
Wonga East				
52-3-0311	Shelter with Deposit	Moderate	Moderate	5
52-3-0313	Artefact Scatter	Moderate	Low	6
52-3-0320	Axe grinding grooves	Moderate	Low	6
Wonga East 1	Shelter with deposit	Moderate	Moderate	5
Wonga East 2	Shelter with deposit	Moderate	Moderate	5
Wonga East 3	Shelter with deposit	Very Low	Moderate	7

The impact assessment scores are between 3 and 9; where 3 is a moderate risk to a highly significant site and 9 is a negligible risk to a low significance site. Sites with impact assessment scores between 2 and 5 need to be managed.

7.4.2 *Impact Assessment by Area*

Wonga West

There are 33 sites in Wonga West, 18 of which will not be impacted by mining subsidence.

There are 15 sites within the potential subsidence footprint including:

- three rock shelters with high significance (52-2-1183 , 52-2-1187 and 52-2-1198);
- one rock shelters with moderate significance (New NRE Rock Shelter 1);
- five rock shelters with low significance (52-2-1184, 52-2-1189, 52-2-1192, 52-2-1195 and 52-2-1225);
- four axe grinding grooves with low significance (52-2-1191, 52-2-1196, 52-2-1197 and 52-2-1224);
- one women's site with high significance (New NRE Women's Site); and
- one scarred tree with low significance (New NRE Scarred Tree).

Wonga East

There are 23 sites in the Wonga East Study Area, 17 of which will not be impacted by mine subsidence. The undisturbed sites include 14 shelters and three axe grinding grooves. Three sites are of high scientific significance, six have moderate significance and four have low significance.

There are six sites within the potential subsidence footprint. These include:

- four rock shelters with moderate significance (52-3-0311, Wonga East 1, Wonga East 2 & Wonga East 3);
- one axe grinding grooves with low significance (52-3-0320); and
- one artefact scatter with low significance (52-3-0313).

Where high or moderately significant sites within the envelope defined by a 600 m barrier around the mining footprint at Wonga East and Wonga West are at moderate or high risk they should be actively managed and monitored throughout and following the mining period. *Section 8* details proposed management and mitigation measures.

8 MANAGEMENT AND MITIGATION MEASURES

The focus of mine planning was to eliminate subsidence risks where possible by avoiding significant environmental features including Aboriginal heritage sites. (Seedsman 2012). Mine planning was informed by a risk assessment workshop reported in Failure Mode and Effect Analysis Report (Olsen 2012).

The following management measures are made having regard to the findings of the Study Area inspection, background research, predictive modelling, heritage significance assessment, relevant NSW legislation protecting Aboriginal heritage (refer to *Annex C*), the OEH Aboriginal Cultural Heritage Assessment Guidelines and consultation with local Aboriginal stakeholders.

8.1 STRATEGY - AVOIDANCE

The iterative mine planning process involved consideration of longwall options in light of archaeological constraints, in order to avoid impact to areas of high conservation value. A number of surface features above the proposed mining area were identifies through the risk management workshop process (Olsen 2012). Luke Kirkwood, ERM archaeologist was involved in the risk assessment workshop process. Utilising an elimination approach for risk management, NRE are proposing not to undertake longwall extraction under or close to some features of special significance (Olsen Consulting 2012).

The proposed mine plans have avoided longwall extraction directly under third and fourth order creeks (Seedsman Geotechnics 2012), with the exception of an unnamed tributary of Lizard Creek in Wonga West and within proximity to Cataract Dam. In addition the proponent has provided an undertaking that it will terminate mining beneath Cataract Creek if subsidence and ground movements exceed 250 mm and the creek experiences greater than minimal impact This approach has enabled large number of significant aboriginal sites to been avoided, particularly those sites located adjacent to Cataract Dam.

There are 56 Aboriginal archaeological sites recorded within Study Area comprising 12 sites of high scientific significance, 20 sites of moderate scientific significance and 24 sites of low significance. The avoidance strategy has ensured that 35 of these sites are not within the potential subsidence footprint. Eight high significance sites, 15 moderate significance sites and 12 of the low significance sites have been avoided.

8.2 STRATEGY – MONITORING

Twenty-one sites are within the potential subsidence footprint. Four sites are of high archaeological significance and five sites are of moderate archaeological significance. Where high or moderately significant sites are at moderate or high impact risk they will be actively managed.

There are five site types present within the potential subsidence footprint. These are axe grinding grooves, artefact scatters, scarred trees, water holes and rock shelters. These will be managed in different ways as the subsidence may impact these sites in different ways. The enclosed sites may collapse, while the open sites may crack or be impacted by tilt.

8.2.1 Open Sites

Axe grinding grooves and artefact scatter sites within the potential subsidence footprint have an impact assessment score of 7 or more and are therefore at a low or very low risk from mine related subsidence. Where relocation of these sites is able to be achieved, monitoring will involve visual inspection and update to the AHIMS site card pre and post mining.

The scarred tree has an impact assessment score of six and therefore is unlikely to be adversely impacted by the project. It requires no further management or mitigation.

The women's site has a score of three and requires further management. The women's site will be photographically recorded and plans drawn, prior to mining. The women's site will be included in a monitoring program developed in consultation with the female elders as this site may be sensitive and may be taboo for males to visit.

8.2.2 Enclosed Sites

Seven enclosed (shelter) sites will be monitored; these are 52-2-1183, 52-2-1187, 52-2-1198 and 52-2-1225 in the Wonga West Study Area; and 52-3-0311 Wonga East 1 and Wonga East 2 in the Wonga East Study Area. The monitoring program will include monitoring in line with Sefton's (2000) program. All seven shelters will be subject to monitoring at the following times:

- pre mining;
- three months after mining beneath the shelter;
- six months after mining beneath the shelter; and
- post mining.

Archival photographic recording of the three Wonga West sites with high significance (52-2-1183, 52-2-1187 and 52-2-1198) will be undertaken in conjunction with the initial pre mining monitoring. This will include:

- photographic recording of the art and the shelter in its entirety; and
- archival recording including sketch plans of the art and shelter.

This information will be produced in a report to be provided to NRE, and a copy given to OEH. The AHIMS site cards will be updated with the information.

If any of the sites show changes during the course of monitoring, additional management and mitigation measures will be determined on a case by case basis by a qualified archaeologist in consultation with an Aboriginal representative.

The remaining shelters in the potential subsidence footprint do not require monitoring. These shelters will be re-located if possible and monitored pre and post mining. The AHIMS site cards will be updated as the sites are located.

The monitoring of all the sites will be undertaken by a qualified archaeologist with the involvement of the Aboriginal community. As the rock shelters with art are of high significance, and the area in which they are found is not generally accessible to the Aboriginal community, sites officers from the Aboriginal community groups will be invited along to attend the monitoring inspection. This will provide sites officers with a teaching and learning experience regarding these cultural heritage sites.

8.3 SUMMARY OF MITIGATION MEASURES

Table 8.1 provides a summary of the management measures for sites within the potential subsidence footprint.

Table 8.1 Management Measures for the Identified Aboriginal Sites

AHIMS Site Number	Site Type	Relocated during survey	Impact Assessment Score	Management Requirement
Wonga West				
52-2-1183	Shelter with Art	Yes	3	Monitoring and photographic archival recording with aboriginal sites officer. Update AHIMS Site card.
52-2-1184	Shelter with Art	Yes	6	Monitor pre and post mining with Aboriginal sites officers. Update AHIMS Site card.
52-2-1187	Shelter with Art	No	3	Relocate if possible. Monitoring and photographic archival recording with aboriginal sites officer. Update AHIMS Site card.
52-2-1189	Shelter with art	No	9	Relocate if possible. Monitoring pre and post mining with Aboriginal sites officers. Update AHIMS Site card.
52-2-1191	Axe grinding grooves	No	9	Relocate if possible. Visual inspection Pre & Post mining Update AHIMS site card.
52-2-1192	Shelter with Art	No	6	Relocate if possible. Monitoring pre and post mining with Aboriginal sites officers. Update AHIMS Site card.

AHIMS Site Number	Site Type	Relocated during survey	Impact Assessment Score	Management Requirement
52-2-1195	Shelter with Art	No	8	Relocate if possible. Monitoring pre and post mining with Aboriginal sites officer. Update AHIMS Site card.
52-2-1196	Axe grinding grooves	Yes	6	Visual inspection Pre & Post mining. Update AHIMS site card.
52-2-1197	Axe grinding grooves	No	6	Relocate if possible. Visual inspection Pre & Post mining. Update AHIMS site card.
52-2-1198	Shelter with Art	No	3	Relocate if possible. Monitoring and photographic archival recording with aboriginal sites officer. Update AHIMS Site card.
52-2-1224	Axe grinding grooves	No	9	Relocate if possible. Visual inspection Pre & Post mining. Update AHIMS site card.
52-2-1225	Shelter with Art and Deposit	Yes	5	Monitoring pre and post mining with Aboriginal sites officer. Update AHIMS Site card.
New LC1	Shelter with Art	Yes	7	Monitoring pre and post mining with Aboriginal sites officers. Update AHIMS Site card.
New NRE Women's Site	Water Hole with Aboriginal Ceremony and Dreaming	Yes	3	Monitoring programme to be established in consultation with the female elders. Update AHIMS site card.
New NRE Scarred Tree	Scarred Tree	Yes	6	Visual inspection Pre & Post mining and update AHIMS site card.
Wonga East				
52-3-0311	Shelter with Deposit	No	5	Relocate if possible. Monitoring and Update AHIMS Site card.
52-3-0313	Artefact Scatter	Yes	6	Visual inspection Pre & Post mining with aboriginal sites officer. Update AHIMS site card.
52-3-0320	Axe grinding grooves	No	6	Relocate if possible. Visual inspection Pre & Post mining with aboriginal sites officer. Update AHIMS site card.
Wonga East 1	Shelter with Deposit	No	5	Relocate if possible Monitoring pre and post mining with Aboriginal sites officers. Update AHIMS Site card.
Wonga East 2	Shelter with Deposit	No	7	Relocate if possible Monitoring pre and post mining with Aboriginal sites officers. Update AHIMS Site card
Wonga East 3	Shelter with Deposit	No	7	Relocate if possible. Visual inspection Pre & Post mining. Update AHIMS site card.

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Annex A

Russell Vale Site Aboriginal Heritage Assessment

A RUSSELL VALE ABORIGINAL HERITAGE

A.1 INTRODUCTION

An Aboriginal heritage assessment was undertaken by ERM for the surface facilities upgrade at the Russell Vale site. This study looked at the existing conditions on the site. A field survey with Aboriginal community representatives was undertaken to determine if Aboriginal archaeological sites were present or if there was any potential for unidentified sites to be present at the Russell Vale site.

A.1.1 Study Area

The study area for assessment of the surface facilities upgrade focuses on the Russell Vale site. The Russell Vale site occupies approximately 100 ha east of the Illawarra Escarpment. The Russell Vale site includes the administration offices and coal handling facilities.

A.1.2 AHIMs Data

A search of the DECCW Aboriginal Heritage Information Management System (AIHMS) database for an area 12 km by 12 km, with the NRE No.1 Colliery at the centre of the search, was undertaken on 17 October 2008. The search identified 254 recorded Aboriginal sites, the substantial majority of which were shelter sites containing a combination of art, archaeological deposits and grinding groove. No sites were identified at the Russell Vale site. West of the Russell Vale site on the Woronora Plateau there are three registered sites 52-2-1147, 52-3-0313 and 52-3-0324, all three are open artefact scatters that sit at the top of the slope. Two are recorded as close to a creek.

East of the Russell Vale site there are sites recorded along the coast and these are all predominantly midden sites.

A.1.3 Predictive Model

The Russell Vale site has been extensively modified during the European use and the long history of mining at this location. The Russell Vale site is located on the lower slopes of the Woronora plateau, and as such contains some sandstone features but few areas of sandstone overhangs as found further up in the Woronora Plateau.

Table A.1 provides a description of the various archaeological site types and the environments where they are generally found. A statement is made on the likely presence of each site type within the Russell Vale site.

Table A.1 Aboriginal sites commonly found in the local area

Site types	Definitions
Stone artefact scatters	Stone artefact scatters are collections of stone, frequently brought from other areas, which demonstrate evidence for Aboriginal working, use and/or discard of the stone at a single location. Stone artefact concentrations may be associated with any of the site types listed in this table. Where such sites are buried by sediment they may not be noticeable unless exposed by erosion. These sites may be found in any undisturbed landform across the local area, but are most likely to be associated with waterways, flat landforms and ridgeline. It is anticipated that if stone artefact scatters are present they will be found in association with Bellambi Gully Creek.
Isolated finds	Sites consisting of only one identified stone artefact, isolated from any other artefacts or archaeological evidence (and defined by an arbitrary separation distance of 50 m). They are generally indicative of sporadic past Aboriginal use of a location. A distinction should be drawn between isolated finds which are a component of the background distribution and objects such as axes, hammer stones, grinding dishes etc which would have been used repeatedly. These sites may be found in any undisturbed landform across the local area, but are most likely to be associated with waterways, flat landforms and ridgeline. It is anticipated that if isolated stone artefacts are present they will be found in association with the original Bellambi Gully Creek.
Grinding grooves	Grooves resulting from the grinding of stone axes or other implements are found on flat areas of suitable sandstone. They are often located near waterholes or creek beds as water is necessary in the sharpening process. In areas where suitable outcrops of rock were not available, transportable pieces of sandstone were used. These site may be found on open sandstone platforms if they occur near the original Bellambi Gully Creek., if this site type is found it is anticipated that they would be located close to or within original Bellambi Gully Creek.
Shelter sites	Sandstone shelters and overhangs were used by Aboriginal people to provide habitation areas sheltered from the rain and sun. The deposits in such sites are commonly very important because they often contain clearly stratified material in a good state of preservation. The Russell Vale site does not contain areas of stone overhangs and thus it is not expected that this site type will be present.

Quarries	These are areas where stone was obtained for flaked artefacts or ground-edge artefacts, or where ochre was obtained for rock paintings, body decoration or decorating wooden artefacts. There are no known sources of stone tool raw materials located within the study area and thus this site type is not predicted to be present.
Art sites	Aboriginal paintings, drawings and stencils are commonly found where suitable surfaces occur in sandstone shelters and overhangs. These sites are often referred to as rock shelters with painted art. Rock engravings, carvings or peckings are also to be found on sandstone surfaces both in the open and in shelters. These are referred to as rock engraving sites. As there are no overhangs at the Russell Vale site and no large open sandstone platforms it is not expected that this site type will be present within the study area.
Scarred trees	Scarred trees bear the marks of bark and wood removal for utilisation as canoes, shields, boomerangs or containers. It is commonly very difficult to confidently distinguish between Aboriginal scars and natural scars or those made by Europeans. Scars may also originate as 'foot-marks', small pockets cut into the bark of a tree enabling the tree to be climbed. The Russell Vale site has been cleared of original vegetation and there is no chance of scarred trees being present.
Burial sites	Burials may be of isolated individuals, or they may form complex burial grounds. Often associated with other site types such as middens, or mounds. These sites are not expected to be located within the local area .
Stone arrangements, carved trees and ceremonial grounds	These site types are often interrelated. Stone arrangements vary from simple cairns or piles of rocks to more elaborate arrangements; patterns of stone laid out to form circles and other designs, or standing slabs of rock held upright by stones around the base. Carved trees may have intricate geometric or linear patterns or representations of animals carved into their trunks. Ceremonial grounds and graves were often marked by such trees. Bora grounds are a common type of ceremonial site and they are generally associated with initiation ceremonies. They comprise two circles, generally edged with low banks of earth but sometimes of stone, a short distance apart and connected by a path. It cannot be predicted whether these sites will occur.

A.1.4 Fieldwork

Fieldwork was undertaken on 20 April 2010. Two Aboriginal community representatives Peter Falk (DKH) and Richard Campbell (ILALC) accompanied Dr Diana Neuweger (ERM).

Methodology

The field survey looked at the areas to be disturbed by the proposed facility upgrades and the area of the original Bellambi Gully Creek.

A hand held GPS was used to record the tracks walked during fieldwork. *Figure A.1* shows the survey tracks undertaken. A digital SLR camera was used to record photographs (refer to *photographs A.1* to *A.5*).

Results

There were no Aboriginal archaeological sites recorded during the field survey. The Russell Vale site has been extensively modified and cleared. There were no old growth trees located within the areas to be impacted by the facility upgrades. There were no areas of archaeological potential identified during the field survey. The Aboriginal community did not express any concern that the proposed works will impact on cultural or spiritual sites.

Ground visibility was almost non existent over the entire Russell Vale site. Vegetation growth along the Bellambi Gully Creek was dense and gave very limited visibility. Coal reject has been dumped over parts of the Russell Vale site for road base and eliminates visibility of the original ground surface.

Legend

- Project Application Area
- Survey Transect

Figure A.1

Survey Transects Recorded During Fieldwork

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery Aboriginal Heritage Assessment
Drawing No:	0079383h_AHA_AnA_C001_R0.cdr
Date:	25/10/2012 Drawing size: A3
Drawn by:	JD Reviewed by: TM
Scale:	Refer to Scale Bar

N 0 30 60 90m

Environmental Resources Management Australia Pty Ltd

Brisbane, Canberra, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM

Photograph A.1 Showing vegetation growth around Bellambi Gully Creek

Photograph A.2 Concrete culvert via which the open channel of Bellambi Gully Creek is currently directed into the underground pipe.

Photograph A.3 Coal reject road base

Photograph A.4 Hillslope in central western area near the ROM Stockpile showing some terracing of the hill slope and past vegetation clearing.

Photograph A.5 The original creek line crossed the decline conveyor and is currently channelled in a concrete culvert under the conveyor.

The Aboriginal representatives present considered that as the site has been extensively modified, there is no concern that any Aboriginal sites may harmed by the proposed works. The Aboriginal representatives advised that no monitoring of works would be required but that a Management Plan for chance find protocols should be in place prior to works being undertaken.

A.2 *MITIGATION MEASURES*

There are no Aboriginal heritage sites or values present within the Russell Vale site, no management for Aboriginal Heritage is required.

A Management Plan for the discovery of suspected Aboriginal objects (chance finds) will be put in place prior to works commencing.

The following provides a chance find protocol in the unlikely event that an artefact or site is found at the Russel Vale site. If a potential Indigenous artefact or site is identified the following actions should be undertaken:

- contact the registered stakeholder groups who participated in fieldwork, Illawarra Local Aboriginal Land Council and the D'harawal Knowledge Holders and have a representative identify if the suspected item is in fact an Aboriginal site or object;

- if the identification is positive, contact a qualified archaeologist to record the site or object. The archaeologist in consultation with the registered stakeholder groups should provide management and mitigation measures as necessary, and provide a short report of the investigation to NRE and a copy to DECCW;

- if human skeletal remains are found the following actions should be undertaken;

    - stop works in the immediate area of the remains;

    - the local police contacted, a physical anthropologist or archaeologist contacted;

    - if the remains are determined to be of antiquity and of Indigenous origin contacted the registered stakeholder groups; and

- management and mitigation measures should be drawn up in consultation with the registered stakeholder groups and the archaeologist.

Annex B

Aboriginal Stakeholder Consultation Log

Table B.1 Stage 1 – Aboriginal Group Registration; Advisory Requests Sent

Organisation	Contact	Date Sent	Comment	Reference
Illawarra Mercury Newspaper	Michelle McCormack	03 October 08	Add to run on 10 October 2008 requesting response by 20 October 2008	Annex B2
DECCW	Laurel Alexander	03 October 08	Emailed; response 15 October 2 groups	Annex B3
Illawarra LALC		16 October 08	Response to Advertisement: 9 groups	Annex B3
Registrar Aboriginal Owners	Kylie McLeod	03 October 08	Emailed	Annex B3
Native Title Services		03 October 08	2 active claims Sada Services and Cubbitch Barta Clan (not in our area)	Annex B3
Local Council	Joel Thompson	03 October 08	Emailed	Annex B3

Table B.2 Aboriginal Group Registrations

Organisation	Contact person	Date Registered	Comments
Illawarra LALC	Sharralyn Robinson	16 October 08	Registered Interest
D'harawal Knowledge Holders	Peter Faulk	21 October 08	Registered Interest
Northern Illawarra Aboriginal Collective (NIAC)	Daniela Reverberi	27 October 08	Fax to Register Interest
Wodi Wodi Elders Corporation		30 October 08	Phone call registering interest
Kullila Welfare and Housing Aboriginal Corporation	Maria Mah	14 October 08	Phone call registering interest

Table B.3 Stage 2 - Briefing & Methodology Advice Sent

Organisation	Date Sent	Reference
NIAC (representing 3 groups)	06 November 08	Annex B5
Illawarra LALC	06 November 08	Annex B5
Wodi Wodi Elders Corporation	06 November 08	Annex B5
D'harawal Knowledge Holders	11 November 08	Annex B5
Kullila Welfare and Housing Aboriginal Corporation	14 November 08	Annex B5

Table B.4 Stage 3 - Aboriginal Group Comments Received

Organisation	Date Received	Comment
D'harawal Knowledge Holders	24 November 08	Letter Registering for fieldwork
Illawarra LALC	27 November 08	Email Registering for fieldwork
NIAC (representing 3 groups)	01 November 08	Letter Registering for fieldwork

Table B.5 Stage 4 – Field Survey

Organisation	Field Representative(s)	Date(s) of fieldwork
D'harawal Knowledge Holders	Virginia Faulk	09 and 10 February 09
Illawarra LALC	Steve Henry	09 and 10 February 09
D'harawal Knowledge Holders	Peter Falk	9-19 November 2009
Illawarra LALC	Michael Pixton, Allan Walker, Craig Tungai and Richard Campbell	9-19 November 2009
D'harawal Knowledge Holders	Peter Falk	20 April 10
Illawarra LALC	Richard Campbell	20 April 10

Table B.6 Stage 5 – Draft Report Sent

Organisation	Contact person	Date Sent	Feedback Received & Date
Illawarra LALC	Sharralyn Robinson	7 November 2012	Awaiting Feedback
D'harawal Knowledge Holders	Peter Falk	7 November 2012	Awaiting Feedback
Northern Illawarra Aboriginal Collective (NIAC)	Daniela Reverberi	7 November 2012	Awaiting Feedback
Wodi Wodi Elders Corporation		7 November 2012	Awaiting Feedback
Kullila Welfare and Housing Aboriginal Corporation	Maria Mah	7 November 2012	Awaiting Feedback

Table B.7 Stage 6 – Aboriginal Community Comments Received

Organisation	Contact person	Date Received	Comment	Reference
Illawarra LALC	Sharralyn Robinson	20 April 2010	Comments on Russell Vale Fieldwork	B6

NOTICE OF ABORIGINAL CONSULTATION

NRE NO. 1 COLLIERY, RUSSELL VALE

An Aboriginal heritage assessment is proposed for planned extensions to underground mining operations at NRE No. 1 Colliery, Russell Vale. Local Aboriginal parties wishing to be consulted for this assessment are invited to register a written expression of their interest by 20 October 2008

Please respond in writing to:

> Attn: Diana Neuweger
> Environmental Resources Management Australia
> Locked Bag 24
> Broadway NSW 2007

Or by fax on 02 8584 8800.

Environmental Resources Management Australia

Building C,
33 Saunders Street
Pyrmont NSW 2009

Locked Bag 24,
Broadway NSW 2007

Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800

www.erm.com

Friday, 28 May 2010

Illawarra Local Aboriginal Land Council
3 Ellen Street
Wollongong NSW 2500

Our Reference: *0079383 Heritage L01*

Dear Sir/Madam,

RE: ABORIGINAL HERITAGE ASSESSMENT – NRE NO. 1 COLLIERY, RUSSELL VALE

In accordance with the Department of Environment and Climate Change Interim Community Consultation Requirements, Environmental Resources Management Australia Pty Ltd (ERM) wishes to inform you that that we are undertaking an Aboriginal heritage assessment of an area proposed for expansion of underground mining operations by NRE No. 1 Colliery, at Russell Vale NSW (please find enclosed a map of the study area). The study is being undertaken on behalf of Gujurat NRE Minerals Ltd as part of environmental assessments of the area.

We would be grateful if you could indicate within ten working days whether your organisation is interested in being consulted regarding this project. In addition could you please supply us with a list of all known Aboriginal groups or individuals who would be interested in being consulted on this project. If you have any specific information concerning the cultural values of the study area, it would be much appreciated if you could let us know. Our contact details are provided at the top right hand side of this letter.

If you have any queries concerning the project, please feel free to contact me by email (Diana.neuweger@erm.com) or on the numbers listed above.

Many thanks,

Diana Neuweger
Heritage Consultant

Environmental Resources Management Australia Pty Ltd
A.C.N. 002 773 248
A.B.N. 12 002 773 248

Offices worldwide

Illawarra Local Aboriginal Land Council

3 Ellen Street WOLLONGONG NSW 2500 Ph: 42263338 Fax: 42263360

31 October 2007

To whom it may concern

As the Acting CEO of the Illawarra Local Aboriginal Land Council I write to inform your organisation of the following Motion endorsed at an Illawarra Local Aboriginal Land Council (ILALC) Ordinary Meeting dated 16 October 2007.

Could you please inform all relevant Divisions within your organisation of the following Motion:

The Motion stated that the Northern Illawarra Aboriginal Collective **(NIAC)** does not represent and is not accepted by the Illawarra Local Aboriginal Community. (All Members present agreed with this Motion)

It needs to be acknowledged that NIAC cannot speak on Country within the Illawarra region as determined by the ILALC members.

If you require any further information regarding this matter, please don't hesitate to contact me on the number listed below.

____

Yours in UNITY

Sharralyn Robinson
Illawarra Local Aboriginal Land Council
Acting CEO
Ph: 42 26 3338
Fax: 42 26 3360
M: 0410 125463

Environmental Resources Management Australia

Building C,
33 Saunders Street
Pyrmont NSW 2009
Telephone (02) 8584 8888
Facsimile (02) 8584 8800
Locked Bag 24,
Broadway NSW 2007
www.erm.com

Friday, 28 May 2010

Kullila Welfare and Housing Aboriginal Corporation
14 Werrang Rd
Primbee 2502

Our Reference: 0079383 Methodology L02.doc

Dear Maria,

RE: ABORIGINAL HERITAGE ASSESSMENT FOR NRE NO.1 COLLIERY

As we indicated in our letter of 21 November 2008, Environmental Resources Management Australia (ERM) is undertaking an Aboriginal heritage assessment of an area of NRE No. 1 Colliery proposed for underground mining, at Russell Vale NSW (please find attached a map of the area). The study is being undertaken on behalf of Gujurat NRE Minerals Ltd as part of environmental assessments.

This fax provides Kullila Welfare and Housing Aboriginal Corporationwith a proposed methodology for this heritage assessment. We would appreciate it if you could provide us with any written feedback on this methodology by **1 December 2008** (our fax number is 8584 8800, or you can email diana.neuweger@erm.com). Please provide all correspondence on letter-headed paper addressed to Diana Neuweger.

We welcome your feedback on the method of assessing the Aboriginal heritage significance of the study area, and we understand that there are a number of methods that could be used in such an assessment. We would also welcome any information that you could provide us with concerning the cultural heritage values of the study area.

Environmental Resources Management Australia Pty Ltd
A.C.N. 002 773 248
A.B.N. 12 002 773 248

Offices worldwide

We propose to assess Aboriginal heritage of the study area through a week long archaeological survey on a date to be advised in December. This survey will aim to locate any previously unidentified Aboriginal heritage sites that occur within the study area, and to assess their significance. The survey will be undertaken on foot and will cover all archaeologically sensitive landforms in the study area, focusing particularly on any soil exposures. Landform elements where we think sites may occur include:

- within 50 m of the 2^{nd} order and above water courses within the study area, including Wallandoola Creek, Lizard Creek, Bellambi Creek and Cataract Creek; and
- ridgelines and elevated areas suitable for camping or travelling through the country.

During the heritage assessment, we propose to:

- identify and record any Aboriginal heritage sites located during the survey;
- take GPS readings and mark site locations on a map;
- estimate the effective survey coverage of the study area;
- assess the impact of the proposed development on known Aboriginal heritage values;
- assess the scientific and Aboriginal significance of sites; and
- provide recommendations on how to manage and mitigate proposed development impacts on known Aboriginal heritage values.

When these tasks have been completed, ERM will provide a copy of the draft Aboriginal heritage assessment report to Kullila Welfare and Housing Aboriginal Corporation for comment.

Following current NSW DECC Aboriginal heritage consultation guidelines, if Kullila Welfare and Housing Aboriginal Corporationwould like to participate in the survey, we invite you to provide (by **December 1 2008**) an offer of your services which describes the skills or experience of a Kullila Welfare and Housing Aboriginal Corporation representative in one or more of the following:

- field identification or survey techniques (including confirmation of physical ability to undertake fieldwork);
- cultural knowledge of the study area and surrounds; and
- ability to assist in communicating the results of the survey back to the stakeholder community for the assessment of cultural values and significance, and returning advice on their response to ERM (DECC Interim Community Consultation Requirements, January 2005, page 8).

A decision to employ any Aboriginal field survey representatives will be based upon the information supplied in these offers. Any employment will be offered by the client and not by ERM. Client decisions are independent of ERM and may not reflect our opinions and/or advice.

In order to participate in the survey, Aboriginal representatives must be adequately insured. Could you please provide your insurance status and copies of your certificate of currency for details concerning your public liability and workers compensation insurance. We would greatly appreciate it if you could respond to us in writing by Monday 1 December 2008 (to diana.neuweger@erm.com or by fax on 8584 8800) with this information in addition to any offer of services. Our contact details are listed at the top right hand side of this fax.

In summary, we request, by **Monday 1 December 2008**:

1. any feedback with regard to the proposed methodology;
2. any further knowledge with regard to Aboriginal heritage within the study area;
3. an offer of your services on the survey if you wish to participate, and any associated rates;
4. details of the skills and experience of the representative proposing to undertake the survey; and
5. certificates of currency for workers compensation and public liability insurance.

If you have any queries concerning the project, please feel free to contact me by email (Diana.neuweger@erm.com) or on the numbers listed above.

Many thanks,

for Environmental Resources Management Australia Pty Ltd

Dr Diana Neuweger

Illawarra Local Aboriginal Land Council

3 Ellen Street WOLLONGONG NSW 2500 Ph: 42263338 Fax: 42263360

ENVIRONMENTAL RESOURCES MANAGEMENT

ARCHAEOLOGIST-DIANNA NEUWEGER

REPORT

ABORIGINAL ARCHAEOLOGICAL AND CULTURAL HERITAGE IMPACT ASSESSMENT NRE 1 COLLIERY RUSSELL VALE

ABORIGINAL SITE OFFICERS

STEVEN HENRY
9-10 FEBRUARY 2009 23-24-25 MARCH 2009

RICHARD CAMPBELL
20 APRIL 2010

Illawarra Local Aboriginal Land Council

3 Ellen Street WOLLONGONG NSW 2500 Ph: 42263338 Fax: 42263360

SURVEY AIM

To identify impacts to all identified Aboriginal and Historical cultural heritage sites and places based on potential changes as a result of underground mining and to make recommendations to protect and preserve identified sites for future generations.

SURVEY EXAMINATION

Steven Henry

A visual inspection on foot was conducted of the study area proposed for underground mining at the NRE No.1 Colliery at Russell Vale. Ground visibility was poor due to the thick undergrowth; no new or existing registered sites were identified.

Richard Campbell

Today I participated in the induction and then Archaeologist, Dianna Neuweger and I participated in a field survey on foot of the proposed area. Ground visibility was poor due to the thick undergrowth and coalwash everywhere.
No new or existing registered sites were identified.

OUTCOME

Due to the thick undergrowth and coalwash everywhere it made it impossible to identify new or existing registered sites.

RECOMMENDATIONS

- The Illawarra local Aboriginal Land Council objects to all longwall mining projects that impact on Aboriginal Heritage and culture. It has clearly been identified that longwall mining causes subsidence and movement; it is therefore imperative that all Aboriginal sites be preserved for future generations.

- Gujarat NRE enters into discussion with the ILALC to address employment opportunities for local Aboriginal people.

If you require any further information regarding this report, please don't hesitate to contact me on the number listed below.

Yours in UNITY

Sharralyn Robinson
CEO
Ph: 42 263338
Fax: 42263360
M: 0410 125463

Environmental Resources Management Australia

Building C,
33 Saunders Street
Pyrmont NSW 2009

Locked Bag 24,
Broadway NSW 2007

Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800

www.erm.com

6 November 2012

Peter Faulk
D'harawal Knowledge Holders
PO Box 392
BUNDANOON NSW 2578

Our Reference: *0079383*

Attention: **Peter Faulk**

Dear Peter,

RE: NRE NO.1 COLLIERY ABORIGINAL HERITAGE ASSESSMENT REPORT FOR NRE NO.1 EXPANSION PROJECT EA (APPLICATION NUMBER MP 09_0013)

In accordance with the Department of Environment, Climate Change and Water (DECCW) *Interim Community Consultation Requirements Guideline 2005*, Environmental Resources Management Australia Pty Ltd (ERM) has enclosed a copy of its "NRE No.1 Colliery Aboriginal Heritage Assessment" report. The study is being undertaken on behalf of Gujarat NRE Coking Coal Ltd and forms part of the NRE No.1 expansion project EA (application number # MP 09_0013).

Community consultation for this project was undertaken in accordance with the DECCW Interim consultation guidelines, not the current 2010 guidelines. The 2010 guidelines are required if an Aboriginal Heritage Impact Permit (AHIP) is required, but as this project is still under Part 3A guidelines and is still a State Significant Project under part 89C of the *Environmental Planning and Assessment Act 1979*, Aboriginal heritage impact permits under section 90 of the *National Parks and Wildlife Act 197* are not required.

ERM has identified that D'harawal Knowledge Holders registered its interest for this project on the 21 October 2008. Three field surveys were undertaken for this project on the 9 and 10 February 2009, the 9-19 November 2009 and on the 20 April 2010. NRE was provided with a list of Aboriginal stakeholders and undertook group selection and engagement for these surveys.

In accordance with Step 3 of the *Interim Community Consultation Requirements Guideline 2005*, ERM's "NRE No.1 Colliery Aboriginal Heritage Assessment" report is enclosed. We would be grateful if you could please review the document and return any comments within 21 days. Feedback provided will be

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A.C.N. 002 773 248
A.B.N. 12 002 773 248

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addressed in final reporting and any subsequent management plans. Please forward all correspondence or queries concerning the project to myself via email (janene.may@erm.com) or the contact details provided at the top right hand side of this letter.

Yours sincerely,
for Environmental Resources Management Australia Pty Ltd

Janene May
Archaeologist

Steve O'Connor
Principle

Annex C

Legislation

C.1 *HERITAGE LEGISLATION*

Aboriginal cultural heritage in NSW is protected by the *National Parks and Wildlife Act 1974* (NP&W Act). Land managers are required to consider the affects of their activities or proposed development on the environment under several pieces of legislation, principally the *Environmental Planning and Assessment Act 1979* (EP&A Act) for projects where Part 3A of the EP&A Act applies Cultural heritage, which includes indigenous heritage, is subsumed within the definition of "environment". Commonwealth legislation protecting indigenous heritage may also apply to indigenous heritage places in NSW in certain circumstances. Key legislation is summarised below.

C.1.1 *Environmental Planning and Assessment Act 1979*

The EP&A Act requires that environmental impacts are considered in land-use planning, including impacts on Aboriginal and non-Aboriginal heritage. Various planning instruments prepared under the Act identify permissible land use and development constraints.

OEH provide guidelines for Aboriginal heritage assessment, including those conducted under the EP&A Act.

C.1.2 *Aboriginal And Torres Strait Islander Heritage Protection Act 1984 (Commonwealth)*

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* protects areas and/or objects which are of significance to Aboriginal people and which are under threat of destruction. The Act can, in certain circumstances override state and territory provisions, or it can be implemented in circumstances where state or territory provisions are lacking or are not enforced. A significant area or object is defined as one that is of particular importance to Aboriginal people according to Aboriginal tradition. The Act must be invoked by or on behalf of an Aboriginal or Torres Strait Islander or organisation.

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Environmental Resources Management

PO Box 3071
Thornton NSW 2322
53 Bonville Avenue
Thornton NSW 2322

T: +61 2 4964 2150
F: +61 2 4964 2152
www.erm.com

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Annex V

Cliffs and Steep Slopes Assessment

SCT Operations Pty Ltd
ABN 23 078 328 953
www.sct.gs

HEAD OFFICE
Cnr Kembla & Beach Streets Wollongong NSW 2500 Australia
PO Box 824 Wollongong NSW 2520 Australia
Telephone: + 61 2 4222 2777 Fax: + 61 2 4226 4884
Email: sctnsw@sct.gs
MACKAY OFFICE
Telephone/Fax: +61 7 4952 5717
Email: p.cartwright@sct.gs
BENDIGO OFFICE
Telephone: +61 3 5443 5941
Email: s.macgregor@sct.gs

13 November 2012

Dr Chris Harvey
Head Corporate Relations
Gujarat NRE Coking Coal Limited
PO Box 281
FAIRY MEADOW NSW 2519

Dear Chris,

ASSESSMENT OF MINING IMPACTS ON CLIFFS AND STEEP SLOPES FOR NRE NO 1 COLLIERY UNDERGROUND EXPANSION PROJECT (MP 09_0013) PART 3A

As requested, please find herein our assessment of the likely impacts on cliffs and steep slopes of longwall mining proposed in the NRE No 1 Colliery Underground Expansion Project. The approach outlined in the Bulli Seam Operations PAC Report (NSW PAC 2010) has been used as the basis for assessing significance.

Our assessment indicates that within the area likely to be affected by mining subsidence from this project there are three features that are considered of special significance:

- A waterfall on Lizard Creek (approximately 20m high)
- A waterfall on Wallandoola Creek (approximately 5m high)
- A 300m long cliff line on the northern side of Lizard Creek

The Illawarra Escarpment is also considered of special significance but proposed mining is not expected to have any potential to impact on this feature because the nearest longwall panel is remote from the escarpment.

Some minor and negligible environmental consequences are considered possible on up to 5% of the length of cliff formations located within the area directly above proposed longwall panels.

Environmental consequences for cliff formations located outside the area directly above proposed panels and intermediate chain pillars are expected to be negligible. Impacts on steep slopes are expected to be limited to potential for subsidence cracks to develop at the top of slopes that are directly mined under. The environmental consequences of impacts on steep slopes are considered to be negligible.

1. INTRODUCTION

Gujarat NRE Coking Coal Limited (NRE) is proposing to longwall mine in two areas known as Wonga East and Wonga West. NRE commissioned SCT Operations Pty Ltd (SCT) to undertake an assessment of the potential for sandstone cliff formations and steep slopes to be impacted by this proposed mining. This report presents the results of our assessment.

Our assessment is based on:

- An analysis by Mine Subsidence Engineering Consultants (MSEC) of LiDAR information to provide slope gradients across the proposed mining areas.

- Site visits to the both Wonga East and Wonga West mining areas to inspect areas alongside major creek lines and the adjacent cliff formations.

- Experience of monitoring subsidence impacts on cliff formations in the Western and Southern Coalfields of NSW.

The approach outlined in NSW PAC (2010) is used as the basis for assessing significance.

The report is structured to provide a site description, a review of observations made during the site visits, a review of general experience of mining under sandstone cliff formations and steep slopes, our assessment of the likely impacts of proposed mining on the sandstone cliff formations and steep slopes in the Wonga East and Wonga West mining areas, and an assessment of the significance of the subsidence impacts expected.

2. SITE DESCRIPTION

2.1 Wonga East Mining Area

Figure 1 shows the surface gradients in the Wonga East mining areas determined by MSEC from 1m resolution LiDAR data. The height of sandstone cliff formations is resolved to 5m. The geomorphological expression of a cliff forming sandstone unit near the base of the Hawkesbury Sandstone is clearly apparent in Figure 1 as a locally steep slope. The extent of the Hawkesbury Sandstone inferred from these rock outcrops is shaded in Figure 1. The edges become less well defined where the base of the Hawkesbury Sandstone dips below the surface.

In the immediate vicinity of the longwall panels, cliff formations are typically less than a few metres high, but up to 5m high for about 30m above Longwall 8 and 5-10m high for about 50m above Longwall 10.

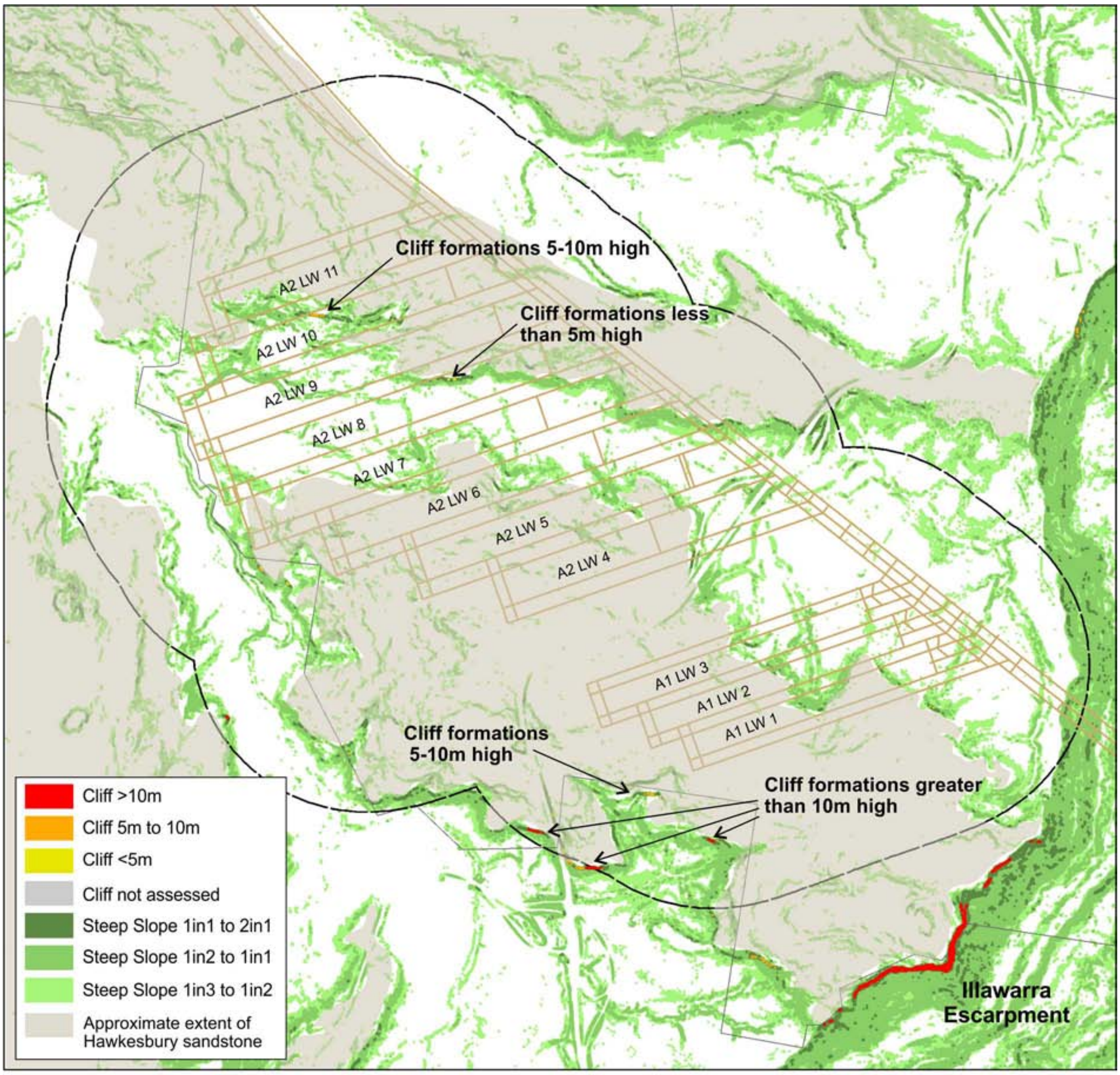


Figure 1: Cliffs and steep slopes - Wonga East.
(Ref: Drawing Number MSEC572-101, 11th July 12).

Figure 2 shows a number of photographs of the types of rock outcrop that are typical of sandstone cliff formations observed in the Wonga East mining area. Individual sandstone rock formations are typically less than about 20m in length with sections of overhang in some of the formations and numerous isolated or toppled boulders scattered on the slopes immediately below.

There are a number of larger cliff formations greater than 10m high around the periphery of the assessed area including the Illawarra Escarpment, but all of these formations are remote from proposed longwall panels and there is not considered to be any potential for subsidence impacts.

The Illawarra Escarpment is located 480m from the eastern corner of Longwall A1-1 but at this location there are no cliff formations on the escarpment because the Hawkesbury Sandstone that forms the cliffs has completely eroded away. The cliff formations on the Illawarra Escarpment nearest to the proposed longwall panels are approximately 780m away. The depth to the mining horizon is 300-350m.

Several cliff formations higher than 10m are located along the southern edge of the Hawkesbury Sandstone outcrop directly south of Longwalls A1-1, A1-2 and A1-3. These features are located from 350-750m from the starting corner of Longwall A1-1. A smaller formation 5-10m high is located approximately 250m from the starting corners of Longwalls A1-1 and A1-2.

Steep slopes within the Wonga East mining are associated with the edge of the Hawkesbury Sandstone outcrop and typically occur at or just below the edge of this outcrop.

2.2 Wonga West Mining Area

Figure 3 shows the surface gradients in the Wonga West mining area. The surface is located entirely within Hawkesbury Sandstone strata. The surface is gently sloping across much of the proposed mining area but there are areas of steep slopes and tiers of smaller cliff formations located alongside the river channels downstream of the waterfalls on Lizard Creek and Wallandoola Creek and alongside an unnamed tributary to Lizard Creek referred to as Lizard Creek Tributary 1 (LCT1). These cliff formations are primarily associated with down-cutting erosion processes as waterfalls have retreated upstream over geological time and the valleys have subsequently broadened through natural erosion.

The proposed longwall panels have been designed to avoid mining directly under Lizard Creek and most of the cliff formations on either side in recognition that cliff formations that are directly mined under are more susceptible to rock falls than cliff formations location outside the footprint of the longwall panels. Much of this area adjacent to Lizard Creek has previously been mined under by longwall panels in the Bulli Seam.

Figure 2: Sandstone cliff formations typical of Wonga East Area.

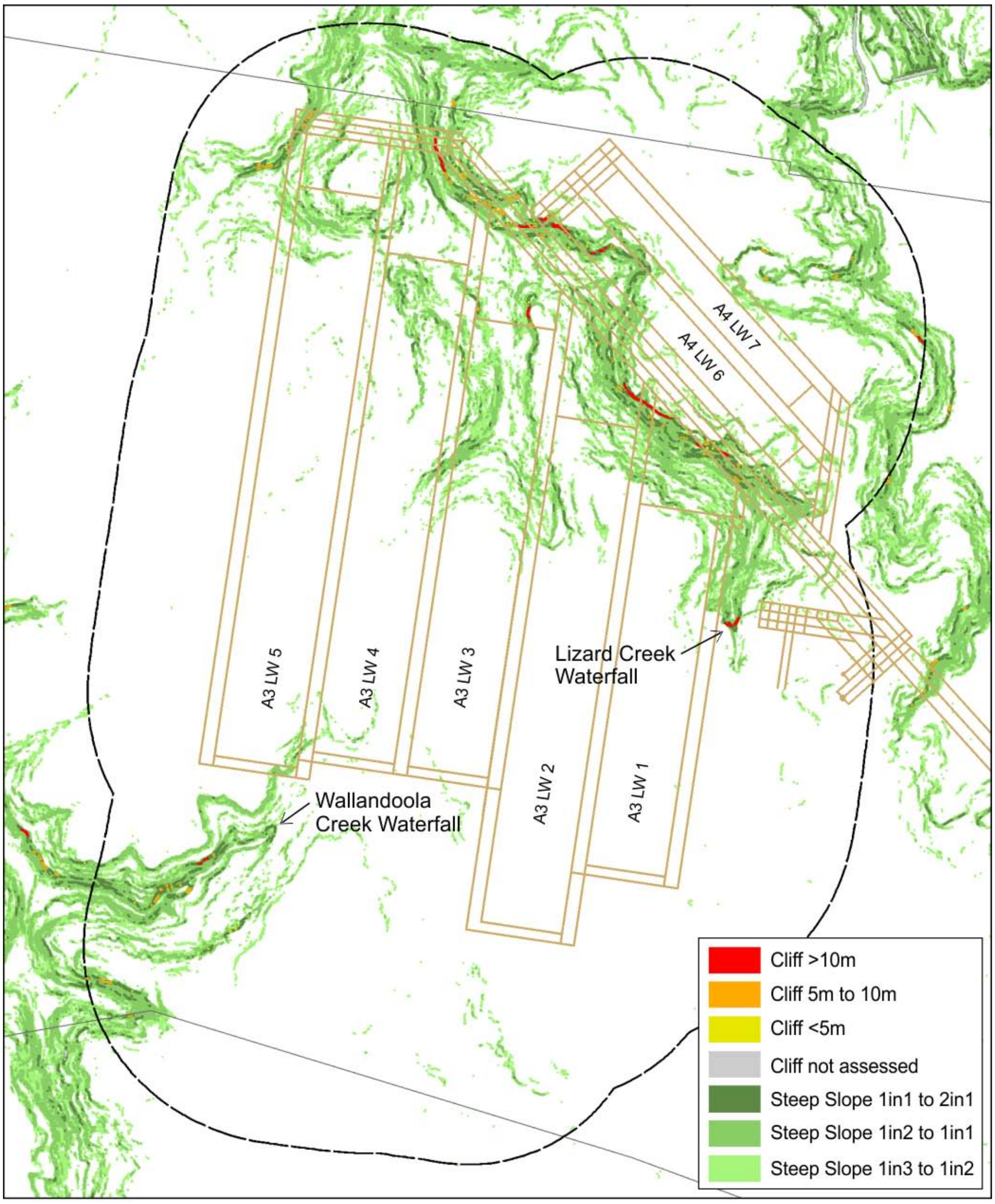


Figure 3: Cliffs and steep slopes - Wonga West.
(Ref: Drawing Number MSEC572-102, 11th July 12).

Figure 4 shows photographs of the types of rock outcrop that are typical of sandstone cliff formations observed in and adjacent to the Wonga West mining area. The top two photographs show cliff formations located alongside Lizard Creek and LCT1 including one where a small rock fall is evident (approximately MGA 295860E, 6205000N). The third photograph is a cliff formation 10-15m high located immediately to the north of the end of Longwall A3-3.

The LiDAR analysis indicates that the only cliff formations directly above longwall panels that are individually greater than 5m high are located above the north-western end of Longwall A4-6. These formations are semi-continuous for a distance of approximately 300m with several short sections over 10m high. The same cliff line extends further northwest over the main headings for a further 700m as a series of disconnected cliffs. These are mainly less than 10m high but there are several sections of greater than 10m high.

A separate 300m long section of continuous cliff formation greater than 10m high is located on the northern side of Lizard Creek over the main headings at a minimum distance of approximately 120m from Longwall A3-LW2 and 200m from Longwall A4-6. There are several similar features located over other parts of the main headings. The individual cliff formations are typically less than 5m high, but particularly alongside Lizard Creek, there are often several tiers of cliff formations stepping back up the slope of the valley side.

Cliff formations are also associated with two waterfalls located within the assessment area but outside the footprint of the proposed longwall panels.

Cliff formations at the location of the waterfall on Lizard Creek are indicated on the LiDAR survey as being greater than 10m high and approximately 100m long. This site is located approximately 90m east of Longwall A3-1 at its nearest point. There is clear evidence of subsidence impacts from previous mining in the Bulli Seam even though the site was not directly mined under and is approximately 90m north of the nearest goaf edge. The impact of previous mining impact is evident as physical disturbance and general iron staining of the water.

Cliff formations at the waterfall on Wallandoola Creek are estimated to be just greater than 5m high although they have not shown up on the LiDAR survey as such. This waterfall is located 280m south of the start of Longwall A3-5. The rock structure of this waterfall has been impacted through cracking as a result of mining in the Bulli Seam. The site is directly above the western most goaf edge of a series of longwall panels.

Figure 4: Sandstone cliff formations typical of Wonga West Area.

There are also numerous steep slopes and smaller sandstone cliff formations located alongside LCT1 located predominantly over Longwall A3-3. These individual formations typically extend laterally for more than 20m. A 10-15m high cliff formation of about 100m length is located immediately to the north of the northern end of Longwall A3-3. This cliff formation was previously mined under by longwall panels in the Bulli Seam without perceptible impact.

3. SITE VISITS

A site visit to the Wonga East area was conducted on 23 August 2012 and a second visit to the Wonga West area was conducted on 13 September 2012. In this section, the observations made during these site visits are presented and discussed. Previous mining in both areas provides a measure of the scale of impacts that can be expected from proposed mining although the potential for cumulative effects is recognised.

3.1 Wonga East Site Visit

The first visit included walking the length of Cataract Creek downstream of Mt Ousley Road and inspecting adjacent cliff formations and steep slopes above the proposed Wonga East mining area on both sides of the highway.

A minor rock fall at approximately MGA 302600E, 6197000N on Hawkesbury Sandstone outcrop is considered likely to have been associated with previous mining activity in the Balgownie Seam (1970-1982). This rock fall at was difficult to detect, and was relatively minor in the context of ongoing natural erosion at the site.

A search of the bushland above the start of the Balgownie Seam longwall panels at the top of a slope leading down to Cataract Creek did not reveal any evidence of surface cracking in an area where cracking is considered likely to have been most evident. It is possible that surface cracks were covered by leaf litter, but no cracks associated with the previous Bulli Seam or Balgownie Seam mining were able to be detected during this site visit.

Surface cracking from recent mining in the Wongawilli Seam Longwall A2-4 was evident on hard rock surfaces near the start of the panel, and it is understood that a further crack is evident on the northern subsidence line near the eastern (upslope) edge of the panel developed as a result of further mining subsequent to the site visit. The location of this crack is consistent with horizontal movement in a downslope direction toward the goaf of Longwall A2-4.

Based on observations made during the site visit to the proposed Wonga East mining area, impacts on cliff formations from previous multi-seam mining in the Bulli Seam and Balgownie Seams are considered to have been nil to negligible using the assessment of significance detailed in NSW PAC (2010).

3.2 Wonga West Site Visit

A second visit included walking the length of the section of Lizard Creek that is located above the proposed Wonga West mining area. The inspection commenced at the waterfall on Lizard Creek and continued downstream to the intersection with LCT1 north of the proposed mining area and then south along LCT1 above Longwall A3-3 including both branches of this tributary. The steep slopes and cliff formations on either side of these creeks were inspected from the valley floor with occasional inspection of some of the larger cliffs. It was not practical or necessary to visit every cliff formation. The waterfall on Wallandoola Creek was also inspected during this visit.

Figure 5 shows photographs of the waterfall on Lizard Creek taken during the site visit and an aerial photograph reproduced from NSW PAC (2010) that provides a better overall perspective of the site. Iron staining and a spring that has developed at approximately the level of the top of the water fall are consistent with previous mining activity and the horizontal movements that would be expected to develop as a result of valley closure even though the waterfall was not directly mined under by longwall panels in the Bulli Seam.

There was some evidence of minor rock falls adjacent to Lizard Creek. Although the impacts of previous mining activity were clearly apparent in the creek channel, it was not clear whether rock falls on the valley sides were associated with previous mining activity or were a result of heavy rainfall and natural erosion processes.

Figure 6 shows a photograph of the waterfall on Wallandoola Creek. This waterfall is located directly above the edge of a previous longwall panel in the Bulli Seam and there is clear evidence of surface cracking in the adjacent rock formations.

No large rock falls were observed during this site visit. Excluding the obvious impacts to cliff formations at waterfalls on Lizard Creek and Wallandoola Creek, impacts on cliff formations from previous mining are generally considered to have been nil to negligible in the Wonga West mining area.

4. General Experience of Mining Under Sandstone Cliff Formations

SCT has studied the impacts of mining on sandstone cliff formations in the Western Coalfields of NSW at overburden depths ranging from about 100m through to about 350m and previously in the Southern Coalfield at several sites impacted by mining subsidence. This experience indicates that rock falls occur as a result of lateral compression of rock formations in a direction along the length of the formation. Except in a few special circumstances such as sometimes occur at features such as waterfalls, horizontal compression movements occur almost entirely within the area directly above the longwall panels and the chain pillars between adjacent panels, so rock falls tend to be limited to this area also.

(Reproduced from NSW PAC 2010)

Photographed during site visit

Figure 5: Waterfall on Lizard Creek.

Figure 6: Waterfall on Wallandoola Creek.

Cliff formations that are less than 20m in lateral extent tend to be less susceptible to mining impacts unless they collide with adjacent formations. When rock formations have a lateral extent of less than about 20m the horizontal movements tend not to be able to generate sufficient force within the rock formation to overload the rock fabric. Instead, the rock formation tends to move en-masse without perceptible impact.

Laterally extensive, high, and overhanging cliff formations tend to be more susceptible to rock falls than smaller, isolated formations. Rock falls are most likely to occur at locations where there is an indent (re-entrant or gully) in the line of the rock formations because horizontal compressive movements tend to be concentrated into these areas by the shape of the formation.

Waterfalls on creek lines are by their nature located in narrow gullies that tend to act as concentration points for horizontal movement within the broader surface topography. Waterfalls also often include cliff formations with overhangs and sheer vertical cliffs that are frequently continuous for 50-100m. As a result, waterfalls tend to be susceptible to impacts from horizontal ground movements. The horizontal movements that can cause impacts to waterfall type structures are able to be generated by vertical subsidence that is occurring remote from the waterfall. The normal offset barriers used for protection against vertical subsidence (angle of draw etc) are not necessarily sufficient to provide a high level of protection. Monitoring based management of these types of features has proved successful at other sites.

At depths of cover (overburden depths) ranging from 150m to 220m, experience indicates that 15-20% of the length of cliff formation directly mined under have potential to be affected by rock falls. This percentage decreases with increasing overburden depth because the magnitude of horizontal movements reduces with increasing overburden depth. Experience in the Southern Coalfield at 500m overburden depth indicates that less than about 3% of the length of typical cliff formations directly mined under have potential to be affected by rock falls when especially vulnerable features are excluded. These vulnerable features need to be considered separately as sites of special significance.

Surface cracking of rock formations has been observed in the Western Coalfield to extend over the longwall panels that are mined, above chain pillars between longwall panels that have both been mined, and to a distance outside the longwall panel of up to about 0.4 times overburden depth. This surface cracking is associated with tensile stretching of the ground surface and is essentially independent of the compressive processes that cause rock falls.

In the Southern Coalfield, horizontal movement in a downslope direction (valley closure) and horizontal movement associated with stress relief have potential to generate low level tensile cracks on hard surfaces at distances beyond the goaf edge of greater than 0.4 times depth. The actual distances that ground movements are perceptible tend to be a function of the surface terrain and the nature of the surface. Tensile cracking is typically evident at the top of slopes and on hard surfaces such as bare rock and compacted road surfaces.

5. Assessment of Likely Subsidence Impacts

Allowing for an increased level of subsidence associated with multi-seam mining and an intermediate overburden depth of about 300-400m, it is considered likely that, on average, up to about 5% of the length of cliff formations directly mined under in the proposed mining areas would experience rock falls. Rock falls are not expected to occur on rock formations that are less than 20m in lateral extent.

For the low height rock formations apparent over the Wonga East mining area, rock falls are expected to be limited in extent and to occur mainly at indents in the line of the formation such as gullies where there is potential for collision of rock strata moving in different directions. The proposed mining layout has relatively large chain pillars compared to the width of the longwall panels so the length of cliff formations where compressive horizontal movements are likely is expected is to be limited to the central part of each longwall panel.

In the Wonga West mining area, except for the 10-15m high cliff formations located over Longwall A4-6, the LiDAR analysis indicates that all the cliff formations directly above longwall panels are individually less than 5m high. In some areas there are multiple tiers of low height cliff formations that together cover a larger vertical height, but these tend to be set back from each other and can reasonably be treated as individual cliff formations.

In the area above the Area 3 longwall panels and above Longwall A4-7, rock falls are considered possible on up to about 5% of the cliff formations that are directly mined under. There is potential for horizontal compression movements to develop along the cliff formations located over Longwall A4-6 and rock falls on up to about 15% of the length of these cliff formations is considered possible because of their greater height and their alignment parallel to the direction of mining.

There is potential for compressive horizontal movements to develop in the vicinity of the two waterfalls on Lizard Creek and Wallandoola Creek. Both waterfalls have previously been impacted by mining in the Bulli Seam. To avoid additional impacts, it would be necessary to develop a trigger, action, response, plan that maintained further horizontal movements at low levels in the vicinity of these features.

The cliff formations located alongside Lizard Creek but not directly over longwall panels, including the 300m cliff line that is greater than 10m high on the northern side of Lizard Creek, are considered unlikely to be significantly impacted by mining subsidence because horizontal subsidence movements are unlikely to be able to develop in a direction along the line of the cliff. It is possible that there may be some locations where indents in the general line of the cliffs allow horizontal movements to be concentrated and small horizontal movements may be concentrated, but in general these types of impacts are not expected to cause large rock falls.

Surface cracking is considered possible at the top of steep slopes, particularly those where the direction of mining is in the same direction as the slope. In general, it is unlikely that surface cracking will be perceptible in a bushland environment, although visible cracking is possible on hard surfaces such as roads, tracks, and bare rock surfaces. Surface cracking is expected to be evident in the ground surface above Longwall A4-6 as it approaches the steep slope adjacent to Lizard Creek and may be evident on bare rock surfaces above the steep slopes associated with the outcrop of the cliff forming Hawkesbury Sandstone unit in the southern parts of the Wonga East mining area.

6. Assessment of Significance

The approach outlined in the NSW PAC (2010) is used as the basis for assessing significance. The categories of significance adopted are:

- Special significance – cliff formations that are longer than 200m, higher than 40m, and higher than 5m that constitute waterfalls.

- Minor environmental consequences – cliff formations where isolated rock falls of less than $30m^3$ are anticipated but where rock falls do not impact on Aboriginal heritage, endangered ecological communities, public safety and the like and rock falls and occur on less than 5% of the total length of cliff formations.

- Negligible environmental consequences – occasional displacement of boulders, hairline cracks, isolated dislodgement of overhanging rock slabs impacting less than 0.5% of the total length of a cliff formation.

- Nil environmental consequences – no mining impacts, although it is recognised that natural processes that cause ongoing erosion such as diurnal and seasonal thermal variations, high intensity rainfall, and the like continue to operate at a low level irrespective of mining activities.

Our assessment indicates that within the area likely to be affected by mining subsidence from this project there are three features that may be considered of special significance:

- A waterfall site on Lizard Creek (also identified as of special significant in NSW PAC, 2010).

- A waterfall site on Wallandoola Creek.

- A 300m long line of cliff formations greater than 10m high on the northern side of Lizard Creek but outside the footprint of the proposed longwall panels.

The Illawarra Escarpment is also considered of special significance but proposed mining is not expected to have any potential to impact on this feature.

Monitoring and adaptive management strategies are recommended to limit mining impacts on these features of special significance.

A line of cliff formations above Longwall A4-6 that is semi-continuous over the panels and extends for approximately 700m outside the north-western end of the panel is considered border line special significance depending on how the length of the cliff is defined. Although there is approximately 300m or so of this cliff line directly above the panel, the cliff formations are discontinuous in this area and the cliff line is therefore not considered to be of special significance using the NSW PAC (2010) ranking system adopted in this study.

Some minor and negligible environmental consequences are considered possible on up to 5% of the length of cliff formations located within the area directly above proposed longwall panels.

Environmental consequences for cliff formations located outside the area directly above proposed panels and intermediate chain pillars are expected to be negligible. Impacts on steep slopes are expected to be limited to potential for subsidence cracks to develop at the top of slopes that are directly mined under. The environmental consequences of impacts on steep slopes are considered to be negligible.

7. CONCLUSIONS

Our assessment indicates that within the area likely to be affected by mining subsidence from this project there are three features that are considered of special significance:

- A waterfall on Lizard Creek (approximately 20m high)
- A waterfall on Wallandoola Creek (approximately 5m high)
- A 300m long cliff line on the northern side of Lizard Creek

The Illawarra Escarpment is also considered of special significance but proposed mining is not expected to have any potential to impact on this feature because the nearest longwall panel is remote from the escarpment.

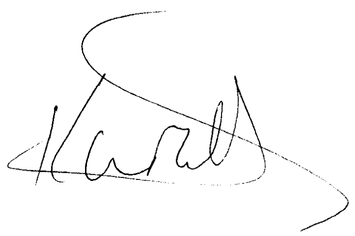
Monitoring and adaptive management strategies are recommended to limit mining impacts on these features of special significance.

Some minor and negligible environmental consequences are considered possible on up to 5% of the length of cliff formations located within the area directly above proposed longwall panels. The impact of proposed mining on cliff formations in these areas is expected to be similar in extent and nature to the minor rock falls evident from previous mining in the Bulli Seam in the same areas.

Environmental consequences for cliff formations located outside the area directly above proposed panels and intermediate chain pillars are expected to be negligible. Impacts on steep slopes are expected to be limited to potential for subsidence cracks to develop at the top of slopes that are directly mined under. The environmental consequences of impacts on steep slopes are considered to be negligible.

If you have any queries, or require further clarification of any issues, please do not hesitate to contact me directly.

Regards



Ken Mills
<u>Senior Geotechnical Engineer</u>

Reference:

NSW Planning Assessment Commission (PAC) 2010 "Bulli Seam Operations PAC Report July 2010" prepared for the NSW Department of Planning.

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Environmental Resources Management

PO Box 71
Thornton NSW 2322
53 Bonville Avenue
Thornton NSW 2322

T: +61 2 4964 2150
F: +61 2 4964 2152
www.erm.com