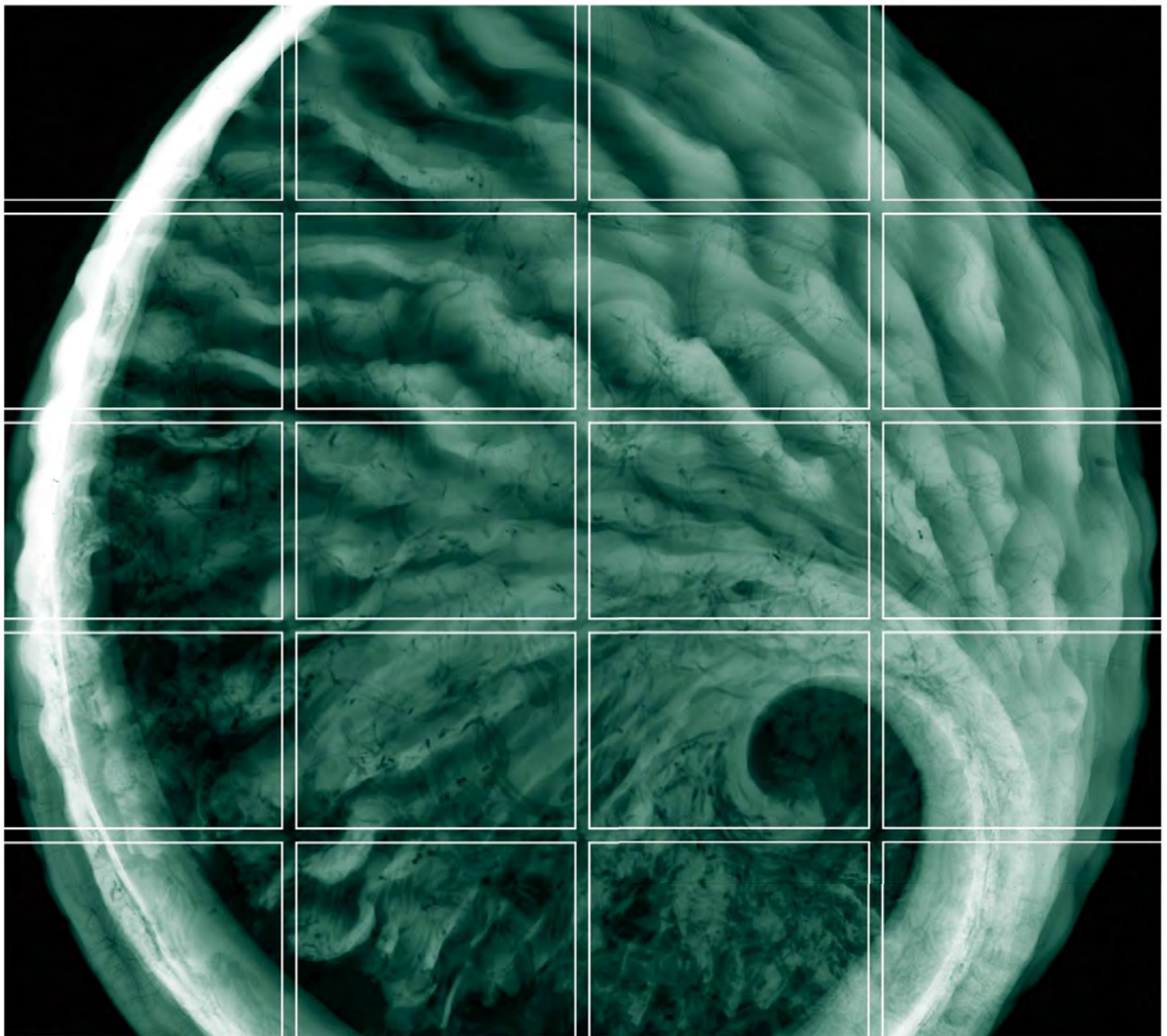




NRE No.1 Colliery Stage 2

Terrestrial Flora and Fauna Assessment

Gujarat NRE Coking Coal Pty Ltd

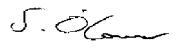
February 2013

0079383

www.erm.com

NRE No.1 Colliery Stage 2

Terrestrial Flora and Fauna Assessment

Date:	8 February 2013
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

Gujarat NRE Coking Coal Limited

February 2013

0079383

www.erm.com

Environmental Resources Management Australia Pty Ltd Quality System



Quality-ISO-9001-FMS302

This disclaimer, together with any limitations specified in the report, apply to use of this report. This report was prepared in accordance with the contracted scope of services for the specific purpose stated and subject to the applicable cost, time and other constraints. In preparing this report, ERM relied on: (a) client/third party information which was not verified by ERM except to the extent required by the scope of services, and ERM does not accept responsibility for omissions or inaccuracies in the client/third party information; and (b) information taken at or under the particular times and conditions specified, and ERM does not accept responsibility for any subsequent changes. This report has been prepared solely for use by, and is confidential to, the client and ERM accepts no responsibility for its use by other persons. This report is subject to copyright protection and the copyright owner reserves its rights. This report does not constitute legal advice.

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
www.erm.com

CONTENTS

1	INTRODUCTION	
1.1	PROJECT DESCRIPTION	11
1.2	PROJECT APPLICATION AREA	11
1.3	DEFINITION OF STUDY AREA	14
1.4	COMPLIANCE WITH RELEVANT DIRECTOR-GENERAL'S REQUIREMENTS	14
1.5	PROPOSED MINING OPERATIONS	15
1.6	PURPOSE OF THIS REPORT	16
1.7	LEGISLATION	16
2	EXISTING ENVIRONMENT	
2.1	GEOLOGY, SOILS AND LANDFORM	19
2.2	WATER RESOURCES	21
2.3	BIOGEOGRAPHY	32
2.4	FEATURES OF SPECIAL SIGNIFICANCE	32
3	METHODS	
3.1	DESKTOP RESEARCH	44
3.2	FLORA AND FAUNA SURVEYS	51
3.3	SUMMARY OF SURVEY EFFORT	64
4	RESULTS	
4.1	DATABASE SEARCH RESULTS	65
4.2	WEATHER CONDITIONS	65
4.3	FLORA	66
4.4	FAUNA	78
4.5	HABITAT CONDITION	82
5	EVALUATION OF IMPACTS	
5.1	SUBSIDENCE IMPACTS	99
5.2	ENVIRONMENTAL CONSEQUENCES OF SUBSIDENCE	103
5.3	THREATENED SPECIES AND EEC CONSIDERATION	108
5.4	REGIONALLY SIGNIFICANT SPECIES	124
5.5	RARE OR THREATENED AUSTRALIAN PLANTS	125
5.6	MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE	126
6	MANAGEMENT AND MITIGATION MEASURES	
6.1	ITERATIVE MINE PLANNING	127
6.2	MITIGATION	129
6.3	MONITORING	130
7	CONCLUSION	

ANNEX A	UPLAND SWAMP VEGETATION MAPS (BIOSIS 2012A)
ANNEX B	HERPETOLOGICAL SUB-CONSULTANT REPORTS
ANNEX C	DATABASE SEARCH RESULTS
ANNEX D	FIELD SURVEY RESULTS
ANNEX E	ASSESSMENTS OF SIGNIFICANCE FOR THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

LIST OF TABLES

TABLE 1.1	COMPLIANCE WITH RELEVANT DIRECTOR-GENERAL'S REQUIREMENTS	14
TABLE 2.2	UPLAND SWAMPS OF SPECIAL SIGNIFICANCE IN WONGA WEST	36
TABLE 2.3	FAUNA SPECIES WITHIN SOUTHERN COALFIELDS VULNERABLE TO SUBSIDENCE	40
TABLE 2.4	FLORA SPECIES WITHIN SOUTHERN COALFIELDS VULNERABLE TO SUBSIDENCE	41
TABLE 3.1	THREATENED SPECIES AND EECs RECORDED BY ERM (2009)	45
TABLE 3.2	STRATIFICATION UNITS	50
TABLE 3.3	COVER ABUNDANCE SCALE USED IN FLORISTIC ASSESSMENTS	51
TABLE 3.4	FLORA SPECIES TARGETED DURING FIELD SURVEYS	54
TABLE 3.5	PERSON HOURS COMMITTED TO TARGETED FLORA SEARCHES	55
TABLE 3.6	FROG AND REPTILE SPECIES TARGETED IN HERPETOLOGICAL SURVEYS	59
TABLE 3.7	CALL BROADCAST EVENTS	62
TABLE 3.8	SURVEY EFFORT PER STRATIFICATION UNIT	63
TABLE 4.1	WEATHER OBSERVATIONS DURING FIELD SURVEYS	64
TABLE 4.2	FROG SPECIES RECORDED WITHIN THE STUDY AREA	76
TABLE 4.3	REPTILE SPECIES RECORDED WITHIN THE STUDY AREA	77
TABLE 4.4	THREATENED, MIGRATORY AND RARE BIRDS RECORDED	78
TABLE 4.5	MAMMAL SPECIES RECORDED IN THE STUDY AREAS	79
TABLE 5.1	POTENTIAL IMPACTS TO FLORA AND FAUNA FROM SUBSIDENCE	94
TABLE 5.2	WONGA EAST MAXIMUM SUBSIDENCE PREDICTIONS	96
TABLE 5.3	WONGA WEST MAXIMUM SUBSIDENCE PREDICTIONS	96

TABLE 5.4	PREDICTED SUBSIDENCE IMPACTS FOR ECOLOGICAL FEATURES OF SPECIAL SIGNIFICANCE	97
TABLE 5.5	EECS IN THE STUDY AREA	107
TABLE 5.6	THREATENED FLORA IN THE STUDY AREA	108
TABLE 5.7	THREATENED FAUNA IN THE STUDY AREA	112
TABLE 5.8	REGIONALLY SIGNIFICANT SPECIES	121
TABLE 5.9	ROTAPS RECORDED IN THE STUDY AREA	123
TABLE 6.1	BIODIVERSITY MONITORING PROGRAM FRAMEWORK	127

LIST OF FIGURES

FIGURE 1.1	LOCALITY MAP	12
FIGURE 1.2	ECOLOGICAL ASSESSMENT STUDY AREA	13
FIGURE 2.1	WONGA EAST SURFACE WATER FEATURES	22
FIGURE 2.2	WONGA WEST SURFACE WATER FEATURES	23
FIGURE 3.1	VEGETATION MAPPING OF THE WONGA EAST STUDY AREA (NPWS 2003)	48
FIGURE 3.2	VEGETATION MAPPING OF WONGA WEST STUDY AREA (NPWS 2003)	49
FIGURE 3.3	WONGA EAST FLORISTIC QUADRAT AND THREATENED FLORA SEARCH LOCATIONS	52
FIGURE 3.4	WONGA WEST FLORISTIC QUADRAT AND THREATENED FLORA SEARCH LOCATIONS	53
FIGURE 3.6	FAUNA SURVEY LOCATIONS WITHIN THE WONGA WEST STUDY AREA	58
FIGURE 4.1	THREATENED FLORA PREVIOUSLY RECORDED WITHIN 10KM OF STUDY AREA66	
FIGURE 4.2	THREATENED FAUNA PREVIOUSLY RECORDED WITHIN 10KM OF STUDY AREA67	
FIGURE 4.3	THREATENED AND RARE SPECIES RECORDED IN THE WONGA EAST STUDY AREA	68
FIGURE 4.4	THREATENED AND RARE SPECIES RECORDED IN THE WONGA WEST STUDY AREA	69
FIGURE 5.1	WONGA EAST ECOLOGICALLY SIGNIFICANT AREAS	98
FIGURE 5.2	WONGA WEST ECOLOGICALLY SIGNIFICANT AREAS	99

LIST OF PHOTOGRAPHS

<i>PHOTOGRAPH 4.1</i>	<i>WALLANDOOLA CREEK UPPER REACHES AROUND WC3</i>	<i>81</i>
<i>PHOTOGRAPH 4.2</i>	<i>WALLANDOOLA CREEK MID REACHES AROUND WC4</i>	<i>82</i>
<i>PHOTOGRAPH 4.3</i>	<i>CREEK BED COLLAPSE IN LIZARD CREEK</i>	<i>83</i>
<i>PHOTOGRAPH 4.4</i>	<i>GIANT BURROWING FROG HABITAT IN GOOD CONDITION IN LIZARD CREEK TRIBUTARY 1</i>	<i>84</i>
<i>PHOTOGRAPH 4.5</i>	<i>GIANT BURROWING FROG HABITAT IN POOR CONDITION IN CENTRAL CREEK (ECO LOGICAL 2009)</i>	<i>84</i>
<i>PHOTOGRAPH 4.6</i>	<i>STUTTERING BARRED FROG HABITAT IN CATARACT CREEK (ECO LOGICAL 2009)</i>	<i>85</i>
<i>PHOTOGRAPH 4.7</i>	<i>DEGRADED HABITAT IN CATARACT CREEK</i>	<i>86</i>
<i>PHOTOGRAPH 4.8</i>	<i>STANDING WATER WITHIN THE LIZARD CREEK SWAMPS (ELEVATION VIEW)</i>	<i>88</i>
<i>PHOTOGRAPH 4.9</i>	<i>POTENTIAL SUBSIDENCE IN WCUS4</i>	<i>90</i>
<i>PHOTOGRAPH 4.10</i>	<i>BROAD-HEADED SNAKE WINTERING HABITAT IN LOWER SECTIONS OF LIZARD CREEK</i>	<i>91</i>

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 <i>Native Vegetation Act 2003</i> 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 <i>Threatened Species Conservation Act 1995</i> or the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
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 <i>Threatened Species Conservation Act 1995</i> or under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
endangered population	Population identified as endangered under Part 2 of Schedule 1 of the <i>Threatened Species Conservation Act 1995</i> .
endangered species	Species identified in Part 1 of Schedule 1 of the <i>Threatened Species Conservation Act 1995</i> or under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
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 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 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 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 <i>Threatened Species Conservation Act 1995</i> or under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
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 <i>Native Vegetation Act 2003</i> 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 <i>Sydney Water Catchment Management Act 1998</i> 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	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 <i>Threatened Species Conservation Act 1995</i> or <i>Environment Protection and Biodiversity Conservation Act 1999</i> 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	<i>Environmental Planning and Assessment Act, 1979</i>
EP&A Regulation	Environmental Planning and Assessment Regulation, 2000
EPA	Environment Protection Authority (NSW)
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act, 1999</i>
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	<i>Native Vegetation Act, 2003</i>
OEI	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./subsp.	sub-species singular / plural
Tpa	Tonnes per annum
TSC Act	<i>Threatened Species Conservation Act, 1995</i>
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.

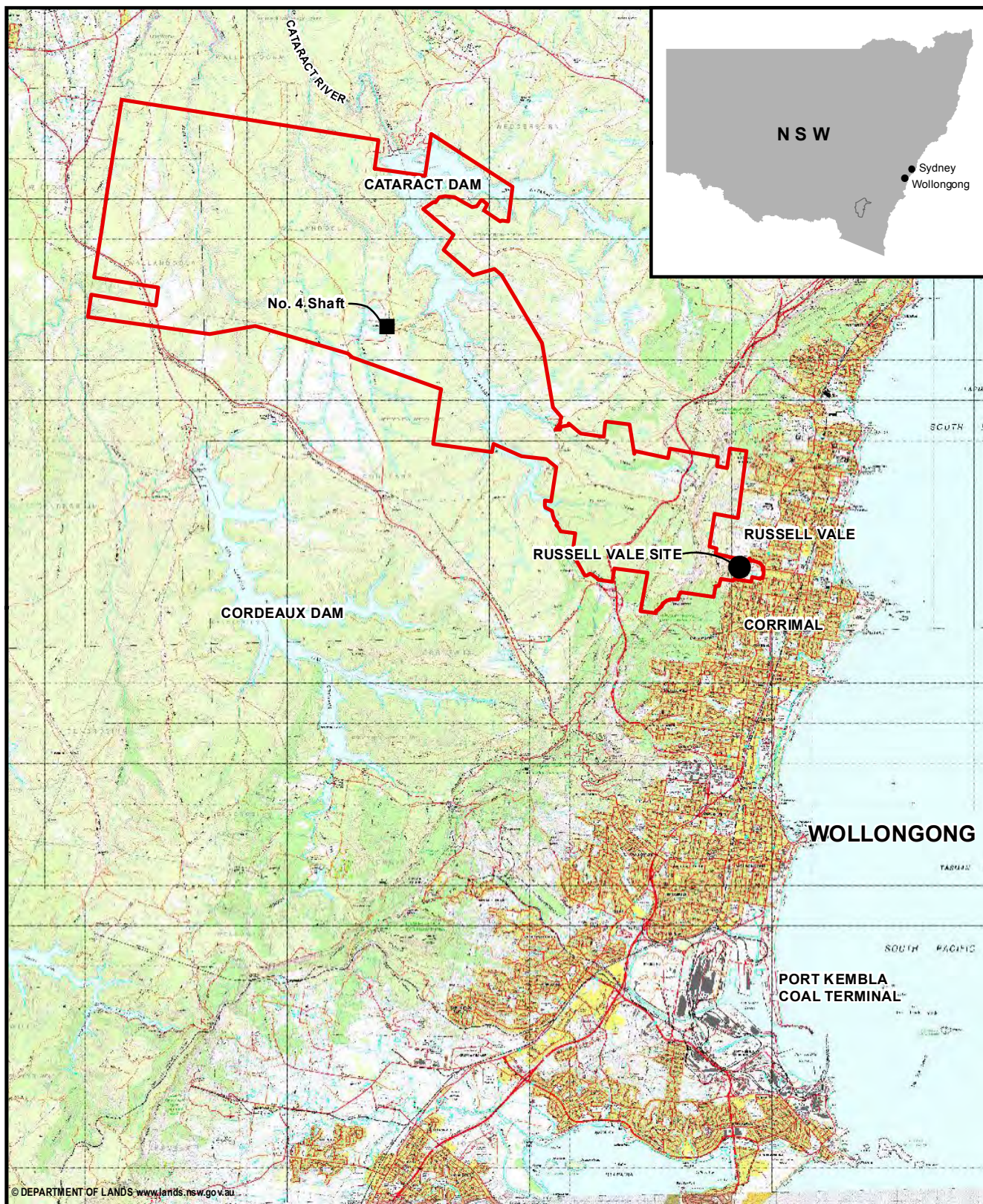
1.2 PROJECT APPLICATION AREA

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

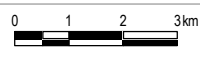
Date: 27/11/2012

Drawing size: A4

Drawn by: GC

Reviewed by: MB

Scale: Refer to Scale Bar

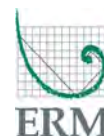


Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Figure 1.1
Locality Map

Environmental Resources Management ANZ

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



- Legend**
- Proposed Application Area
 - Study Area
 - Subject to Separate Application (MP 10_0046_UMD 1)
 - Upland Swamps (Bosch 2012)
 - Catacart Dam
 - 1st Order Stream
 - 2nd Order Stream
 - 3rd Order Stream
 - 4th Order and Above Stream
 - Major Hoic
 - Shall Locations
 - Stream Monitoring Sites (GeoTerra 2012)
 - Swamp Piezometers (GeoTerra 2012)
 - Basement Piezometers (GeoTerra 2012)

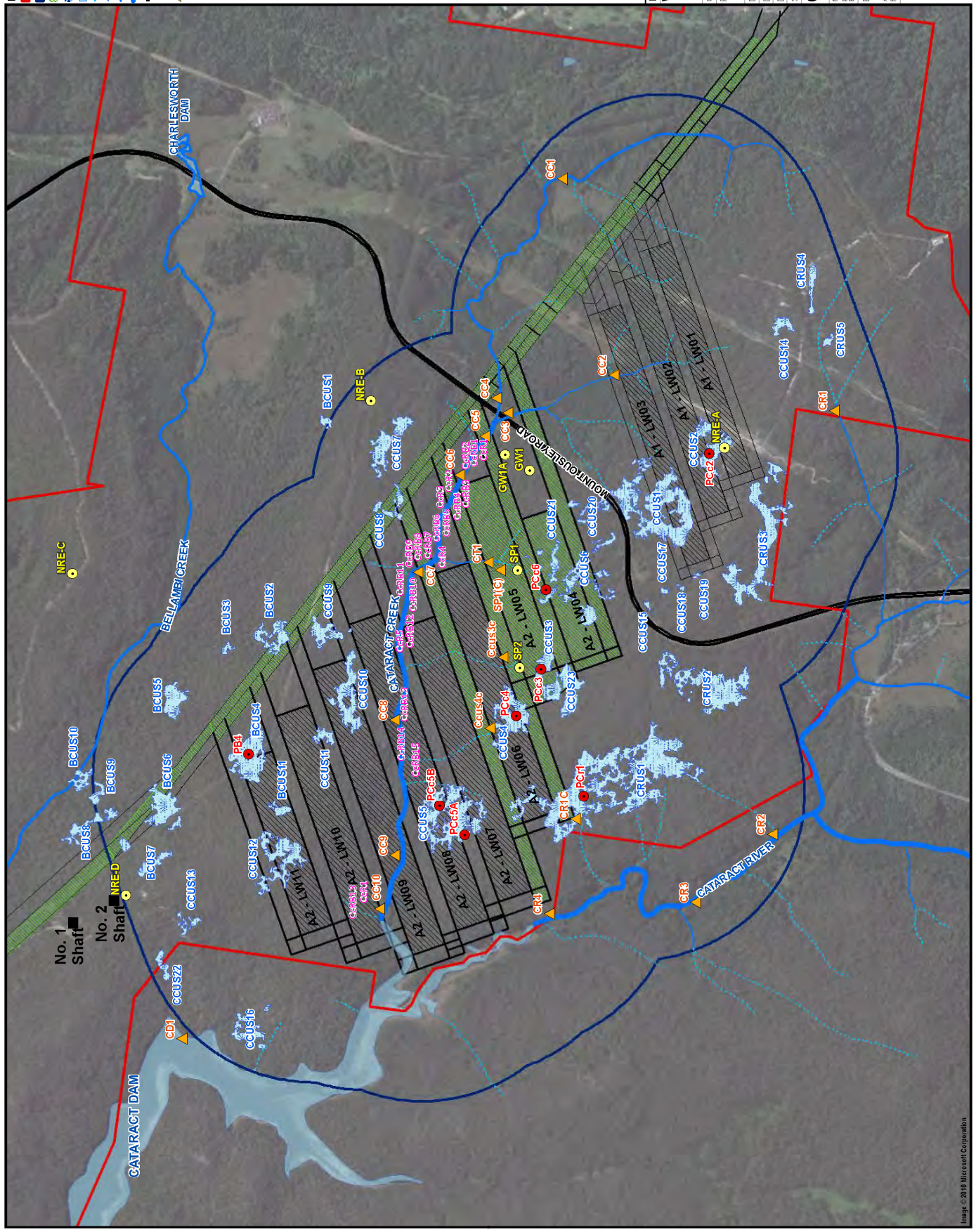


Figure 2.1
Wonga East Surface Water Features

Client:	Guarat NRE Coaling Coal Limited
Project:	NRE No. 1 Colliery Ecological Assessment
Drawing No:	007/000s, ECA, 0004_R3.mxd
Date:	13/11/2012
Drawn by:	SQM
Reviewed by:	NB
Scale:	Refer to Scale Bar
Scale:	0 150 300 450m

Notes 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



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 hectares (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

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 Minister 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 Hawkesbury 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 Gynea 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 southern 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**
- Proposed Application Area
 - Study Area
 - Subject to Separate Application (MP 10_0046_UMD 1)
 - Upland Swamps (Bosch 2012)
 - Catacart Dam
 - 1st Order Stream
 - 2nd Order Stream
 - 3rd Order Stream
 - 4th Order and Above Stream
 - Major Hoic
 - Shall Locations
 - Stream Monitoring Sites (GeoTerra 2012)
 - Swamp Piezometers (GeoTerra 2012)
 - Basement Piezometers (GeoTerra 2012)

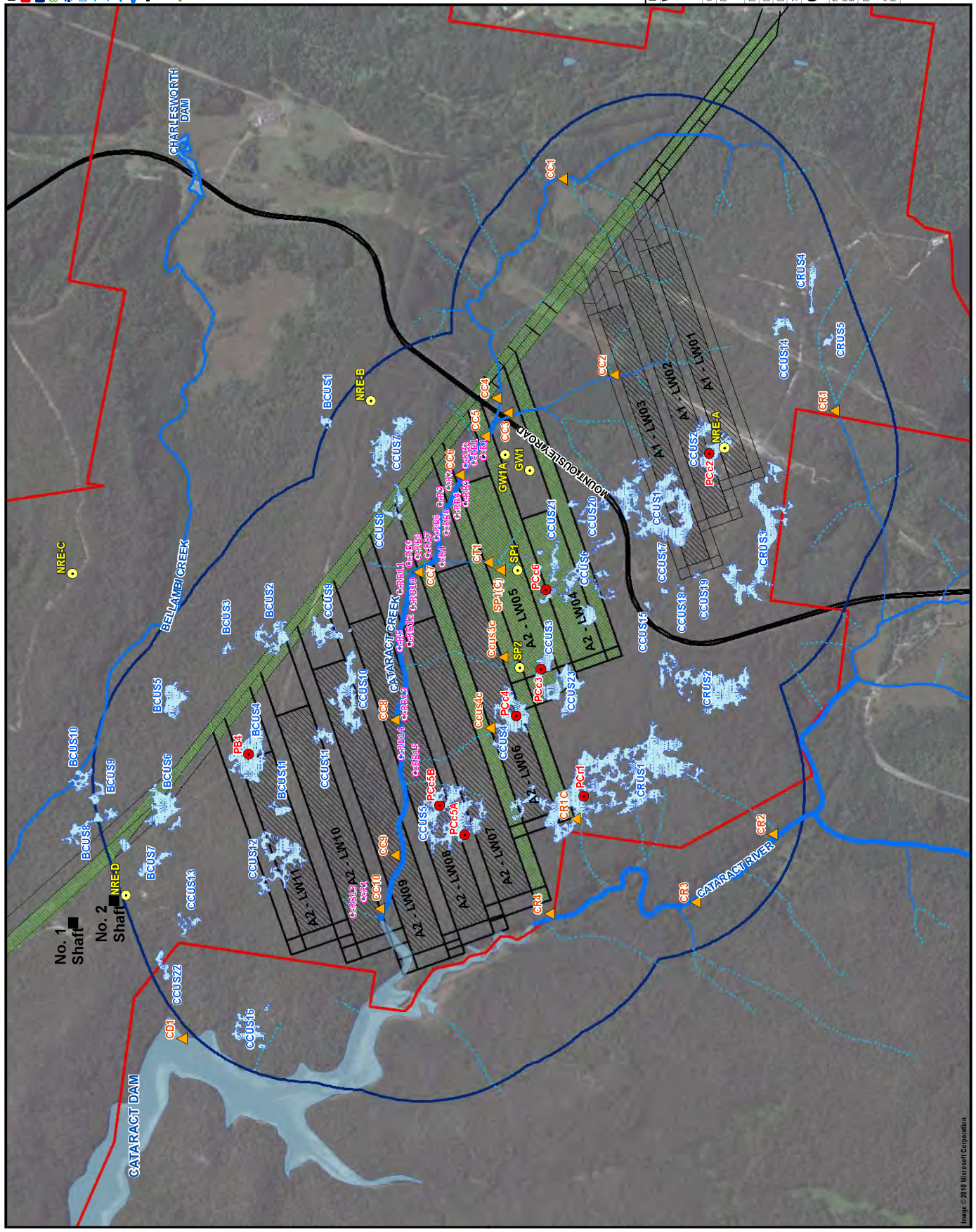


Figure 2.1
Wonga East Surface Water Features

Client:	Guarat NRE Coaling Coal Limited
Project:	NRE No 1 Colliery Ecological Assessment
Drawing No:	007/000s, ECA, 0004_R3.mxd
Date:	13/11/2012
Drawn by:	SQM
Reviewed by:	NB
Scale:	Refer to Scale Bar
Scale:	0 150 300 450m

When used together with the document may be used on their own. This document 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

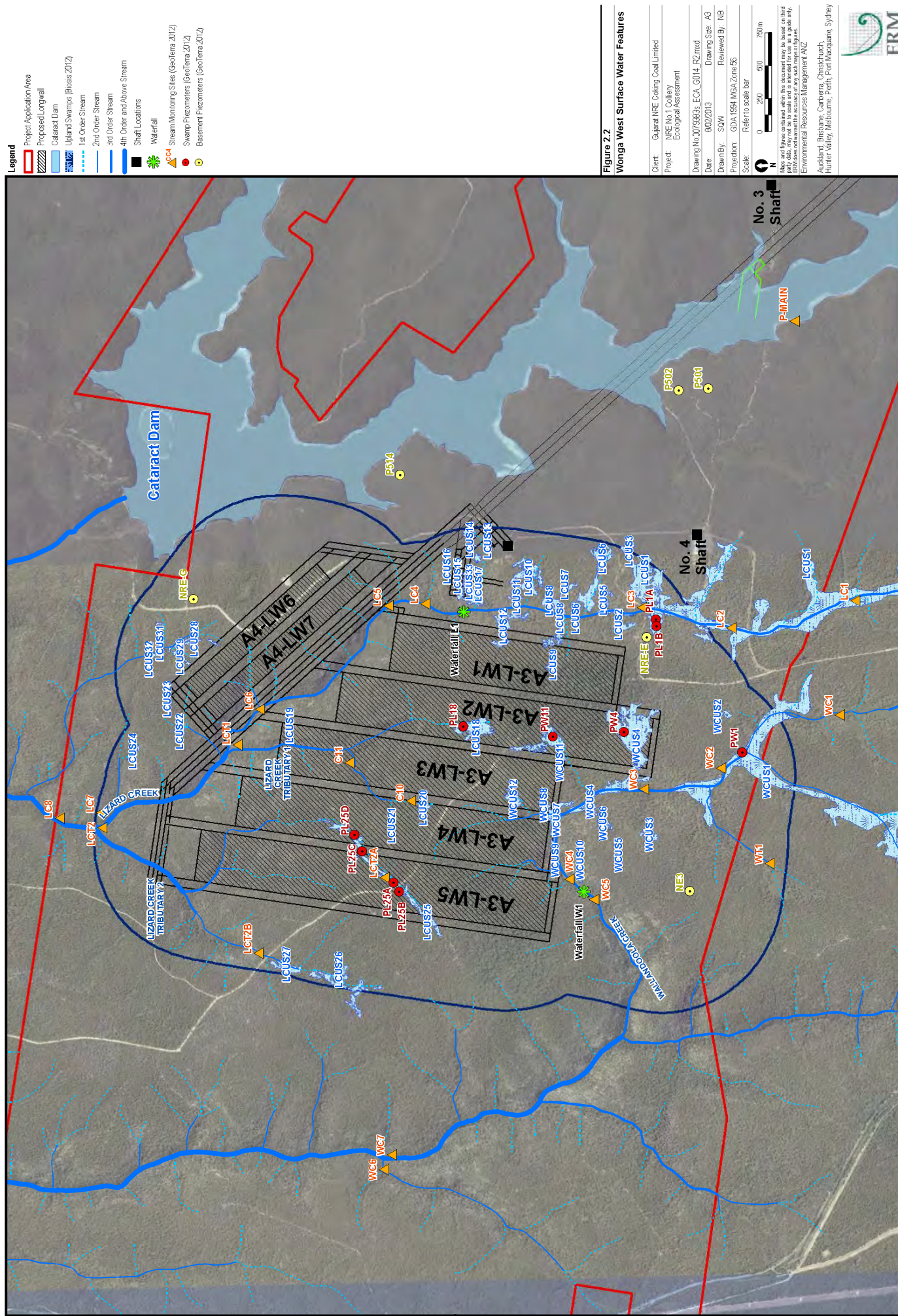


Figure 2.2
Wonga West Surface Water Features

Client	Guarant NRE, Coking Coal Limited
Project	NRE No.1 Colliery Ecological Assessment
Drawing No.	2073938c-ECA_G014_P2.mxd
Date	08/02/2013
Drawn By	SQW
Reviewed By	NB
Projection	GDA 1994 MGA Zone 56
Scale	Ratio 1:50,000

0 250 500 750m

Notes:
 1. All data and figures contained within this document must be based on the latest available information.
 2. This drawing is for information only and does not constitute any form of warranty or guarantee.
 3. The client must ensure the accuracy of any such maps or figures.

Prepared by: Environmental Resources Management ANZ
 Auckland, Dunedin, Christchurch, Wellington, Melbourne, Perth, Port Moresby, 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 it 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 its 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 reinstated 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 overlie 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	Statutory	Size (ha)	Special Significance Criteria			Reason
			Complexity	Closely Proximate Habitat	Scientific	
CCUS1	Coastal	4.81	Yes (MU42, MU43, MU44b, MU44c)	All part of the	No	Statutory, complexity, closely proximate habitat
CCUS10	Upland	1.63	Yes (MU42, MU43, MU44c)	Wallandoola		Statutory, complexity, closely proximate habitat
CCUS4	Swamps	1.77	Yes (MU42, MU43, MU44c)	Swamp Cluster		Statutory, complexity, closely proximate habitat
CCUS5	FEC	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	Statutory	Size (ha)	Special Significance Criteria			Reason
			Complexity	Closely Proximate Habitat	Scientific	
LCUS1	Coastal	129.9	Yes (MU42, MU43, MU44b)	All part of the Wallandoola Swamp Cluster	No	Statutory, complexity, size, closely proximate habitat
LCUS27	Upland	1.04	Yes (MU42, MU43, MU44b)			Statutory, complexity, closely proximate habitat
LCUS6	Swamps	3.74	Yes (MU42, MU43, MU44a, MU44b, MU44c)			Statutory, complexity, closely proximate habitat
LCUS8	FEC	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 to 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	<i>Stagonopleura bella</i>	-	-	Moderately High	NA - regional significance	Yes	No	No
Black Bittern	<i>Ixobrychus flavicollis</i> #	V	-	High	-	No	Yes	No
Broad-headed Snake	<i>Hoplocephalus bungaroides</i> #	E	V	High	-	No	No	Yes
Brush-tailed Rock Wallaby*	<i>Petrogale penicillata</i>	E	V	Highest	-	No	No	Yes
Eastern Bentwing-bat**	<i>Miniopterus schreibersii oceanensis</i> #	V	-	Lower	-	No	No	Yes
Eastern Bristlebird*	<i>Dasyornis brachypterus</i>	E	E	Highest	No - national significance	Yes	No	No
Eastern Pygmy Possum	<i>Cercartetus nanus</i> #	V	-	Moderate	Yes - regional significance	Yes	No	No
Giant Burrowing Frog	<i>Heleioporus australiacus</i> #	V	V	Moderate	Yes - national significance	Yes	Yes	No
Giant Dragonfly ⁴	<i>Petalura gigantea</i>	E	-	-	No - state significance	Yes ⁵	-	-
Green and Golden Bell Frog*	<i>Litoria aurea</i> #	E	V	Highest	Yes - national significance	No	Yes	No
Ground Parrot*	<i>Pezoporus wallicus wallicus</i>	V	-	Highest	No - state significance	Yes	No	No
Heath Frog or Littlejohn's Tree Frog	<i>Litoria littlejohni</i> #	V	V	High	Yes - national significance	Yes	Yes	No
Large-eared Pied Bat	<i>Chalinolobus davyeri</i>	V	V	High	-	No	No	Yes
Large-footed Myotis	<i>Myotis macropus</i> #	V	-	High	-	No	Yes	No
Little Tern	<i>Sterna albifrons</i> #	E	-	-	-	No	Yes	No
Long-nosed Potoroo *	<i>Potorous tridactylus</i>	V	V	Highest	Yes - national significance	Yes	No	No
Platypus***	<i>Ornithorhynchus anatinus</i>	-	-	Lower	-	No	Yes	No
Red-crowned Toadlet	<i>Pseudophryne australis</i> #	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	<i>Varanus rosenbergi</i> #	V	-	Moderate	Yes - regional significance	Yes	No	No
Southern Emu-wren	<i>Stipiturus malachurus</i>	-	-	Moderate	NA - regional significance	Yes	No	No
Stuttering Barred Frog	<i>Mixophyes balbus</i>	V	V	Highest	-	No	Yes	No
Tawny-crowned Honeyeater	<i>Phylidonyris melanops</i>	-	-	Moderate	NA - regional significance	Yes	No	No
Turquoise Parrot	<i>Neophema pulchella</i>	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
Christmas Bells	<i>Acacia baueri</i> subsp. <i>aspera</i> #	V	-	2RC-	No	No	Yes
Lizard Orchid	<i>Blandfordia cunninghamii</i>	-	-	3RCi	Yes	No	Yes
	<i>Bumettia cuneata</i>	-	-	3RC-	Yes	No	No
	<i>Darwinia grandiflora</i>	-	-	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
	<i>Epacris coriacea</i>	-	-	3RC-	No	No	Yes
	<i>Epacris purpurascens</i> var. <i>purpurascens</i> #	V	-	2KC-	Yes	Yes	No
Yellow-topped Mallee-ash	<i>Eucalyptus lucimaniiana</i>	-	-	2RCa	No	No	Yes
Creeping Raspwort	<i>Gonocarpus salsoloides</i>	-	-	3RCa	Yes	No	No
Fern-leaf Grevillea	<i>Grevillea longifolia</i>	-	-	2RC-	No	Yes	Yes
Small-flower Grevillea	<i>Grevillea parviflora</i> subsp. <i>parviflora</i>	V	V	-	Yes	No	No
Wedge-Leaf Hibbertia	<i>Hibbertia hermanniifolia</i>	-	-	3RCa	No	No	yes
Shiny-leaf Guinea Flower	<i>Hibbertia nitida</i>	-	-	2RC-	No	Yes	No
Woronora Beard-heath	<i>Leucopogon exaltatus</i>	V	V	2VC-	No	Yes	No
Native Cranberry	<i>Lissanthe sapida</i>	-	-	3RCa	No	No	Yes
River Mat-Rush	<i>Lomandra fluviatilis</i>	-	-	3RCa	No	Yes	No
Yellow Loosestrife	<i>Lysimachia vulgaris</i> var. <i>daurica</i>	E	-	-	Yes	Yes	No
Deane's Paperbark	<i>Melaleuca deanei</i>	V	V	3RC-	Yes	No	No
	<i>Monotoca ledifolia</i>	-	-	3RCa	No	Yes	Yes
Needle Geebung ⁵	<i>Persoonia acerosa</i>	V	V		Fringing habitat	No	No
Brown Pomaderris	<i>Pomaderris brunnea</i> #	V	V	2VC-	No	Yes	No
Prickly Bush-pea	<i>Pultenaea aristata</i> #	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 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 Commission (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 <i>Callocephalon fimbriatum</i>	V	-
Eastern Pygmy Possum <i>Cercartetus nanus</i>	-	V
Brown Treecreeper <i>Climacteris picumnis victoriae</i>	V	-
Eastern False Pipistrelle <i>Falsistrellus tasmaniensis</i>	V	-
Eastern Bentwing-bat <i>Miniopterus schreibersii oceanensis</i>	V	-
Eastern Freetail-bat <i>Mormopterus norfolkensis</i>	V	-
Powerful Owl <i>Ninox strenua</i>	V	-
Greater Broad-nosed Bat <i>Scoteanax rueppellii</i>	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 (*Heleioporus 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 (*Isodon obesulus obesulus*), Brush-tailed Rock-wallaby (*Petrogale penicillata*), 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 Littlejohn'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 (*Pseudophryne 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 Scrubby 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

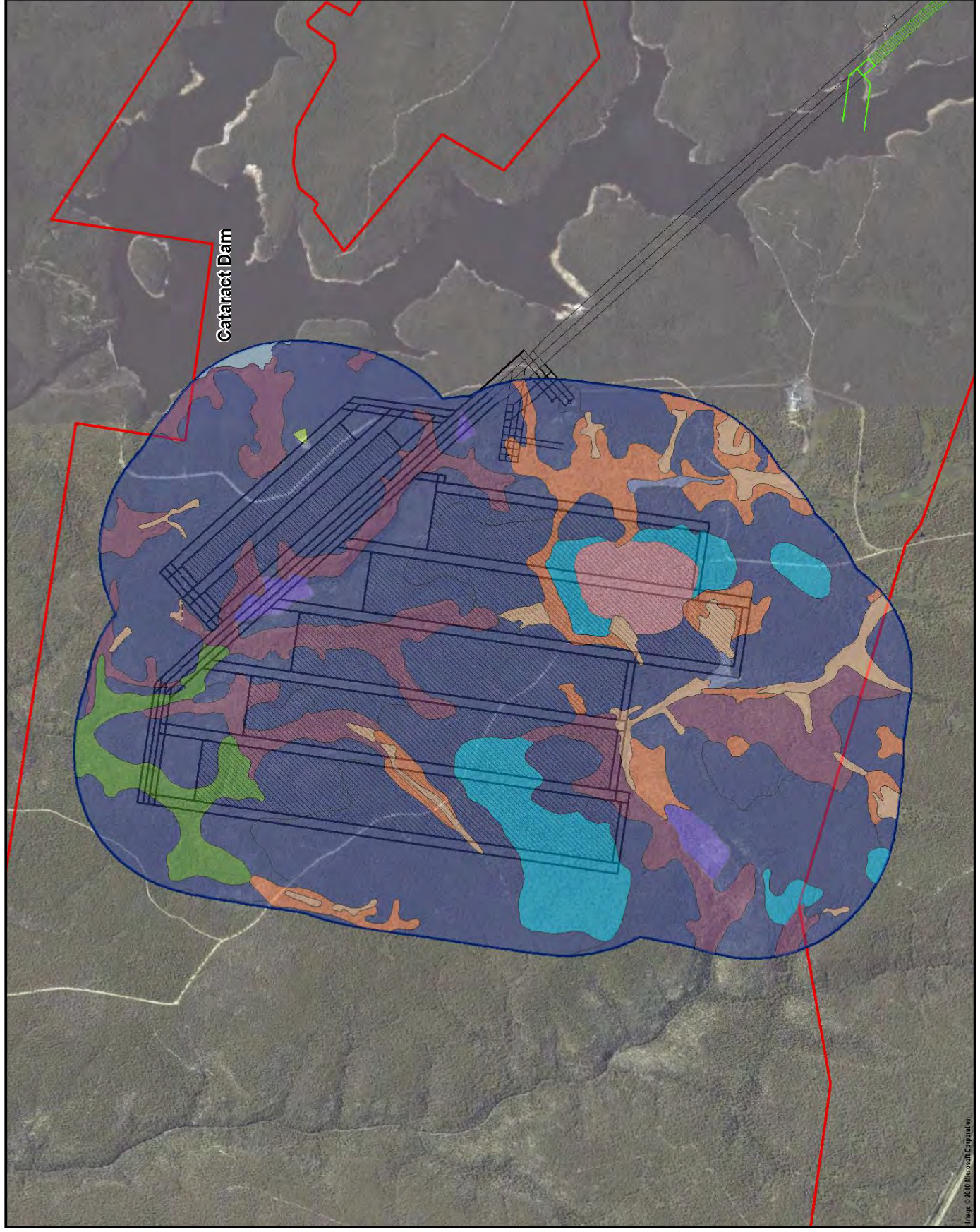


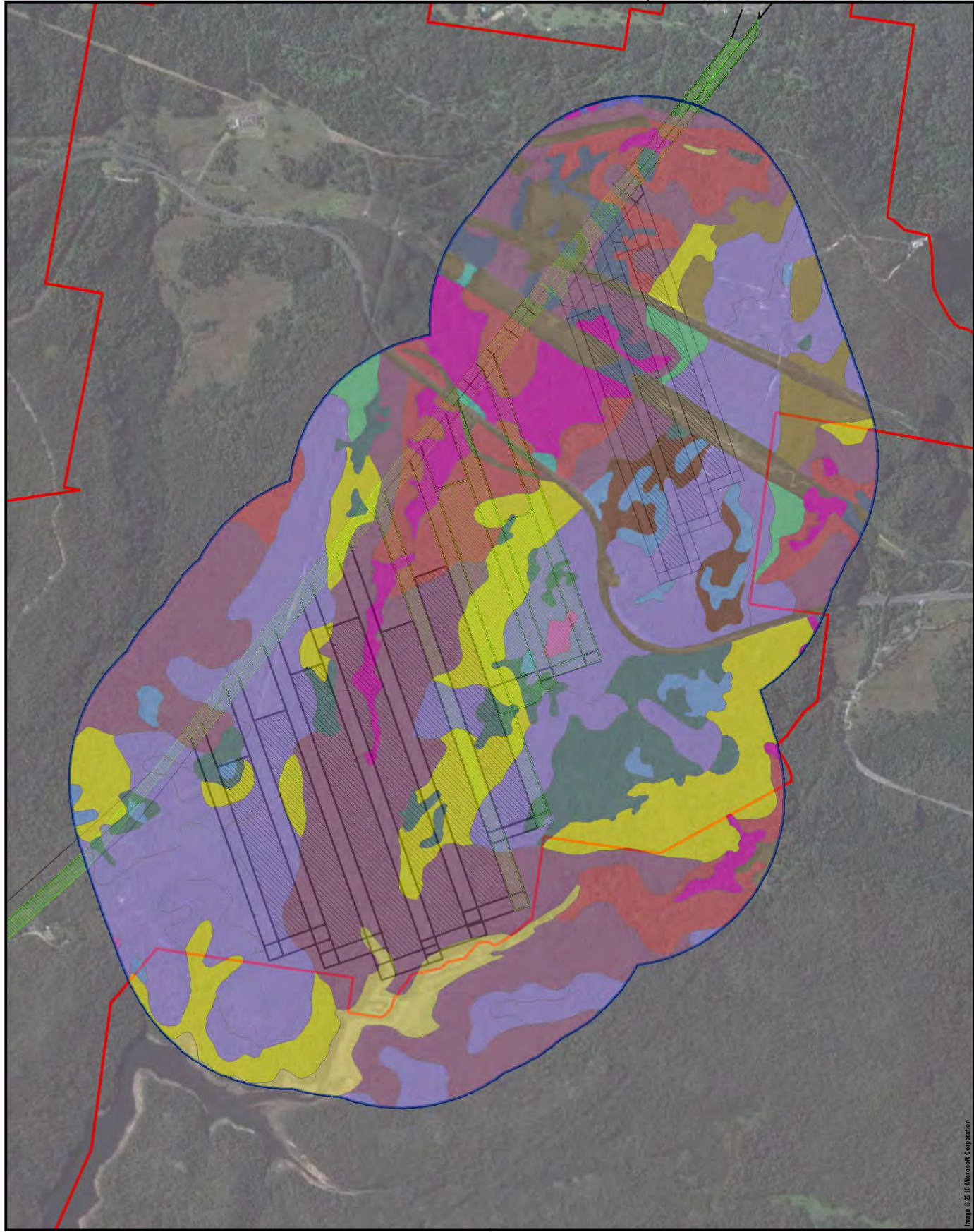
Figure 3.1
Vegetation Mapping Of Wonga West
Study Area (NPWS 2003)

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery Ecological Assessment
Drawing No:	007/3465, ECA, 0017_R1.mxd
Date:	12/05/2012
Drawn by:	SJM
Reviewed by:	MB
Scale:	Refer to Scale Bar
Scale:	0 200 400 800m

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





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:	007/3465, ECA, 0002, R1, rmd
Date:	12/09/2012
Drawn by:	SQM
Reviewed by:	MB
Scale:	Refer to Scale Bar
	0 150 300 450m

Notes 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 Australia

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



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 400m² (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

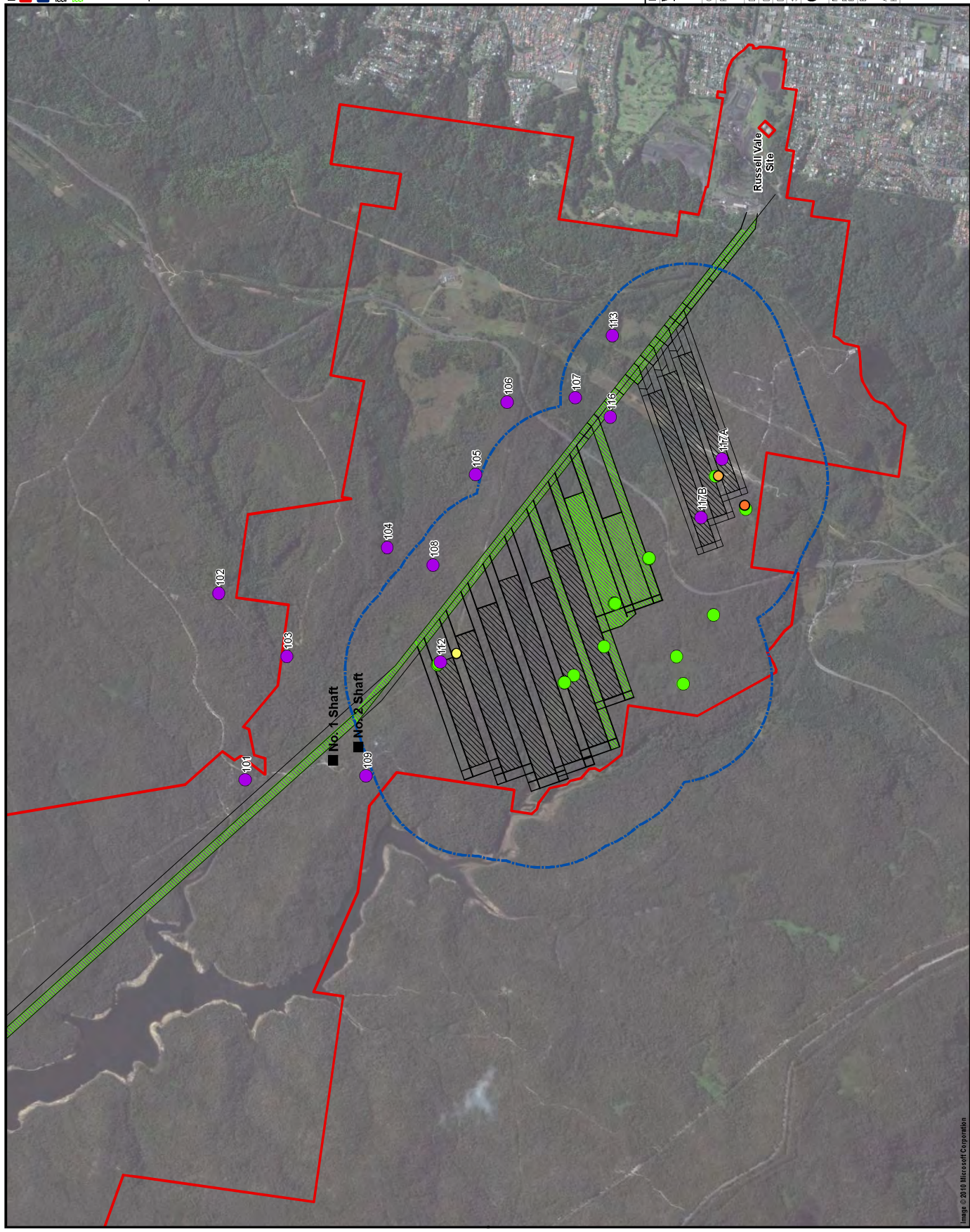


Figure 3.3
Wonga East Floristic Quadrat and
Threatened Flora Search Locations

Client:	Gularrat NRE Coking Coal Limited
Project:	NPE No.1 Colliery Ecological Assessment
Drawing No:	007/3460s, ECA, 0002_R3.mxd
Date:	19/09/2012
Drawn by:	SQM
Reviewed by:	NB
Scale:	Refer to Scale Bar
Scale Bar:	0 250 500 750m

Notes 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.

Legend

- Project Application Area
- Study Area
- Proposed Longwall
- Shaft Locations**
- Floristic Quadrant Sites Feb 09
- Floristic Quadrant Sites Sept 11
- Threatened Flora Search Oct 09
- Swamp1
- Swamp2
- Swamp3

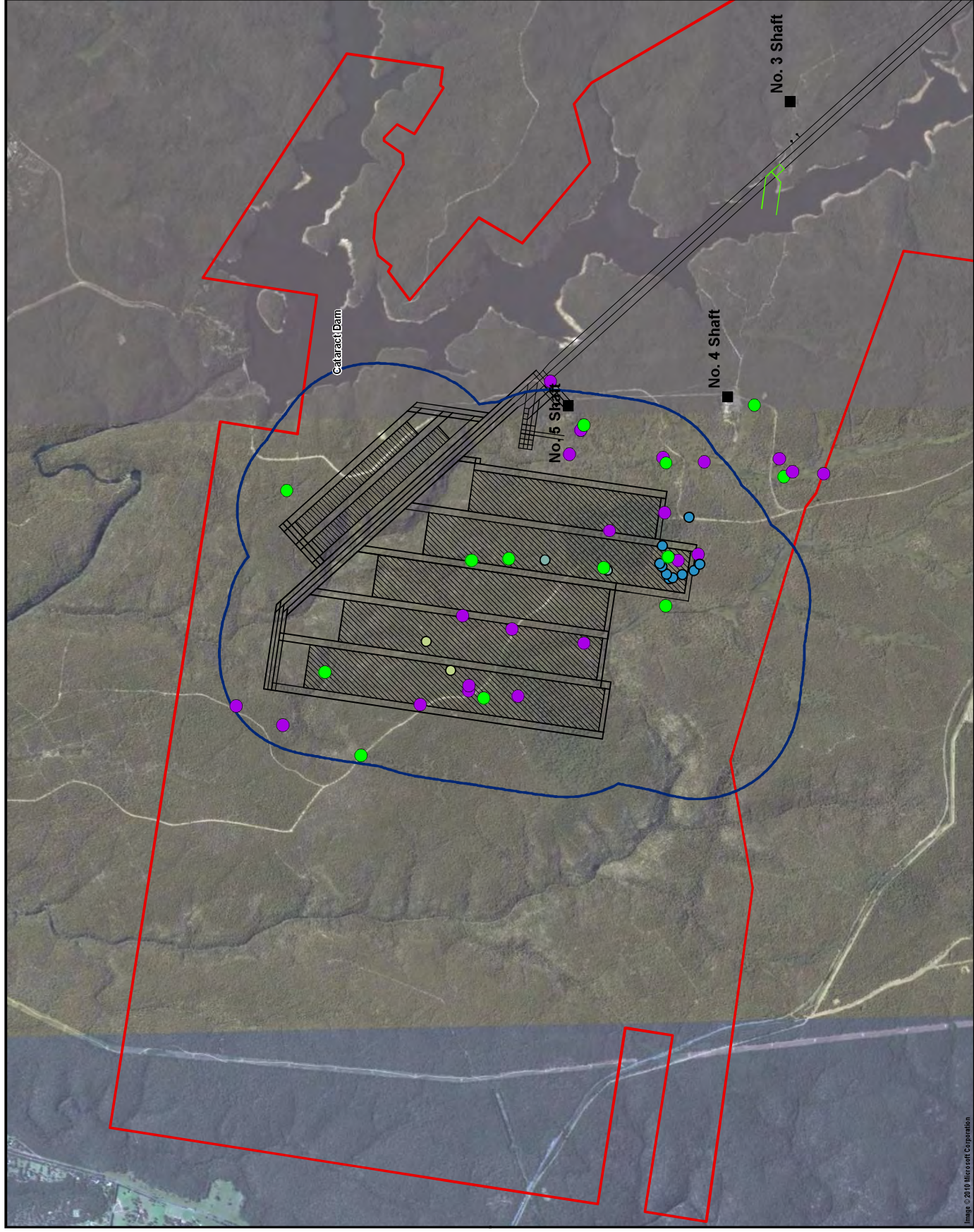


Figure 3.4
Wonga West Floristic Quadrant and Threatened Flora Search Locations

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery EAP Post Adequacy 2012 Ecological Assessment
Drawing No:	007/4805, ECA, 0015, R1.mxd
Date:	30/11/2012
Drawn by:	SQM
Reviewed by:	MD
Scale:	Refer to Scale Bar
	0 250 500 750m

Notes 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



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	yes	no	yes
<i>Blandfordia cunninghamii</i>			
Lizard Orchid	yes	no	no
<i>Burnettia cuneata</i>			
<i>Darwinia grandiflora</i>	yes	no	no
<i>Epacris purpurascens</i> var. <i>purpurascens</i>	yes	yes	no
Creeping Raspwort	yes	no	no
<i>Gonocarpus salsoloides</i>			
Small-Flower Grevillea	yes	no	no
<i>Grevillea parviflora</i> subsp. <i>parviflora</i>			
Yellow Loosestrife	yes	yes	no
<i>Lysimachia vulgaris</i> var. <i>davurica</i>			
Deane’s Melaleuca	yes	no	no
<i>Melaleuca deanei</i>			
Prickly Bush Pea	yes	no	no
<i>Pultenaea aristata</i>			
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 (MF10_0046)
 - 1st Order Stream
 - 2nd Order Stream
 - 3rd Order Stream
 - 4th Order and Above Stream
 - Spotlight Routes
 - Shaft Locations
 - Analyst Locations
 - Bird Area Search
 - Bird Point Counts
 - Call Broadcasting
 - Frog Habitat Survey
 - Hair Funnels
 - Durnal Frog Call-playback
 - Durnal Herpetofauna Search
 - Habitat Assessment
 - Habitat Assessment
 - Nocturnal Frog Call-playback
 - Frog Habitat Survey Sites Sept 11

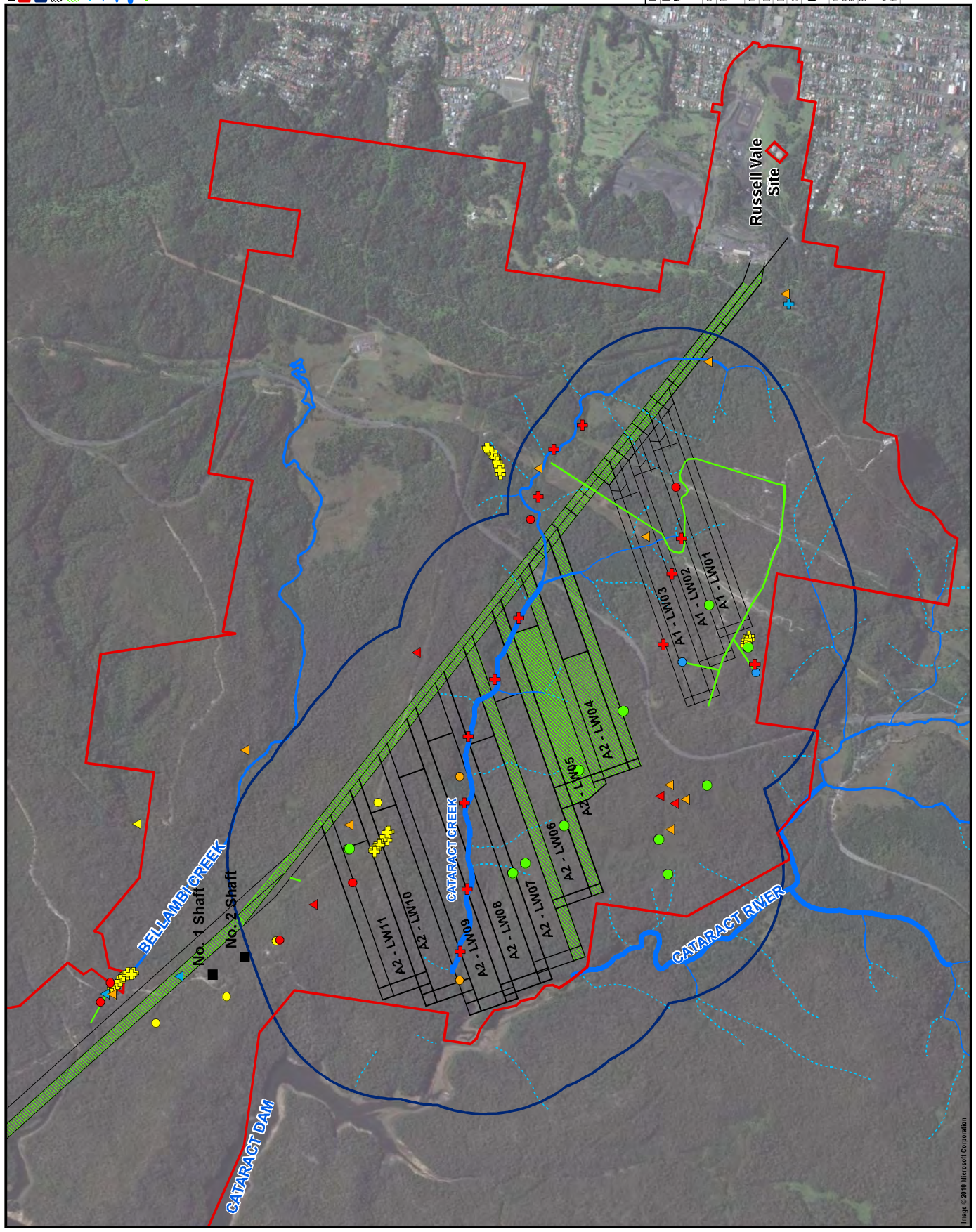


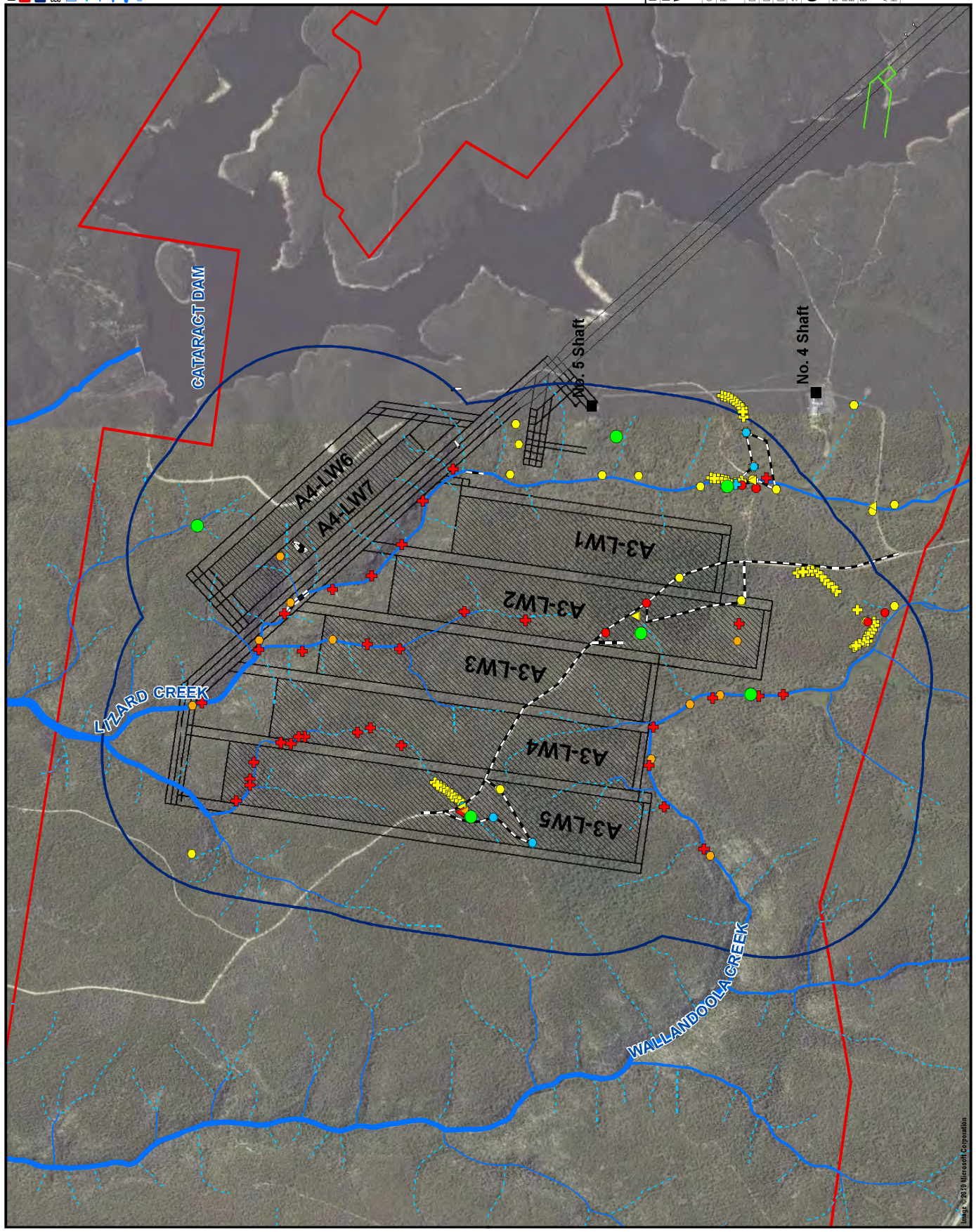
Figure 3.5
Fauna Survey Locations Within The
Wonga East Study Area

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery EAP Post Adequacy 2012 Ecological Assessment
Drawing No:	007/0400, ECA, 0002, R3.mxd
Date:	27/11/2012
Drawn by:	SQM
Reviewed by:	ME
Scale:	Refer to Scale Bar
	0 200 400 600m

Notes 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 Australia Pty Ltd
 Auckland, Brisbane, Canberra, Christchurch,
 Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney





- 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 Tunnels
 - 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 (EAB Post Adequacy 2012 Ecological Assessment)
Drawing No:	007/2400, ECA, 0016, R1, mod
Date:	30/11/2012
Drawn by:	KB
Reviewed by:	MB
Scale:	Refer to Scale Bar
	0 250 500 750m

Notes 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



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	<i>Heleioporus australiacus</i> #	V	V
Green and Golden Bell Frog*	<i>Litoria aurea</i> #	E	V
Heath Frog	<i>Litoria littlejohni</i> #	V	V
Red-crowned Toadlet	<i>Pseudophryne australis</i> #	V	-
Stuttering Barred Frog	<i>Mixophyes balbus</i> **	E	V
Reptiles			
Broad-headed Snake	<i>Hoplocephalus bungaroides</i> #	E	V
Rosenberg's Goanna	<i>Varanus rosenbergi</i> #	V	-
Eastern Three-lined Skink	<i>Acritoscincus duperreyi</i> **	-	-
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 2040 hair 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 specialist herpetologists.						

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.

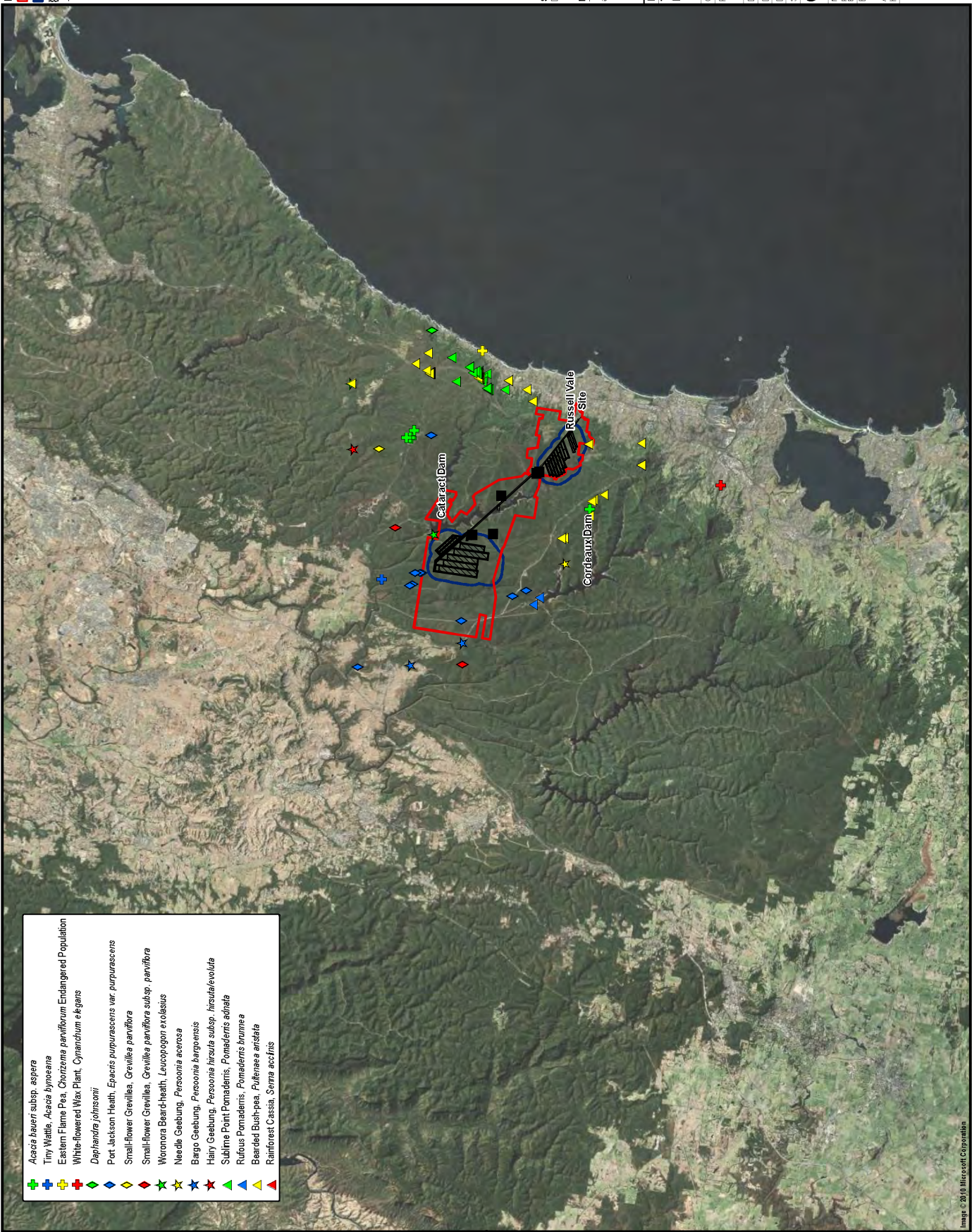
The location of rare and threatened flora species records is shown in *Figure 4.3* and *Figure 4.4*.

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
 - Shall Locations

- Threatened Flora Previously Recorded Within 10km Of Study Area**
- Acacia laevis* subsp. *aspera*
 - Tiny Wattle, Acacia lysocarpa*
 - Eastern Flame Pea, Chortzema parviflorum* Endangered Population
 - White-flowered Wax Plant, Cynanchum elegans*
 - Daphandra johnstonii*
 - Port Jackson Heath, Epacris purpurascens* var. *purpurascens*
 - Small-flower Greivillea, Greivillea parviflora*
 - Small-flower Greivillea, Greivillea parviflora* subsp. *parviflora*
 - Woronora Beard-heath, Leucopogon excolatus*
 - Needle Geebung, Persoonia acerosa*
 - Bargo Geebung, Persoonia bargoensis*
 - Hair Geebung, Persoonia hirsuta* subsp. *hirsuta*
 - Sublime Point Pomadour, Pomadouria adnata*
 - Rufous Pomadour, Pomadouria brunnea*
 - Bearded Bush-pea, Pullenaea aristata*
 - Rainforest Cassia, Senna acutifolia*

Source:
DECOW Wildlife Data Unit

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

Figure 4.1
Threatened Flora Previously Recorded Within 10km Of Study Area

Client:	Gularrat NRE Coking Coal Limited
Project:	NRE No. 1 Colliery / EAB Post Adequacy 2012 Ecological Assessment
Drawing No:	00/5440s, ECA, G012, R1, mtd
Date:	29/11/2012
Drawn by:	NS
Reviewed by:	NB
Scale:	Refer to Scale Bar
Scale Bar:	0 2,500 5,000 7,500m

Notes 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

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

Source:
DECOM Wildlife Data Unit

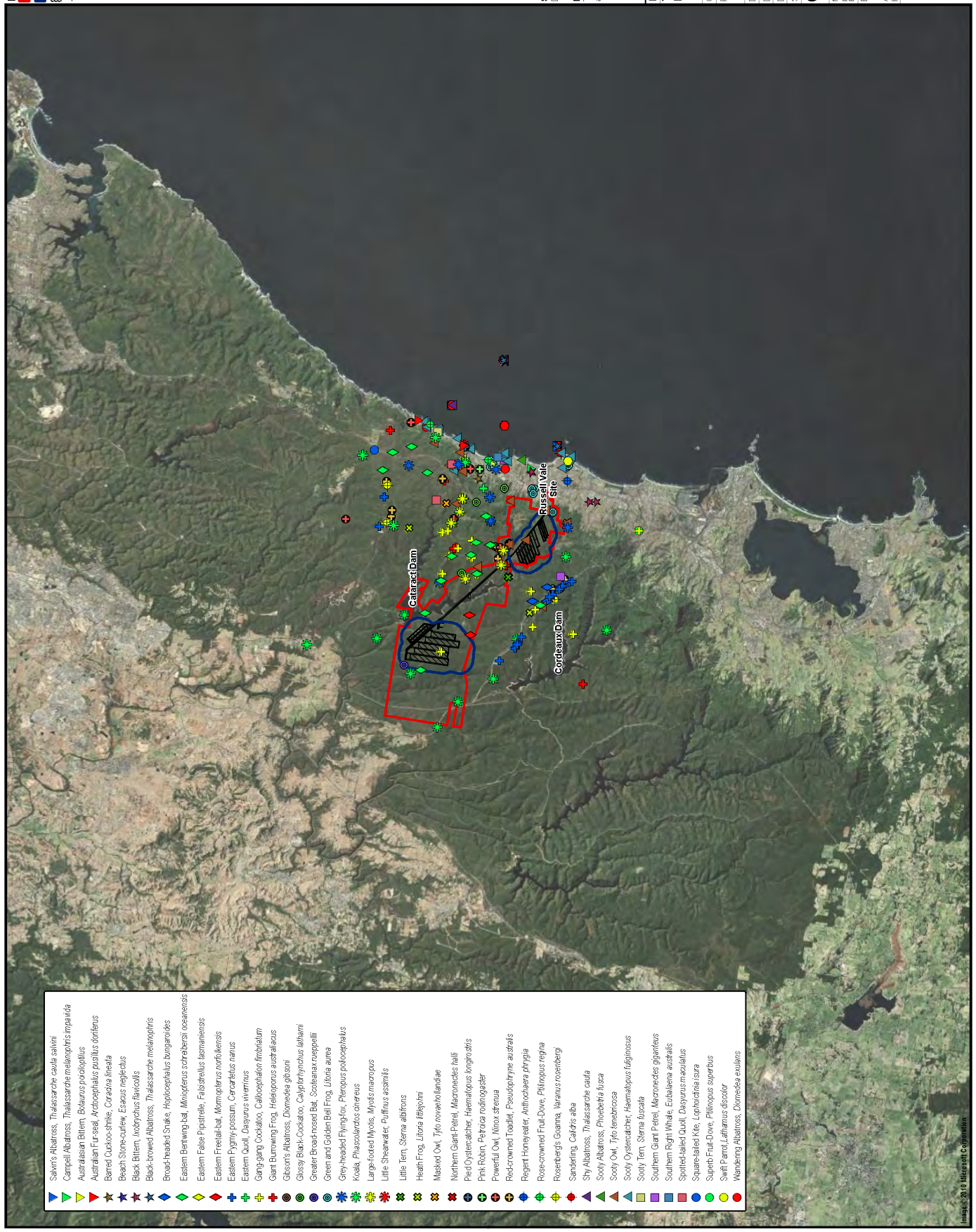
Notes:
This data has been projected at a scale of 1:250,000 in accordance with DECOM data specifications

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

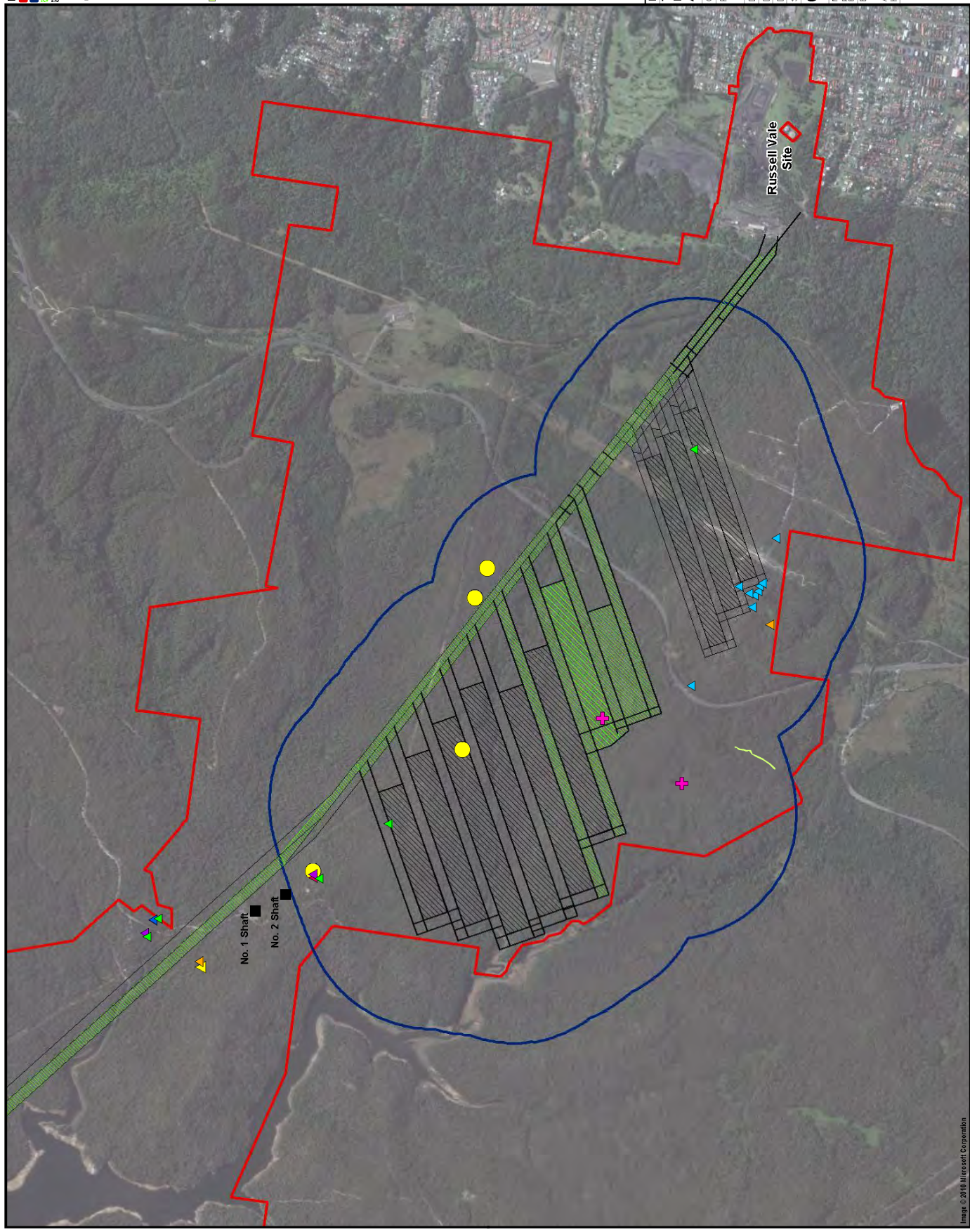
Client:	Gujarat NRE Coaling Coal Limited
Project:	NRE No 1 Colliery EAP Post Adequacy 2012 Ecological Assessment
Drawing No:	00/54405_ECA_G011_LRI.mxd
Date:	29/11/2012
Drawn by:	NS
Reviewed by:	MB
Scale:	Refer to Scale bar
Scale bar:	0 2,500 5,000 7,500 m

When used in conjunction with this document, this map may be used 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



- Salvin's Albatross, *Thalasarche caudata salvinii*
- Campbell Albatross, *Thalasarche melanophrys impavida*
- Australasian Bittern, *Botaurus poecilopus*
- Australian Fur seal, *Arctophila pusillus doriferus*
- Banded Oystercatcher, *Haematopus lineatus*
- Black Duck, *Ardeotis nasutus*
- Black-browed Albatross, *Thalasarche melanophrys*
- Brook-headed Snake, *Hoplocephalus bungaroides*
- Eastern Bunting, *Minidulus schrederi*
- Eastern False Pipebird, *Falsipetiolus tasmanicus*
- Eastern Freetail, *Mormonotus norfolkensis*
- Eastern Pygmy-possum, *Cercartetus nanus*
- Eastern Quail, *Diaparsus swainsoni*
- Gang-gang Cockatoo, *Callopheopsittacus acronotus*
- Giant Burrowing Frog, *Hyalinobatrachium*
- Glossy Black-cuckoo, *Chalcophaps indica*
- Greater Broad-billed Bittern, *Scolopax rostrata*
- Green and Golden Bell Frog, *Litoria aurea*
- Grey-headed Flyingfox, *Pteropus poliocephalus*
- Koala, *Phascolarctos cinereus*
- Large-footed Myotis, *Myotis macropus*
- Little Shearwater, *Puffinus pacificus*
- Little Tern, *Sterna altilis*
- Heath Frog, *Litoria ilhevoensis*
- Mottled Owl, *Tyto novaehollandiae*
- Northern Giant Petrel, *Macronectes halli*
- Pied Oystercatcher, *Haematopus longirostris*
- Pink Robin, *Petroica rodinogaster*
- Powerful Owl, *Ninox strenua*
- Red-crowned Toadlet, *Pseudophryne australis*
- Regent Honeyeater, *Anthochaera phrygia*
- Rose-crowned Fruit-Dove, *Ptilinopus regina*
- Rose-backed Fairy, *Varanus rosenbergi*
- Sandling, *Calidris alba*
- Shy Albatross, *Thalasarche caudata*
- Sooty Albatross, *Phoebastria fusca*
- Sooty Owl, *Tyto tenebrosa*
- Sooty Oystercatcher, *Haematopus fuliginosus*
- Sooty Tern, *Sterna fuscata*
- Southern Giant Petrel, *Macronectes giganteus*
- Southern Right Whale, *Eubalaena australis*
- Spotted-tailed Quail, *Diaparsus maculatus*
- Square-tailed Kite, *Lopholais isra*
- Superb Fruit-Dove, *Ptilinopus superbus*
- Swift Parrot, *Lathamus discolor*
- Wandering Albatross, *Diomedea exulans*



- Legend**
- Project Application Area
 - Study Area
 - Approved Workings (MP10_0046)
 - Proposed Longwalls
 - Shaft Locations
 - Pulmonaria anisotoma (Bosch 2012)
 - Pulmonaria anisotoma (ERM 2011)
 - Quercus grandiflora
 - Brachylaima
 - East Coast Freetail Bat
 - Eastern Bristlebill
 - Eastern Falcate
 - Black-chinned
 - Southern Emu-wren
 - Spotted Burrowing Frog Tadpoles (Bosch 2012)

Figure 4.3
Threatened And Rare Species
Recorded In the Wonga East Study
Area

Client: Gurrat NRE Coking Coal Limited
 Project: NRE No.1 Colliery EAP Part A/February 2012
 Ecological Assessment
 Drawing No: 00/3480s, ECA, 0010, RZ, mtd
 Date: 29/11/2012
 Drawn by: KB
 Reviewed by: MB
 Scale: Refer to Scale Bar
 0 200 400 600 m

Notes 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



- Legend**
- Project Application Area
 - Study Area
 - Proposed Longwall
 - Shaft Locations
 - Ptilinopus aristata* (Breis 2012)
 - Monodon leucomela*
 - Beautiful Firetail
 - East Coast Freetail Bat
 - Eastern Barwing Bat
 - Eastern Falsistrelle
 - Giant Burrowing Frog
 - Greater Broad-nosed Bat
 - Powerful Owl
 - Red-crowned Towlbat
 - Southern Emu-wren

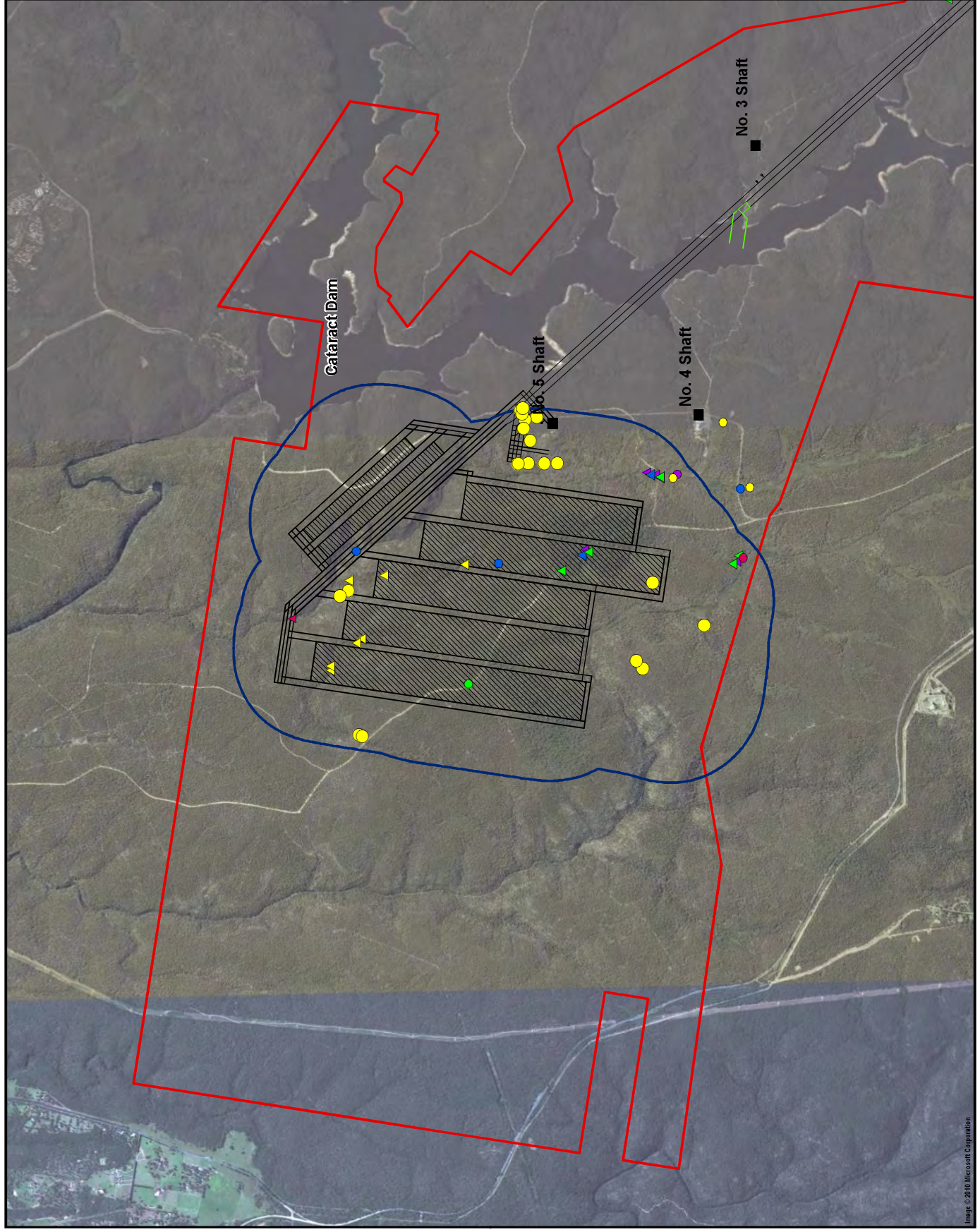


Figure 4.4

**Threatened And Rare Species
Recorded In the Wonga West Study
Area**

Client:	Gajeral NRE Mining Coal Limited
Project:	NRE No.1 Colliery EAP Post Adequacy 2012 Ecological Assessment
Drawing No:	00/0400s, ECA, 0016, R0.mxd
Date:	07/12/2010
Drawn by:	NS
Reviewed by:	MD
Scale:	Refer to Scale Bar
	0 300 600 900m

Notes 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,
Hunee Valley, Melbourne, Perth, Port Moresby, Sydney



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 eugenoides*) 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 oblongifolia*, *Grevillea*, *Hakea 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 (*Acmena 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	<i>Crinia signifera</i>	-	-
Giant Burrowing Frog	<i>Heleioporus australiacus</i>	V	V
Banjo Frog	<i>Limnodynastes dumerilii grayi</i>	-	-
Striped Marsh Frog	<i>Limnodynastes peronii</i>	-	-
Green Tree Frog	<i>Litoria caerulea</i>	-	-
Lesueur's Frog	<i>Litoria leseuri</i>	-	-
Southern Leaf-green Tree frog	<i>Litoria nudidigitis</i>	-	-
Peron's Tree Frog	<i>Litoria peronii</i>	-	-
Verreaux's Tree Frog	<i>Litoria verreauxii</i>	-	-
Haswell's Frog	<i>Paracrinia haswelli</i>	-	-
Red-crowned Toadlet	<i>Pseudophryne australis</i>	V	-
Brown Toadlet	<i>Pseudophryne bibronii</i>	-	-
Red-backed Brood Frog	<i>Pseudophryne coriacea</i>	-	-

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	<i>Amphibolurus muricatus</i>	-	-
Eastern Snake-necked Turtle	<i>Chelodina longicollis</i>	-	-
Copper-tailed Ctenotus	<i>Ctenotus taeniolatus</i>	-	-
Eastern Water-skink	<i>Eulamprus quoyii</i>	-	-
Dark-flecked Garden Sunskink	<i>Lampropholis delicata</i>	-	-
Pale-flecked Garden Sunskink	<i>Lampropholis guichenoti</i>	-	-
Lesueur's Velvet Gecko	<i>Oedura lesueurii</i>	-	-
Broad-tailed Gecko	<i>Phyllurus platurus</i>	-	-
Eastern Water Dragon	<i>Physignathus lesueurii</i>	-	-
Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>	-	-
Eastern Brown Snake	<i>Pseudonaja textilis</i>	-	-
Blackish Blind Snake	<i>Ramphotyphlops nigrescens</i>	-	-
Mountain Heath Dragon	<i>Rankinia diemensis</i>	-	-

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	<i>Calyptorhynchus lathami</i>	V	-
Black-faced Monarch	<i>Monarcha melanopsis</i>	-	M
Powerful Owl ^	<i>Ninox strenua</i>	V	-
Rufous Fantail	<i>Rhipidura rufifrons</i>	-	M
Beautiful Firetail*	<i>Stagonopleura bella</i>	-	-
Southern Emu Wren*	<i>Stipiturus malachurus</i>	-	-

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

Common name	Scientific name	TSC Act status	EPBC Act status
Large Forest Bat	<i>Vespadelus darlingtoni</i>	-	-
Eastern Forest Bat	<i>Vespadelus pumilus</i>	-	-
Southern Forest Bat	<i>Vespadelus regulus</i>	-	-
Little Forest Bat	<i>Vespadelus vulturinus</i>	-	-
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 WCUS7 where 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 sedgeland-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.

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. Changes in water quality / quantity in streams and creeks including increased iron-oxidisation and bacteria flocculation. Stream bank erosion altering aquatic and riparian habitat. Inundation of vegetation. 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. Gullyling 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.
	Water-rock chemical interactions along new flow pathways.	
	Tilting of stream beds.	
	Ponding in subsidence troughs.	
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.	

Natural Feature	Subsidence Impact	Potential Consequence for Flora/Fauna
Rocky Habitats	Surface cracking	Reduced health of riparian vegetation an in-stream habitats.
	Cliff collapse and rockfall	Loss of or change in shelter sites for wintering reptiles and other animals.
		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 Channel	Creek	Main	0.25	4.0	-2 to 8	120	200
Cataract Channel	River	Main	0	0	0	<60	<100
Bellambi Channel	Creek	Main	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 <i>Table 5.1</i> and <i>Table 5.2</i> .				

- Legend**
- Project Application Area
 - Study Area
 - Proposed Longwalls
 - Catacart 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

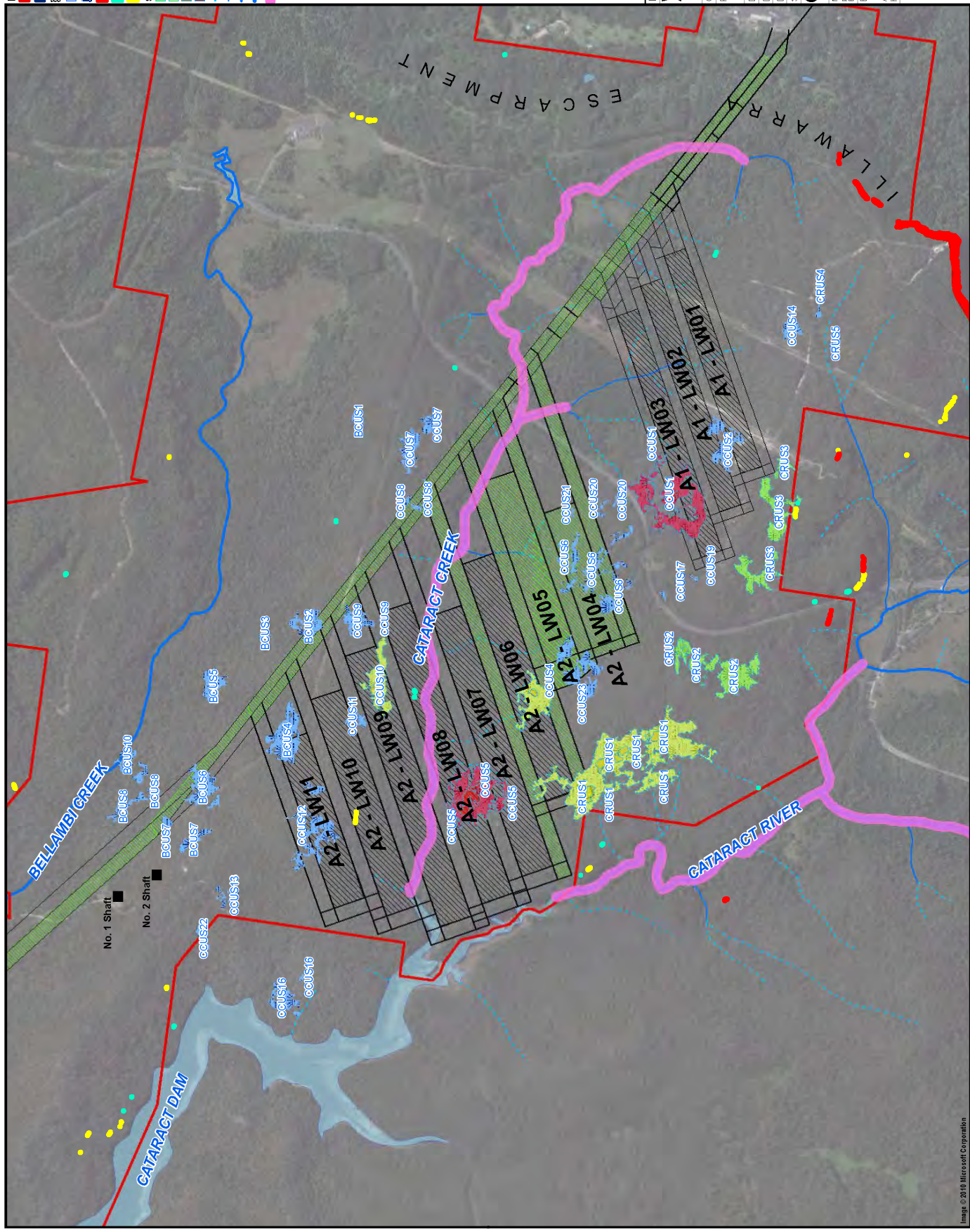


Figure 5.1
Wonga East Ecologically Significant Areas

Client:	Guarat NRE Colong Coal Limited
Project:	NRE No.1 Colong EAR Post Aquatic 2012 Ecological Assessment
Drawing No:	007/3400, EAPPA2012, 007, R3 mod
Date:	30/11/2012
Drawn by:	KB
Reviewed by:	NB
Scale:	Refer to Scale Bar
Scale Bar:	0 150 300 450m

Notes 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

- 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
 - Shall Locations
 - Stream Monitoring Sites (GeoTerra 2010a)

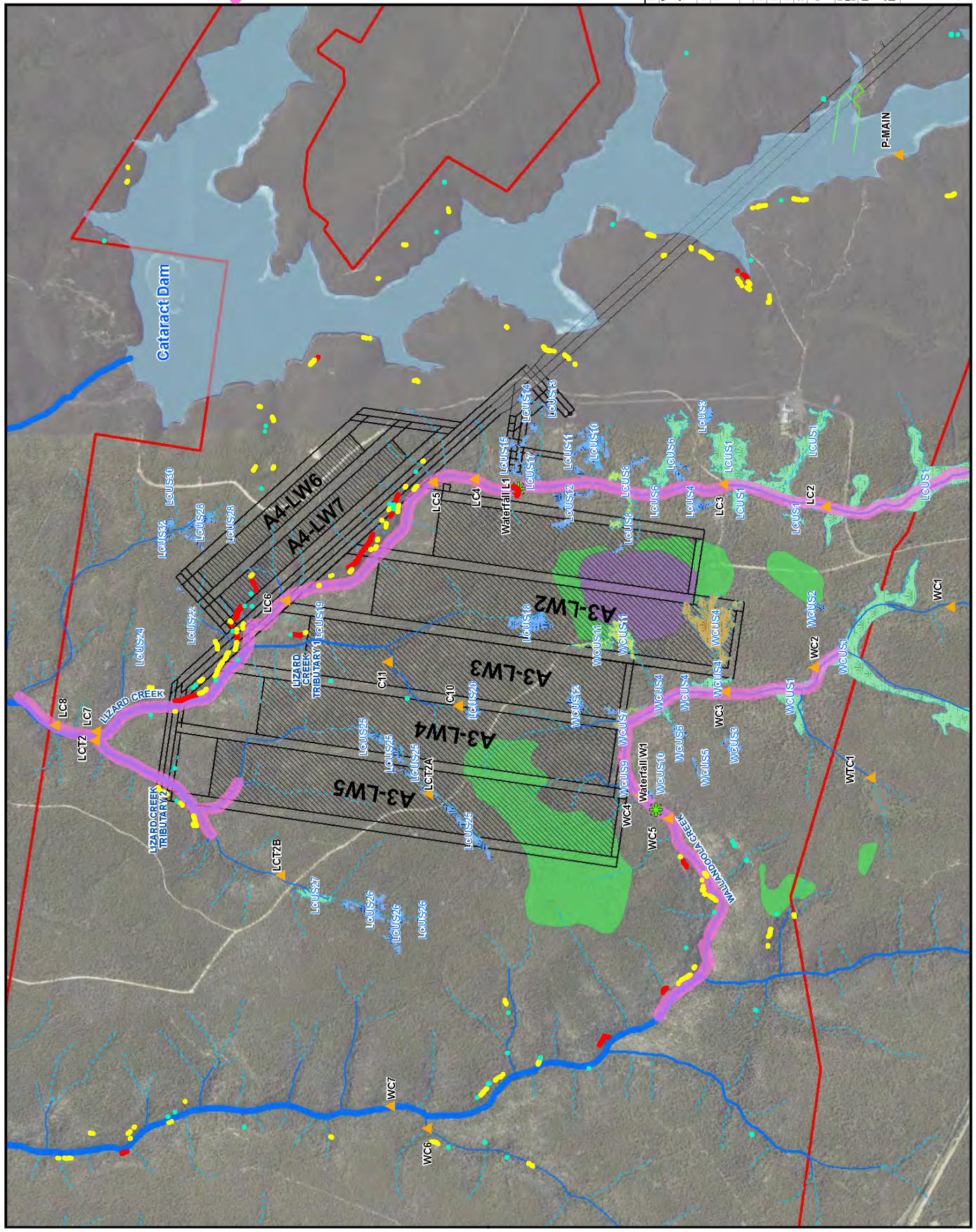


Figure 5.2
Wonga West Ecologically Significant Areas

Client	Gippsland NRE Consulting Ltd
Project	NRE No.1 Colliery EAP Post Adequacy 2012 Ecological Assessment
Drawing No.	00/55884s_ECA_G005_P2 mod
Date	8/02/2013
Drawn By	KB
Reviewed By	NB
Projection	GDA 1994 MGA Zone 56
Scale	Refer to scale bar
Scale	0 200 400 750m

Map and figures contained within this document may be based on third party data. 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



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 <i>Eucalyptus piperita</i> and <i>E. globoides</i> , and <i>Angophora costata</i> .	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?
<i>Acacia baueri</i> subsp. <i>aspera</i>	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 <i>Acacia bynoeana</i>	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 <i>Astrotrichia crassifolia</i>	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 <i>Caladenia tessellata</i>		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 <i>Chorizema parviflorum</i>	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 <i>Cynanchum elegans</i>	E	Climber or twiner occurring mainly at the ecotone between dry subtropical rainforest and sclerophyll forest / woodland communities.	Moderate	No	No
Illawarra Socketwood <i>Daphnandra johnsonii</i> syn <i>D. sp C Illawarra</i>	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
<i>Epacris purpurascens</i> var. <i>purpurascens</i>	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 <i>Grevillea parviflora</i> subsp. <i>parviflora</i>	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 <i>Leucopogon exolatus</i>	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 communities 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 <i>Lysimachia vulgaris</i> var. <i>daurica</i>	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 <i>Melaleuca deanei</i>	V	Occurs in the Sydney basin Bioregion in Wollondilly LGA, and grows on flat broad plateaus and ridges in sandstone ridgetop woodland, coastal sandstone forest and similar vegetation types (OEH online profile). The distribution is consistent with the Study Area.	Moderate	Yes	Yes
Needle Geebung <i>Persoonia acerosa</i>	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 <i>Persoonia bargoensis</i>	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 <i>Persoonia hirsuta</i>	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 <i>Pomaderris adnata</i>	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 <i>Pomaderris brunnea</i>	V	The species occurs in open forest in association with <i>Eucalyptus amplifolia</i> , <i>Angophora floribunda</i> , <i>Acacia parramattensis</i> , <i>Bursaria spinosa</i> and <i>Kimzey ambigua</i> . 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 <i>Pultenaea aristata</i>	V	Prickly Bush-pea occurs on the Woronora Plateau, and can be found within Upland Swamp Banksia Thicket and Restioid 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 <i>Senna acclinis</i>	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 <i>Anthochaera phrygia</i>	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 <i>Botaurus poiciloptilus</i>		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 (<i>Typha</i> spp.) and spikerushes (<i>Eleocharis</i> 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 <i>Callocephalon fimbriatum</i>	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 <i>Calyptorhynchus lathami</i>	V	Found in forests on sites with low soil-nutrient status, reflecting distribution of <i>Casuarina</i> spp. and <i>Allocasuarina</i> 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?
Barred Cuckoo-shrike <i>Coracina tenuirostris</i>	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	vulnerable to subsidence. No	No
Eastern Bristlebird <i>Dasyornis brachypterus</i>	E	This species is known to inhabit dense, low vegetation including heath and open woodland with healthy 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 <i>Ixobrychus flavicollis</i>	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 <i>Lathamus discolor</i>	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 <i>Lophoictinia isura</i>	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?
Hooded Robin <i>Melanodryas cucullata cucullata</i>	V	with grassy understoreys, particularly along watercourses. Within Sydney Basin Bioregion mostly restricted to the Hutner, Capertee and Burrigorong 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 <i>Neophema pulchella</i>	V	Eucalypt woodland and open forest with groundcover of grasses and low understorey of shrubs. Usually associated with mixed assemblage of native pine <i>Callitris</i> sp and a variety of <i>Eucalyptus</i> 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 <i>Ninox strenua</i>	V	Mountain forests, gullies and forest margins; sparser hilly woodlands, coastal forests, woodland, urban areas.	Common resident, secure.	Present	No	No
Pink Robin <i>Petroica rodinogaster</i>	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 <i>Pezoporus wallicus wallicus</i>	V	This species can be found in low coastal heaths, upland swamps, sedgeland 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 <i>Ptilinopus regina</i>	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 <i>Ptilinopus superbus</i>	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 <i>Sterna albifrons</i>	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 <i>Tyto novaehollandiae</i>	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 <i>Tyto tenebricosa</i>	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 <i>Cercartetus nanus</i>	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 <i>Chalinolobus dwyeri</i>	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 (<i>Hirundo ariel</i>), 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?
Spotted-tailed Quoll <i>Dasyurus maculatus maculatus</i>	V	features. Found in well-timbered areas containing gullies. 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 <i>Dasyurus viverrinus</i>	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 <i>Falstrellus tasmaniensis</i>	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 <i>Isodon obesulus obesulus</i>	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 <i>Miniopterus schreibersii oceanensis</i>	V	Roosts in caves, old mines, stormwater channels; forages above the forest canopy.	Common resident, probably stable	Present	Yes	Yes.
Eastern Freetail-bat <i>Mormopterus norfolkensis</i>	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 <i>Myotis macropus</i>	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 <i>Petrogale penicillata</i>	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 <i>Phascolarctos cinereus</i>	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) <i>Potorous tridactylus</i>	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 <i>Pteropus poliocephalus</i>	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 <i>Scotomax rueppellii</i>	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 <i>Hoplocephalus bungaroides</i>	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 <i>Varanus rosenbergi</i>	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 <i>Heleioporus australiacus</i>	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 <i>Litoria aurea</i>	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 <i>Litoria littlejohni</i>	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 <i>Pseudophryne australis</i>	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 <i>Mixophyes balbus</i>	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 <i>Petaltura gigantea</i>	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	<i>Acritoscincus duperreyi</i>	Moderate: Likely to be associated with upland swamps and wet heath areas.	Yes
Chestnut-rumped Heath-wren	<i>Calamanthus pyrrhopygius</i>	High: Habitat in low heath and dense upland swamp, one unconfirmed observation in Lizard Creek swamp LCUS4.	Yes
Pheasant Coucal	<i>Centropus phasianidus</i>	Moderate: Unconfirmed incidental observation on a fire road in Wonga East.	No
Tawny-crowned Honeyeater	<i>Gliciphila melanops</i>	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	<i>Stagonopleura bella</i>	Present: recorded in Exposed Sandstone Scribbly Gum Woodland in Wonga East and suitable habitat is widespread in the area.	Yes
Southern Emu-wren	<i>Stipiturus malachurus</i>	Present: recorded frequently in Lizard Creek swamp complex, particularly in LCUS1.	Yes
Platypus*	<i>Ornithorhynchus anatinus</i>	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		TSC	EPBC	ROTAP	Vulnerable to subsidence? *
Common name	Scientific name	Act status	Act status		
<i>Darwinia grandiflora</i>	<i>Darwinia grandiflora</i>	-	-	2RCi	Yes
Shining Guinea Flower	<i>Hibbertia nitida</i>	-	-	2RC-	Yes
<i>Monotoca ledifolia</i>	<i>Monotoca ledifolia</i>	-	-	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	-	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
Upland Swamps			
Vegetation		Three 20m by 20m (400m ²) quadrats along Cataract Creek and 3 rd order tributaries of Cataract Creek and Lizard Creek	Once in Autumn and once in Spring
creeklines			

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.		

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.

REFERENCES

Biosis (2009) **NRE Gujarat Targeted Herpetological Surveys** Report prepared for ERM Australia

Blombery, A.M. & B. Maloney (1992) **The Proteaceae of the Sydney Region**. Kenthurst, NSW: Kangaroo Press.

Briggs and Leigh (1995) **Rare or Threatened Australian Plants** Revised Edition CSIRO, Australia

Cadwallader, P.L. & A.K. Eden (1979) **Observations of the food of the Macquarie Perch *Macquaria australasica* (Pisces: Percichthyidae), in Victoria**. *Australian Journal of Marine and Freshwater Research*. 30:401-9.

Department of Environment and Conservation (DEC) (2004) **Threatened Biodiversity Survey and Assessment: Guidelines for development activities**, Working Draft, Department of Environment and Conservation, NSW.

Department of Environment and Conservation (DEC) (2005) ***Pimelea spicata* R. Br. Recovery Plan**. Department of Environment and Conservation (NSW), Hurstville NSW.

Department of Environment and Conservation (DEC) (2005b). *Daphnandra* sp. C 'Illawarra' (Illawarra Socketwood) **Recovery Plan**. [Online]. Available from: <http://www.environment.gov.au/biodiversity/threatened/publications/recovery/daphnandra/index.html> as *Daphnandra johnsonii*.

Department of Environment and Conservation and Department of Primary Industries (DEC & DPI) (2005) **Draft guidelines for Threatened Species Assessment under Part 3A of the Environment Planning and Assessment Act 1979**, Department of Environment and Conservation (NSW), Hurstville NSW.

Department of Environment and Climate Change (DECC) (2005a) **Leafless Tongue-orchid profile**. [Online]. Available from: <http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10187>.

Department of Environment and Climate Change (DECC) (2007a) **Submission on the Strategic Review of the Impacts of Underground Mining in the Southern Coalfield**. Department of Environment and Climate Change, Sydney.

Department of Environment and Climate Change NSW (2007b) **Alps to Atherton Initiative NSW Business Plan**

Department of Environment and Climate Change (DECC) (2007c) **Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 2 - Fauna of Conservation Concern and Priority Pest Species**. Sydney Catchment Authority and Department of Environment and Climate Change, Sydney.

Department of Environment and Climate Change (DECC) (2007d) **Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 4 - The Fauna of the**

Metropolitan, O'Hares Creek and Woronora Special Areas. Sydney Catchment Authority and Department of Environment and Climate Change, Sydney.

Department of Environment and Climate Change (DECC) (2008) **Scientific Committee Determinations, Alteration of habitat following subsidence due to longwall mining - key threatening process listing. NSW Scientific Committee - Final determination**
<http://www.environment.nsw.gov.au/determinations/LongwallMiningKtp.htm>

Department of Environment, Climate Change and Water (NSW DECCW) (2010f). *Brown Pomaderris - profile*. [Online]. Available from:
<http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10647>.

Department of Environment, Climate Change and Water (NSW DECCW) (2005gy). *Woronora Beard-heath - profile*. [Online]. Available from:
<http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10473>.

Department of Environment, Climate Change and Water (NSW DECCW) (2005im). *Bargo Geebung - profile*. [Online]. Available from:
<http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10592>.

Department of Environment, Climate Change and Water (NSW DECCW) (2005ir). *Nodding Geebung - profile*. [Online]. Available from:
<http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10598>.

Department of Environment, Climate Change and Water (DECCW) (2010) **Department of Environment Climate Change and Water Threatened Species Profile database** [online]
http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/home_species.aspx

Department of Environment, Climate Change and Water (DECCW) (2010b), **Recovery Plan for *Melaleuca deanei***, Department of Environment, Climate Change and Water (NSW), Sydney.

Department of Environment, Climate Change and Water (DECCW) (2011) **Upland Swamp Environmental Assessment Guidelines**. Guidance for the underground mining industry operating in the southern and western coalfields. Draft Version: V0.9.

Department of Environment, Water, Heritage and the Arts (DEWHA) (2009a) **Matters of National Environmental Significance Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999** Department of Environment, Water, Heritage and the Arts, Canberra.

Department of Environment, Water, Heritage and the Arts (DEWHA) (2009b) **Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest** EPBC Act Policy Statement 3.31.

Department of Land and Water Conservation (DLWC) (2001) **Submission to the Commission of Inquiry into the Proposed Dendrobium Underground Coal Mine Project by BHP Steel (AIS) Pty Ltd, Wollongong, Wingecarribee & Wollondilly Local**

Government Areas. Department of Land and Water Conservation, July 2001. Referenced by DECC (2008)

Department of Planning (DoP) (2008) **Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review** NSW Department of Planning, Sydney.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) (2010a) ***Neophema chrysogaster* in Species Profile and Threats Database**, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 9 Nov 2010 10:06:39 +1100.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) (2010b) ***Myiagra cyanoleuca* in Species Profile and Threats Database**, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 9 Nov 2010 10:09:00 +1100.

Department of Sustainability, Environment, Water, Population and Communities (2010c). ***Ardea ibis* in Species Profile and Threats Database**, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 9 Nov 2010 10:02:37 +1100.

Department of Sustainability, Environment, Water, Population and Communities (2010d). ***Thelymitra* sp. Kangaloon (D.L.Jones 18108) in Species Profile and Threats Database**, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 16 Nov 2010 17:47:07 +1100.

Duncan, A., G.B. Baker & N. Montgomery (1999) The Action Plan for Australian Bats. [Online]. Environment Australia. Canberra: Environment Australia. Available from: <http://www.environment.gov.au/biodiversity/threatened/publications/action/bats/index.html>.

Duncan, M. (2010) **National Recovery Plan for the Thick-lip Spider-orchid *Caladenia tessellata***. Department of Sustainability and Environment, Melbourne.

Eastern Cod Recovery Team (1999). **Eastern (Freshwater) Cod (*Maccullochella ikei*) Draft Recovery Plan**. Page(s) 36. E. Cod Recov. Team & NSW Fisheries Thr. Sp. Unit. NSW Fisheries Port Stephens Research Ctr, NSW.

Eco Logical Australia (2009) **Wonga East and Wonga West Threatened Fauna Habitat Assessment** Report prepared for ERM Australia

ERIN (2005) **Turpentine - Ironbark Forest of the Sydney Basin Bioregion** Environmental Resources Information Network Australian Government Department of the Environment and Heritage

Environmental Resources Management Australia Pty Limited (ERM) (2009) **V-Mains Terrestrial Flora and Fauna Assessment** Report prepared for NRE Gujarat Minerals

Environmental Resources Management Australia Pty Limited (ERM) (2013a) **NRE No. 1 Colliery Stage 2 Environmental Assessment** Report prepared for NRE Coking Coal Ltd

Environmental Resources Management Australia Pty Limited (ERM) (2013b) **NRE No. 1 Colliery Longwall Mining in Wonga East and Wonga West EPBC Act Matters of National Environmental Significance** Report prepared for NRE Coking Coal Pty Ltd

Fairley, A. and P. Moore (2000) **Native Plants of the Sydney District, An Identification Guide**. Roseville, NSW; Kangaroo Press.

Geological Survey NSW (1966) **Wollongong 1:250 000 Geological Series Sheet S1 56-9 (2nd Edition)** NSW Department of Mines

GeoTerra (2012a) **NRE No.1 Colliery Major Expansion Stream Assessment Bellambi, NSW**. Report prepared for Gujarat NRE Coking Coal Limited.

GeoTerra (2012b) **NRE No.1 Colliery Major Expansion Groundwater Assessment Bellambi, NSW**. Report prepared for Gujarat NRE Coking Coal Limited. November 2012.

Harden, G.J. (ed) (1990) **Flora of New South Wales. Volume One**. Kensington, NSW: University of NSW Press.

Harden, G.J. (ed.) (1991) **Flora of New South Wales, Volume Two**. Kensington, NSW: University of NSW Press.

Hazelton and Tille, (1990) **Soil Landscapes of the Wollongong - Port Hacking 1:100,000 Sheet** Soil Conservation Service NSW, Sydney

Hoye, G.A. and P.D. Dwyer (1995) **Large-eared pied bat *Chalinolobus dwyeri***. In: Stahan, R, ed. *The Mammals of Australia*. Page(s) 510-511. Chatswood, NSW: Reed Books.

Hoye, G.A. (Fly By Night Bat Surveys Pty Ltd) (2005) **Recovery plan for the Large-eared Pied Bat *Chalinolobus dwyeri***. Brisbane: Queensland Parks and Wildlife Service.

Hunter, D. and Gillespie, G.R. (2010) **National Recovery Plan for the Stuttering Frog *Mixophyes balbus***. Department of Sustainability and Environment, Melbourne.

Keith, D.A. (1994) **Floristics, structure and diversity of natural vegetation in the O'Hares Creek Catchment, south of Sydney**. *Cunninghamia* 3(3) pp 543-594.

Keith, D.A. (2006) **From ocean shores to desert dunes: the vegetation of New South Wales and the ACT**. Department of Environment and Conservation NSW.

- Kevin Mills and Associates (1995) **Flora and Fauna Assessment Mine Subsidence Surveys, No 4 Shaft**, South Bulli Colliery Report No.2
- Kevin Mills and Associates (2005) **Flora and Fauna Assessment No 4 Shaft, NRE Colliery No. 1 Picton Road, Wilton Shire of Wollondilly** Prepared for Gujarat NRE Australia Pty Ltd, June 2005.
- Land Information Centre (2000) **Bulli Topographic and Orthophoto Map 9029-2N (3rd Edition)** NSW Department of Information Technology and Management, Bathurst.
- Long, K and Nelson, J (2010) **National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculata*. Draft.** State of Victoria Department of Sustainability and Environment.
- Maryott-Brown, K. & D. Wilks (1993) **Rare and Endangered Plants of Yengo National Park and Adjacent areas.** NSW NPWS.
- National Parks and Wildlife Service NPWS (2003) **Native vegetation of the Woronora, Ohares Creek and Metropolitan Catchments**, Central Conservation Programs and Planning Division, NSW National Parks and Wildlife Service
- NSW DPI (2005). **Profile for species, populations and ecological communities. Eastern Freshwater Cod.**
http://pas.dpi.nsw.gov.au/Species/Species_Profile.aspx?SpeciesListingID=3
- NSW Fisheries (2001). **Trout Cod, *Maccullochella macquariensis*. Fishfacts. Threatened Species in NSW.** Threatened Species Unit, Port Stephens. NSW Fisheries Office of Conservation.
- NSW Government (2005) Bionet Website accessible via
http://www.bionet.nsw.gov.au/BioNet.cfm?is_ie5up
- NSW National Parks & Wildlife Service (2002). **Threatened Species Information: *Cynanchum elegans*.** [Online]. Hurstville, NSW: NSW Department of Environment and Conservation (currently known as Department of Environment and Climate Change). Available from:
http://www.npws.nsw.gov.au/wildlife/thr_profiles/Celegans_profile.pdf.
- NSW Scientific Committee (2011) **Coastal Upland Swamp in the Sydney Basin Bioregion – proposed endangered ecological community listing.** April 2011.
- Olsen Consulting Group Pty Ltd (2009) **NRE No 1 Colliery Wongawilli East and West Mining Areas Failure Mode and Effects Analysis Report Report to Gujarat NRE Minerals.**
- Peacock, R.J. (1996). **ROTAP Species of the Walcha/Nundle and Styx River Management Area.**
- Reed, J. (1995). **Action Statement No. 38 Trout Cod *Maccullochella macquariensis*.** Melbourne: Dept. Natural Resources & Environment.

- Rowland, S.J. (1996). **Threatened fishes of the world: *Maccullochella ikei*** Rowland, 1985 (Percichthyidae). *Environmental Biology of Fishes*. 46:350.
- Schulz, M. (1998). **Bats and other fauna in disused Fairy Martin *Hirundo arial* nests.** *Emu*. 98:184-191.
- Seedsman Geotechnics Pty Ltd (2012) **Gujarat NRE No1 Colliery: Management of Subsidence Risks associated with Wongawilli seam extraction Report to Gujarat NRE Minerals**, July 2012
- Stout B (2003) **Impact of longwall mining on headwater streams in northern West Virginia. Final Report.** Prepared for West Virginia Water Research Institute, June 2003. Referenced by DECC (2008)
- Strahan, R (1995) **Australian Museum complete book of Australian mammals**, Reed Books, NSW
- Sutter, G. 2010. **National Recovery Plan for Rufous Pomaderris (*Pomaderris brunnea*).** Department of Sustainability and Environment, East Melbourne.
- Sydney Catchment Authority (SCA) (2007) **Special Areas Strategic Plan of Management** Sydney Catchment Authority
- Threatened Species Scientific Committee (2008). **Commonwealth Conservation Advice on Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest.** [Online]. Department of the Environment, Water, Heritage and the Arts. Canberra, ACT: Department of the Environment, Water, Heritage and the Arts.
- Threatened Species Scientific Committee (2008b). **Commonwealth Conservation Advice on *Pterostylis saxicola* (Sydney Plains Greenhood).** [Online]. Department of the Environment, Water, Heritage and the Arts. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/64537-conservation-advice.pdf>.
- Threatened Species Scientific Committee (2008c). **Commonwealth Conservation Advice on *Pultenaea aristata*.** [Online]. Department of the Environment, Water, Heritage and the Arts. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/18062-conservation-advice.pdf>.
- Total Environment Centre (2007) **'Impacts of longwall coal mining on the environment in New South Wales' Sydney South.** Available at: http://www.tec.org.au/dev/index.php?option=com_content&task=view&id=521&Itemid=301
- Trout Cod Recovery Team (2008). **Background and Implementation Information for the Trout Cod *Maccullochella macquariensis* National Recovery Plan.** Department of Sustainability and Environment, Melbourne.
- Umwelt Pty Ltd (2004) **Flora and Fauna Assessment for Section 138 Application.** Report prepared for Bellpac Pty Ltd.

Wager, R. & P. Jackson (1993). **The Action Plan For Australian Freshwater Fishes**. Canberra, ACT: Australian Nature Conservation Agency.

Western Research Institute and Biosphere Environmental Consultants (Western Research Institute) (2009) **Metropolitan Coal Project Terrestrial Vertebrate Fauna Survey** Appendix F, Metropolitan Coal Project Environmental Impact Assessment

Weston, P.H. & L.A.S. Johnson (1991) **Taxonomic changes in Persoonia (Proteaceae) in New South Wales**. Telopea. 4(2):269-306.

Weston, P.H. (1995b) **Subfam. 1. Persoonioideae**. In: **Flora of Australia**. 16:47-125. Melbourne, Victoria: CSIRO.