Appendix G

Ecology Specialist Reports

NRE No. 1 Colliery – Underground Expansion Project:

Preferred Project Report – Biodiversity

DRAFT REPORT

Prepared for Gujarat NRE Coking Coal Ltd

20 September 2013

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- SCT Operations: Ken Mills

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- Ashleigh Pritchard for mapping
- Robert Speirs for review and quality assurance

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Summary

NRE previously submitted an Environmental Assessment (EA) for the Underground Expansion Part 3A project to the NSW Department of Planning and Infrastructure (DP&I) in February 2013. As a result of the submissions received, NRE has made the decision to substantially modify the project application, including:

- Removal of Wonga West from the project application;
- Shortening of the Wonga Main drivage to not extend under the south arm of Cataract Reservoir through the known geological feature (in the Bulli Seam); and,
- Modification of the longwall layout in Wonga East.

Due to the substantive changes made DP&I have requested NRE prepare a Preferred Project Report (PPR).

This report provides revised impact assessments for significant natural features previously recorded within the study area, based on the revised mine plan and associated revised subsidence predictions, as well as additional surveys and information that have been undertaken or has become available since the EA was submitted. This report also includes an assessment of likely historic impacts to these natural features based on past mining of the Bulli and Balgownie Seams.

The revised impact assessment concluded that there was a reduced risk of impact for many species due to the removal of Wonga West from the project application, the removal of longwalls from beneath Cataract Creek and a reduction in the number and extent of upland swamps being undermined.

1. Introduction

1.1 Project background

NRE No. 1 Colliery is located at Russell Vale, to the west of Bellambi, in the Illawarra region of New South Wales (NSW). NRE purchased the Colliery in December 2004, but extensive underground mining has been undertaken within the Colliery holdings dating from the late nineteenth century. However, a substantial volume of high quality coking coal resources remain along with some potential thermal coal resources.

The Colliery holding includes a number of sub leases between NRE and surrounding mine operators, including Consolidated Coal Lease (CCL) 745, Mining Purposes Lease (MPL) 271 and Mining Lease (ML) 1575, and covers a total area of approximately 6,973 hectares (ha).

Originally, NRE intended to expand its operations in two stages. Stage 1 plans were included in the Preliminary Works Part 3A project application that was approved on 13 October 2011, allowing some first workings coal extraction and surface facility upgrades. On 24 December 2012, the Preliminary Works Part 3A project was modified to allow the extraction of Longwalls 4 and 5 and the establishment of Maingate 6.

The original Stage 2 application, known as the Underground Expansion Project Part 3A, was lodged with the NSW Department of Planning and Infrastructure (DP&I) on 12 August 2009 and contained an application to extract 11 longwalls in the Wonga East area and 7 longwalls in the Wonga West area along with surface facilities upgrades to allow production up to 3 million tonnes per annum (Mtpa) for up to 20 years. Since that time it has been progressing through the Major Project approvals process and was placed on Public Exhibition on 18 February 2013. As a result of the submissions received on the application, NRE has made the decision to substantially revise the application to facilitate the approval process and allow continuity in operations. Due to the scope of the changes, the DP&I request NRE prepare a Preferred Project Report (PPR) for the revised Underground Expansion Project Part 3A.

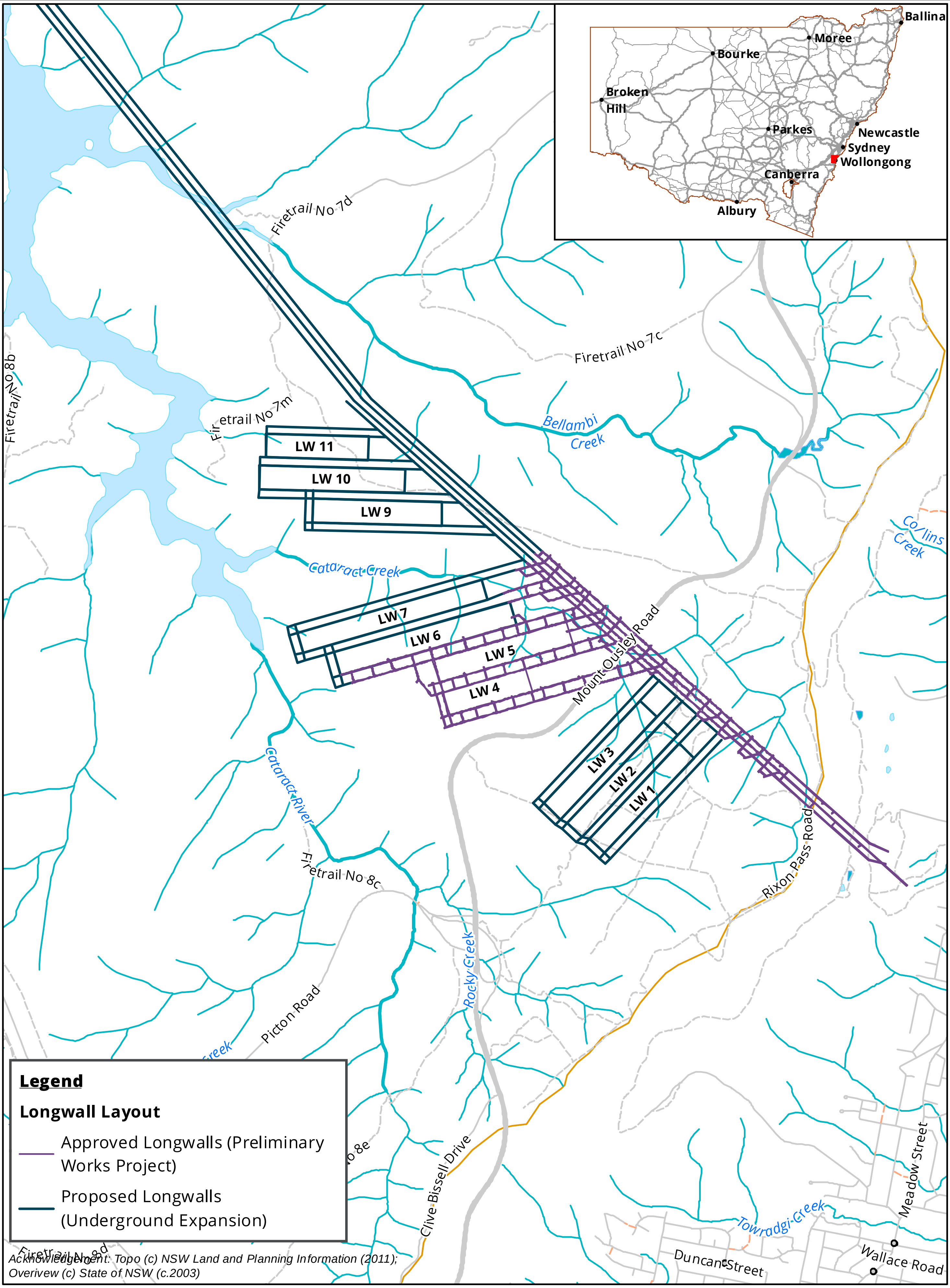
The Preferred Project Report (NRE 2013) outlines the revised Underground Expansion Project which has been reduced to a five year interim stage project, with extraction of eight longwalls in the Wonga East area and upgrading of surface facilities to manage an extraction rate of up to 3 Mtpa run of mine (ROM) coal per annum. The original Wonga West longwall extraction will be resubmitted to DP&I as a separate application.

This report provides revised impact assessments for terrestrial ecology, aquatic ecology and upland swamps (Section 3). A response to submissions received is provided in Section 4.

1.2 Scope of assessment

The objectives of this report are to:

- Provide details of changes to the original project relevant to terrestrial ecology, aquatic ecology and upland swamps;
- Prepare revised impact assessments based on these changes, including revised subsidence predictions; and,
- Provide a response to submissions received on the original Ecological Assessment (EA) (ERM 2013a) based on the changes outlined above.



Acknowledgement: Topo (c) NSW Land and Planning Information (2011); Overivew (c) State of NSW (c.2003)

Figure 1: Location of the Study Area, New South Wales

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0 300 600 900 1,200
Metres
Scale 1:30,000 @ A4, GDA 1994 MGA Zone 55

2. Preferred Project Changes

After serious consideration of the community and agency submissions, NRE has decided to modify its Underground Expansion Project Part 3A application in the following manner:

1. The Wonga East longwall layout will be modified to minimise impacts to identified significant features while recovering the maximum volume of coal reserves possible.
2. The Wonga Mains driveage will not be extended northwards under the south arm of Cataract Reservoir through the known geological feature (in the Bulli Seam).
3. The Wonga West longwalls will be removed from this application and resubmitted as a separate application.
4. No change to the Pit Top from the original proposal.

A more detailed summary comparing the original proposal presented in the Environmental Assessment with the current Preferred Project is presented in Table 1 and Figure 2.

Table 1: Detailed Summary of Project Changes

Project Area	Original Project	PPR
Project Application Area	• As per Figure 1.2 of Underground Expansion Project Environmental Assessment	• No changes proposed
Production Limit	• 3 Mtpa	• No changes proposed
Pit Top	• Two new stockpiles of 140,000 tonnes capacity each (SP2 & SP3) with associated reclaim facilities • New truck loading facilities • Designated coal dispatch road • Progressive upgrading of trucking fleet • Continued road haulage of ROM coal to the Port Kembla Coal Terminal. • 6ML Settling Pond • Continuing use of No.4 Shaft for mine access, bathhouse, parking and offices • Ongoing maintenance and refurbishment of ventilation shafts, water and electrical facilities. • Ongoing geological and geotechnical investigations to determine coal	• No changes proposed

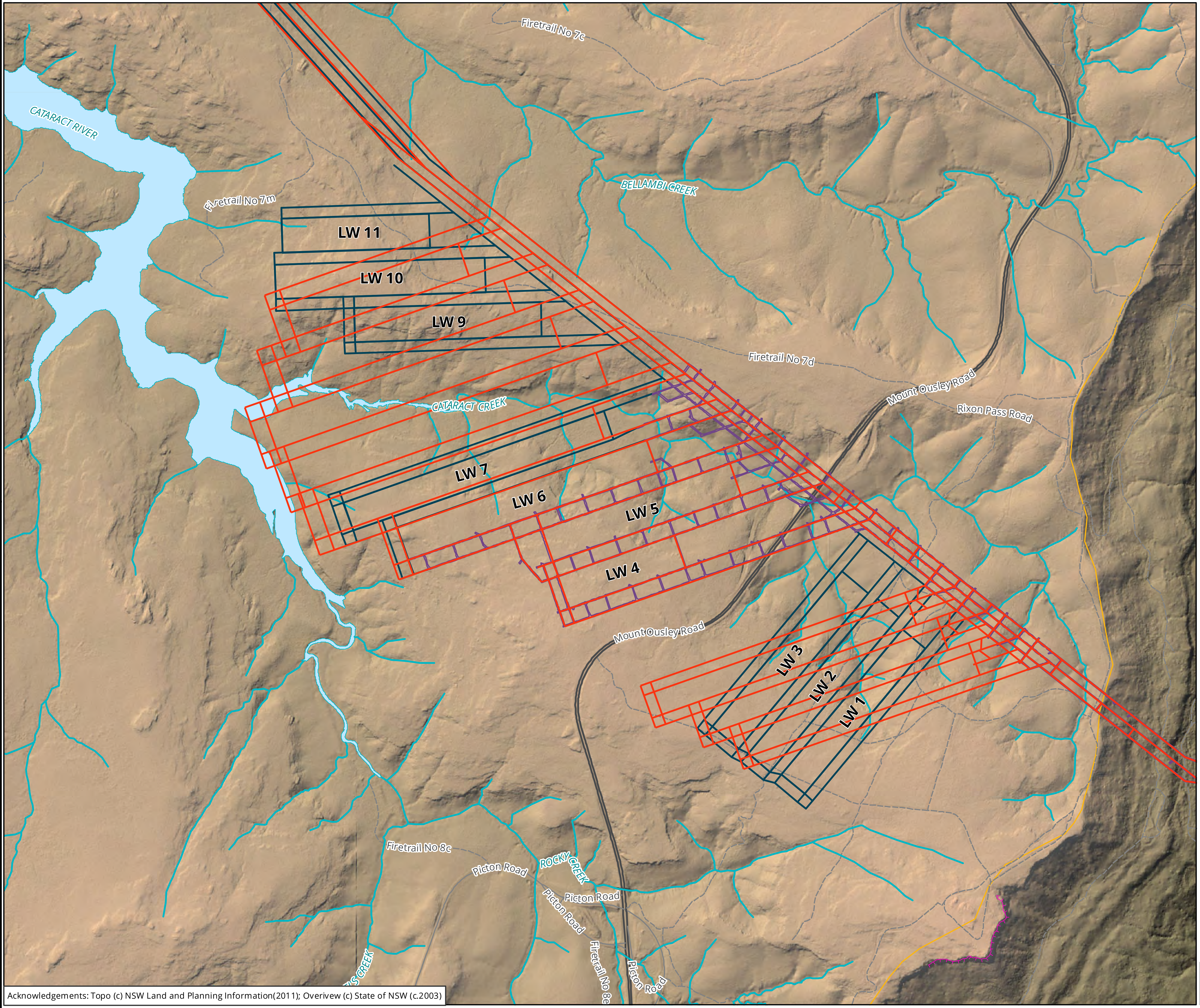
Project Area	Original Project	PPR
	quality and geotechnical conditions using drilling and related techniques.	
Wonga East Longwalls	• 9 longwalls (LW) in two Areas – Area 1 – LW's 1-3 – Area 2 – LW's 6-11	• 8 longwalls in two Areas (see Figure 2). – Area 1 – LW's 1-3 shortened and reoriented to the southwest – Area 2 – LW 6 shortened – Area 2 – LW7 shortened and moved slightly south east – Area 2 – LW 8 removed – Area 2 – LW9-11 shortened and reoriented to the northwest
Wonga Mains	• Mains drivage from the end of the Preliminary Works approved drivage heading north west, beneath Cataract Reservoir to bisect the proposed Wonga West Areas 3 and 4.	• Mains drivage from the end of the Preliminary Works approved drivage heading west-northwest to what was the southern end of Wonga West Area 3.
Wonga West Longwalls	• 7 longwalls in two Areas – Area 3 – LW's 1-5 – Area 4 – LW's 6-7	• Removed from this application. To be resubmitted as a separate application to Department of Planning and Infrastructure.
Bulli West - Bulli Seam 1st Workings	• 1st workings to the Bulli Seam to access the Bulli Seam in the western area of the Project Application Area.	• No changes proposed
Balgownie Seam 1st Workings	• 1st workings in the Balgownie Seam to access the Balgownie Seam in the western area of the Project Application Area.	• No changes proposed

For further detail see Section 1 of the PPR (NRE 2013).

These changes have resulted in the following changes to significant natural features in the Wonga East area:

- Cataract Creek will no longer be undermined;
- A reduction in undermining of cliffs associated with Cataract Creek;
- Upland swamp CCUS1 will no longer be undermined;
- Minimisation of the extent of upland swamps CCUS5 and CCUS10 that will be undermined; and,
- Changes in impacts to significant natural features based on revised subsidence predictions.

These changes and their impacts are discussed further below.



Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

Legend

Previous Wonga East Longwalls

Longwall Layout

Approved Longwalls (Preliminary Works Project)

Proposed Longwalls (Underground Expansion)

Figure 2: Proposed PPR mine plan

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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16646 PPR_F2_Mine Plan

3. Revised Impact Assessments

This section provides a revised impact assessment for ecological features within the Wonga East study area. The study area is defined as the area located within 600m of proposed secondary extraction for the revised longwall layout (Figure 3).

The Wonga East study area supports a wide range of ecological features, including the following significant natural features:

- Thirty-two upland swamps (an endangered ecological community (EEC));
- Third and fourth order streams, including Cataract Creek and Cataract River;
- Rocky habitats, including rocky outcrops and cliffs; and,
- Threatened species and their habitats.

Significant natural features are shown in Figure 4. For a comprehensive discussion of these features see Section 2.4 of ERM (2013b).

This revised impact assessment focuses on those species, populations and communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the NSW *Threatened Species Conservation Act 1995* (TSC Act) and deemed at risk of impact due to subsidence associated with longwall mining. This includes species that are reliant on natural features at risk of impact; particularly aquatic ecosystems (streams and creeks), upland swamps and rocky environments (including caves and overhangs) (DECC 2007a, DoP 2008). Past experience with longwall mining in the Southern Coalfield indicates that impacts to terrestrial ecosystems are generally less significant than those experienced by aquatic ecosystems, upland swamps and rocky environments. Terrestrial ecosystems are considered to be at negligible risk of impact from subsidence associated with longwall mining (DECC 2007a) and are not considered further.

3.1 Terrestrial ecology

A number of ecological assessments of the Wonga East area have been undertaken by ERM (summarised in ERM 2013b) and Biosis (2012a, 2012b, 2013). Together, these assessments provide a comprehensive inventory of the terrestrial biodiversity values present within the Wonga East area. A summary of these assessments can be found in ERM (2013a, 2013b).

Species, populations and communities either recorded during previous assessment, or deemed likely to occur within the study area, and considered vulnerable to impacts due to subsidence (DECC 2007a, ERM 2013b) are listed in Table 2.

Table 2: Threatened species, populations and communities likely to occur in the study area and vulnerable to impacts due to subsidence (DECC 2007a, ERM 2013b)

E – Endangered, V - Vulnerable

Scientific name	Common name	EPBC Act status	TSC Act status
Flora			
Acacia baueri* ssp. *aspera	-	-	V

Scientific name	Common name	EPBC Act status	TSC Act status
Epacris purpurascens* var. *purpurascens	-	-	V
Grevillea parviflora* ssp. *parviflora	Small-flowered Grevillea		
Leucopogon exolasius	Woronora Beard-heath	V	V
Melaleuca deanei	Deane's Melaleuca	V	V
Persoonia bargoensis	Bargo Geebung	V	E
Pultenaea aristata	Prickly Bush-pea	V	V
Threatened ecological communities			
-	*Coastal Upland swamp in the Sydney Basin Bioregion*	-	E
Birds			
Pezoporus wallicus wallicus	Eastern Ground Parrot	-	V
Mammals (excl. bats)			
Cercartetus nanus	Eastern Pygmy Possum	-	V
Dasyurus maculatus maculatus	Spotted-tailed Quoll	E	V
Mammals - Bats			
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	-	V
Myotis macropus	Large-footed Myotis	-	V
Reptiles			
Hoplocephalus bungaroides	Broad-headed Snake	V	E
Varanus rosenbergi	Rosenberg's Goanna	-	V
Frogs			
Heleioporus australiacus	Giant Burrowing Frog	V	V
Litoria littlejohni	Littlejohn's Tree frog	V	V
Pseudophryne australis	Red-crowned Toadlet	-	V
Mixophyes balbus	Stuttering Frog	V	E
Invertebrates			
Petalura gigantea	Giant Dragonfly	-	E

These species are discussed further below in Sections 3.1.1 (flora) and Section 1.1.1 (fauna). A revised impact assessment is provided in Section 3.1.4.

Upland swamps are discussed further in Section 3.3.

3.1.1 Flora

ERM (2013b) identified seven flora species at risk of impact due to subsidence associated with extraction of coal from the Wonga East and Wonga West areas. Given the changes to the project, including the removal of the Wonga West area from the application, a reassessment of the potential for species to occur within the study area is required.

Table 3 provides a reassessment of habitat for these species, the potential for this habitat to occur within the study area, and a determination of the reliance of these species on microhabitats that are at risk of impacts from subsidence associated with the Preferred Project.

Species that are considered likely to occur within the study area and are considered to be at risk of impact from subsidence associated with the Preferred Project are considered further in Section 3.1.4.

Table 3: Terrestrial flora species vulnerable to impacts from subsidence (DECC 2007a), and an assessment of microhabitats within the study area

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Acacia baueri* ssp. *aspera	*Acacia baueri* ssp. *baueri* occurs in damp heaths associated with sandstone woodland (ERM 2013b) and often occurs in small depressions on rocky outcrops. Further, targeted and opportunistic surveys in the study area have not recorded this species. The Wonga East area does not contain many rocky outcrops, and suitable habitat for this species within the study area is limited.	Yes Rocky outcrops
Epacris purpurascens* var. *purpurascens	*Epacris purpurascens* var. *purpurascens* is found within a wide range of habitat, usually associated with moisture, most of which have a strong shale influence (ERM 2013b, BHPBIC 2009). It is not considered to be a swamp specialist. This habitat is considered to be at negligible risk of impact. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No
Small-flowered Grevillea	Small-flower Grevillea grows in sandy or light clay soils, usually over thin shales, and occurs in a wide range of vegetation types (ERM 2013b). Habitat for this species is considered to be at negligible risk of impact. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No
Woronora Beard-heath	Woronora Beard-heath occurs in a wide range of habitat types, including woodland, rocky hillsides and creeks (ERM 2013b). The wide range of habitats this species occurs in are considered to be at negligible risk of impact. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No
Deane's Melaleuca	Deane's Paperbark grows in heath communities on sand, and has been recorded from ridgetops, dry ridges and slopes. It is often associated with sandy loam soils (ERM 2013b). This species is not considered to be reliant on microhabitats that are at risk of impact due to subsidence. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Bargo Geebung	Bargo Geebung grows in woodland and dry Sclerophyll forest on a wide variety of soils types. This species is not reliant on microhabitats at risk of impact from subsidence. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No
Prickly Bush-pea	Prickly Bush-pea has been recorded within the study area from open habitats, including upland swamps and adjacent woodland. The species occurs where drainage is impeded (NPWS 2003), usually in areas where low degree slopes result in slowing of surface and groundwater flows (Biosis pers. obs.). Since the original EA (ERM 2013a) was submitted this species has been recorded at a number of additional locations and the species is known to be common and widely distributed in the study area.	Yes Upland swamps

3.1.2 Fauna

ERM (2013b) identified thirteen fauna species at risk of impact due to subsidence associated with the original project. This assessment considered available habitat in the Wonga East and Wonga West area. Given changes to the project, including the removal of the Wonga West area from the application, a reassessment of the potential for species to occur within the study area is required. Table 4 provides a reassessment of habitat for these species, the potential for this habitat to occur within the study area, and a determination of the reliance of these species on microhabitats that are at risk of impacts from subsidence.

Species that are considered likely to occur within the study area and at risk of impact from subsidence associated with the Preferred Project are considered further in Section 3.1.4.

Table 4: Terrestrial fauna species vulnerable to impacts from subsidence (DECC 2007a), and an assessment of microhabitats within the study area

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Eastern Ground Parrot	The Eastern Ground Parrot was previously thought to be extinct within the local area (DECC 2007b) prior to several observations of this species during surveys for the Metropolitan Coal Project and the Bulli Seam Operations Project. The Eastern Ground Parrot occurs in low heathlands and sedgelands, generally below one metre in height and very dense (OEH 2013b). Habitat within the study area is largely limited to MU 44 Upland swamp: Sedgeland-Heath Complex. This vegetation community is severely restricted and highly fragmented within the study area. The previous assessment (ERM 2013b) assessed that this species could potentially occur in the Wonga West area, but was unlikely to occur within the Wonga East area. This species is considered unlikely to occur within the study area.	No
Eastern Pygmy Possum	The Eastern Pygmy Possum occurs in a wide variety of habitat types, including rainforest, sclerophyll forest and heaths (DECC 2007b) and upland swamps (Biosis pers. obs., DECC 2007a). Given the wide range of habitat types that this species inhabits it is not considered to be at significant risk of impact from subsidence.	No
Spotted-tailed Quoll	The Spotted-tailed Quoll utilises a wide range of habitat types, with cliffs, rock benches or overhangs listed as habitat with potential to be impacted (DECC 2007a). Given the widespread nature of this species' habitat the risk of impact is considered to be negligible.	No
Large-eared Pied Bat	The Large-eared Pied Bat is considered rare within the local area and has narrow habitat requirements, including productive land close to suitable roosting habitats (DECC 2007b). The species roosts in caves and overhangs, and it is this habitat which is of high conservation significance (DECC 2007b). Cliffs that may provide suitable roosting sites within the study area are limited in extent, and restricted to an area over LW9.	Yes Cliffs over LW9
Eastern Bentwing-bat	The Eastern Bentwing-bat is common in the local area, being one of the most commonly recorded bats	Yes

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
	during surveys (Biosis pers. obs.). This species has been recorded within the study area. The species forages within a wide range of habitat types and across a large area. The species roosts in caves and overhangs, and it is this habitat which is of high conservation significance (DECC 2007b). Cliffs that may provide suitable roosting sites within the study area are limited in extent, and restricted to an area over LW9.	Cliffs over LW9
Large-footed Myotis	The Large-footed Mytois is considered to be rare in the local area (DECC 2007b). The species forages along waterways, including disturbed waterways in urban environments, and is more common in more highly productive environments, although the species has been recorded on the Woronora plateau. The species roosts in caves and overhangs, and it is this habitat, which is of high conservation significance (DECC 2007b). Cliffs that may provide suitable roosting sites within the study area are limited in extent, and restricted to an area over LW9. Cataract Creek provides potential foraging habitat for this species. The species may be susceptible to changes in water quality or natural flow regimes (DECC 2007b).	Yes Cliffs over LW9 and Cataract Creek
Broad-headed Snake	The Broad-headed Snake occurs on exposed rocky outcrops with bedrock providing suitable winter sheltering habitat. This species is extremely rare in the local area (DECC 2007b). Due to the presence of this species on rocky outcrops that are susceptible to fracturing due to subsidence, the species is listed by DECC (2007a) as being at risk of impact from longwall mining. Biosis has previously undertaken monitoring of rocky outcrops for the Dendrobium, Wongawilli and Nebo mines. While subsidence effects, including fracturing of rocky outcrops, have been observed, no impacts to sheltering habitat for reptiles was observed in these areas. The Wonga East area does not contain many rocky outcrops, and suitable habitat for this species within the study area is limited. The risk of impact to this species is considered minimal. However, if specific locations for this species were identified these would be considered of high conservation value given the species' rarity. For this reason, the species is considered further below.	Yes Rocky outcrops

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Rosenberg's Goanna	Rosenberg's Goanna inhabits ridgetops with higher levels of rocks and shrubs that provide habitat for prey species (DECC 2007b). Although this species is located on rocky outcrops which are at risk of impacts from subsidence (DECC 2007a) the species or its prey do not rely on specific habitat features at risk of impact. Thus the species is considered at negligible risk of impact from the preferred project.	No
Giant Burrowing Frog	The Giant Burrowing Frog occurs in sandstone environments and is generally associated with first and second order intermittent creeks that provide suitable breeding pools (Biosis pers. obs.). Although often associated with upland swamps, DECC (2007b) assert that this association is not direct, rather that upland swamps are associated with minor drainage lines that provide suitable breeding pools and burrowing habitat for this species. Detailed habitat mapping was undertaken by Biosis (2012b, 2013a) with suitable breeding habitat for this species mapped at four locations in the study area (Figure 5). Targeted surveys undertaken by Biosis as a part of the ecological monitoring program for Longwalls 4 and 5 in August and December 2012 and February, April and May 2013 have detected tadpoles for the Giant Burrowing Frog in a tributary of CRUS2. A total of 17 tadpoles were observed in three breeding pools located along the 245 metre transect (Figure 5). This tributary of CRUS2 is located approximately 700 m from the nearest longwall (LW4) and is outside the active subsidence zone. The species has not been recorded elsewhere within the study area.	Yes Creeks shown in Figure 5
Littlejohn's Tree frog	Littlejohn's Tree Frog occurs in sandstone environments and is generally associated with first and second order intermittent creeks that provide suitable breeding pools (Biosis pers. obs.). The species has been recorded within a wide variety of vegetation types, all associated with more open habitat and intermittent creeks. This includes, but is not restricted to, upland swamps (Biosis pers. obs.). Detailed habitat mapping was undertaken by Biosis (2012b, 2013a) with suitable breeding habitat for this species mapped at four locations in the study area (Figure 5). Targeted surveys undertaken by Biosis as a part of the ecological monitoring program for Longwalls 4 and 5 in August and December 2012 and February, April and May 2013 have not recorded this species.	Yes Creeks shown in Figure 5

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Red-crowned Toadlet	The Red-crowned Toadlet is fairly common in preferred ridgetop habitat and first order ephemeral creeks below ridges (DECC 2007b) and has been recorded, using drainage lines, sheltering under bushrock on ridgetops and in depressions along fire trails (Biosis pers. obs.). Habitat for this species within the study area has not been mapped, as it is widely distributed and common. Targeted surveys for the Red-crowned Toadlet have been undertaken by Biosis as a part of the ecological monitoring program for Longwalls 4 and 5 (Biosis 2013a). Surveys were conducted using auditory recording devices located in suitable breeding habitat along two ephemeral creeks below ridgelines above Longwall 4 and Longwall 5 (Figure 4). The Red-crowned Toadlet was recorded calling at both sites (Biosis 2013a). However, preferred habitat for this species is considered to be at limited risk of impact.	No
Stuttering Frog	The Stuttering Frog is generally considered rare within the Sydney Basin bioregion and is now close to extinction in the local area (DECC 2007b). Detailed habitat mapping was undertaken by Biosis (2012b, 2013a) with suitable breeding habitat for this species mapped along Cataract Creek in the study area (Figure 5). Cataract Creek has been impacted by past mining of the Bulli and Balgownie coal seams, with an iron seep located along a tributary of Cataract Creek resulting in moderate to high levels of iron flocculent in the creek. This past impact is likely to reduce the suitability of the habitat for this species (ERM 2013b). Targeted surveys undertaken by Biosis as a part of the ecological monitoring program for Longwalls 4 and 5 in October, November and December 2012 and February 2013 have not recorded the Stuttering Frog along Cataract Creek.	Yes Cataract Creek (Figure 5)
Giant Dragonfly	The Giant Dragonfly is found in upland swamps with open vegetation and free water (OEH 2013d). Suitable habitat for this species within the study area is limited to lower sections of upland swamp CCUS4. Given the limited extent of suitable habitat within the study area this species is considered unlikely to occur within the study area.	No

3.1.3 Assessment of historic impacts to terrestrial biodiversity from extraction of the Bulli and Balgownie seams

Sections 3.1.1 and 1.1.1 identify the following significant natural features at risk of impact due to subsidence:

- Rocky outcrops;
- Upland swamps;
- Cliffs over Longwall 9;
- Cataract Creek; and
- Threatened frog habitat as identified in Figure 5.

ERM (2013a) and ERM (2013b) provide a summary of potential impact mechanisms. This section assesses the potential impacts of past mining of the Bulli and Balgownie seams, before assessing the impacts of the original project versus the preferred project on these significant natural features

Extraction of the Bulli and Balgownie seams has occurred within the Wonga East area. Within the study area, the Bulli seam was extracted via hand workings and pillar extraction between 1890 and 1960. The Balgownie seam was extracted using continuous miner pillar extraction in 1969 and the retreat longwall mining method from 1970 to 1982. Assessment of subsidence data from the extraction of the Bulli and Balgownie coal seams has been undertaken by SCT Operations (2013).

Table 5 provides subsidence predictions for identified significant natural features from the extraction of the Bulli and Balgownie Seams in the Wonga East area.

Table 5: Balgownie seam subsidence predictions for selected significant features in the study area

	Bulli seam and Balgownie seam Subsidence (m)	Balgownie seam Tilt (mm/m)	Balgownie seam Max Tensile Strain (mm/m) and Typical (in brackets)	Balgownie seam Max Compressive Strain (mm/m) and Typical (in brackets)	Balgownie seam Closure (mm)
Selected natural features					
Threatened frog habitat CRUS2 Trib	0.5	5	3	4	-
Threatened frog habitat CRUS1 Trib1	0.5	5	3	4	-
Threatened frog habitat CRUS1 Trib2	0.9	11	3	4	-
Threatened frog habitat CCUS4 Trib	1.2	18	7.5 (3)	14 (4)	-
Cliffs over LW9	0.5	N/A	N/A	N/A	-
Cataract Creek	1.4	15	N/A	N/A	310

Available data indicates that past mining of the Bulli and Balgownie Seams is likely to have resulted in fracturing of bedrock beneath identified threatened frog habitat, and that closure in Cataract Creek is likely to have been sufficient to have resulted in diversion of surface flows using criteria identified by MSEC (DoP 2010).

Based on this data, it is likely that there are pre-existing impacts to identified natural features, as outlined above. There is evidence to support this conclusion, with iron seeping from a tributary of Cataract Creek resulting in a significant amount of iron flocculent in Cataract Creek. Cliffs in the study area show signs of previous collapse, including some where likely mining-induced collapse has occurred (K. Mills pers. comm.).

This assessment of past mining in the Wonga East area indicates that natural features in the study area have been subject to subsidence resulting from extraction of the Bulli and Balgownie Seams. This data provides a baseline against which assessments of potential impacts resulting from extraction of the Wongawilli Seam, as part of the preferred project, must be assessed.

3.1.4 Revised impacts assessment for terrestrial biodiversity

A summary of subsidence predictions for extraction of the Wongawilli Seam in the Wonga East area is provided in Table 6. This table provides predicted subsidence parameters for each longwall, as well as predicted subsidence for significant natural features outlined above.

The extraction of the Wongawilli Seam in the Wonga East area will result in a maximum of 2.1 m of subsidence, with tilts between 24 and 51 mm / m, tensile strain of between 7 and 15 mm / m and compressive strains between 14 and 31 mm / m. Closure within Cataract Creek will be managed to be less than 200 mm.

As can be seen from Table 6, the majority of significant natural features within the study area are at minimal risk of impact, with subsidence predictions indicating subsidence effects are likely to be minimal. The exception to this is threatened frog habitat in CRUS4 Trib and cliffs over Longwall 9.

Table 7 provides impact assessments, including an assessment of impacts from the original project compared to the preferred project, for natural features identified in Sections 3.1.1 and 1.1.1.

Tilts, tensile strains and compressive strains in CRUS4 Trib are sufficient to result in fracturing of the bedrock beneath this tributary. However, no threatened frogs have been recorded at this location to date. Known habitat in CRUS2 Trib will not be impacted.

Subsidence predictions for cliffs over Longwall 9 are of sufficient magnitude to result in impacts to these cliffs. Impacts, including tensile cracking of the rock strata and collapse, are likely to occur, particularly where horizontal compression exceeds 50 – 100 mm per 20 m length of cliff formation. However, It is difficult to predict the location/s at which where impacts may occur. Given the limited extent of suitable roosting sites for microchiropteran bats the risk of impact is considered low, particularly when compared with the availability of suitable habitat in the local area. Risk of collapse is considered minimal.

Subsidence predictions for Cataract Creek indicate that this waterway is unlikely to be subject to negative environmental consequences. Closure will be managed to ensure it does not exceed 200 mm / m, and tilts, compressive and tensile strains are unlikely to be of sufficient magnitude to result in fracturing of the bedrock of Cataract Creek. However, fracturing of tributaries of Cataract Creek may result in decreased inflow into Cataract Creek, and an increase in iron seepage at the base of these tributaries and resultant potential for increased iron flocculent in Cataract Creek (A. Dawkins pers. comm.). It is difficult to determine whether these impacts will result in observable impacts to Cataract Creek above and beyond those present.

Further assessment and discussion of potential impacts is provided below.

Table 6: Wongawilli seam subsidence predictions for longwalls and selected significant features in the study area

	Overburden depth to Wongawilli Seam (m)	Subsidence predicted (m) and measured (in brackets)	Tilt predicted (mm/m) and measured (in brackets)	Tensile strain predicted (mm/m) and measured (in brackets)	Compressive strain predicted (mm/m) and measured (in brackets)	Closure on Cataract Creek (mm)
Longwall 1	260	2.1	40	12	24	-
Longwall 2	260	2.1	40	12	24	-
Longwall 3	255	2.6	51	15	31	-
Longwall 4	300	2.1 (1.6)	35 (30)	10.5 (7.5)	21 (14)	< 5
Longwall 5 (mining still in progress)	265	1.9 (1.5)	36 (16*)	10.8 (4.5*)	22 (14*)	130 (20*)
Longwall 6	280	2.1	38	11	23	130
Longwall 7	270	1.5	28	8	17	200
Longwall 9	330	2.1	32	10	19	120
Longwall 10	340	1.6	24	7	14	20
Longwall 11	350	2.1	30	9	18	0
Selected natural features						
Threatened frog habitat CRUS2 Trib	300	0	0	0	0	-
Threatened frog habitat CRUS1 Trib1	320	0	0	0	0	-
Threatened frog habitat CRUS1 Trib2	320	0.02	0	0	0	-
Threatened frog habitat CCUS4 Trib	270	1.5	28	8	17	-
Cliffs over LW9	330	2.1	32	10	19	-

	Overburden depth to Wongawilli Seam (m)	Subsidence predicted (m) and measured (in brackets)	Tilt predicted (mm/m) and measured (in brackets)	Tensile strain predicted (mm/m) and measured (in brackets)	Compressive strain predicted (mm/m) and measured (in brackets)	Closure on Cataract Creek (mm)
Cataract Creek	260	0.1	1	0	N/A	200

Table 7: Impact assessment for species at risk of subsidence, including comparison of risks from the original project and preferred project

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
Acacia baueri* ssp. *aspera	Rocky outcrops	Fracturing of the base of minor depressions in rocky outcrops, leading to reduced moisture in these areas and potential loss of individual plants.	The general risk of fracturing of rocky outcrops within the study area is considered moderately high; however suitable habitat (i.e. rocky outcrops with minor depressions) is limited within the study area	Low	Low
Prickly Bush-pea	Upland swamps	Fracturing of bedrock resulting in changes in water availability or changes in vegetation composition resulting in increased competition. Changes in slope gradient resulting in decreased water availability.	The species is widespread and common within the study area, having been recorded at a greater number of locations since the submission of the EA (ERM 2013b). Although there is potential for fracturing of bedrock beneath suitable upland swamp habitat, and changes in hydrology, impacts to wider habitat are predicted to be minimal.	Low	Low

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
Large-eared Pied Bat **Eastern Bentwing-bat** **Large-footed Myotis**	Cliffs	Overhang collapse resulting in destruction of roosting habitat	Potential roosting habitat within the study area is limited in extent, and restricted to an area above LW9. Further, the risk of collapse of these cliffs is considered to be low (~5%; K. Mills pers. comm.). The removal of Wonga West from the project, where suitable habitat was much more prevalent along Lizard and Wallandoola Creeks, has resulted in a reduction in risk.	Moderate (Wonga West)	Low
	Cataract Creek (Large-footed Mytois only)	Fracturing of stream bed resulting in diversion of flows along sections of creeks. Increased iron entering the waterway, resulting in changes in water quality and choking of vegetation by iron flocculent.	The revision of the mine plan now avoids mining below Cataract Creek. No impacts to the bed of Cataract Creek are predicted to occur and diversion of flows is unlikely (A. Dawkins pers. comm.). There is potential for fracturing of the base of tributaries of Cataract Creek, resulting in diversion of flows, decreased inflow into Cataract Creek and iron seepage (A. Dawkins pers. comm.). The extent and magnitude of impact will be dependent on past impacts from extraction of the Bulli and Balgownie seams.	Low	Low
Broad-headed Snake	Rocky outcrops	Fracturing of rocky outcrops leading to a loss or change in shelter sites for this species or its prey.	The general risk of fracturing of rocky outcrops within the study area is considered moderately high with perceptible cracking in up to 30% of bare rock areas located directly above longwalls (k. Mills pers. comm.). However suitable habitat	Moderate (Wonga West)	Low

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
			(i.e. rocky outcrops with suitable shelter) is limited within the study area. Suitable habitat for the species, identified within the EA (ERM 2013b) was largely limited to Wonga West.		
Giant Burrowing Frog **Littlejohn's Tree frog**	Creeks shown in Figure 5	Fracturing of stream bed resulting in diversion of flows along sections of creeks providing breeding habitat, resulting in loss of breeding pools. Fracturing of the base and draining of breeding pools. Increased iron entering the waterway, resulting in changes in water quality and choking of vegetation by iron flocculent. Release of methane gas into the water column, resulting in vegetation dieback in riparian environments and impacts to water quality.	Suitable habitat for these species has been identified in three tributaries of Cataract River and one tributary of Cataract Creek (Figure 5; Biosis 2012a, Biosis 2013a). Surveys undertaken as a part of the ecological monitoring program for Longwalls 4 and 5 have identified Giant Burrowing Frog tadpoles at one of these locations, in a tributary of Cataract River below CRUS2. This site is located outside of the predicted subsidence impact zone. These species have not been recorded at any other sites. Additional targeted surveys and the removal of Wonga West from the project application have resulted in a significant reduction in risk of impact to this species.	High	Low
Stuttering Frog	Yes Cataract Creek (Figure 5)	Fracturing of stream bed resulting in diversion of flows along sections of creeks	Suitable habitat for this species has been identified in Cataract Creek (Figure 5; Biosis 2012a, Biosis 2013a). Surveys undertaken as a	Moderate	Low

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
		providing breeding habitat, resulting in impacts to suitable breeding habitat. Fracturing of the base and draining of breeding pools. Increased iron entering the waterway, resulting in changes in water quality and choking of vegetation by iron flocculent. Release of methane gas into the water column, resulting in vegetation dieback in riparian environments and impacts to water quality.	part of the ecological monitoring program for Longwalls 4 and 5 have not recorded this species in the study area. Additional targeted surveys have resulted in a reduction in risk of impact to this species.		

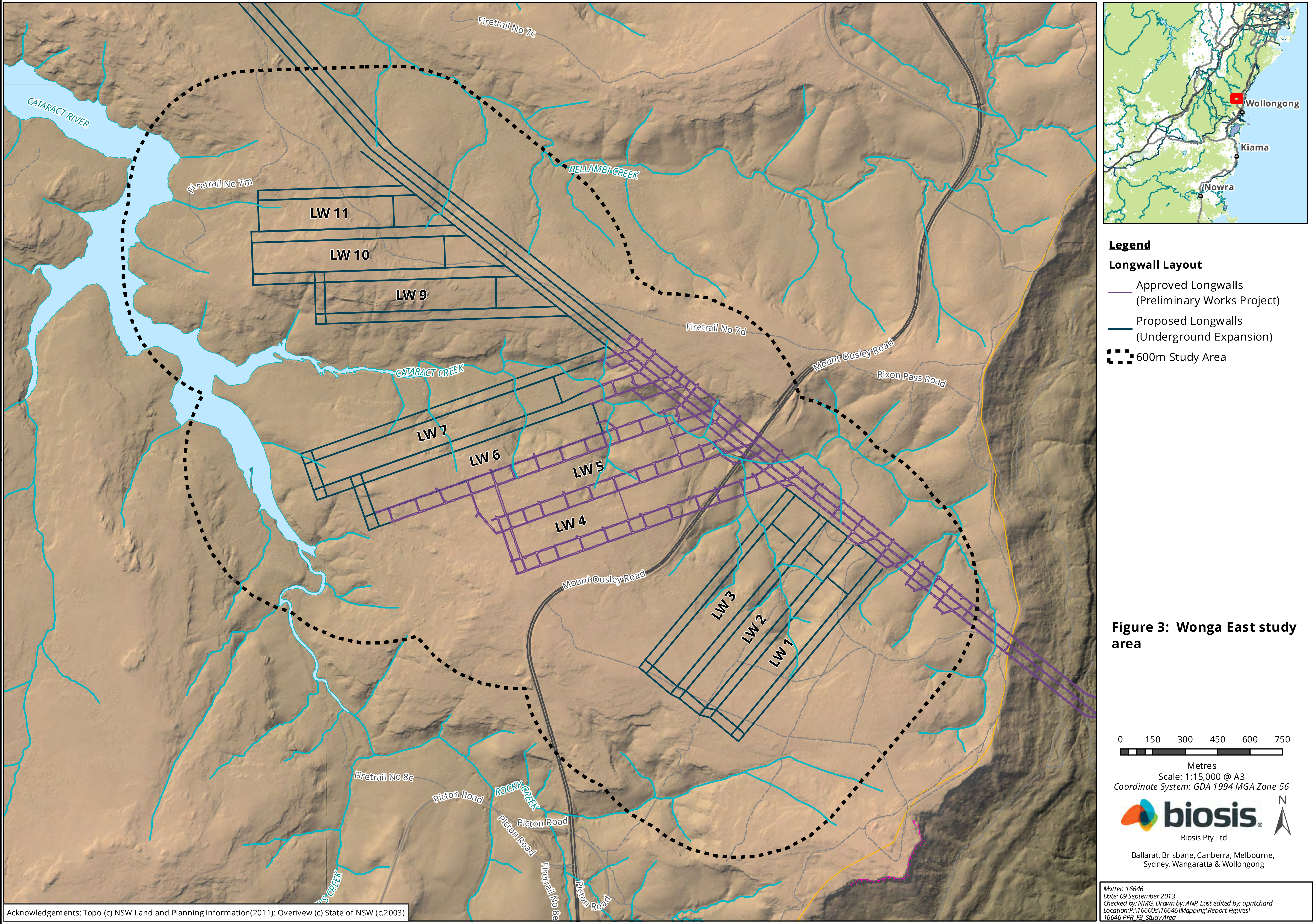

Figure 3: Wonga East study area

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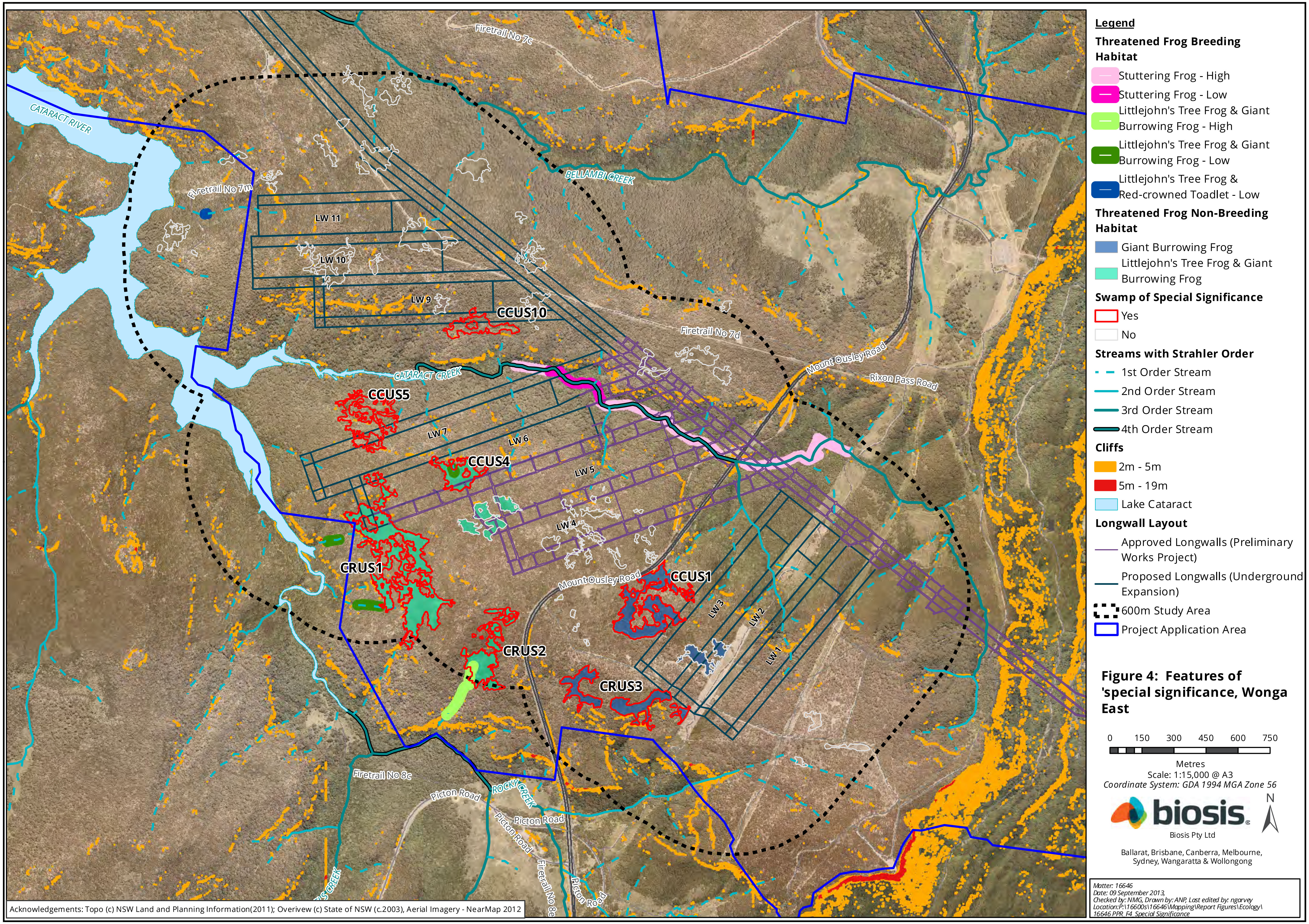
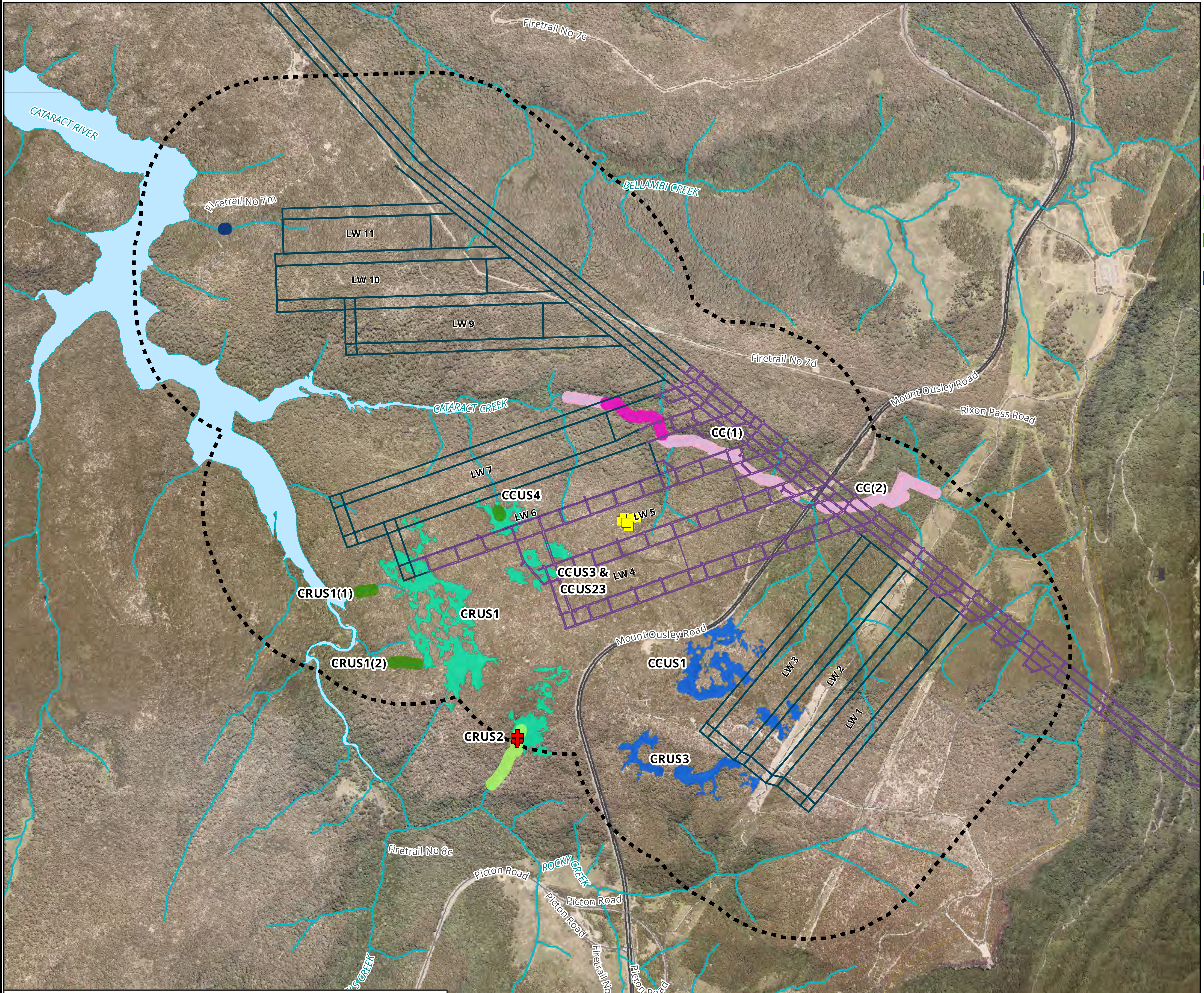


Figure 4: Features of 'special significance, Wonga East



Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

Legend

Threatened Frogs Located by Biosis

- Red-crowned Toadlet - Adult
- Giant Burrowing Frog - Pool Containing Tadpoles

Threatened Frog Breeding Habitat

- Stuttering Frog - High
- Stuttering Frog - Low
- Littlejohn's Tree Frog & Giant Burrowing Frog - High
- Littlejohn's Tree Frog & Giant Burrowing Frog - Low
- Littlejohn's Tree Frog & Red-crowned Toadlet - Low

Threatened Frog Non-Breeding Habitat

- Giant Burrowing Frog
- Littlejohn's Tree Frog & Giant Burrowing Frog

Longwall Layout

- Approved Longwalls (Preliminary Works Project)
- Proposed Longwalls (Underground Expansion)
- 600m Study Area

Figure 5: Breeding and non-breeding habitat for threatened frogs, Wonga East

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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16646 PPR_F5_Frog Habitat

3.2 Aquatic ecology

Cardno Ecology Lab (2009; 2011a, b; 2012a, b) and Biosis (In Prep.) have undertaken seasonal assessments of aquatic habitat condition and macroinvertebrate assemblages at impact and control monitoring reaches in spring and autumn each year since 2008. Table 8 and Table 9 provide a summary of work undertaken to date. These assessments provide a comprehensive inventory and understanding of the aquatic biodiversity values present in the Wonga East area.

Table 8: Aquatic ecology monitoring approach

Aquatic Ecological Value	Monitoring	Frequency
Aquatic Habitat	Habitat assessment (including photopoint monitoring).	Baseline monitoring has been conducted twice per year specifically during spring and autumn each year.
Aquatic Macroinvertebrates	Macroinvertebrates (AUSRIVAS) including threatened species.	Baseline monitoring has been conducted twice per year specifically during spring and autumn each year.
Fish	Targeted threatened fish surveys.	Surveys have been undertaken according to the 'Survey guidelines for Australia's threatened fish' (DSEWPaC 2011).
Water Quality	In-situ water quality provides a snapshot of each monitoring reach.	During each monitoring event.

Table 9: Overview of previous aquatic surveys in Cataract Creek (*n* = 2), Cataract River (*n* = 2) and Allen Creek (*n* = 2)

✓ = sampled, N/A = not sampled

	Spring 2008	Autumn 2009	Spring 2009	Autumn 2010	Spring 2010	Autumn 2011	Spring 2011	Autumn 2012	Spring 2012	Autumn 2013
Water Quality (*in situ*)	✓	✓	✓	✓	N/A	✓	✓	✓	N/A	✓
Aquatic Habitat Assessments (HABSCORE)	✓	✓	✓	✓	N/A	✓	✓	✓	N/A	✓
Aquatic Macronvertebrate Sampling (AUSRIVAS)	✓	✓	✓	✓	N/A	✓	✓	✓	N/A	✓
Threatened Fish Surveys	N/A	✓	N/A	Summer 2010	N/A	Summer 2011	N/A	Summer 2012	N/A	✓
Reference	Cardno Ecology Lab (2010)	Cardno Ecology Lab (2010)	Cardno Ecology Lab (2012a)	Cardno Ecology Lab (2012a)		Cardno Ecology Lab (2012a) Cardno Ecology Lab (2012b)	Cardno Ecology Lab (2012a) Cardno Ecology Lab (2012b)	Cardno Ecology Lab (2012a) Cardno Ecology Lab (2012c)	N/A	Biosis (In Prep)

3.2.1 Threatened aquatic species

Due to the potential presence of threatened aquatic species and the potential of suitable habitat for these species, targeted threatened species surveys were undertaken to confirm their presence/absence. An overview of the threatened species relevant to the Wonga East Domain is provided in Table 10 . An overview of the survey locations is presented in Figure 6.

Table 10: Aquatic species likely to occur in the study area and vulnerable to impacts due to subsidence

E = endangered, V = vulnerable

Scientific name	Common name	EPBC Act status	FM Act status
Fish			
Macquaria australasica	Macquarie Perch	E	E
Maccullochella macquariensis	Trout Cod	E	E
Maccullochella peelii	Murray Cod	V	-
Bidyanus bidyanus	Silver Perch	-	V
Macroinvertebrates			
Archaeophya adamsi	Adam's Emerald Dragonfly	-	E
Austrocordulia leonardi	Sydney Hawk Dragonfly	-	E

Silver Perch have previously been captured from Lake Cataract (Cardno Ecology Lab 2012; Horrobin 1996) and these individuals would have resulted from a translocation of these species into this catchment. Targeted threatened fish surveys undertaken in the Wonga East area between Spring 2008 and Spring 2011 have confirmed the presence of Macquarie Perch and Silver Perch, and an unidentified freshwater cod, which was assumed to be either Murray Cod or Trout Cod, within the lower reaches of Cataract Creek (Cardno Ecology Lab 2010; 2011).

Biosis (In Prep.) has undertaken surveys of additional sections of Cataract Creek upstream of the sites surveyed by Cardno Ecology Lab (see Fish Reach 19US in Figure 6 and Additional Fish Reach in Figure 7). These additional surveys did not record any threatened fish species.

Numbers of Macquarie Perch, Murray Cod, Silver Perch and Trout Cod recorded between 2009 and 2013 are presented in Table 11. The locations of Macquarie Perch and Murray Cod captured during the most recent survey undertaken in Cataract Creek (Biosis In Prep.) are presented in Figure 7.

Table 11: Numbers of threatened fish captured in Cataract Creek

	2009/2010	2010/2011	20011/2012	2012/2013
Macquarie Perch	30	90	18	14
Murray Cod	0	0	0	16
Silver Perch	9	9	0	0
Trout Cod	0	0	0	0

In order to ascertain the presence/absence of two species of threatened dragonfly listed under the NSW *Fisheries Management Act 1994* (FM Act), Adam's Emerald Dragonfly and Sydney Hawk Dragonfly, surveys undertaken in autumn 2013 included an assessment of habitat suitability for these two species, based on the habitat requirements outlined in DPI (2007) and DPI (2012), as well as targeted searches for exuviae. Furthermore, the presence of individuals of the appropriate dragonfly family was assessed during live-picking of macorinvertabrates undertaken in the field. Neither of the two threatened dragonfly species have been recorded during aquatic surveys in the Wonga East area since 2008.

3.2.2 Aquatic macroinvertebrates (AUSRIVAS)

A summary of aquatic macroinvertabrate data is provided in Table 12.

Table 12: AUSRIVAS, OE50 Taxa and SIGNAL2 scores for Wonga East (including control sites)

a) AUSRIVAS data, 2008 – 2012

X = Invertebrate assemblage is richer than reference condition; A = equivalent to reference condition; B = below reference condition (i.e. significantly impaired); C= well below reference condition (i.e. severely impaired).

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Cataract Creek	WGE-AQ5	B	A	B	B	B	A	C	B	B	C	B
	WGE-AQ6	B	B	B	A	A	A	C	C	B	B	A
Cataract River	WGE-AQ9	A	B	A	A	B	B	B	C	B	A	B
	WGE-AQ10	A	A	B	A	A	X	C	B	A	B	B
Allen's Creek	WGE-AQ13	-	-	B	A	A	A	B	B	A	A	A
	WGE-AQ14	-	-	A	A	A	A	B	B	A	B	A

b) OE50 Taxa scores, 2008 – 2012

A score of 1 indicates that the observed water bug community is similar to the expected one and therefore equivalent to that of a reference or undisturbed stream. A score lower than 1 means that less water bugs were observed than expected and that the community is impoverished when compared to a reference site.

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Cataract Creek	WGE-AQ5	0.6	0.85	0.6	0.7	0.7	0.85	0.3	0.7	0.65	0.5	0.625
	WGE-AQ6	0.7	0.7	0.6	1.05	0.825	0.875	0.3	0.35	0.75	0.6	0.925
Cataract	WGE-AQ9	0.925	0.8	1.1	1.125	0.725	0.8	0.5	0.375	0.575	0.85	0.7

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
River	WGE-AQ10	0.925	0.925	0.575	1.1	1	1.2	0.35	0.6	0.8	0.575	0.5
Allen's Creek	WGE-AQ13	-	-	0.8	1.1	0.95	1.175	0.5	0.525	1	0.875	0.9
	WGE-AQ14	-	-	0.9	1.1	0.025	0.925	0.625	0.675	1.025	0.7	0.85

c) SIGNAL2 scores, 2008 – 2012

Score < 4 = severely polluted; 4-5 moderately polluted, 5-6 mildly polluted

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Cataract Creek	WGE-AQ5	4.9	4.6	4.9	6	5.8	4.9	4.5	4.6	5	5.2	5.8
	WGE-AQ6	4.9	4.8	4.5	5.2	5.1	4.9	4.8	3.6	4.9	5.1	5.1
Cataract River	WGE-AQ9	4.9	4.8	4.9	4.8	5.2	5.2	4.5	2.8	5.5	5.1	5.5
	WGE-AQ10	5	4.5	5.7	5.3	4.6	4.6	4.5	4	4.9	5.5	6
Allen's Creek	WGE-AQ13	-	-	5	5	5	4.7	4.9	4	5.2	4.8	5.5
	WGE-AQ14	-	-	5.2	5.4	4.8	4.9	5.2	2.9	5	5.2	5.5

The number of taxa collected at each monitoring reach varied at a temporal and spatial scale (Cardno Ecology Lab 2009; 2011a, b; 2012a, b; Biosis In Prep.). Samples collected from Cataract Creek were generally less diverse than those collected from Cataract River and Allen's Creek. However, AUSRIVAS and OE50 Taxa scores indicate that there is little difference in the macroinvertebrate assemblage present in Cataract Creek when compared to control sites. SIGNAL2 scores indicate that, while Cataract Creek is moderately polluted, there is little difference in the presence or absence of pollution sensitive aquatic macroinvertebrate species when compared to control sites.

More detail on each of these surveys can be found in Cardno Ecology Lab (2009; 2011a, b; 2012a, b) and Biosis (2013a).

3.2.3 Impact Assessment

The main aquatic habitat present in the Wonga East area is along Cataract Creek, which provides habitat for several threatened fish species. Macroinvertebrate monitoring of Cataract Creek indicates that there is a lower diversity of macroinvertebrate taxa, but AUSRIVAS, OE50 Taxa and SIGNAL2 scores indicate that there is little difference between Cataract Creek and control sites in Cataract River and Allen's Creek. Lower diversity of macoinvertebrate taxa in Cataract Creek may be indicative of historic impacts to this waterway from extraction of the Bulli and Balgownie seams.

Extraction of the Bulli seam has resulted in up to 0.2 m of subsidence, whilst extraction of the Balgownie seams has resulted in subsidence of 1.1 m beneath Cataract Creek. Based on compressive tilts and strains, fracturing of the base of Cataract Creek and its tributaries is likely to have occurred. This has resulted in observable impacts to Cataract Creek, particularly iron flocculent within the creek, as discussed previously in Section 3.1.3.

As outlined in Section 3.1.4, there are unlikely to be any direct impacts to Cataract Creek; however additional fracturing of tributaries of Cataract Creek may result in decreased inflow into Cataract Creek and an increase in iron seepage at the base of these tributaries (A. Dawkins pers. comm.). Increases in iron flocculent has potential to smother eggs of Macquarie Perch and result in changes in water quality, whilst reduced flows into Cataract Creek have the potential to reduce the quality of habitat for Macquarie Perch and result in changes to community composition of macroinvertebrate communities. However, given past mining, it is considered unlikely that these impacts will result in observable changes to Cataract Creek above and beyond those present.

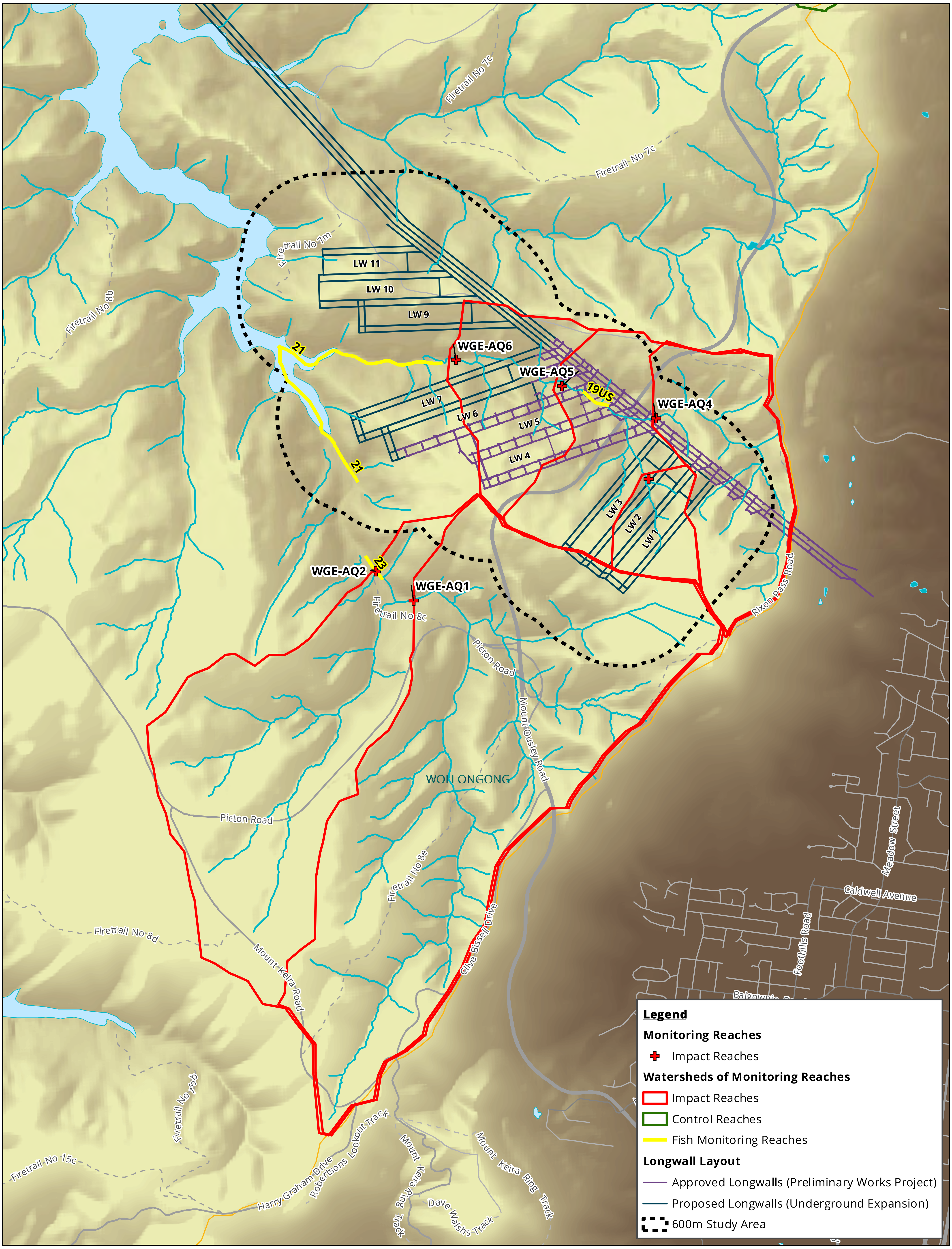

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Figure 6: Study Area and Catchment of Monitoring Reaches

Acknowledgements: Topo (c) NSW Land and Planning Information (2012)

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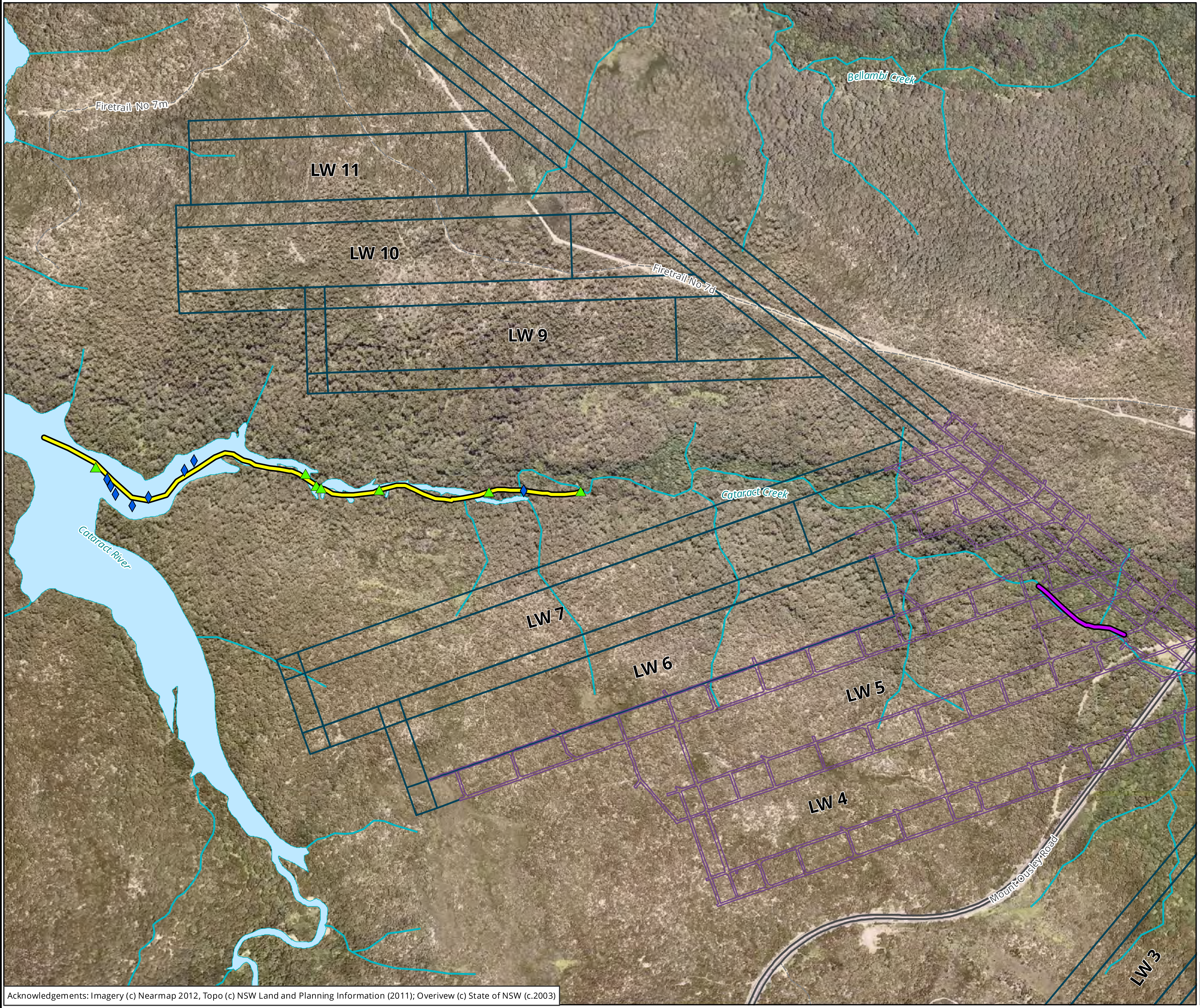

Acknowledgements: Imagery (c) Nearmap 2012, Topo (c) NSW Land and Planning Information (2011); Overivew (c) State of NSW (c.2003)

Legend

- Fish Monitoring Reaches
- Additional Fish Monitoring Reach (Biosis in Prep.)

Recorded fish locations

- Macquarie Perch
- Murray Cod

Longwall Layout

- Approved Longwalls (Preliminary Works Project)
- Proposed Longwalls (Underground Expansion)

Figure 7: Threatened fish species locations in Cataract Creek

0 80 160 240 320 400

Metres

Scale: 1:8,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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3.3 Upland swamps

Mapping and characterisation of upland swamps in the Wonga East and Wonga West area was undertaken by Biosis (2012b). This previous assessment included assessment of the 'special significance' of upland swamps in the project area using criteria outlined in OEH (2012). This assessment of upland swamps for the preferred project should be read in conjunction with Biosis (2012b).

Biosis (2012b) included an assessment of impacts to upland swamps, based on the previous mine plan. This impact assessment included several steps:

- An initial risk assessment using criteria outlined in DoP (2010) and OEH (2012);
- A comparative analysis of impacts to upland swamps that have resulted from previous mining, as required by OEH (2012);
- A summary of available data on groundwater in upland swamps within the project area;
- An analysis of flow accumulation based on changes in water flow due to subsidence levels; and,
- Use of tensile and compressive strains to assess where fracturing of bedrock may occur, and potential resultant impacts to upland swamp vegetation communities.

This impact assessment identified a number of upland swamps considered to be at risk of negative environmental impacts. Based on this impact assessment, Biosis recommended a number of changes to the original mine plan with the objective of avoiding and mitigating impacts to upland swamps.

A number of submissions were received critiquing the methodology used in the upland swamp impact assessment process. Section 3.3.1 provides further information on how the methodology used addresses issues and recommendations raised in DoP (2008), DoP (2009), DoP (2010) and OEH (2012), while Section 3.3.2 provides a rationale for the upland swamps impact assessment and discusses how criticisms have been addressed in the updated assessment.

An assessment of potential impacts arising from historic mining of the Bulli and Balgownie Seams in the Wonga East area is provided in Section 3.3.3.

Section 3.3.4 provides an updated upland swamp impact assessment based on the revised mine plan and revised subsidence calculations.

3.3.1 Criticisms of the upland swamp impact assessment

The upland swamp impact assessment (Biosis 2012b) was the first upland swamp impact assessment to utilise the methodology outlined in OEH (2012). Although the impact assessment was commended by OEH for the mapping and characterisation of swamps as well as how upland swamps of 'special significance' were determined, a number of concerns and criticisms were raised. These criticisms, and our response to these criticisms, are provided below.

The previous assessment did not consider impacts to all swamps, only swamps of special significance

OEH (2012, p.3) sets out several steps that are required to undertake an environmental assessment of the level of significance and risks to upland swamps. Step 4 requires that, following the initial risk assessment and comparative analysis, the mine plan should be adjusted if damage to swamps of 'special significance' is predicted to occur. This is further detailed in Section 3 (p.12) of the guidelines, which states proponents must assess the following:

- *'If negative outcomes are predicted for a special significance swamp, the mining plan should be adjusted in advance so that no negative environmental outcomes are anticipated.*
- *If no negative environmental outcomes are predicted, then proceeding to mining, monitoring and adaptive management.'* (OEH 2012, p.12)

Given the focus of this section on swamps of 'special significance' Biosis understood the intent of the guidelines was to assess potential impacts to these 'special' swamps.

In the current impact assessment (Section 3.3.4) potential impacts to all upland swamps within the study area has been undertaken.

Consideration of measures other than the fracturing of bedrock, and resultant changes in hydrology, in the assessment of impacts to upland swamps

Section 3 of OEH (2012, p.11) defines six criteria used to identify upland swamps at risk of negative environmental outcomes. It is our understanding that these criteria come from values defined by MSEC to determine longwall setback distances from major creeks, and were used by DoP (2010) and OEH (2012) for assessment of upland swamps to be considered at risk of negative environmental impacts. As stated in DoP (2010), these criteria are a *'threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*' (p. 120), i.e. these swamps are at risk and further assessment is required.

The use of multiple criteria in Biosis (2012b) is an attempt to address this requirement, by assessing other factors such as groundwater availability (and thus potential for draining), changes in flow accumulation (to assess risk of erosion and scouring and potential changes in water availability), orientation in relation to longwalls (to assess potential for ponding) and vegetation sub-communities (to assess the presence of species reliant on soil moisture and thus with greatest risk of change).

We believe this multi-criteria approach is valid, and have used a similar methodology in the current assessment. See Section 3.3.2 for a rational behind our methodology.

Reliance on flow accumulation modeling and poor definition of 'small' potential for change to flow accumulation

DoP (2009) identifies three potential impact mechanisms to upland swamps:

1. The bedrock below the swamp cracks as a consequence of tensile strains and water drains into the fracture zone. If the fracture zone is large enough or connected to a source of escape (e.g. a deeper aquifer or bedding shear pathway to an open hillside) then it is possible for sufficient water to drain to alter the hydrologic balance of the swamp.
2. Tilting of sufficient magnitude occurs to either re-concentrate runoff leading to scour and erosion, potentially allowing water to escape from the swamp margins (possibly affecting the whole swamp) or to alter water distribution in parts of the swamp, thus favouring some flora species associations over others.
3. Buckling and bedding shear enhances fracture connectivity in the host bedrock which promotes vertical then lateral drainage of the swamp. This mechanism is similar to redirected surface flow observed in subsidence-upsidence affected creek beds.

Flow accumulation modelling pre- and post-mining is undertaken by modelling flow pathways across a catchment using a digital elevation model (DEM) constructed from LiDAR data. Changes in surface topography are modelled by deducting predicted subsidence values (Smax) from the pre-mining DEM. Flow accumulation is then re-modelled. This is used to predict changes to surface and sub-surface flow through an upland swamp in relation to changes in ground level (tilt) and is unrelated to tilts and strains. This method directly addresses swamp impact mechanism 2 outlined above, and in particular addresses dot point 2 on page 116 of DoP (2010), which states that changes in water distribution in parts of the swamp can lead to changes in swamp health or vegetation composition.

In previous upland swamps assessments (BHPBIC 2009) changes in water flow through an upland swamp have been assessed using a single cross-section of an upland swamp. This methodology was criticised in DoP (2010) due to the reliance on a single cross-sectional representation. The use of flow accumulation modelling across an entire swamp addresses this concern.

In line with DoP (2010) Biosis (2012b) has used multiple criteria to determine the potential for impacts to upland swamps. These criteria have been developed with reference to the three potential upland swamp impact mechanisms outlined in DoP (2009) and outlined above. In this case we believe that the use of flow accumulation modelling in the assessment of impacts to upland swamps is valid.

Use of inexact subsidence predictions to determine potential zones of fracturing

Upland swamps form across a range of soil moisture gradients supporting different flora species and vegetation communities (Keith et al 2006, NSW Scientific Committee 2012). The model of upland swamp response to climatic change outlined in Keith et al (2006) describes a transition between MU43 Tea-tree Thicket to MU44c Cyperoid Heath and MU44a Sedgeland / MU44b Restioid heath / MU42 Banksia Thicket in response to changes on soil moisture. MU43 Tea-tree Thicket is likely to be reliant on semi-permanent to permanent waterlogging and MU44C Cyperoid heath on intermittent waterlogging, whilst the water table is likely to reach the root zone in other vegetation communities only following heavy rains. Similar changes in vegetation community composition within an upland swamp would be expected to occur due to changes in soil moisture resulting from fracturing of bedrock beneath an upland swamp.

Changes in soil moisture can occur in two ways; either through loss of water through fracturing of the bedrock and / or through changes in water flow through an upland swamp resulting. Whilst we use the flow accumulation model to assess the second potential mechanism of change, we must use predictions for tensile and compressive strain to assess the potential for fracturing of the base of upland swamps and potential for loss of groundwater availability.

In light of this, we believe it is reasonable to use such parameters to assess potential for impacts to particular vegetation communities within an upland swamp, despite their inexact nature.

3.3.2 Rationale behind Biosis' approach to upland swamp impact assessment

DoP (2008) recognises that certain swamp characteristics mean some upland swamps are more susceptible to impacts from subsidence than others. For example, given their location in the landscape, valley infill swamps are more likely to be in direct contact with surrounding groundwater, and much more susceptible to fracturing due to valley closure and upsidence (swamp impact mechanism 3 above). DoP (2009) states that, other than one headwater swamp (Swamp 1) in Dendrobium Area 2, the panel was not aware of any other headwater swamps that have been negatively impacted. However, in DoP (2010) evidence of impacts to several other upland swamps were bought to the attention of the panel, and available data now indicates that changes in groundwater availability have occurred at Swamp 12 (also a headwater swamp) and Swamp 15B (a valley infill swamp).

Changes in groundwater availability through fracturing of bedrock beneath an upland swamp is one type of impact. Fracturing of the bedrock beneath upland swamps, and/or changes in groundwater availability have been observed at a number of upland swamps on the Woronora plateau. To date, secondary impacts, including erosion, gullying, changes in size of an upland swamp or changes in vegetation within an upland swamps have been observed at a limited number of undermined upland swamps. This may be due to a lack of suitable quantitative monitoring (DoP 2010). Given the long history of mining on the Woronora plateau, and evidence of significant, observable impacts to only a limited number of previously undermined upland swamps, we do not believe that the available scientific evidence supports a conclusion that this primary impact (our term) will lead to secondary impacts (our term) in all cases, or will result in the catastrophic loss of upland swamps.

In their submission OEH raise statistical analysis of Swamp 1 in Symbolix (2011), as discussed in Krogh (2012), and a lack of the use of this data by Biosis (2012b) in our comparative analysis. The Krogh (2012) paper is not currently available for Biosis to comment on, but further analysis of data available from Swamp 1 indicates a gradual change in species diversity and richness indices at two out of three monitoring sites between 2006 and 2012. However, this change has also been observed at a number of control sites over the same period, albeit not at the same rate. Further to this, the rate of decline at Swamp 1 appears to be slowing, with an increase in both indices in recent years. To date, the data does not clearly indicate whether changes in groundwater in Swamp 1 have resulted in secondary impacts to vegetation or vegetation communities above and beyond what has been observed at control swamps, using a Before After Control Impact (BACI) design.

Biosis does not assert that subsidence associated with longwall mining does not result in impacts to upland swamps, or that a change in groundwater availability is not an impact to upland swamps. Rather, that the maintenance and persistence of upland swamps is much more complex than has been recognised, and that further research and assessment is required to understand the complex processes that maintain upland swamps, particularly in relation to changes brought about by longwall mining.

The swamp impact assessment methodology employed by Biosis (2012b) assesses multiple upland swamp characteristics to determine the potential for impact, in line with the recommendation of DoP (2010) that upland swamps that exceed these thresholds indicating they are risk of negative environmental consequences require further investigation.

3.3.3 Assessment of the historic impacts to upland swamps in Wonga East

Extraction of the Bulli and Balgownie seams has occurred within the Wonga East area. Within the study area, the Bulli Seam was extracted via hand workings and pillar extraction between 1890 and 1960. The Balgownie Seam was extracted using continuous miner pillar extraction in 1969 and the retreat longwall mining method from 1970 to 1982. Table 13 and Table 14 provide modelled subsidence data for upland swamps within the study area.

Table 13: Subsidence data from extraction of the Bulli seams for upland swamps within the study area (values in bold exceed subsidence criteria in OEH 2012)

Swamp	Subsidence (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Compressive Strain (mm/m)	Max Tilt (mm/m)
CCUS1	0.7	285	945	**0.3**	**3.7**	**7.4**	**12**
CCUS2	0.1	285	-	-	0.5	1.1	2
CCUS3	1	300	55	5.45	**5**	**10**	**17**
CCUS4	0.1	290	50	5.8	0.5	1	2
CCUS5	0.5	272	230	**1.18**	**2.8**	**5.5**	**9**
CCUS6	1	285	605	**0.47**	**5.3**	**10.5**	**18**
CCUS7	1	270	276	**0.98**	**5.6**	**11.1**	**19**

Swamp	Subsidence (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Compressive Strain (mm/m)	Max Tilt (mm/m)
CCUS8	0.1	270	20	13.5	**0.6**	1.1	2
CCUS9	0.1	293	25	11.72	0.5	1	2
CCUS10	0.5	280	185	1.51	**2.7**	**5.4**	**9**
CCUS12	0.5	355	185	1.92	**2.1**	**4.2**	**7**
CCUS13	0.1	335	195	1.72	0.4	0.9	1
CCUS14	1	275	-	-	**5.5**	**10.9**	**18**
CCUS15	0.1	325	40	8.13	0.5	0.9	2
CCUS16	0.5	300	-	-	**2.5**	**5**	**8**
CCUS17	0.1	325	45	7.22	0.5	0.9	2
CCUS18	0.1	325	30	10.83	0.5	0.9	2
CCUS19	0.1	325	10	32.5	0.5	0.9	2
CCUS20	1	290	570	**0.51**	**5.2**	**10.3**	**17**
CCUS21	1	280	490	**0.57**	**5.4**	**10.7**	**18**
CCUS22	0.5	317	150	2.11	**2.4**	**4.7**	**8**
CCUS23	0.1	310	45	6.89	0.5	1	2
CRUS1	0.5	300	310	**0.97**	**2.5**	**5**	**8**
CRUS2	0.5	210	280	**0.75**	**3.6**	**7.1**	**12**
CRUS3	0.4	295	45	6.56	**2**	**4.1**	**7**
BCUS1	1	270	270	**1**	**5.6**	**11.1**	**19**
BCUS2	0.5	285	40	7.13	**2.6**	**5.3**	**9**
BCUS3	0.5	265	80	3.31	**2.8**	**5.7**	**9**
BCUS4	0.5	295	230	**1.28**	**2.5**	**5.1**	**8**
BCUS5	0.5	273	105	2.6	**2.7**	**5.5**	**9**
BCUS6	0.1	308	15	20.53	0.5	1	2
BCUS11	0.5	335	225	1.49	2.2	4.5	7

Table 14: Subsidence data from extraction of the Balgownie seams for upland swamps within the study area (values in bold exceed subsidence criteria in OEH 2012)

Swamp	Subsidence Used (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS1	0.8	295	130	2.27	**4.1**	**8.1**	**14**
CCUS2	1	295	130	2.27	**5.1**	**10.2**	**17**
CCUS3	1	310	170	1.82	**4.8**	**9.7**	**16**
CCUS4	0.8	300	170	1.76	**4**	**8**	**13**
CCUS5	0.1	282	-	-	0.5	1.1	2
CCUS6	1	295	170	1.74	**5.1**	**10.2**	**17**
CCUS7	0.1	280	-	-	0.5	1.1	2
CCUS8	0.1	280	-	-	0.5	1.1	2
CCUS9	0.1	303	-	-	0.5	1	2
CCUS10	0.1	290	-	-	0.5	1	2
CCUS12	0.1	365	-	-	0.4	0.8	1
CCUS13	0.1	345	-	-	0.4	0.9	1
CCUS14	0.1	285	130	2.19	0.5	1.1	2
CCUS15	0.5	335	-	-	**2.2**	**4.5**	**7**
CCUS16	0.1	310	-	-	0.5	1	2
CCUS17	0.3	335	-	-	**1.3**	**2.7**	4
CCUS18	0.1	335	-	-	0.4	0.9	1
CCUS19	0.1	335	-	-	0.4	0.9	1
CCUS20	1	300	170	1.76	**5**	**10**	**17**
CCUS21	1	290	170	1.71	**5.2**	**10.3**	**17**
CCUS22	0.1	327	-	-	0.5	0.9	2
CCUS23	1	320	170	1.88	**4.7**	**9.4**	**16**
CRUS1	0.1	310	-	-	0.5	1	2
CRUS2	0.1	220	-	-	**0.7**	1.4	2
CRUS3	0.1	305	-	-	0.5	1	2
BCUS1	0.1	280	-	-	0.5	1.1	2

Swamp	Subsidence Used (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
BCUS2	0.1	295	-	-	0.5	1	2
BCUS3	0.1	275	-	-	0.5	1.1	2
BCUS4	0.1	305	-	-	0.5	1	2
BCUS5	0.1	283	-	-	0.5	1.1	2
BCUS6	0.1	318	-	-	0.5	0.9	2
BCUS11	0.1	345	-	-	0.4	0.9	1

Subsidence data for upland swamps in the study area from extraction of the Bulli and Balgownie seams indicates that all upland swamps in the study area, except CCUS13, CCUS18, CCUS19 and BCUS6, have been subject to subsidence criteria sufficient to have placed these upland swamps at risk of negative environmental consequences, according to criteria outlined in DoP (2010) and OEH (2012).

This assessment of past mining in the Wonga East area indicates that natural features in the study area have been subject to subsidence resulting from extraction of the Bulli and Balgownie Seams sufficient to have placed the majority of upland swamps in the study area at risk of negative environmental consequences. This data provides a baseline against which assessments of potential impacts resulting from extraction of the Wongawilli Seam, as part of the preferred project, must be assessed.

Two pertinent examples are provided in CCUS4 and CCUS1. Through the extraction of the Bulli and Balgownie seams, upland swamp CCUS4, which is recognised as a 'wet swamp' containing MU44c Cyperoid Heath and MU43 Tea-tree Thicket, has previously been subject to:

- 900 mm of subsidence
- 4.7 mm / m of tensile strain
- 9.3 mm / m of compressive strain
- 16 mm / m of tilt

Upland swamp CCUS1, which contains a mix of all upland swamp vegetation communities, has previously been subject to:

- 2000 mm of subsidence
- 10.5 mm / m of tensile strain
- 21.1 mm / m of compressive strain
- 35 mm / m of tilt

Due to a lack of quantitative monitoring of these upland swamps during extraction of the Bulli and Balgownie seams we cannot determine with any degree of certainty what primary or secondary impacts, if any, did or did not result from this historic mining. However, these two swamps continue to support a wide range of vegetation communities, and provide an illustration of how subsidence criteria from DoP (2010) and OEH (2012) cannot be used alone to determine the impacts to upland swamps.

3.3.4 Revised upland swamp impact assessment

Following on from the swamp impact assessment undertaken by Biosis (2012b), a recommendation was made suggesting a number of changes to the original mine plan with the objective of avoiding and mitigating impacts to upland swamps. NRE have now redesigned the mine plan for Wonga East and have removed Wonga West from the project application. This revised impact assessment follows the methodology outlined in Biosis (2012b), and is based on the revised mine plan and revised subsidence predictions.

In summary, 39 upland swamps have been mapped as occurring within the study area (Figure 8). Section 3.1 and Appendix 1 of Biosis (2012b) provide a summary of upland swamps within the study area, while Table 6 in Biosis (2012b) provides an assessment of 'special significance' against criteria outlined in OEH (2012). This assessment identified that seven upland swamps in the Wonga East area meet the criteria of 'special significance', including CCUS1, CCUS4, CCUS5, CCUS10, CRUS1, CRUS2 and CRUS3. Swamps of 'special significance' are shown in Figure 9.

Initial risk assessment

Following step 1 of OEH (2012), a risk assessment has been undertaken to determine upland swamps at risk of negative environmental consequences. To address concerns raised by OEH (2012), the risk assessment has been undertaken for all upland swamps within the study area.

Table 15: Initial Risk Assessment for Wonga East (Swamp names in italics indicate 'special significance'

Figures in bold are greater than criteria outlined in OEH (2012).

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
BCUS1	< 0.1	1	270	-	-	0.5	1	2
BCUS2	< 0.1	0.5	285	-	-	0.5	0.9	2
BCUS3	< 0.1	0.5	265	-	-	0.5	1	2
BCUS4	1	0.5	295	150	1.97	**6.8**	**13.6**	**23**
BCUS5	< 0.1	0.5	273	-	-	0.5	1	2
BCUS6	< 0.1	< 0.1	308	-	-	0.4	0.9	1
BCUS11		0.5	335	150	2.23	**6.1**	**12.2**	**20**
CCUS1	0.6	0.7	285	-	-	**7**	**14.1**	**23**
CCUS2	2	< 0.1	285	150	1.90	**9.4**	**18.8**	**31**
CCUS3	1	1	300	125	2.40	**6.7**	**13.4**	**22**
CCUS4	1.4	< 0.1	290	150	1.93	**9.2**	**18.5**	**31**
CCUS5	1.2	0.5	272	131	2.08	**7.3**	**14.7**	**24**
CCUS6	2	1	285	125	2.28	**9.4**	**18.8**	**31**
CCUS7	< 0.1	1	270	-	-	0.5	1	2
CCUS8	< 0.1	< 0.1	270	-	-	0.5	1	2

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS9	< 0.1	< 0.1	293	-	-	0.5	0.9	2
CCUS10	0.8	0.5	280	150	1.87	**3.8**	**7.6**	**13**
CCUS11	1.8	1	340	150	2.27	**8.8**	**18**	**29**
CCUS12	1	0.5	355	150	2.37	**5.8**	**11.5**	**19**
CCUS13	< 0.1	< 0.1	335	-	-	0.4	0.8	1
CCUS14	< 0.1	1	275	-	-	0.5	1	2
CCUS15	< 0.1	< 0.1	325	-	-	0.4	0.8	1
CCUS16	< 0.1	0.5	300	-	-	0.4	0.9	1
CCUS17	< 0.1	< 0.1	325	-	-	0.4	0.8	1
CCUS18	< 0.1	< 0.1	325	-	-	0.4	0.8	1
CCUS19	< 0.1	< 0.1	325	-	-	0.4	0.8	1
CCUS20	< 0.1	1	290	-	-	0.5	0.9	2
CCUS21	< 0.1	1	280	-	-	**9.5**	**19**	**32**
CCUS22	< 0.1	0.5	317	-	-	0.4	0.9	1
CCUS23	0.2	< 0.1	310	125	2.48	**6.5**	**13**	**22**
CRUS1	1.4	0.5	300	150	2.00	**6.7**	**13.4**	**22**
CRUS2	< 0.1	0.5	210	-	-	0.6	1.2	2

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CRUS3	< 0.1	0.4	295	-	-	0.5	0.9	2

Reassessment of subsidence predictions following monitoring of Longwalls 4 and 5 indicates that past mining has resulted in the softening of the underlying rock strata, and that subsidence is occurring over a much shorter distance than has previously occurred in un-mined areas, with subsidence largely restricted to immediately above the goaf. Whilst this means that subsidence movements occur over a smaller area, it also means that tilts and strains are greater than previously predicted (SCT Operations 2013). Subsidence predictions for all upland swamps within the predicted impact subsidence zone, except upland swamp CCUS10, are greater than previously predicted.

Upland swamps outside of the predicted subsidence impact zone are not discussed further. To address criticisms received on the previous upland swamps impact assessment (Biosis 2012b), all upland swamps within the predicted subsidence impact zone are considered further.

Comparative analysis

A comparative analysis was undertaken in Biosis (2012b). Additional data has become available following the completion of mining in the Wongawilli domain at NRE Wongawilli Colliery. Table 16 provides a summary of subsidence predictions for four upland swamps located above the Wongawilli longwalls. Observed data is not available for Swamp 20; however observed values along subsidence monitoring lines located to the east and west of Swamp 20 were greater than predicted (MSEC 2012), so it is reasonable to assume that predictions listed below are conservative.

Table 16: Predicted and observed subsidence for four upland swamps located above the Wongawilli domain

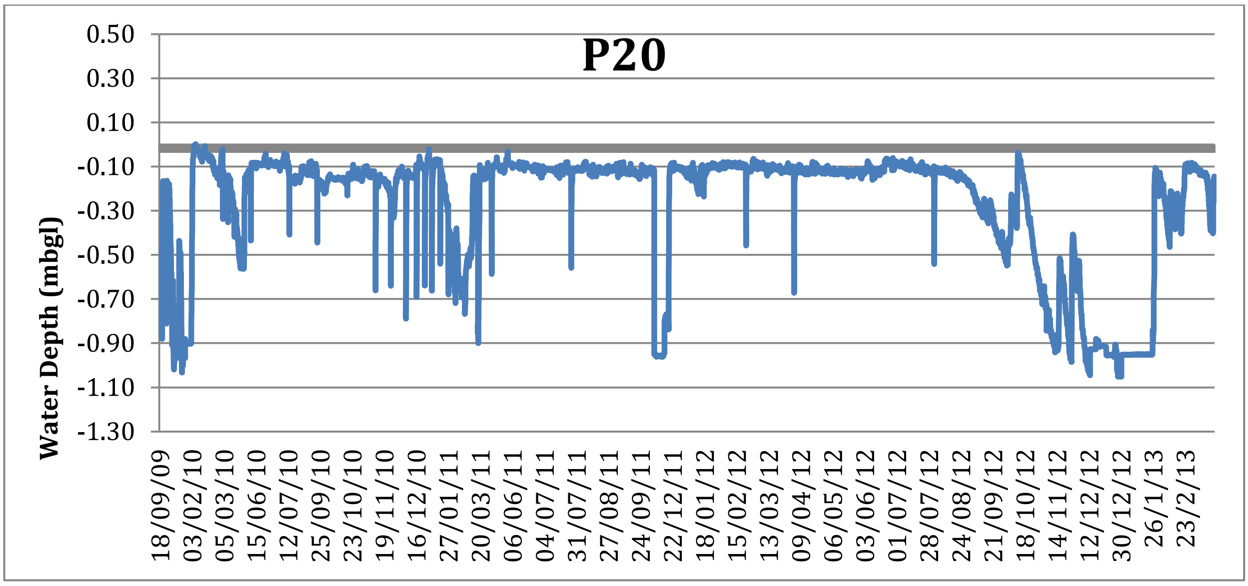
Figures in bold are greater than criteria outlined in OEH (2012)

Swamp	Subsidence (mm)	Tensile strain (mm / m)	Compressive strain (mm / m)	Tilt (mm / m)
20	895	**1.3**	**2.0**	**6.8**
21a	170	0.2	0.5	1.1
24	270	0.3	0.3	2.2
46	285	0.3	0.8	2.0

Subsidence predictions outlined above indicate that predictions for Swamp 20 exceeded criteria in OEH (2012), and thus upland swamps would be considered at risk of negative environmental consequences from extraction of Longwalls 11 and 20. One swamp piezometer is located approximately 100m east of Longwall 20 and overlies the eastern end of Longwall 11. Data from this piezometer is presented in Graph 1. This data indicates that "*no sustained change in groundwater levels in Swamp 20 due to subsidence induced impacts from extraction of Longwalls 11, 12, 19 and 20 has been observed*" (Geoterra 2012, p.8). Further, no impacts to vegetation within Swamp 20 have been observed (Biosis 2013b). Although Swamp 20 has been undermined previously by the Elouera Colliery, mining under the swamp used a bord and pillar mining method, resulting in negligible subsidence. Extraction of Longwalls 11 and 20 was undertaken using longwall mining techniques.

This data indicates that, despite subsidence predictions exceeding criteria in DoP (2010) and OEH (2012) for determining risk of negative environmental consequences, no impacts to groundwater or vegetation have been observed.

Graph 1: Swamp piezometer, P20, groundwater levels



Groundwater analysis

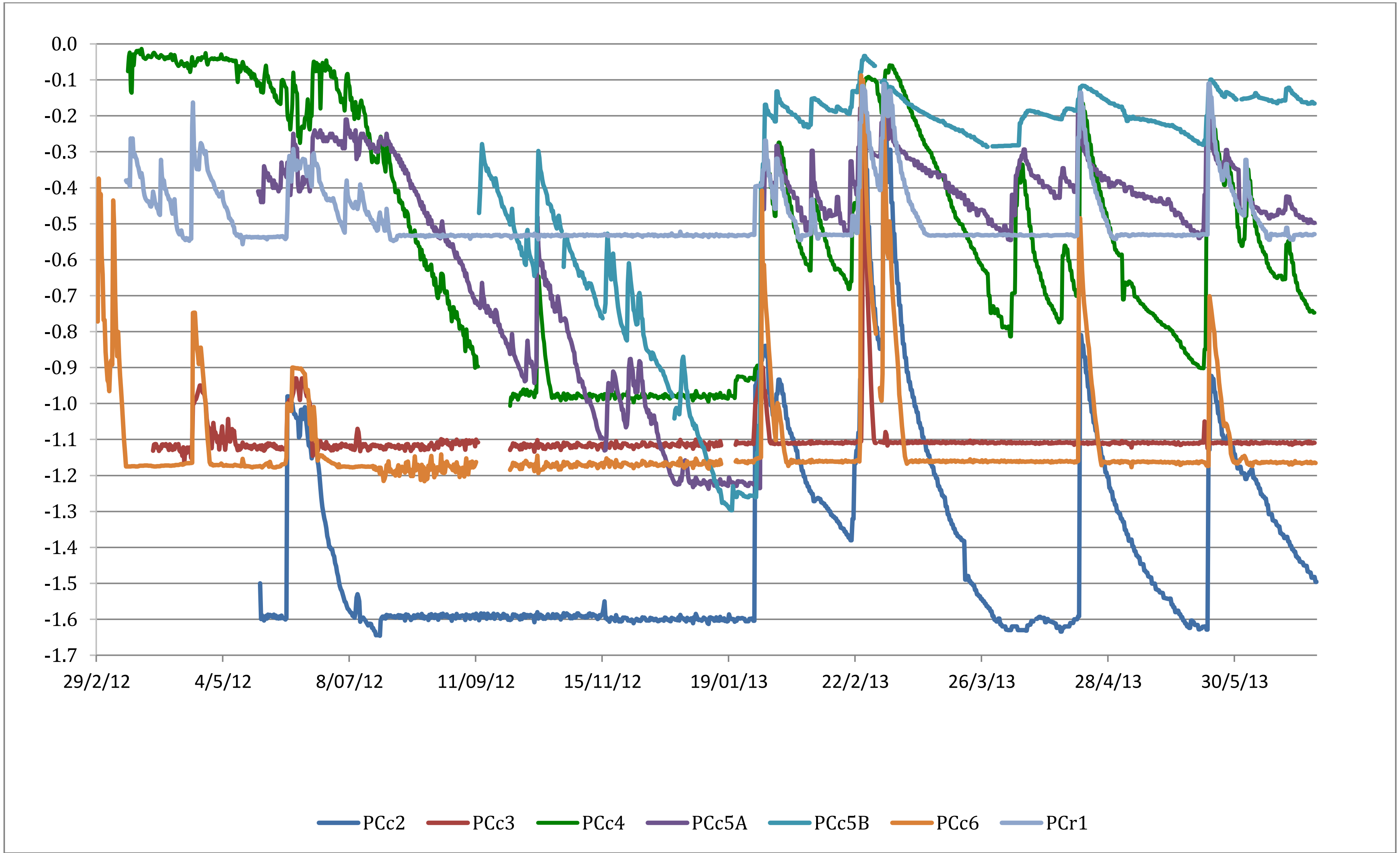
Groundwater monitoring piezometers have been installed in upland swamps CCUS2 (PCc2), CCUS3 (PCc3), CCUS4 (PCc4), CCUS5 (PcC5a and PCC5b), CCUS6 (PCc6) and CRUS1 (PCr1). Data from these piezometers indicates:

- CCUS2 fills to near surface level following significant rainfall, but recedes to basement level within one month;
- CCUS3 shows very little response to rainfall and remains dry the majority of the time;
- CCUS4 shows significant recharge to near surface levels after rainfall, and recedes gradually over approximately three months;
- CCUS5 shows significant recharge to near surface levels following rain. Groundwater recession is gradual, occurring over a five month period;
- CCUS6 shows a muted response to rainfall, with spikes in groundwater to near surface levels following significant rainfall, and receding rapidly to basement levels within one week; and,
- CRUS1 shows a brief response to rainfall with recharge to near surface levels following rainfall and recession to basement levels within a few weeks. CRUS1 is situated in shallow (0.5 m) soils.

Groundwater data from piezometers located in upland swamps within the study area indicates that there are varying degrees of contact with groundwater resources in these upland swamps. CCUS4 and CCUS5 show significant groundwater contact for prolonged periods, CCUS2 shows some contact but recedes rapidly, while CCUS3 and CCUS6 show little groundwater recharge following rainfall. This corresponds with the vegetation communities within these upland swamps, with CCUS4 and CCUS5 supporting areas of MU43 Tea-tree Thicket (both upland swamps) and MU44c Cyperoid Heath (CCUS4 only), which both rely on permanent to intermittent waterlogging. In contrast, CCUS2, CCUS3 and CCUS6 support MU42 Banksia Thicket (CCUS3 and CCUS6) or MU44a Sedgeland and MU44b Restioid Heath (CCUS2) which are less reliant on waterlogging. CRUS1, which supports a mix of MU42 and MU43, is an anomaly. This upland swamp has shallow soils and areas of MU43 are likely to be located in areas of terracing, resulting in water accumulation in depressions in bedrock.

It is worth noting that all of the upland swamps listed above have been subject to significant tilts and strains from past mining (see Table 13 and Table 14), substantially above what has been predicted by MSEC to result in fracturing of bedrock in waterways (DoP 2010) and the criteria listed in OEH (2012) for assessing the risk of negative environmental consequences to upland swamps. These levels of tilts and strains are likely to have resulted in fracturing of the bedrock beneath these upland swamps from past mining. However, monitoring data is not available to confirm whether this has occurred.

Graph 2: Swamp piezometer data from upland swamps in the Wonga East area



Flow accumulation

Flow accumulation modelling was undertaken based on the revised longwall layout and revised subsidence predictions (SCT Consultants 2013). The methodology for undertaking flow accumulation modelling is presented in Biosis (2012b). To address criticism regarding quantification of impacts from flow accumulation modelling, the percentage change in flow accumulation following mining is presented in Table 17, in addition to a discussion on flow accumulation.

Table 17: Discussion of changes in flow accumulation pre- versus post-mining for upland swamps in Wonga East (swamps of 'special significance' are shown in italics)

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
BCUS4	114.64	Flow accumulation modeling for BCUS4 pre-mining indicates that there is a dispersed flow through this upland swamp, with four exit points from the base of the upland swamp. Modeling of post-mining flow indicates an increase in catchment yield of 14.64%. There are minimal changes to the exit points within this upland swamp; however a redistribution of water within the swamp may result in decreased water flow through a small patch of MU43 Tea-tree Thicket. This may result in changes to vegetation composition in this area.
BCUS11	108.29	Flow accumulation modeling for BCUS11 pre-mining indicates that this small upland swamp has three flow pathways through the swamp. Following mining, changes in tilt are likely to result in a very minor increase in summed flow within this upland swamp of 8.29%. There is unlikely to be any change to flow pathways through the upland swamp. Changes are predicted to be negligible.
CCUS1	98.32	Flow accumulation modeling pre-mining indicates the presence of two main flow pathways through this upland swamp – one exiting the swamp in the northeast section of the swamp and one in the southeast section of the swamp. These exit points coincide with area of MU42 Tea-tree Thicket and MU44c Cyperoid Heath. Flow accumulation modeling post-mining indicates that tilts associated with Longwall 3 will result in a minor change to the flow pathway through the southeast section of the upland swamp with a minor (8.32%) increase in catchment area. This is likely to result in an increase in water availability for a small section of MU44a Sedgeland in this southeastern section. Any changes are likely to be minor.
CCUS2	99.62	Pre-mining flow accumulation modeling for CCUS2 indicates a dispersed flow of water through this upland swamp. Tilts associated with Longwalls 2 and 3 will result in only a negligible (0.38%) change to water availability across the swamp. Flow pathways through the swamp are likely to change following mining; however there are no significant concentrations of water, and given the dispersed nature of flow prior to mining

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
		this is predicted to result in minor changes.
CCUS3	99.18	Modeling of pre-mining flow accumulation through CCUS3 indicates the presence of two main flow pathways through this upland swamp, largely through areas of MU42 Banksia Thicket. Tilts associated with extraction of Longwall 5 are likely to result in only negligible (0.72%) changes in overall catchment yield for this upland swamp, and a minor re-direction of flow from the western edge of CCUS3 to the centre. This change in unlikely to result in any significant impacts to this upland swamp.
CCUS4	95.23	Flow accumulation modeling pre-mining indicates the presence of two main flow pathways through this upland swamp. One minor flow path passes through the eastern section of the swamp, while the main flow pathway passes through the western section of the swamp. The western flow pathway corresponds with areas of MU43 Tea-tree Thicket and MU44c Cyperoid Heath. Post-mining, tilts will result in a minor (4.77%) decline in overall catchment yield. Only negligible changes in the western flow accumulation pathway are predicted to occur, with minor changes in flows through the patches of MU43 and MU44c. Tilts will result in result in a new flow pathway through the centre of this upland swamp, with resultant increases in water availability to patches of MU42 Banksia Thicket. A shift in the flow pathway through the eastern section of the swamp will result in a minor redistribution of water in this eastern section.
CCUS5	73.49	Pre-mining flow accumulation modeling indicates that this upland swamp has a dispersed flow accumulation, with numerous flow pathways through the swamp. There is a significant flow pathway through the eastern section of the swamp, corresponding with an area of MU43 Tea-Tree Thicket. Substantial benching within this swamp appears to be correlated with vegetation sub-communities; with areas of Tea-Tree Thicket (MU43) corresponding with the location of rockbars within the swamp, and it is likely that community composition in this swamp relates to a combination of flow and these rockbars allowing pooling of water at these locations. Tilts associated with Longwall 7 are likely to result in a significant (26.51%) decline in overall water availability within this swamp. This decline is likely to impact most on the eastern section of this upland swamp, diverting flow away from the major flow pathway mentioned above, resulting in a decrease in water availability for a patch of MU43. This may result in changes to vegetation composition within this swamp; however it is predicted to impact on a small section of the swamp only.
CCUS6	97.69	Flow pathways through CCUS6 prior to mining are dispersed, with multiple entry and exit points reflecting the disconnected nature of this upland swamp. Tilt associated with extraction of Longwall 4 and 5 may result in a minor (2.31%)

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
		decrease in flow accumulation, but is unlikely to result in any significant changes in these pathways. Minor changes are predicted to occur.
CCUS10	106.91	Flow accumulation modeling pre-mining indicates a dispersed flow accumulation across this upland swamp. This swamp has a small catchment area that commences just above Longwall 9. Vegetation sub-communities appear to correspond with area of benching down the slope, with these rockbars resulting in accumulation of water in these areas. Post-mining flow accumulation modeling indicates a small (6.91%) increase in catchment yield, and only minor changes in flow pathways through this swamp.
CCUS11	50.35	Flow accumulation modeling indicates that this upland swamp has a small catchment, with the upland swamp likely to be reliant on terracing and accumulation of water. Post-mining modeling indicates a significant (49.65%) decline in this catchment yield. Tilts associated with extraction of Longwall 8 are likely to result in a diversion of this flow pathway around this upland swamp, reducing water availability. There is potential that this decline in water availability may result in impacts to this upland swamp.
CCUS12	103.58	CCUS12is located at the boundary between the catchments of Cataract Creek and Bellambi Creek, and as a result, has a very small catchment area. Pre- versus post-mining flow accumulation modeling indicates that only minor (3.58%) increases in catchment yield and no change in flow pathways. Negligible changes are predicted to occur.
CCUS23	97.06	Given the orientation of the flow pathway perpendicular to the longwall, flow accumulation modeling pre- versus post-mining indicates only a minor (2.94%) increase in catchment yield for this upland swamp. There is unlikely to be any change in flow pathways through this swamp. Negligible changes in water availability due to flow are predicted.
CRUS1	100.21	Only the upper northern section of CRUS1 is located above Longwall 6. An assessment of pre- versus post-mining flow accumulation through the upland swamp indicates a negligible (0.21%) increase in catchment yield and negligible changes in flow pathways through this upland swamps. No changes in water availability are predicted to occur.

Flow accumulation modelling for upland swamps within the study area indicates that, for the majority of upland swamps, only negligible or minor changes in both cumulative flow and flow pathways are likely to occur following mining. No significant reconcentration of flows, that may result in increased erosion risk, are likely to occur. For the majority of upland swamps mining is likely to result in only minor changes in water availability.

Flow accumulation modelling indicates that BCUS4, CCUS5 and CCUS11 are at risk of impact due to changes in water availability, particularly to vegetation communities sensitive to decreases in water availability. Of these, only CCUS5 is considered to be of 'special significance'.

Compressive and tensile strain

Reassessment of subsidence predictions following monitoring of Longwalls 4 and 5 indicates that past mining has resulted in the softening of the underlying rock strata, and that subsidence is occurring over a much shorter distance than has previously occurred in un-mined areas, with subsidence largely restricted to immediately above the goaf. Whilst this means that subsidence movements occur over a smaller area, it also means that tilts and strains are greater than previously predicted (SCT Operations 2013).

Subsidence predictions are presented in Table 15. This data indicates that tensile and compressive strains and tilts are of sufficient magnitude to result in fracturing of bedrock beneath upland swamps within the Wonga East area. Table 18 assesses the risk of a significant impact to these upland swamps based on vegetation communities present, and recorded response to groundwater (for upland swamps with groundwater data available).

Table 18: Discussion of tensile and compressive and strains for upland swamps within the study area (swamps of 'special significance' are shown in italics)

Swamp	Discussion of tilts and strains
BCUS4	BCUS4 is located over the edge of Longwall 9. Tilts and strains affect a small section of MU43 Tea-tree Thicket. Lower sections of the upland swamp are unlikely to be subject to strains of sufficient magnitude to fracture bedrock. No groundwater data is available. Risk is assessed as low due to impacts to a small section of this swamp.
BCUS11	BCUS11 does not support vegetation communities reliant on waterlogging. No groundwater data is available. Risk is assessed as low.
CCUS1	Given changes to the longwall layout, impacts are likely to be restricted to a very small section of this upland swamp at the eastern end. Any changes here are likely to be limited in extent, and are unlikely to result in a significant impact to this upland swamp. No groundwater data is available. Risk is assessed as low.
CCUS2	CCUS2 does not support vegetation communities reliant on waterlogging. In addition, groundwater levels in CCUS2 recede rapidly following rainfall. Risk of impact is considered low.
CCUS3	CCUS3 supports MU42 Banksia Thicket and MU44a Sedgeland, which are not reliant on waterlogging and are thus deemed less susceptible to decreased groundwater availability. Groundwater data indicates rapid recession to basement levels following rainfall. Risk is assessed as low.
CCUS4	CCUS4 supports MU43 Tea-tree Thicket and MU44c Cyperoid heath, which are reliant on permanent to semi-permanent water availability, as well as MU42 Banksia Thicket. Strains and tilts have increased significantly following the revision of subsidence data by SCT Operations (2013). The location of water MU42 Banksia Thicket and MU43 Tea-tree Thicket at the base of the longwall, in areas of lowest strain and tilt, are likely to mitigate impacts to

Swamp	Discussion of tilts and strains
	some degree. Groundwater data indicates a strong retention of groundwater following rainfall. Risk is assessed as moderate.
CCUS5	CCUS5 supports a mix of MU43 Tea-tree Thicket, which depends on permanent water availability, and MU42 Banksia Thicket and MU44a Sedgeland. Following revision of the longwall layout only a small section of this swamp will be subject to subsidence, and areas of MU43 Tea-tree Thicket are located in areas of lower strain. Groundwater monitoring in CCUS5 indicates a strong response to rainwater recharge, with groundwater recharge to near surface and a very gradual decline over months. Risk is assessed as low.
CCUS6	CCUS6 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. Groundwater data indicates rapid recession to basement levels rapidly following rainfall. Risk is assessed as low.
CCUS10	CCUS10 supports a mix of MU43 Tea-tree Thicket and MU44c Cyperoid Heath, which depends on permanent water availability, and MU42 Banksia Thicket. Following revision of the longwall layout only a small section of this swamp will be subject to subsidence, and areas of MU43 Tea-tree Thicket and MU44c Cyperoid Heath are located in areas of lower strain. No groundwater data is available. Risk is assessed as low.
CCUS11	CCUS11 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. No groundwater data is available. Risk is assessed as low.
CCUS12	CCUS12 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. No groundwater data is available. Risk is assessed as low.
CCUS23	CCUS23 supports MU42 Banksia Thicket and MU44a Sedgeland. No groundwater data is available. Risk is assessed as low.
CRUS1	CRUS1 supports a mix of MU43 Tea-tree Thicket and MU42 Banksia Thicket. Based on shallow soil profile, MU43 Tea-tree Thicket is likely to persist in areas of water accumulation resulting from rock terracing, as evident from analysis of slope. Only the upper section of this upland swamp is located within the predicted subsidence zone. Groundwater data indicates rapid recession following rainfall. Risk is assessed as low.

Final risk assessment

Following assessment of a variety of risk factors, Table 19 provides an overall assessment of the potential for a significant impact to occur. This final risk assessment assesses the overall risk of a primary impact (based on the initial risk assessment) and the consequent risk of a secondary impact (based on factors such as groundwater data, reliance of vegetation communities on water availability, changes in flow accumulation and the position of water dependent communities within the upland swamp compared to areas of greatest tilt and strain).

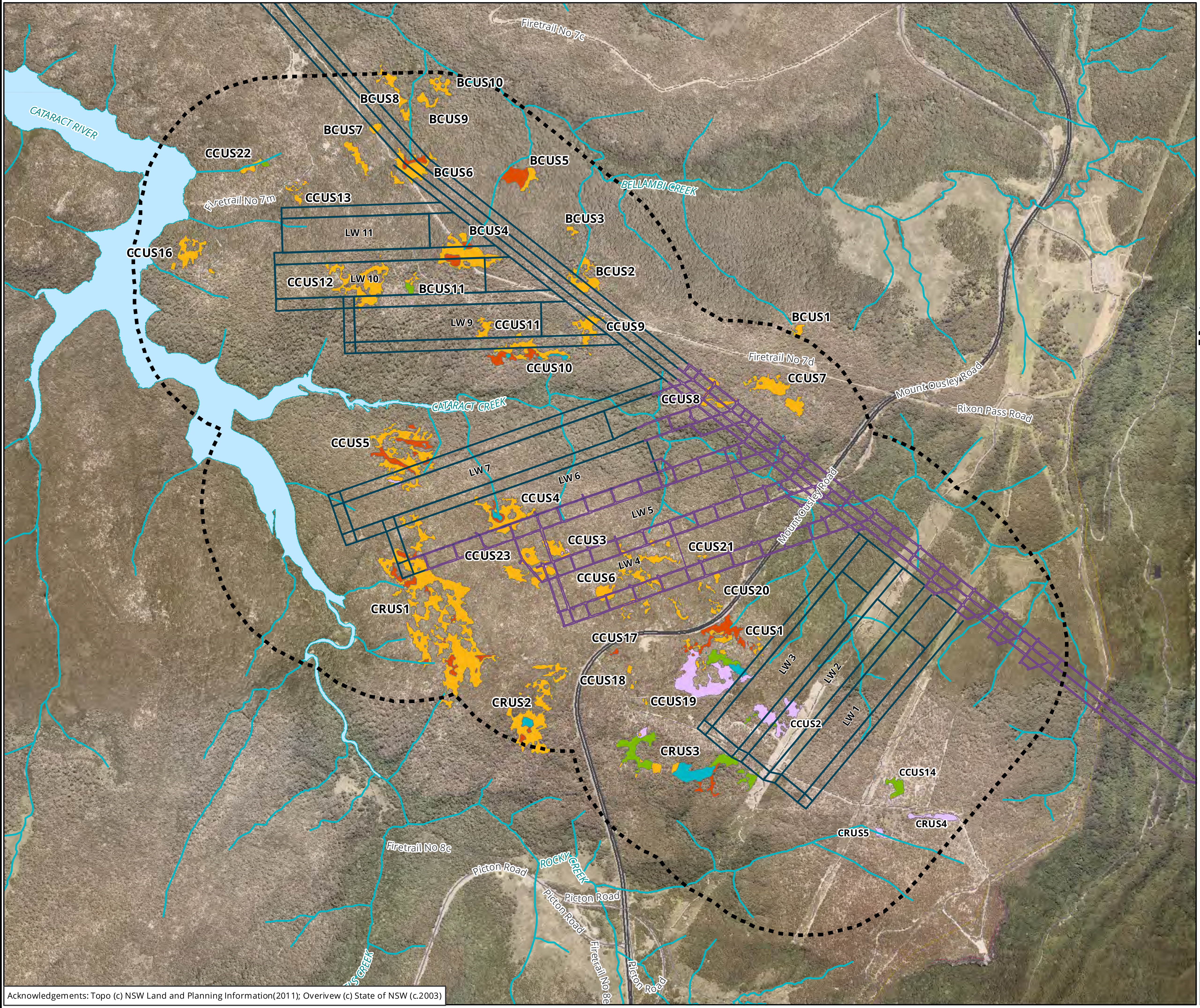
This final risk assessment indicates that there is a risk of a significant secondary impact to upland swamps BCUS4 and CCUS4 from the proposed extraction of coal in Wonga East. Only CCUS4 is considered to be of special significance.

The revision of the mine plan for Wonga East has resulted in a reduction in risk to upland swamps of 'special significance' CRUS2 and CRUS3 due to these upland swamps now being situated outside of the predicted subsidence impact zone. Revision of the longwall layout has also resulted in a reduction in risk for CCUS5, as only the upper reaches of this upland swamp are now within the predicted subsidence impact zone.

The changes in subsidence predictions and higher tilts and strains have resulted in an increase in risk level for CCUS4.

Table 19: Final risk assessment for upland swamp sin the Wonga East area (swamps of 'special significance' are shown in italics)

Swamp	Initial risk assessment (risk of negative environmental consequences?)	Groundwater	Flow accumulation	Compressive tilts and strains	Final risk assessment
BCUS4	No	N/A	Moderate	Low	Moderate
BCUS11	Yes	N/A	Negligible	Low	Low
CCUS1	Yes	N/A	Low	Low	Low
CCUS2	Yes	Low	Low	Low	Low
CCUS3	Yes	Low	Low	Moderate	Low
CCUS4	Yes	Moderate	Moderate	Low	Moderate
CCUS5	Yes	High	Moderate	Low	Low
CCUS6	Yes	Low	Low	Low	Low
CCUS10	Yes	N/A	Low	Low	Low
CCUS11	Yes	N/A	Moderate	Low	Low
CCUS12	Yes	N/A	Negligible	Low	Low
CCUS23	Yes	N/A	Negligible	Low	Low
CRUS1	Yes	Low	Low	Low	Low



Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

Legend

Vegetation Sub-Communities

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

Longwall Layout

- Approved Longwalls (Preliminary works project)
- Proposed Longwalls (Underground Expansion)
- 600m Study Area

Figure 8: Upland swamps in the study area

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

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Date: 09 September 2013,
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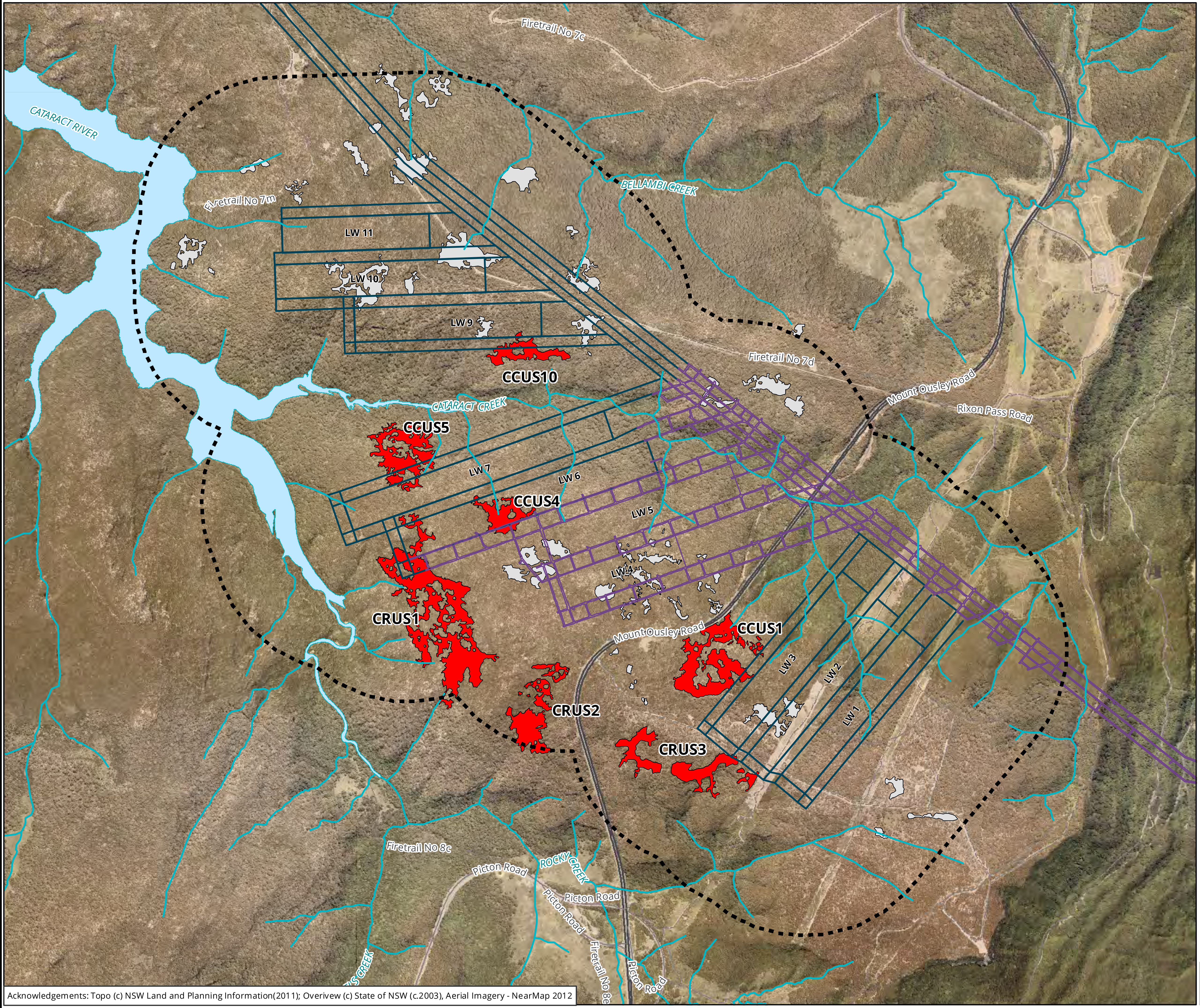
16646 PPR_F8_Upland Swamps



Legend

Swamp of Special Significance

- Yes
- No

Longwall Layout

- Approved Longwalls (Preliminary Works Project)
- Proposed Longwalls (Underground Expansion)
- 600m Study Area

Figure 9: Upland swamps of 'special significance' in the study area

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

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Date: 09 September 2013,
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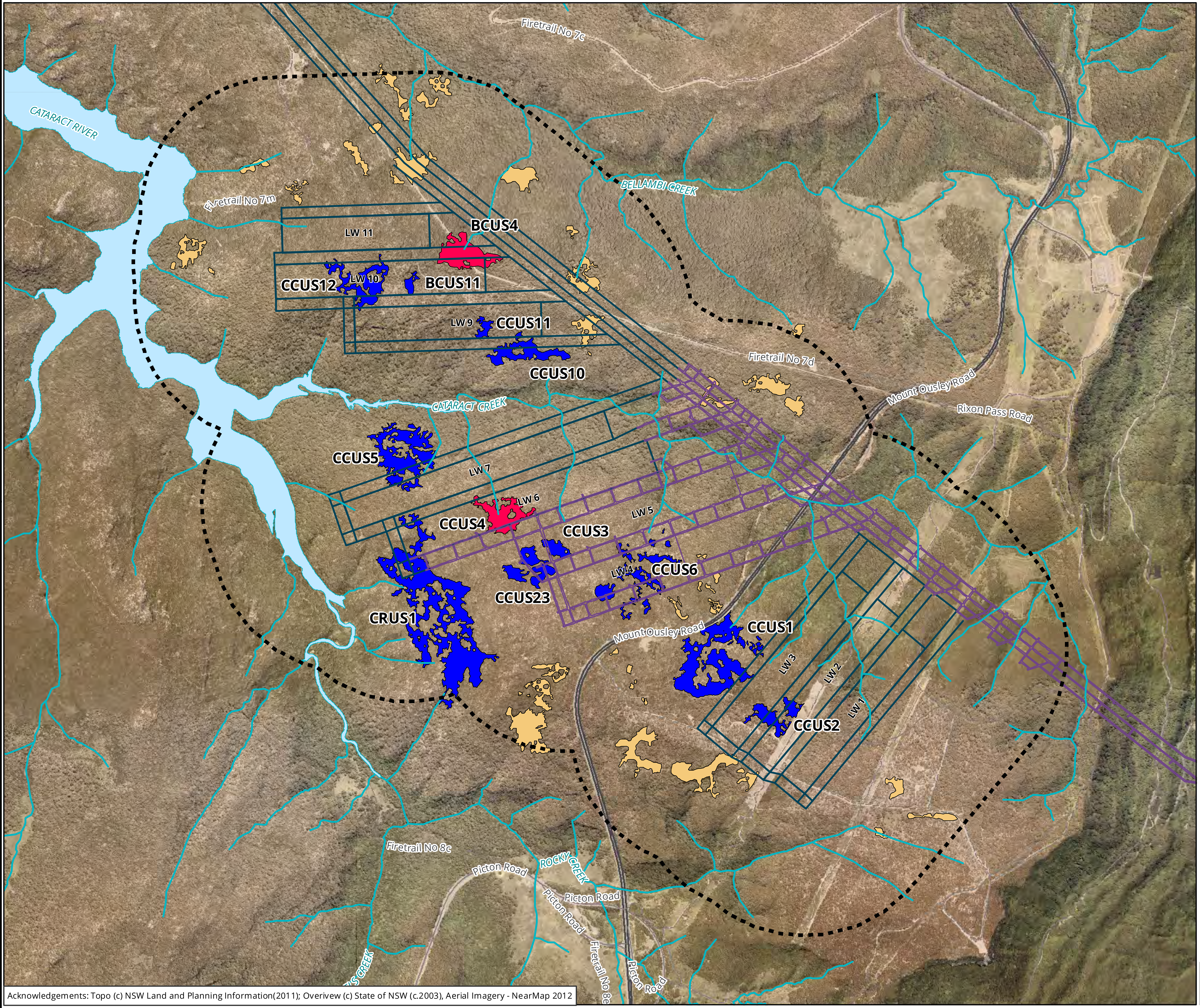
16646 PPR_F9_Swamps of Special Significance



Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003), Aerial Imagery - NearMap 2012

Legend

Risk Assessment

- Moderate
- Low
- Negligible

Longwall Layout

- Approved Longwalls (Preliminary Works Project)
- Proposed Longwalls (Underground Expansion)
- 600m Study Area

Figure 10: Final risk assessment for upland swamps in Wonga East

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 16646
Date: 09 September 2013,
Checked by: NMG, Drawn by: ANP, Last edited by: apritchard
Location:P:\16600s\16646\Mapping\Report Figures\16646 PPR_F10_Swamps Final Risk

4. Response to Submissions

This section provides a response to submissions received on the Underground Expansion Project (UEP) EA based on changes outlined in Section 2 and revised impact assessments present in Sections 3.1.4, 3.2.3 and 3.3.4.

Responses are provided to submissions received from the general public (Section 4.1) and from government agencies (Section 4.2).

4.1 Public submissions

A total of 804 public submissions were received for the UEP. Public submissions received, relevant to biodiversity, largely related to upland swamps, including the use of the OEH (2012) *Upland swamp environmental assessment guidelines*, the use of flow accumulation modelling and the conclusion of the Biosis (2012b) upland swamp impact assessment.

Table 20 provides a summary of public submissions and outlines responses to these submissions.

Table 20: Summary of public submissions, including responses

Submission	Response
Impacts and consequences to swamps will be greater than accepted by NRE. Swamps are critical to maintain baseflow water for the streams and rivers. Adaptive management and TARP's are not effective. The only way to manage swamp impacts is to not mine beneath them or within a 35 degree angle of draw	The upland swamp impact assessment has been revised based on a revised mine plan and associated subsidence predictions. The preferred project will result in reduced risk of impact for upland swamps CCUS1, CCUS5, CCUS10, CRUS2 and CRUS3. BCUS4 and CCUS4 are considered to have a moderate likelihood of impacts, of which only CCUS4 is considered to be of 'special significance'.
Monitoring of swamps must be improved to meet BACI standards and capture data on surface retention of water and flow from the swamps. It needs to allow the impacts of mining to be separated from other influences such as variable rainfall	The current ecological monitoring program undertaken for NRE for Longwalls 4 and 5, as well as the Wongawilli Colliery, uses a BACI approach. NRE are currently re-designing the monitoring plan to integrate surface water, groundwater and ecological monitoring programs to ensure a comprehensive assessment of the ecosystem function of upland swamps within the study area.
There are major differences between the 2003 NPWS Vegetation Mapping and the 2012 Biosis mapping of swamps. This may represent climate effects or different mapping techniques or is quite possibly due to subsidence impacts changing the character and spatial coverage of swamps	Vegetation mapping prepared by NPWS (2003) "*has a number of potential sources of error*" (p. 62) and NPWS recommends that detailed site inspection is undertaken. Upland swamp mapping prepared by Biosis (2012b) uses a combination of LiDAR data and on-ground assessment to map the vegetation of upland swamps. Differences between mapping by Biosis and NPWS is likely a result of the fine-scaled mapping completed

Submission	Response
	by Biosis when compared to the large scale, regional mapping prepared by NPWS.
Biosis assessment of risk to swamps is incorrect and the system by which they arrive at their conclusions is puzzling and is probably due to overreliance on flow accumulation changes. Biosis make no reference to the BSO account of swamp impact mechanisms	As outlined in Section 3.3.1, the criteria outlined in DoP (2010) are thresholds for further investigation, not a conclusion that a swamp will be impacted. The use of flow accumulation modeling provides an additional tool to assess potential changes in surface and groundwater flow through an upland swamp in relation to changes in ground level (tilt). A change in water flow is recognised as one potential impact to upland swamps (DoP 2009, DoP 2010).
Biosis' bias toward mining as evidenced by claims that mine subsidence is only a contributory factor in swamp damage rather than the cause. There is plenty of evidence from Metropolitan and Dendrobium Collieries End of Panel and Annual Environmental Management Reviews to prove this is the case.	To date, a large number of upland swamps on the Woronora Plateau have been undermined. Mining has included a combination of bord and pillar and longwall mining. Changes in groundwater availability have been observed at a number of upland swamps (e.g. Swamp 1 in Dendrobium Area 2 and Swamp 15b in Dendrobium Area 3A), and gully erosion and scouring have been observed at a number of additional upland swamps (e.g. Swamp 37, Swamp 18A and Flatrock Swamp). Biosis recognises that subsidence associated with longwall mining can result in the fracturing of bedrock below upland swamps and changes in groundwater availability. However, the persistence of upland swamps in previously mined areas, as illustrated in Section 3.3.3 of this report, indicates that fracturing of bedrock and changes in groundwater availability do not result in secondary impacts to vegetation or increased erosion, or the catastrophic loss of upland swamps. DoP (2008) recognises that certain swamp characteristics mean some upland swamps are more susceptible to impacts from subsidence than others. For example, given their location in the landscape, valley infill swamps are more likely to be in direct contact with surrounding groundwater, and much more susceptible to fracturing due to valley closure and upsidence. Biosis does not assert that subsidence associated with longwall mining does not result in impacts to upland swamps, or that changes in groundwater availability are not an impact to upland swamps. Rather, that the maintenance and persistence of upland swamps is much more complex than has

Submission	Response
	been recognised, and that further research and assessment is required to understand the complex processes that maintain upland swamps, particularly in relation to changes brought about by longwall mining.
Biosis have only identified 15 of 72 swamps as of 'special significance'. All 74 swamps are significant. Biosis make no reference to the BSO account of swamp impact mechanisms	The upland swamp impact assessment (Biosis 2012b) uses the methodology for identifying swamps of special significance outlined in OEH (2012). In their submission OEH recognises that *'Biosis has applied the OEH draft guidelines appropriately in identifying swamps of potential special significance'*.
Swamps can't be remediated once the base of the swamp is cracked	Attempts have been made to remediate upland swamps following impacts such as erosion using techniques such as coir logs, wooden structures etc. (Save Our Swamps 2010). However, these remediation techniques have been undertaken in relation to erosion. Biosis is not aware of the successful remediation of upland swamps impacted by the fracturing of bedrock. It is not feasible to remediate bedrock fractures and changes in groundwater availability, as the degree of impact from the remediation works would likely be far greater than the degree of benefit.

4.2 Agency submissions

Submissions relevant to biodiversity were received from the following agencies:

- Department of Resources and Energy (DRE)
- Department of Fisheries
- Office of Environment and Heritage (OEH)
- NSW Office of Water (NOW)
- Sydney Catchment Authority (SCA)
- Wollongong City Council (WCC)

Submissions related to several key issues, including subsidence predictions, the use of flow accumulation modelling and the conclusion of the Biosis (2012b) upland swamp impact assessment.

Table 21 provides a summary of agency submissions and outlines responses to these submissions.

Table 21: Summary of agency submissions, including responses

Submission	Response
Subsidence predictions	
Subsidence impacts are likely to have been underestimated with consequences for the adequacy of the environmental and Aboriginal heritage impact assessments	Subsidence predictions have been updated following revision of the mine plan (see SCT Operations 2013).
Creeks	
Location of Longwalls in relation to third order and fourth order streams, including cataract Creek, Lizard Creek and Wallandoola Creek	The revision of the mine plan now avoids mining below Cataract Creek. Mining in the Wonga West area, and thus beneath Lizard Creek and Wallandoola Creek, has now been removed from the preferred project.
Threatened species	
Potential impacts to threatened frogs	As outlined in Section 1.1.1, the Giant Burrowing Frog, Littlejohn's Tree Frog and Stuttering Frog have not been recorded within the subsidence impact zone and no impacts to identified breeding habitat for the Giant Burrowing Frog (below CRUS2) are predicted to occur. Although the Red-crowned Toadlet has been recorded above Longwall 4 and 5, habitat for this species is widespread and unlikely to be significantly impacted by subsidence. The Green and Golden Bell Frog has not been recorded within the study area. Suitable habitat is not present.
The sampling methods used to assess impacts on aquatic ecology are not scientifically robust	Additional sampling of aquatic habitat has been undertaken by Biosis (In Prep.), including sampling of fish using a backpack electrofisher in upstream reaches of Cataract Creek. No threatened species were recorded in this area.
Impacts to Macquarie Perch and Trout Cod, particularly spawning habitat and refugia for juveniles	It should be noted that due to past mining of the Bulli and Balgownie seams significant iron flocculent is already present in Cataract Creek, smothering some sections of the creek. Additional fish surveys have been undertaken by Biosis, and the results of these surveys are outlined in Section 3.2. The revision of the mine plan now avoids mining below Cataract Creek.
Potential presence of Adam's Emerald Dragonfly in Lizard Creek and Wallandoola Creek	Mining in the Wonga West area has now been removed from the preferred project.

Submission	Response
Upland swamps	
Mining under upland swamps due to the potential for fracturing of bedrock below upland swamps and resultant loss of groundwater, base flow and increased erosion potential	A revised upland swamp impact assessment has been undertaken using the revised mine plan and subsidence predictions. The revised mine plan has resulted in a reduction in the number of upland swamps at risk of negative environmental impacts, as well as a reduction in the number of upland swamps at risk of secondary impacts.
Mining under swamps of special significance	Revision of the mine plan has reduced the number of upland swamps of 'special significance' that will be undermined. Upland swamps CRUS3 and CCUS1 are no longer within the predicted subsidence impact zone, while CCUS1, CCUS5, CCUS 10 and CRUS1 are now largely located over pillars. CCUS4 is the only upland swamp of 'special significance' that will now be wholly undermined.
Objection to the use of flow accumulation modeling and definition of 'small' potential for change without defining small	The flow accumulation modeling has been used to predict changes to surface and groundwater flow through an upland swamp in relation to changes in ground level (tilt). A change in water flow is recognised as one potential impact to upland swamps (DoP 2009). Flow accumulation is modeled using vertical subsidence data (Smax) to model changes in flow pathways through an upland swamp. It is unrelated to tensile stress and strains.
Despite the impacts to upland swamps, no offsetting or remediation of groundwater or biodiversity impacts are proposed. This is not consistent with current government principles of avoid, mitigate or offset environmental impacts.	NRE proposes to outline an offset strategy once a Project Approval is received. This offset strategy will be developed in conjunction with relevant stakeholders, including OEH.

5. Conclusions

Changes to the project, as outlined in Section 2 have resulted in a significant reduction in predicted impacts to terrestrial and aquatic biodiversity and upland swamps. A summary of the reduced impact predictions is provided below:

- Removal of Wonga West from the program has resulted in reduced impacts to cliffs, providing habitat for threatened bats, rocky outcrops, providing habitat for threatened flora species and the Broad-headed Snake, and habitat for threatened frogs. The risk assessment for each of these groups of species now indicates a low risk of potential impact.
- The revision of the mine plan to avoid undermining of Cataract Creek has resulted in a reduced risk of impact to Macquarie Perch, Murray Cod and Silver Perch, as well as habitat for the threatened Adam's Emerald Dragonfly.
- The revision of the mine plan has resulted in a reduction in risk for several upland swamps, including CRUS2, CRUS3 and CCUS5, and will result in low risk of impact for all upland swamps except BCUS4 and CCUS4.
- The revised mine plan and revised subsidence predictions have resulted in an increase in risk to one upland swamp, CCUS4.

References

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