LIDDELL COLLIERY

2014 FLORA AND FAUNA MONITORING REPORT

Prepared for
Liddell Coal Operations Pty. Ltd.

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Abbreviations

ABBREVIATION	DESCRIPTION
ANZECC	Australian and New Zealand Environment and Conservation Council
CRC	Cooperative Research Centre
DPI	NSW Department of Primary Industries
DoP	NSW Department of Planning, now known as the NSW Department of Planning and Infrastructure
ELA	Eco Logical Australia
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
LCO	Liddell Coal Operations Pty. Ltd.
LFA	Landscape Function Analysis

LGA	Local Government Area
LHPA	Livestock Health and Pest Authority
NW Act	NSW Noxious Weeds Act 1993
TN	Total Nitrogen
TP	Total Phosphorus
TSC Act	NSW Threatened Species Conservation Act 1995
Umwelt	Umwelt (Australia) Pty. Ltd / Umwelt Environmental Consultants
VPRU	Vertebrate Pest Research Unit
XCN	Xstrata Coal NSW
Xstrata	Xstrata Coal Australia Pty. Ltd.

Executive summary

Liddell Colliery is an open cut coal mine located at Ravensworth approximately 25 km north-west of Singleton, in the Hunter Valley of NSW. Liddell Colliery is a Joint Venture between Xstrata Coal Pty. Ltd. (Xstrata) and Mitsui Matsushima Australia Pty. Ltd. Liddell Coal Operations Pty. Ltd. (LCO) manages the operation which is wholly owned by GlencoreXstrata.

Eco Logical Australia (ELA) was commissioned to conduct the annual flora and fauna monitoring survey for 2014, following recommendations specified by the 2011 monitoring program review conducted by ELA.

The 2014 flora and fauna monitoring survey addressed Liddell Colliery's environmental objectives and built on the baseline data recorded during the 2012 and 2013 monitoring surveys. These objectives were:

- to create functional Blue-billed Duck habitat
- to avoid impacts from mining operations on remnant vegetation within Liddell Colliery
- to avoid impacts from mining operations on native fauna that utilise habitat within Liddell Colliery (especially threatened fauna)
- to implement a revegetation program to restore disturbed areas designated for native vegetation to pre-mining condition
- to ensure native revegetation supports native fauna (especially threatened species) at similar diversity and abundance to pre-mining condition.

Blue-billed Duck habitat at Dam 3 is considered to be managed, maintained and functioning well with considerable vegetated growth in the past year. The Triangle Dams (Upper and Lower) currently form part of a larger temporary cattle grazing trial, and as such the Blue-Billed Duck habitat enhancement of these dams is not being actioned. The previous 2013 ELA monitoring report stated that "at completion of the grazing trial it is recommended that the triangle dams be reassessed for Blue-Billed Duck habitat potential. Following assessment, applicable enhancement measures should be identified for Triangle Dam and actioned or an alternative waterbody will be determined". Since the 2013 monitoring there has been little to no improvement to these dams in regard to creating functional Blue-billed duck habitat. As such, it is recommended that either cattle be excluded from these areas and further effort be made to enhance the triangle dams for the Blue-billed Duck; or alternatively another dam or waterbody (e.g. Dam 6, Dam 1) be nominated as the second area for which habitat is enhanced/created for this species. This allows the Triangle Dams, and surrounding paddocks to continue to be used for the purposes of the grazing trial. If the second option is chosen then efforts should be focused on planting and establishing suitable aquatic plant species in and around the selected site / area.

Direct impacts from mining activities (e.g. direct vegetation / habitat loss through clearing for mining purposes and associated infrastructure; weeds introduced / spread via mining practices; dieback induced by dust, erosion, etc.) on the LCO site include the loss of portions of remnant native vegetation through the augmentation of mine activities (within approved LCO clearing boundaries) and hence reduces the available habitat for flora and fauna species to utilise portions of the LCO site.

Riparian and woodland vegetation remnants, particularly along Bowmans Creek still provide for an important vegetation and fauna movement corridor across and beyond the site. As little remnant vegetation remains both within Liddell Colliery and in the locality, keeping these areas in sound

condition is imperative. These woodland and riparian habitats both support a range of diurnal birds and microchiropteran bats, including threatened species.

The woodland rehabilitation sites have not yet reached the required reference condition, however, as initial establishment only occurred 3-4 years ago the vegetation planted on site is considered to be progressing satisfactorily.

No threatened flora species have been recorded during the monitoring surveys at Liddell Colliery in 2014. Threatened fauna species recorded during the 2014 survey were *Chthonicola sagittatus* (Speckled Warbler), *Mormopterus norfolkensis* (East-Coast Freetail bat), *Miniopterus schreibersii oceanensis* (Eastern Bentwing Bat) and *Myotis macropus* (Large-footed Myotis). Three other fauna species observed during the monitoring, *Merops ornatus* (Rainbow Bee eater), (*Hirundapus caudacutus*) White-throated Needletail and *Haliaeetus leucogaster* (White-bellied Sea Eagle), are listed as migratory under the EPBC Act.

As a result of the 2014 monitoring, a number of recommendations have been developed in order to meet Liddell Colliery's environmental objectives. Briefly the main recommendations relate to:

- Restricting access by cattle at specific locations, particularly in the vicinity of waterbodies such as Bowmans Creek (where within the LCO property boundary) as well as remnant and naturally regenerating woodland areas.
- Continue to enhance identified fauna habitat and native vegetation areas for Blue-billed Duck.
- Continue to develop habitat corridors for threatened species such as Spotted-Tail Quoll, woodland birds and microchiropteran bats as per the approved final landform design.
- Continue to develop the functionality of habitat corridor vegetation (i.e. structure and native flora diversity) to provide a wider habitat value for a greater diversity of fauna species. This includes placement of wood debris, increasing flora species cover utilising local native species and continued targeted weed control.

Detailed recommendations can be located in **section 5.0**.

1 Introduction

1.1 Background

Liddell Colliery, initially commencing as an underground mine, is now a long established open cut coal mine located at Ravensworth, approximately 25 km north-west of Singleton in the Hunter Valley, NSW (**Figure 1**). Liddell Colliery is operated by Liddell Coal Operations Pty. Ltd. (LCO) on behalf of the Liddell Joint Venture between Xstrata Coal Pty. Ltd. (67.5 %) (Xstrata) and Mitsui Matsushima Australia Pty. Ltd. (32.5 %). Liddell Coal Operations Pty. Ltd. (LCO) manages the operation, which is wholly owned by GlencoreXstrata.

Eco Logical Australia (ELA) was commissioned by LCO to conduct the annual flora and fauna monitoring survey for 2014. The annual flora and fauna monitoring program was initiated by HLA-Envirosciences Pty. Ltd. in 2005 and was subsequently conducted by Umwelt (Australia) Pty. Ltd (Umwelt) between 2006 and 2010 and by ELA in 2011, 2012 and 2013.

Following a review of the flora and fauna monitoring program (ELA 2012a), a revised program was initiated. Due to inconsistencies in previous monitoring efforts as well as changes to site locations and the LCO site configuration, data collected in 2014 has not been compared extensively to data collected prior to 2012. However, the 2014 data has been compared to the last two years of monitoring (2012 and 2013).

The monitoring program review was undertaken to ensure the monitoring program was consistent with the NSW Department of Planning (DoP) Consent Conditions, XCN SD GDL 0010 10.0 Environment, Biodiversity and Landscape Functions Guideline (XCN 2011), LCO guidelines and plans including the LCO SD GDL 0019 Biodiversity and Land Management Guidelines (LCO 2007) and the Liddell Colliery Landscape Management Plan (Umwelt 2008a).

1.2 Report structure

The report is structured utilising the following chapters:

1. **Introduction** – provides the context for the flora and fauna monitoring program
2. **Previous monitoring** – summarises the previous monitoring works and effort
3. **Methodology** – outlines the methods used in the 2014 monitoring survey. These methods were derived from the monitoring program review (ELA 2012a)
4. **Results and discussion** – provides a summary and brief discussion of the survey results
5. **Recommendations** – provides recommendations for land management and future flora and fauna monitoring
6. **Conclusion** – concluding remarks

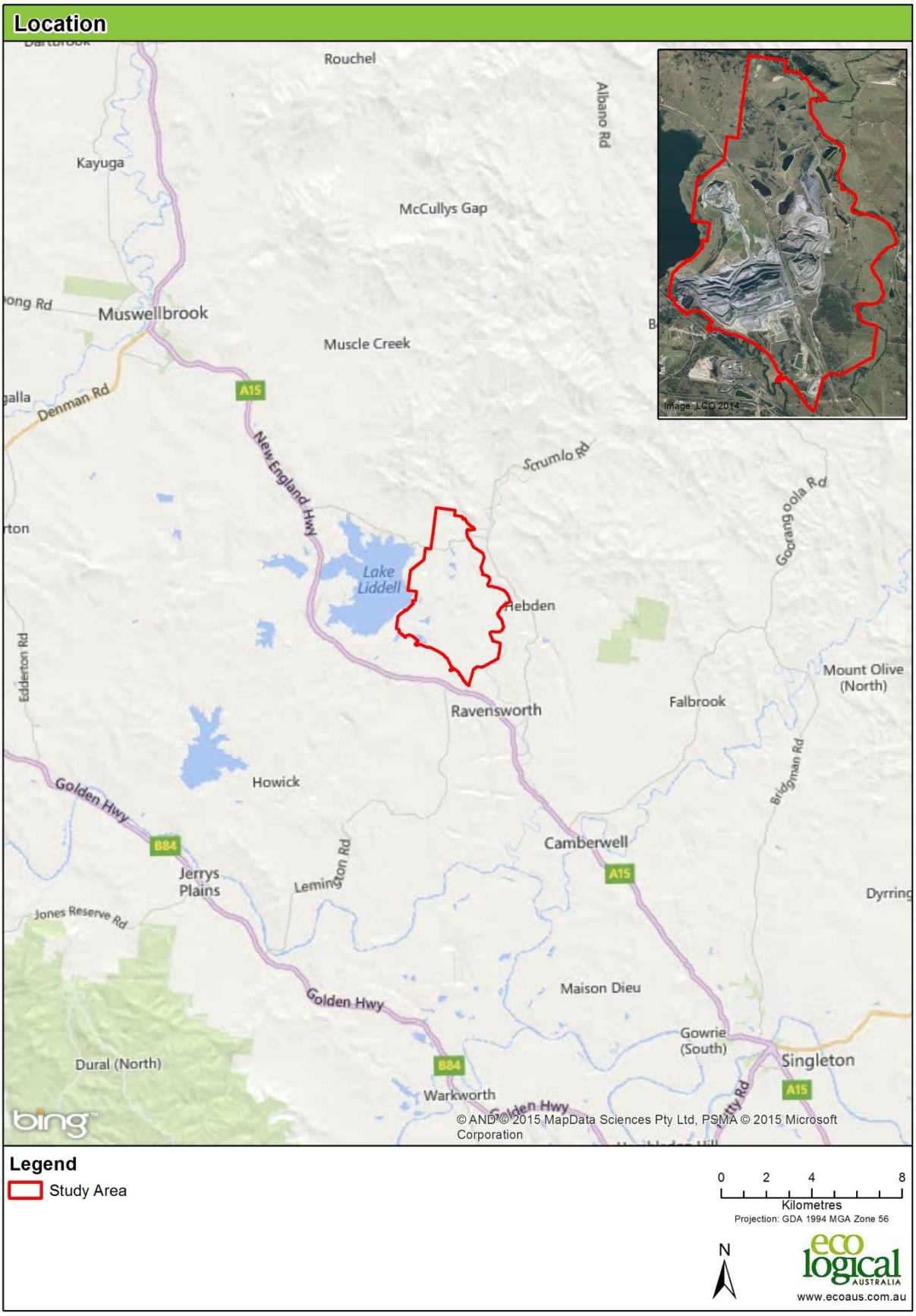

Figure 1: Liddell Colliery - located adjacent to Lake Liddell and 26 km north-west of the town of Singleton

1.3 Monitoring requirements

LCO has an obligation to conduct environmental monitoring at Liddell Colliery. The requirement for environmental monitoring was set by the DoP in its Consent Conditions issued to LCO for continuing open cut mining at the Liddell Colliery and associated surface facilities and infrastructure.

1.4 Objectives and performance targets

In establishing objectives and performance targets to measure the progress and success of environmental management, the following matters must be addressed, as per ELA (2012a):

- monitoring environmental performance
- conservation of scarce natural resources
- monitoring impacts during and post mining operations including rehabilitated areas
- number and location of monitoring sites
- methodology required for each monitoring site
- preferred timing required for detection of flora and fauna species
- implementation of habitat enhancement monitoring for Blue-billed Duck habitat.

Table 1 provides the objectives and performance targets for the annual flora and fauna monitoring.

Table 1: Objectives and performance targets for the annual flora and fauna monitoring

Objectives		Performance targets	Management actions	Timing
1	Implement functional Blue-billed Duck habitat	Blue-billed Ducks are observed in dams with habitat enhanced during annual monitoring events No decrease in native species diversity and habitat structure when compared amongst monitoring events	Plant habitat	Habitat was initially established in 2011
			Monitor habitat condition and presence of Blue-billed duck including any signs of breeding	Annual monitoring for the first five years after habitat enhancement and then once every five years for the following 10 years (if a less frequent monitoring event is deemed appropriate)
			Maintain habitat condition through replanting and weed control	Planting of macrophytes best undertaken during spring Planting / weed control in response to recommendations from a monitoring event

Objectives		Performance targets	Management actions	Timing
2	Avoid impacts from mining operations on remnant vegetation within Liddell Colliery (includes remnant vegetation areas beyond already approved clearing boundaries)	Diversity and structure maintained or improved when compared amongst monitoring events (unless explained by natural causes i.e. drought)	Monitor remnant woodland and riparian vegetation outside of disturbance boundary (to provide reference sites for comparative purposes)	Annual monitoring every spring throughout project operations
			Maintain habitat condition by following recommendations from monitoring event	Throughout year as necessary
3	Avoid impacts from mining operations on native fauna that utilise habitat within Liddell Colliery (especially threatened fauna)	Diversity and structure maintained or improved when compared amongst monitoring event (unless explained by natural causes i.e. drought)	Monitor fauna assemblages with threatened fauna known to occur at Liddell Colliery (Target both woodland and riparian habitat)	Annual monitoring every spring throughout project operations
			Monitor nest box occupation	Annual monitoring every spring throughout project operations
			Maintain required habitat characteristics by following recommendations from monitoring event	Throughout year as necessary
		No loss of habitat characteristics (especially those required by threatened species)	Undertake habitat assessment	Annual monitoring every spring throughout project operations
4	Implement revegetation program to restore disturbed areas designated for native vegetation to pre-mining condition	Restore native plant species richness, and native canopy, mid-storey and grass cover of 75% of reference condition	Restoration activities including natural rehabilitation, direct seeding and planting	Performance target to be reached within the following timing categories: Canopy:15 years Mid-storey:10 years Groundcover: 5 years

Objectives		Performance targets	Management actions	Timing
			Monitor revegetated sites following approved monitoring methodology	Annual monitoring every spring within first five years of revegetation and then once every five years for the following 10 years or until target has been reached
			Maintain vegetation condition by following recommendations from monitoring event	Throughout year as necessary
5	Native revegetation supports native fauna (especially threatened species) at similar diversity and abundance to pre-mining condition	Native fauna assemblages are within 75% of reference abundance and diversity. In particular, threatened fauna must be at 75 % diversity	Monitor revegetated sites following approved monitoring methodology	Annual monitoring every spring within first five years of revegetation and then once every five years for the following 10 years unless target has been reached
			Maintain and improve habitat condition by following recommendations from monitoring event	Target to be reached within 15 years Management actions throughout year as necessary
		Restore lengths of fallen logs per hectare to within 25% of reference condition	Fauna habitat components reinstated (fallen logs)	3 months after revegetation commences
6*	Implement revegetation program to restore pasture land to reference condition	Restore plant species richness and grass cover to within 75% of reference condition	Restoration activities including direct seeding	To be achieved within five years
			Monitor revegetated sites following approved monitoring methodology	Annual monitoring every spring within first five years of revegetation and then once every five years for the following 10 years or until target has been reached

* Note that Objective 6 is now to be incorporated into the annual rehabilitation inspection which is separate to the Annual Flora and Fauna Monitoring Program

2 Previous monitoring

Flora and fauna monitoring was initiated at Liddell Colliery by HLA-Envirosciences in 2005 (HLA 2005). Annual monitoring from 2006 to 2010 was undertaken by Umwelt (2008b, 2010, 2011) and in 2011 to 2013 by ELA.

During the 2005 to 2010 flora and fauna monitoring period at Liddell Colliery, the number of monitoring sites for flora and fauna has fluctuated, with some monitoring sites removed from the monitoring program and others added. The seasons in which surveys were conducted also differed between years. Furthermore, the surveys in 2010 and 2011 did not cover all monitoring sites; rather, Umwelt (2011) determined that biennial surveys were adequate for monitoring sites. As such, half of the flora and fauna sites were surveyed in 2010, and the remainder were surveyed in 2011, with the intention that sites monitored in 2010 would again be monitored in 2012, and sites monitored in 2011 would again be monitored in 2013.

Each survey year from 2005 to 2011 measured the parameters as outlined in the Landscape Management Plan for flora and fauna monitoring (Umwelt 2008a) (summary provided in **Table 2**). **Table 3** and **Table 5** summarise the annual flora and fauna monitoring effort and season at Liddell Colliery between 2005 and 2011. **Table 4** and **Table 6** provide the survey locations for 2012 to 2014.

Table 2: Variables measured during annual flora and fauna, and rehabilitation monitoring from 2005 - 2011, as specified in the Liddell Colliery Landscape Management Plan

Monitoring activity	Parameters monitored
Flora	Flora was monitored at four plots. Parameters monitored: • Cover abundance values • General health of vegetation • Evidence of natural regeneration • Occurrence and abundance of weed species • Signs of disturbance either by stock or humans • Evidence of feral animals • Any impacts from mining activities • Percentage of bare ground, log and rock present • Photo

Monitoring activity	Parameters monitored
Fauna (terrestrial)	Fauna was monitored at five sites. Parameters monitored: • Diurnal bird, herpetofauna, terrestrial mammal and microchiropteran bat species richness • Threatened species presence Measurements of habitat were also made. Parameters monitored: • Evidence of fire • Nature and extent of erosion • Extent of weed species • Presence of feral animals • Type of groundcover • Degree of dieback • Presence of mistletoe • Structure and floristics of vegetation cover • Number of habitat trees
Fauna (waterbirds, targeting Blue-billed Duck)	Waterbirds were monitored at seven dams (Dams 1, 3, 5, 6, 7, 13, and 17). Parameters monitored: • Waterbird species richness • Blue-billed Duck presence
Fauna (nest boxes)	Ten nest boxes at the Entrance Block near Dam 1 and Dam 3 (**Figure 3**) were assessed for: • The condition of the nest box, including the condition of the tree attachment • The presence of fauna and whether they are used by target fauna species • Predator use of the nest box

Table 3: Summary of annual flora monitoring at Liddell Colliery between 2005 and 2011

Survey year	Monitoring locations								Survey time	Notes
	Site 1 (Remnant)	Site 2 (Remnant)	Site 3 (Revegetated)	Site 4 (Remnant)	Site 6 (Revegetated)	Site 7 (Revegetated)	Site 8 (Revegetated)	Site 9 (Remnant)		
2005 (HLA)	X	X	X	X					Spring	
2006 (UMWELT)	X	X	X	X					Winter	
2007 (UMWELT)	X	X	X	X					Autumn	
2008 (UMWELT)	X	X	X	X					Autumn	
2009 (UMWELT)	X	X	X		X	X	X	X	Winter	Site 4 removed due to limited ecological value as a reference site and for its limited contribution toward the development of management recommendations for rehabilitation areas. Sites 6, 7, 8 and 9 were added to the monitoring program, one to replace Site 4, and three to begin monitoring revegetated sites.
2010 (UMWELT)	X	X			X		X		Spring	Following a review of the 2009 monitoring program, it was determined that biennial (two-yearly) monitoring was adequate. Thus, only half the sites were surveyed in 2010.
2011 (ELA)			X			X			Summer	ELA commissioned to undertake 2011 annual monitoring. Sites not surveyed in 2010 were targeted. Site 9 is located outside of Liddell Colliery. As such, this site was excluded from the monitoring program.

Source: Umwelt 2008b, 2010, and 2011; ELA 2012

Table 4: Annual flora monitoring locations at Liddell Colliery 2012, 2013 and 2014

Survey year	Monitoring locations											Survey time	Notes
	Site W01 (woodland remnant)	Site W02 (woodland remnant)	Site W03 (Woodland remnant)	Site R01 (riparian remnant)	Site R02 (riparian remnant)	Site WR01 (woodland revegetated)	Site WR02 (woodland revegetated)	Triangle Dam (macrophyte revegetation)	Dam 3 (macrophyte revegetation)	Site P01P (pasture revegetation)	Site P02P (pasture revegetation)		
2012 (ELA)	X	X		X	X	X	X	X	X	X	X	Summer	Based on the modifications and changes made to the monitoring program as a result of the flora and fauna monitoring review (ELA 2012a), new permanent flora monitoring locations were established.
2013 (ELA)	X	X	X	X	X	X	X	X	X	*	*	Summer	New permanent monitoring W03 site was established. Monitoring of Sites P01P and P02P were incorporated into the annual rehabilitation inspection.
2014 (ELA)	X	X	X	X	X	X	X	X	X	*	*	Summer	Monitoring of Sites P01P and P02P were incorporated into the annual rehabilitation inspection.

Source: ELA 2012 and 2013

Code: X – monitoring undertaken

* Note: now incorporated into the annual rehabilitation inspection which is separate to the Annual Flora and Fauna Monitoring Program

Table 5: Summary of annual fauna monitoring at Liddell Colliery between 2005 and 2011

Survey year	Monitoring locations																							Survey time	Notes
	Entrance Block	Mountain Block (revegetation)	Mountain Block (remnant)	Dam 13 (dam and vegetation to east)	Bowman's Creek	Dam 1	Dam 3	Dam 5	Dam 6	Dam 7	Dam 17	Dam 13 (dam only)	Nest boxes sites (Entrance Block)	Lake Liddell (seven locations)	Site 1 (equivalent to Entrance Block)	Site 2	Site 3 (equivalent to Mountain Block revegetation)	Site 5 (equivalent to Bowman's Creek)	Site 6	Site 7	Site 8	Site 9	Nest boxes sites (Mountain Block)	New Dam		
2005 (HLA)	X	X	X	X	X								?												Spring	
2006 (UMWELT)	X	X	X	X	X								?												Winter	
2007 (UMWELT)	X	X	X	X	X	X	X	X	X	X	X		?												Autumn	Six dams were added to the monitoring program to target Blue-billed Duck.
2008 (UMWELT)	X	X	X	X	X	X	X	X	X		X	X	X	X											Autumn	Dam 7 was dropped from the survey as this was drained just prior to the survey. Seven sites at Lake Liddell and Dam 13 were added to the survey to target Blue-billed Duck.
2009 (UMWELT)						X	X				X	X	X		X	X	X	X	X	X	X	X			Winter	New sites were added to the monitoring program, some of which overlap with the previous monitoring sites (Entrance Block overlaps with Site 1, Mountain Block rehab overlaps with Site 3, and Bowman's Creek overlaps with Site 5). Dams 5 and 6 were removed from the survey based on observations from previous years that they provided limited potential habitat for the Blue-billed Duck. Lake Liddell was dropped from the survey as the 2008 survey did not record any Blue-billed Ducks.
2010 (UMWELT)						X	X					X	X		X	X			X		X				Spring	Following a review of the 2009 monitoring program, it was determined that biennial (two-yearly) monitoring was adequate due to the consistent nature of the vegetation communities year to year and the highly dispersive nature of fauna within the study area. Thus, only half of the original sites were surveyed in 2010. Dam 17 was dropped from the survey due top steep banks and the lack of appropriate vegetative habitat.
2011 (ELA)						X	X					X					X	X		X			X	X	Summer	ELA was commissioned to complete the sites not surveyed in 2010. Site 9 is located outside of Liddell Colliery. As such, this site was excluded from the monitoring program. Nest boxes at the Entrance Block were removed so new nest boxes established in the Mountain Block area were surveyed. A new dam to the west of Dam 3 was surveyed at the request of LCO.

Source: Umwelt 2008b, 2010, and 2011; ELA 2012

Code: X – monitoring undertaken

? – data not available to indicate if monitoring was undertaken or not

Table 6: Annual fauna monitoring locations at Liddell Colliery 2012, 2013 and 2014

Survey year	Monitoring locations												Survey time	Notes
	W01 (woodland remnant)	W02 (woodland remnant)	W03 (woodland remnant)	R01 (riparian vegetation)	R02 (riparian vegetation)	WR01 (woodland rehabilitation area)	WR02 (woodland rehabilitation area)	Dam 1	Dam 3	Triangle Dam (upper and lower)	Mountain Block Dam	Nest box monitoring		
2012 (ELA)	X	X		X	X	X	X	X	X	X	X	X	Summer	Based on the modifications and changes made to the monitoring program as a result of the flora and fauna monitoring review (ELA 2012a), new permanent fauna monitoring locations – in conjunction with the flora monitoring locations were established.
2013 (ELA)	X	X	X	X	X	X	X	X	X	X	X	X	Summer	New permanent monitoring W03 site was established.
2014 (ELA)	X	X	X	X	X	X	X	X	X	X	X	X	Summer	Monitoring at all locations was undertaken

Source: ELA 2012 and 2013

Code: X – monitoring undertaken

3 Methodology

The flora and fauna monitoring survey was undertaken over 5 days from 1-5th December 2014. The surveys were undertaken by ELA Ecologist Lily Gorrell and Ecologist Emily Mowat (qualifications provided in **Table 7**).

Table 7: ELA field team and qualifications

Staff member	Role	Qualifications
Lily Gorrell	Ecologist	Bachelor of Natural Resource Management (Honours), University of New England, Armidale
Emily Mowat	Ecologist	Bachelor of Science (Honours), University of Sydney

3.1 Objective 1: Implement functional Blue-billed Duck habitat

Habitat enhancement was undertaken in 2011 which involved planting native aquatic vegetation at Dam 3 and Triangle Dam (upper) (a replacement for Mountain Block Dam) in accordance with the Blue-Billed Duck Management Strategy in Appendix 2 of the Landscape Management Plan (Umwelt 2008a).

Triangle Dam (upper) was part of the monitoring process for Objective 1 in 2012, 2013 and 2014, however both Triangle Dams are currently being used as part of a temporary cattle grazing trial utilising the paddocks immediately surrounding the Triangle Dams; for this purpose the short-term management of both Triangle dams is providing for the watering of stock rather than for the management of functional Blue-billed duck habitat.

Since the 2013 monitoring there has been little improvement to these dams in regards to creating functional Blue-billed duck habitat. As such it is recommended that either cattle be excluded from these areas and further effort be made to enhance the triangle dams for the Blue-billed Duck or alternatively another dam or waterbody (e.g. Dam 6, Dam 1) be nominated the second area for which habitat is enhanced/created for this species. This allows for the Triangle Dams, and surrounding paddocks to continue to be used for the purposes of the grazing trial. If the second option is chosen then efforts should be focused on planting and establishing suitable aquatic plant species in and around the chosen Dam/waterbody.

The monitoring program for Objective 1 involved an assessment of the following environmental values.

3.1.1 The general health, densities and species diversity of the terrestrial and aquatic vegetation associated with the dams

This involved a permanent 50 m transect being installed along the edge of Dam 3 and Triangle Dam (upper) (**Figure 2**). The transect was marked by installing a 900 mm star picket with yellow cap at 0 and 50 m, respectively. The density and diversity of aquatic, emergent and terrestrial vegetation within 3 m either side of the transect was recorded. Cover abundance of each species was provided utilising the Braun-Blanquet scale as presented in **Section 3.2.1**. Additionally the presence and extent of any aquatic or terrestrial weeds, evidence of introduced fauna, presence of information signage (relating to the presence of Blue-billed Duck habitat) and evidence of pesticide and herbicide runoff was assessed (areas of unexplained plant/fauna death).

3.1.2 Macroinvertebrate Sampling

It was agreed with LCO that macroinvertebrate sampling was not to be undertaken as part of this year's monitoring and as such does not form part of this report. The reasoning behind this was in regard to the data received during the macroinvertebrate sampling in 2013. This data indicated that the water quality and vegetation at the Blue-billed Duck sites requires management in order to support a higher diversity and abundance of macroinvertebrates. It was suggested that monitoring of only water quality and vegetation is necessary for 2014, as it is unlikely that sufficient changes to macroinvertebrates would have occurred over the preceding 12 months. It was considered that the data obtained from water quality and vegetation monitoring would sufficiently indicate the health of the Blue-billed Duck sites.

3.1.3 The numbers of Blue-billed Ducks utilising Dam 3 and Triangle Dams

This involved observing the dam surface, the shore, and any emergent vegetation habitats present at Dam 3 and Triangle Dams using a 60 x magnification spotting scope and 10 x 42 binoculars (**Figure 3**). Survey effort was in accordance with the species-time curve approach as described in the NSW Department of Environment and Conservation Threatened Biodiversity Survey and Assessment Guidelines (DEC 2004). This method requires the survey to be undertaken for a minimum of 20 minutes. After the 20 minute period, each new species that is recorded triggers a further 5 minutes of survey effort. All bird species were identified based on their calls, flight patterns and visual observations, and were recorded as either within, outside or flying over the dams.

3.1.4 Water quality

Water quality measurements were obtained from LCO as part of their monthly water monitoring program. This testing did not include the Triangle (Upper or Lower) dams and as such no comparison can be made with the previous year's results. Water quality testing included measuring for pH, Conductivity, Total suspended solids (TTS) and total dissolved solids (TDS) and are presented in **Table 8** for dams 3 and 6.

Figure 2: Flora monitoring locations

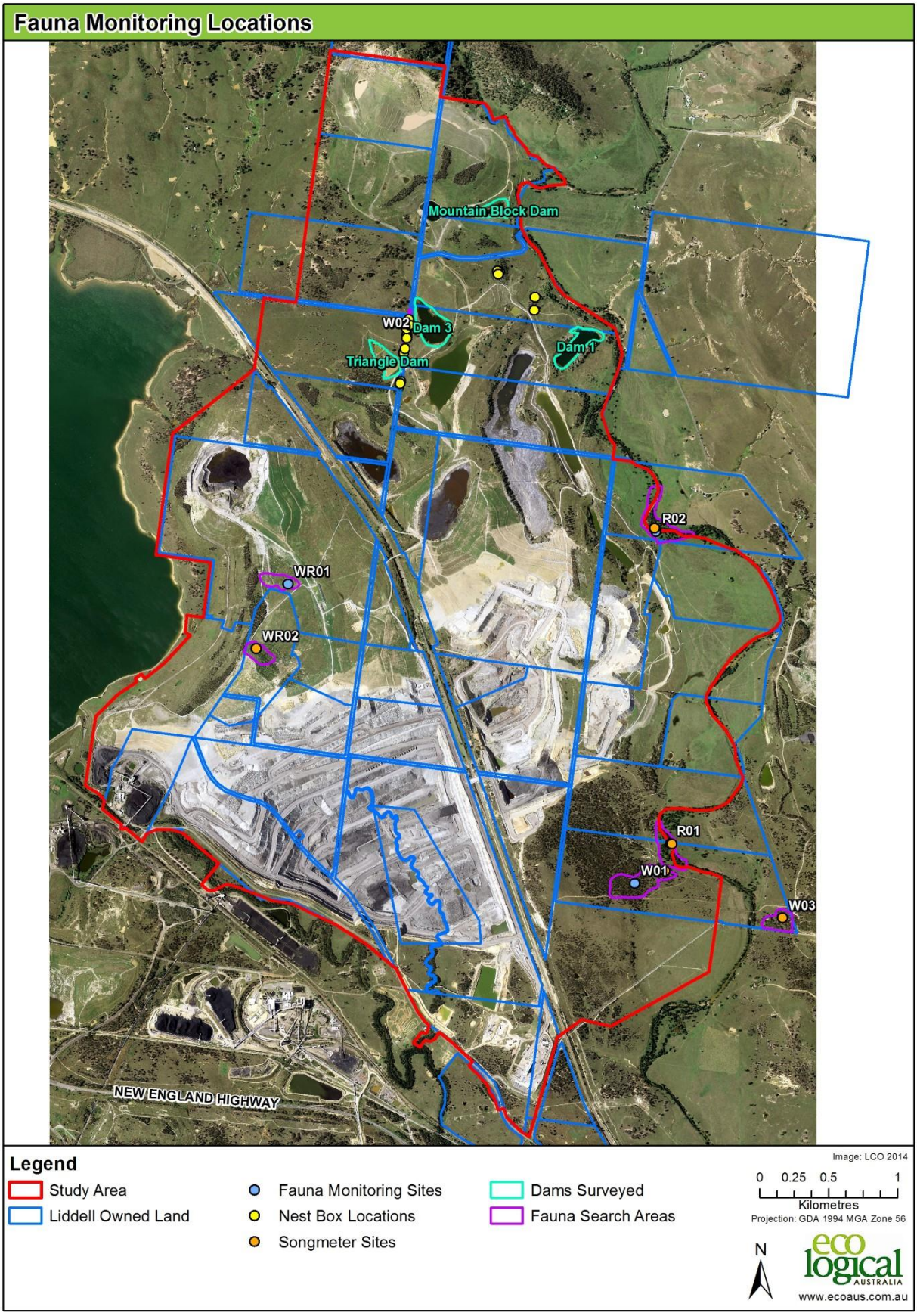

Figure 3: Fauna monitoring locations

3.2 Objective 2: Avoid impacts from mining operations on remnant vegetation within Liddell Colliery

3.2.1 Floristics

Permanent flora plots within native remnant vegetation patches were installed, with three woodland and two riparian sites (**Figure 2**). Only two woodland sites were installed as part of the 2012 baseline surveys, an additional monitoring site was added (W03) during the 2013 monitoring to compensate for the future loss of a monitoring site (W01) which will be removed due to mine expansion. To ensure accurate monitoring in subsequent years, the start and end of the 50 m transect was marked with a star picket and yellow cap. The four corners of the 20 m x 20 m plot were marked with a pink marking flag **(Figure 4)**.

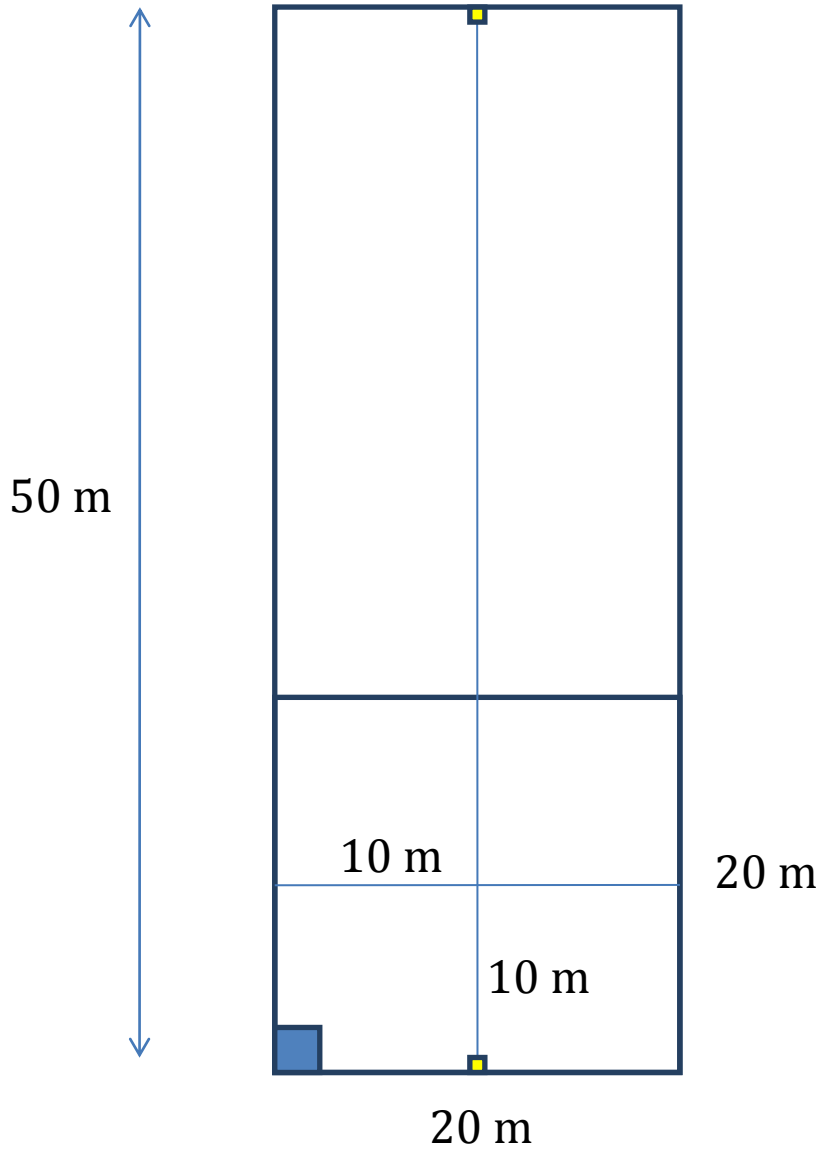

Figure 4: 50 m x 20 m vegetation plot with 20 m x 20 m, 10 m x 10 m and 1 m x 1 m nested vegetation sub-plots

The methodology used for the flora plots involved the following parameters being recorded within a permanent plot and the surrounding vegetation community (vegetation zone) at each site following the Bio Banking methodology (DECC 2008):

- full floristics (including cover abundance) in 0.04 ha plot (20 m x 20 m)
- general health of vegetation in whole vegetation zone
- evidence of natural regeneration in whole vegetation zone
- occurrence and abundance of weed species in 0.04 ha plot (20 m x 20 m)
- signs of disturbance either by stock or humans in whole vegetation zone
- evidence of feral animals in whole vegetation zone
- any impacts from mining activities in whole vegetation zone
- percentage of bare ground, logs and rock present within the 50 m x 20 m survey area
- photo (facing left, centre and right from star picket at start of 50 m transect).

The abundance of each species in the 0.04 ha plot was estimated, using a modified Braun-Blanquet scale (Braun-Blanquet 1927), as follows:

- 1 = few, small cover (<5%)
- 2 = numerous (<5%)
- 3 = 5 – 20%
- 4 = 20 – 50%
- 5 = 50 – 75%
- 6 = >75%

As part of the vegetation monitoring two additional sub-plots were also carried out. The sub-plots were in a nested configuration in relation to the 20 m x 20 m plot location with the origin located to the left of the central star picket. The two sub-plots established include a 1 m x 1 m plot in the left front corner of the 0.04 ha plot and a 10 m x 10 m plot originating at the same location **(Figure 4)**. Within both plots all species present were recorded. In addition, the number and species of individual plants growing between 1 and 5 m in height in the 10 m x 10 m sub-plot were recorded. Within the 1 m x 1 m sub-plot, the number and species of individual plants less than 1 m in height were recorded.

All vascular plants species were recorded and identified to the lowest taxonomic level possible, with samples of unknown species collected for further identification. Nomenclature followed the Flora of New South Wales (Harden 1992; 1993; 2000; 2002), and any subsequent recent taxonomic changes as presented on PlantNET (RBGDT 2014) and other specific botanical sources.

3.3 Objective 3: Avoid impacts from mining operations on native fauna that utilise habitat within Liddell Colliery (especially threatened fauna)

Permanent fauna survey sites were established within native remnant vegetation patches; three in woodland habitats and two in riparian habitat areas (**Figure 3**) following the initial monitoring design. Target fauna assemblages were selected to focus survey effort on fauna groups most likely to show changes in abundance or distribution due to the influence of mining operations. As a result, the following fauna were targeted in this monitoring program:

- Diurnal woodland birds
- Microchiropteran bats
- Spotted-tailed Quoll
- Blue-billed Duck and other waterbirds
- Hollow-reliant fauna utilising nest boxes.

3.3.1 Diurnal woodland bird surveys

Morning and afternoon diurnal bird surveys were undertaken at each monitoring site within the first four hours / last four hours of sunlight (**Figure 3**). The survey consisted of slowly walking transects within a 2 ha survey area. Bird species were identified based on their calls, flight patterns and visual observations through 10 x 42 and 8 x 42 binoculars. Their location was recorded as either within, outside or flying over the 2 ha survey area. Survey effort was in accordance with the species-time curve approach as described in the NSW Department of Environment and Conservation Threatened Biodiversity Survey and Assessment Guidelines (DEC 2004). This method requires the survey to be undertaken for a minimum of 20 minutes. After the 20 minute period, each new species that is recorded triggers a further 5 minutes of survey effort.

All opportunistic observations were also recorded during the survey period.

3.3.2 Microchiropteran bats

For the identification of bats on the Liddell site Songmeter devices were placed at five of the six survey localities over four nights. Each songmeter device was directed along a potential flyway in the woodland and riparian sites. A time delay was programmed such that the songmeter records calls from prior to dusk until after dawn. Bat calls were analysed by a suitably qualified Ecologist and assigned to four levels of confidence as per Mills et al. (1996): definite, probable, possible, and unknown. Only species or species groups that have been identified to a definite or probable level have been included within this report. Bat activity was calculated using calls identified to a “definite” and “probable” confidence level.

Note: due to technical issues a songmeter was not positioned at one of the woodland rehabilitation sites (WR01).

3.3.3 Mammal species (inc. Spotted-tailed Quoll)

A motion sensor remote camera was installed at all six sites and directed toward a plastic bait station, baited with fish (Tuna). The bait station and camera set-up was positioned in a high fauna activity area (i.e. along or adjacent to a used fauna track) to increase the chances of attracting fauna to the bait. The camera was programmed to take five images each trigger event with a one second delay between triggers. The remote cameras were active for four nights and all photographs were downloaded and analysed.

All opportunistic observations were also recorded during the survey period.

3.3.4 Waterbirds

Dam surveys of Dam 1, Dam 3, Triangle Dam (upper and lower) and Mountain Block Dam (**Figure 3**) focused on searching for Blue-billed Ducks as well as recording all bird species and the number of each species using the dams at the time of survey. Dam 3 and Triangle Dam were also surveyed to address Objective 1 in addition to Objective 3. The waterbird survey involved observing the dam surface, the shore, and any emergent vegetation habitats present for 20 minutes using a 60 x magnification spotting scope and 10 x 42 binoculars. All bird species were identified based on their calls, flight patterns and visual observations, and were recorded as either within, outside or flying over the dams.

This waterbird survey was carried out in conjunction with the Blue-billed Duck surveys described in section 3.1.3 of Objective 1.

3.3.5 Nest box monitoring

Using a remote camera attached to the end of an extendable pole nest boxes were monitored for evidence of use by fauna, such as microchiropteran bats, native arboreal mammals, reptiles and hollow dependant birds. The condition of the nest boxes was also assessed including any collapsing joints, removed lids, bowing timber and/or timber perishing with age.

The five nest boxes north-west of Dam 1 and the nine nest boxes west of Dam 3 were monitored (**Figure 3**).

3.3.6 Habitat assessment

A habitat assessment was also undertaken in a permanent 50 m x 20 m plot established at each site. This assessment ensures habitat features required by native fauna are maintained in accordance with the performance targets specified. In particular, the habitat features that were recorded are:

- general health of vegetation
- evidence of natural seedling recruitment
- occurrence and abundance of weed species
- structure and floristics of vegetation cover
- signs of disturbance, either by stock, humans or feral animals
- nature and extent of erosion
- evidence of fire
- characteristics of ground cover (e.g. litter, logs, rock, soil)
- nectar or fruit resources and perch sites
- water resources
- secondary evidence of fauna occupation such as scats, diggings or tree scratches.

3.4 Objective 4: Implement revegetation program to restore disturbed areas designated for native vegetation to pre-mining condition

3.4.1 Floristics

Permanent flora plots within areas of native rehabilitation and native remnant vegetation patches were installed (**Figure 2**) according to the design in Figure 4. To ensure accurate monitoring in subsequent years, the start and end of the 50 m transect was marked with a star picket and yellow cap. The four corners of the 20 m x 20 m plot were marked with a pink marking flag (**Figure 4**).

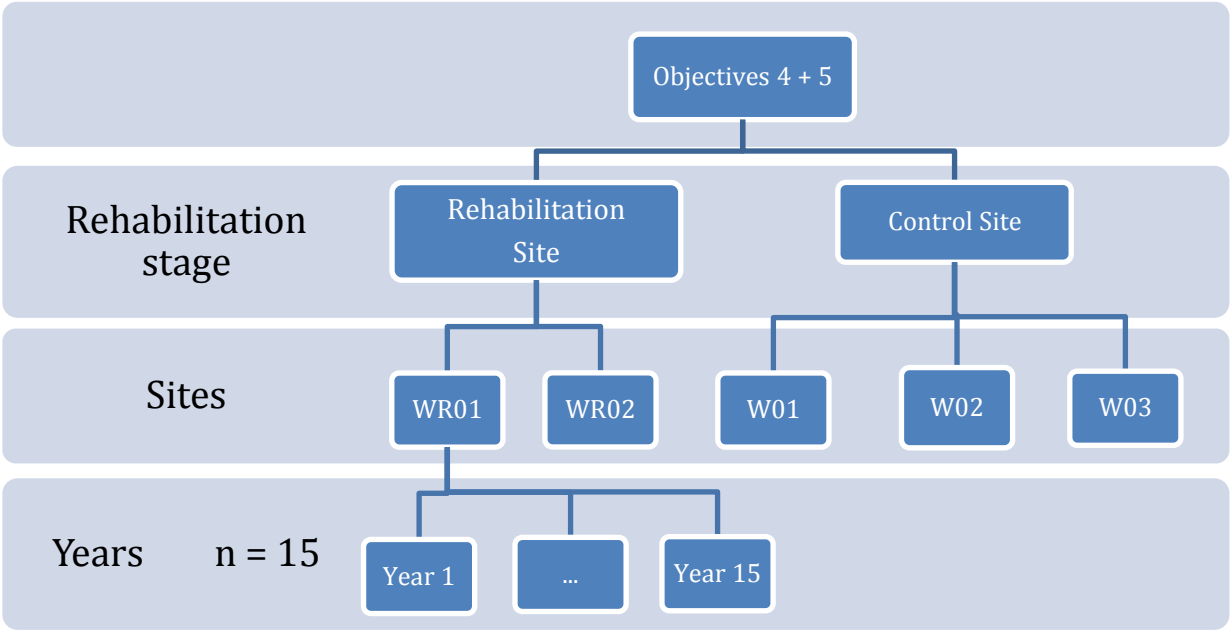

Figure 5: Monitoring design for Objectives 4 and 5

Data for the two control sites was obtained from field work undertaken to address Objective 2. Hence, additional works to address Objective 4 involved undertaking flora plots at two sites within the area of native rehabilitation at the WR01 and WR02 (RL-195 Dump South-Cut Site). Areas that are rehabilitated with native vegetation in subsequent years will be added to this design.

The methodology used for the flora plots was as described in **Section 3.2**.

3.4.2 Landscape Function Analysis

It was agreed with LCO that LFA was not to be undertaken as part of the 2014 monitoring and as such does not form part of this report.

3.5 Objective 5: Native revegetation supports native fauna (especially threatened species) at similar diversity and abundance to pre-mining condition

Permanent fauna survey sites were established within native remnant woodland habitat (W01 and W02 in 2012; W03 in 2013) and woodland rehabilitation (WR01 and WR02) (**Figure 3**) following the monitoring design in Figure 4. Data for the two remnant woodland sites was obtained from field work undertaken to address Objective 3. Hence, additional works to address Objective 5 involved diurnal woodland bird surveys, Songmeter recording of microchiropteran bat calls, remote camera detection of Spotted-tailed Quoll and other fauna species and a habitat assessment at two woodland rehabilitation sites. The specific methodology required for each of these surveys is outlined in **Section 3.3**. In subsequent years, additional sites will be added to this program to account for the increase in the extent of rehabilitation area.

3.6 Objective 6: Implement revegetation program to restore pasture land to reference condition

Note that Objective 6 has now been absorbed into the monitoring component of the Annual Rehabilitation Inspection which specifically addresses the pasture rehabilitation areas of LCO.

4 Results and discussion

The results obtained from the 2014 monitoring event have been used to assess which performance targets have been met. An outline on the progress and whether management actions are required is displayed in tables and discussed further at the end of each objective. For those performance targets that still require management actions, recommendations have been discussed in **Section 4.6.**

4.1 Objective 1: Implement functional Blue-billed Duck habitat

4.1.1 Blue-billed duck survey

Dam 3 contained the largest number and highest diversity of waterbirds of all the dams surveyed during 2014, although no Blue-billed Ducks were observed during waterbird surveys at Dam 3 or Triangle Dam. Blue-billed Ducks have not previously been recorded at either of these dams (ELA 2012, 2013). Blue-billed Ducks were previously observed in Dam 13 (now drained and to the south of Dams 3 and Triangle) during the 2005, 2006, 2007 and 2009 monitoring surveys.

4.1.2 The general health, densities and species diversity of the terrestrial and aquatic vegetation associated with the dams

The Blue-billed Duck is thought to prefer deep water in large permanent wetlands and swamps with dense aquatic vegetation which support its diet of seeds, buds, stems, leaves, fruit and small aquatic insects and provide dense vegetation in which to breed (DEH 2012). Little remains of the vegetation planted in 2011 at the lower triangle dam and there is marginal growth along one edge of the upper triangle dam (**Plate 1**) and as such both dams, at this stage lack the density and diversity of aquatic vegetation preferred by the Blue-billed Duck. Both Triangle Dams contain very little aquatic vegetation and the grasses that are present are quite in limited in both density and height. One of the main reasons for the limited amount of aquatic vegetation and grass growth is expected to be as a result of cattle trampling and grazing.

In contrast to the poor growth of planted vegetation in the Triangle Dams, the planted macrophytes in Dam 3 are now well established. The plantings and subsequent growth since 2011 in Dam 3 are in the process of providing developing functional Blue-billed Duck habitat. Additional, details of the dam vegetation is provided in **Section 4.1.5**.

4.1.3 Water quality

Water quality at Dam 3 and Dam 6 generally exceeded ANZECC guidelines for slightly disturbed freshwater lakes and reservoirs of South-Eastern Australia. Shaded values in **Table 8** indicate where water quality parameters were outside these guidelines. 2013 water quality testing included measuring for Dissolved oxygen saturation, total phosphorus, total nitrogen and total alkalinity. These were not included in testing conducted by LCO and so have not been included in the monitoring results. Triangle dams were also not included in the monthly monitoring undertaken by the LCO and as such results have been taken from the December 2014 monitoring of Dam 3 and Dam 6 only.

Table 8: Water quality parameters at Dam 3 and Triangle Dam for month of December 2014

Dam	pH	Conductivity (ppm)	Total Suspended Solids (TSS)(mg/L)	Total Dissolved Solids (TDS)(mg/L)
Dam 3 2013	8.9	4720	7	2640

Dam	pH	Conductivity (ppm)	Total Suspended Solids (TSS)(mg/L)	Total Dissolved Solids (TDS)(mg/L)
Dam 6	8.4	6400	21	4660
ANZECC guidelines *	6.5-8.0	12.8-19.2	1-20	2400**

* Guidelines for freshwater lakes and reservoirs. The values represent the default trigger values for south-east Australia for slightly disturbed ecosystems. For alkalinity, no recommended guideline was available, so the value represents the guideline for protection of aquaculture species.

** Guidelines from ANZECC relating to tolerances of livestock to TTS in drinking water

Note: Shaded values indicate where water quality parameters were outside of guidelines

4.1.4 Macroinvertebrate survey

It was agreed with LCO that macroinvertebrate sampling was not to be undertaken as part of this year's monitoring and as such does not form part of this report.

As indicated in the Methodology (**Section 3.1.2**), the reasoning why a macroinvertebrate survey was not undertaken in 2014 was in regard to the data received during the macroinvertebrate sampling in 2013. This data indicated that the water quality and vegetation at the Blue-billed Duck sites required management in order to support a higher diversity and abundance of macroinvertebrates and nesting habitat. It was suggested that monitoring of only water quality and vegetation is necessary for 2014, as it was unlikely that sufficient changes to macroinvertebrates would have occurred over the preceding 12 months. It was considered that the data obtained from water quality and vegetation monitoring would sufficiently indicate the health of the Blue-billed Duck sites for 2014.

4.1.5 Flora transect monitoring

Table 9 provides the results of the vegetation survey carried out at both dam survey sites. At Dam 3 we were unable to locate either the start or end star pickets of the 50 m transect. This may be due to the flooding event in 2013 and may have caused the pickets to come loose. Based on the previous reports and discussion with 2013 survey staff the transect was conducted as close as possible to the original location. The survey results between 2013 and 2014 show a significant increase in the density, width and height of the planted aquatic vegetation at the edge of Dam 3 which is positive in establishing functional Blue-billed duck habitat.

Cattle were observed at the edges of the Lower Triangle Dam and subsequent grazing was evident at this dam and surrounding pasture areas. The upper Triangle Dam and surrounding pasture did not appear to show signs of cattle with the dam edge intact and moderate growth of macrophyte vegetation. There is fencing around the dam, however cattle have not been excluded from the area as it still forms part of the cattle grazing trial. On consultation with LCO staff cattle seem to prefer the lower Triangle Dam as they are regularly observed at this dam. There appeared to be no evidence of herbicide or pesticide runoff at either survey area. Fencing that effectively excluded cattle and Blue-Billed Duck habitat signage was observed at Dam 3 (**Plate 4**).

Vegetation in the transition areas between dam edge and the grassland contain few native species, considerable bare ground and exotic species including *Plantago lanceolata* (Lamb's Tongues) and *Paspalum dilatatum* (Paspalum). Species planted include *Typha orientalis* (Bulrush), *Juncus usitatus* (Common Rush) and *Schoenoplectus validus* (River Club-rush). Weed species were present at both locations. No submerged aquatic vegetation was evident in either of the Triangle Dams at the time of

the survey, although the aquatic plant *Vallisneria australis* (Ribbonweed) was common in Dam 3. *Vallisneria australis* is a useful native aquatic plant for the provision of habitat and as a food source for macroinvertibrates, as such the species is considered as beneficial in the establishment of Blue-billed Duck habitat.

Note: In the fenced area surrounding Dam 3 two invasive weed species were observed, being *Opuntia stricta* (Prickly Pear) and *Galenia pubescens* (Galenia). These weed species will need to be controlled in this area.

Table 9: Results of 2013 and 2014 flora transect monitoring

Site	Indicator	Terrestrial species		Aquatic species		Cover	
		Native	Exotic	Native	Exotic	Vegetative	Bare earth
* Dam 3 2013	Counts	-	-	3	0	-	-
	Native Composition	-		100% native		-	
Dam 3 2014	Counts	3	3	3	0	80%	20%
	Native Composition	50%		100% native		75%	
Triangle Dam (upper) 2013	Counts	3	13	2	0	20% total	80%
	Native Composition	11.54% native		100% native		6% native	
Triangle Dam (upper) 2014	Counts	5	4	3	0	58% total	42%
	Native Composition	55% native		100% native		51% native	

* Dam 3 was in flood at the time of the 2013 inspection.

Plate 1: Vegetation transect showing a moderate increase in both aquatic and terrestrial species

Plate 2: Photo from 2013 showing reduced vegetation compared with 2014 (above)

Plate 3: Moderately intact waters edge at Triangle Dam (Upper).

Plate 4: Blue-billed Duck fencing and signage around Dam 3

4.1.6 Analysis of performance targets and actions required

Table 10: Performance targets, results and whether action is required to meet targets

Objective	Performance target(s)	Result	Preventative or remedial action required?
Implement functional Blue-billed Duck habitat	Blue-billed Ducks are observed in dams where habitat has been enhanced	Blue-billed Ducks not observed to date	**Yes**
	No decrease in native species diversity and habitat structure when monitoring events are compared	Triangle Dams require vegetation to become suitable for Blue-billed Duck **	**Not as yet****

4.1.7 Discussion on performance and actions required

Blue-billed Duck was not observed within Dam 3 or Triangle Dam (upper or lower). The largest numbers and diversity of waterbirds were recorded on Dam 3 where some aquatic vegetation exists.

Blue-billed Ducks inhabit fresh to saline waters of primarily deep permanent open wetlands and deep, densely vegetated lakes and dams. Blue-billed ducks are likely to migrate or re-establish to other areas either locally or more widely if existing habitat becomes unsuitable or sub-optimal, as is the case for the decommissioned and drained LCO Dam 13. At this stage Blue-billed Ducks have not been lured back into using the dams of LCO due to the habitat not being optimal or the habitat being better at other off-site locations. It is likely that after more years of dam establishment (e.g. higher macrophyte distribution and density, restriction of cattle access as well as favourable weather conditions) there will be a higher probability of Blue-billed Ducks utilising the Dams. It must be noted that the aquatic vegetation was initially established as planted seedlings in 2011 and as such is still in a developing process.

Cattle have been excluded from Dam 3 since November 2012 by the installation of appropriate fencing. Habitat enhancement measures in both Triangle Dam areas are compromised by the access and presence of cattle due to the cattle grazing trial, although appropriate habitat creation species have been planted. Measures to exclude cattle from the dams and remediate and augment these areas are recommended to improve function for Blue-billed Duck. Alternatively another dam or waterbody (e.g. Dam 6, Dam 1) be nominated as the second area for which habitat is enhanced/created for this species. Dam 3 vegetation, including the planted macrophyte areas, are improving in density and quality since the previous survey in 2013, with fencing creating a barrier from cattle disturbance of the area. Dam 3 is currently regarded as having sections of moderate quality Blue-billed Duck habitat.

Supplementary dam plantings (tubestock) should be carried out in Autumn or Spring and placed in a clumping or grouping arrangement to ensure dense plant growth (i.e. eight to ten plants per sq./m) and should be done in conjunction with any woody debris placement. Suitable species for planting include: *Juncus usitatus*, *Schoenoplectus validus*, *Carex appressa*, *Typha orientalis* (Cumbungi), *Phragmites australis* (Native Reed), *Eleocharis sphacelata* (Tall Spike Rush), *Philydrum lanuginosum* (Frogs-mouth), *Alisma Plantago-aquatica* (Water Plantain) and *Lomandra longifolia* (Spiny-headed Mat-rush). Additional recommendations in regard to Blue-billed Duck habitat creation are presented in **Section 5**.

While many of the measured water quality parameters exceeded ANZECC guidelines, water chemistry in dams, lakes and reservoirs is influenced by local geology, soils, groundwater inputs as well as external human induced factors such as land-use practices within the catchment area.

The pH measured in both Dam 3 and 6 were just above the guideline range for suitable pH levels. The conductivity at both dams was well above the ANZECC guidelines. Total suspended solids (TSS) was within normal range for Dam 3 and only just outside normal range for dam 6. The guideline threshold level used for Total dissolved solids (TDS) has been based upon the levels indicated as tolerable for drinking from a range of stock including beef cattle, sheep, horses and poultry, etc. The range of TDS is not outside the tolerable range for a few of these animals however, it is stated in the guidelines that if the TDS concentration is above 2400 mg/L, the water should be further analysed to determine the concentrations of specific ions (ANZECC 2000).

ANZECC guidelines for freshwater lakes and reservoirs, although not ideal, are currently the most appropriate guidelines to use for constructed dams. Due to the presence of nine species of waterbirds at Dam 3 and 15 recorded more widely across the LCO site in the past three survey years, the sites dams do constitute suitable habitat for a growing number of waterbird species. Additionally, the level of growth of the planted vegetation, particularly in Dam 3 over the preceding years since planting, indicate that the requirements in regard to plant growth are suitable for a variety of species.

Improvements to aquatic vegetation diversity and structure, along with improvements in water quality could be achieved by:

- Excluding stock from the Triangle Dams and augment areas of aquatic vegetation; or alternatively select another dam or waterbody (e.g. Dam 6, Dam 1) for the purpose of creating functional Blue-billed Duck habitat.
- Supplementary planting of macrophytes in Dam 3 (as indicated above).
- Incorporating weed control (targeting noxious and highly invasive species) in the fenced area of Dam 3.

4.2 Objective 2: Avoid impacts from mining operations on remnant vegetation within Liddell Colliery

Diversity and structure maintained or improved when compared amongst monitoring events (unless explained by natural causes, i.e. drought).

The following section provides information on the condition, species richness and composition, canopy cover and general vegetation descriptions at each of the five established permanent vegetation plots within native remnant vegetation patches (**Figure 2**). **Table 12** provides a summary of the findings of all five vegetation plots.

4.2.1 Plots location descriptions

Woodland Vegetation W01 - *(Equivalent biometric community type - Grey Box - Narrow-leaved Ironbark shrubby woodland on hills of the Hunter Valley, North Coast and Sydney Basin)*

Vegetation at this location was in a state of regeneration and primarily dominated by mature, although young, *Allocasuarina luehmannii* (Bulloak). Scattered individuals of *Eucalyptus crebra* (Narrow-leaved Ironbark) and *Eucalyptus moluccana* (Grey Box) were present in the wider community although in low numbers and not within the W01 plot. The site shows evidence of past clearing and currently forms an open grassy woodland with a projected canopy foliage cover of 4%. The reduction in grass cover in this year's monitoring as compared to the 2013 monitoring may be attributed to the higher than average

rainfall (BOM 2014) that fell in the month prior to 2013 monitoring which may have led to an increase in general groundcover. The plot is situated on a gentle slope of approximately 2 degrees having a north-west aspect.

Woodland Vegetation W02 *- (Equivalent biometric community type - Grey Ironbark - Spotted Gum - Grey Box open forest on hills of the Hunter Valley, Sydney Basin)*

The vegetation at this location comprised a remnant of mature eucalypt dominated woodland. The site and adjacent timbered areas comprise a narrow band of remnant timbered woodland and forms a grassy open woodland community. All adjacent areas have been cleared and contain grassland or scattered remnant trees or young regrowth. The plot is situated on a moderately gentle slope of approximately 3 degrees having a southerly aspect. Domestic stock damage is evident in and the site has both stock and vehicular tracks crossing this linear patch of remnant vegetation.

The canopy is predominantly dominated by mature *Corymbia maculata* (Spotted Gum), but also contains scattered *E. moluccana*. Some remnant *Eucalyptus tereticornis* (Forest Red Gum) are present in the southern and lower elevated portion of this community, although not within the actual plot.

Woodland Vegetation W03 *- (Equivalent biometric community type - Grey Box - Narrow-leaved Ironbark shrubby woodland on hills of the Hunter Valley, North Coast and Sydney Basin)*

This community, which is contiguous with stands of similar vegetation on the adjacent property, was located to the east of Bowmans Creek in lands outside the LCO DA boundary but within the boundary of Liddell owned land. This community was in good condition both structurally and from a disturbance perspective, and additionally contained weeds at an easily managed level. The community canopy was dominated by mature and some regenerating *Eucalyptus crebra* and *Eucalyptus moluccana* with a projective foliage cover in the range of 15-20 %. Tree height averaged 15m, although some specimens were 20+ m. Numerous tree seedlings were evident, mostly being *Allocasuarina luehmannii* (Bulloak) within the generally open grassy understorey.

The plot was situated on a gentle slope of around 3 degrees with a south-west aspect. Areas adjacent to the north are primarily cleared of trees but contain a high density of native grass and herbaceous species. To the south the vegetation is similar to the surveyed area but generally in a more disturbed state. There is little evidence of impacts from cattle, with only a few fairly old hoof marks imprinted into the soil. There is evidence (scats), as well as visual observations of rabbits in the area.

Riparian Vegetation R01 *- (Equivalent biometric community type - River Oak riparian woodland of the North Coast and northern Sydney Basin)*

R01 was located adjacent to the western side of Bowmans Creek and comprises a canopy dominated by *Casuarina cunninghamiana* (River Oak) and a disturbed understorey with a moderate to high cover of exotic vegetation. At this location the majority of trees in the near vicinity of the current watercourse are generally of a younger age and size than those located further from Bowmans Creek. Areas of rock and logs are evident within the plot and adjoining areas as evidence of past flooding events as well as log jams and debris in trees.

Riparian Vegetation R02 *- (Equivalent biometric community type - River Oak riparian woodland of the North Coast and northern Sydney Basin)*

R02 was also located along Bowmans Creek to the north of plot R01. The vegetation at this location was similar in most aspects to R01. Evidence of cattle was observed in this area and have direct access to Bowmans Creek.

Table 15 indicates the floristic plot performance and any actions resulting from the plot monitoring surveys.

Table 11: GPS locations of remnant native vegetation monitoring sites

Monitoring site	GPS co-ordinates	
W01	315861.64855563	6413965.79069626
W02	314210.93310436	6417934.75159192
W03	316906.77008880	6413699.73017075
R01	316121.90179060	6414254.97752707
R02	316016.27564728	6416515.98539011

Table 12: Structure of remnant woodland sites, 2014

Measurement	W01	W02	W03	R01	R02
Native plant species	25	26	24	11	15
Native over-story (%)	4	25	17	18	23.5
Native mid-story (%)	0	0	0	0	0
Native grass cover (%)	18	28	34	44	16
Native shrub cover (%)	0	0	0	0	0
Native other (%)	8	0	12	2	2
Exotic plant cover (%)	0	20	0	32	32
Leaf litter/woody debris (%)	66	42	46	32	48
Bare ground/rock (%)	4	14	10	0	0
Cryptogam (%)	0	0	0	0	0
Number of hollow-bearing trees	0	12	1	2	0
Proportion of overstorey regenerating	1	0.5	2	1	0
Fallen logs (m)	34	32	7	0	67

Table 13: Floristic plot performance and required actions

Objective	Performance targets	Site code	20 x 20 m plots						Action required
			No. of introduced plant species 2012	No. of introduced plant species 2013	No. of introduced plant species 2014	No. of native species 2012	No. of native species 2013	No. of native species 2014	
Avoid impacts from mining operations on remnant vegetation within Liddell Colliery	Diversity maintained or improved when compared amongst monitoring events (unless explained by natural causes i.e. drought)	W01	11	15	7	25	28	25	**No***
		W02	7	9	8	26	26	26	**No**
		W03	Site added 2013	7	6	Site added 2013	28	24	**No***
		R01	25	11	17	11	10	10	**No**
		R02	31	23	21	25	13	15	**No****

*Slight reduction in species diversity attributed to drier conditions in 2014 as opposed to optimal growing conditions in 2013.

** Reduction in native species numbers at R02 in 2013 and 2014 are due to high flow flooding events in the survey plot location – scouring has temporarily removed herbaceous native species and allowed a suite of opportunistic annual exotic species to establish.

Discussion on performance and actions required

The results indicate that there are no direct mining impacts to the vegetation within and immediately surrounding the five control monitoring plots, as no obvious clearing or plant and equipment incursions or subsidence is obvious. It is noted that the woodland area containing W01 will be incorporated into the mining production footprint of LCO in the near future.

Species densities is relatively similar across the three woodland sites. Both W01 and W02 have similar results to 2012 although there seems to be a slight decrease in introduced species as compared to 2013, likely due to rainfall events prior to the 2013 surveys and opportunistic growth by some annual weed species. The slight reduction in species diversity across both W01 and W03, as compared to the 2013 monitoring results may also be attributed to opportunistic growth of some native species during optimal rainfall periods in 2013 with a reduction occurring in 2014 due to drier conditions.

In the riparian sites species diversity has remained relatively consistent between 2013 and 2014. Reduction in native species numbers at R02 in 2013 and 2014 in comparison to 2012 are due to high flow flooding events in the survey plot location just prior to the survey period; the related scouring has temporarily removed herbaceous native species and allowed a suite of opportunistic annual exotic species to establish. The exception to this is R01 which had a moderate increase in introduced species

from 2013 to 2014 and is most likely attributed to optimal growing conditions for certain opportunistic weed species.

Results from the 1 x 1 m and 10 x 10 m survey plots are in line with the results of the overall 20 x 20 m plot and show no significant changes from 2013 to 2014 surveys.

No evidence of natural dieback was noticed at any of the five reference sites. There was evidence of cattle, particularly at W02 and R02 sites.

- There is an issue with cattle utilising the remnant woodland vegetation in the vicinity of W02. It is evident that cattle are using this area as it provides a shaded location. This however, is leading to trampling of fallen timber and ground hollows and creating large areas of bare ground, making it difficult for plants to establish and grow successfully and reducing viable habitat for various reptile and other ground dwelling species. To ensure the long-term enhancement of the vegetation and habitat, cattle need to be fenced out of this area with a narrow pathway retained where the existing vehicular track is present to allow access east to west. Fencing should include all regrowth areas beyond the existing mature trees.
- The riparian vegetation along Bowmans Creek in the vicinity of monitoring site R02 should be considered for exclusion of stock to help enhance the habitat in the area. The area contains a good diversity of native flora and fauna species and contains numerous fauna habitats for both common and threatened native species. Based on past survey results (ELA 2012) there is potential for Spotted-tail Quoll in this locality due to the presence of log-jams which may provide suitable den sites. Exclusion fencing, in addition to weed control and potentially a planting program would help this community type to provide better habitat and greater security for the native fauna species of the Liddell Colliery site. This approach could also be extended to other sections of Bowmans Creek.

It is noted that LCO don't graze cattle along Bowmans Creek, although there are limitations to the complete removal of cattle from sections of the creek, as LCO doesn't own all land adjacent to the Creek, the property boundary crosses the creek line multiple times, and as such this poses issues to maintaining boundaries due to matters such as flooding events, etc. Additionally, the majority of privately owned or managed neighbouring properties in the vicinity of Bowmans Creek are primarily utilised for grazing purposes.

4.3 Objective 3: Avoid impacts from mining operations on native fauna within Liddell Colliery (especially threatened fauna)

Performance targets for this objective state that the diversity of fauna and habitat structure should be maintained or improved when compared amongst monitoring events (unless explained by natural causes i.e. drought). The loss of habitat characteristics (especially those required by threatened species) should not be occurring outside of areas directly affected by mining.

4.3.1 Woodland birds

In total 74 species of bird were recorded during 2014; this includes all species recorded during specific surveys at the woodland site, woodland rehabilitation sites, riparian areas and dams as well as opportunistically during the entire survey period. New species recorded for the study area in 2014 included *Geopelia humeralis* (Bar-shouldered Dove), *Myiagra inquieta* (Restless Flycatcher), *Circus approximans* (Swamp Harrier) and *Hirundapus caudacutus* (White-throated Needletail).

Diversity

49 bird species were recorded during surveys at woodland and riparian sites in 2014, an increase from 2012 and 2013 when 36 and 33 species were recorded, respectively. Note that woodland site W03 was added to the monitoring program in 2013, so the 2012 survey sampled only two woodland sites.

The average number of bird species recorded per site decreased at all sites between 2012 (mean of 17) and 2013 (mean of 10), then increased in 2014 (mean of 15; **Figure 6**).

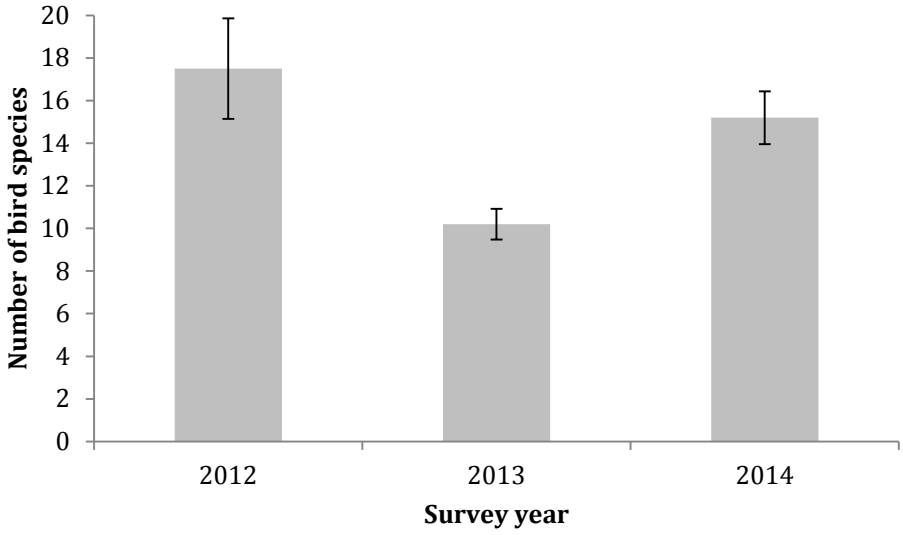

Figure 6: The average (mean) number of bird species recorded per site during the 2012-2014 surveys (Error bars represent standard error).

The reasons behind this increase in overall species diversity per site remain unclear as the woodland sites remained structurally similar between years with only small variations in native and introduced species and abundance. Possible reasons for this change include human induced changes in surrounding environment, natural changes in environmental (weather) conditions between surveys and also surveyor bias from the use of different survey personnel.

The observations (between 2012 and 2014) are still relatively short-term and monitoring efforts over coming years should aim to detect any trends in diversity and abundance.

4.3.2 Threatened and migratory species

Two species listed as Vulnerable under Schedule 2 of the NSW TSC Act (*Chthonicola sagittata*, Speckled Warbler; and *Pomatostomus temporalis*, Grey-crowned Babbler) and three species listed as migratory under the federal EPBC Act (*Merops ornatus* , Rainbow Bee Eater; *Haliaeetus leucogaster*, White-bellied Sea Eagle; and *Hirundapus caudacutus*, White-throated Needletail) were detected during 2014 surveys (**Appendix C)**.

The Speckled Warbler has consistently been detected at site W01 during the 2012, 2013 and 2014 surveys. The Grey-Crowned Babbler was recorded at sites W01 and W03 in 2014; prior to this it had been recorded at W03 in 2013 and opportunistically in 2012. Of the listed migratory species, the Rainbow Bee Eater had previously been recorded in 2013, and the White-bellied Sea Eagle in 2011. The White-throated Needletail represents a new species for the study area.

4.3.3 Woodland Rehabilitation Sites (WR01 and WR02)

Due to the relatively recent establishment of the woodland rehabilitation sites at WR01 and WR02 the presence of bird species has only been recorded for the previous two years (2012 and 2013) and again during this 2014 monitoring period. The results over the last three years show a considerable increase from 2012 to 2013 and a steady increase from 2013 to 2014 (**Table 14**).

Table 14: Number of bird species at the woodland rehabilitation sites WR01 and WR02

Site	Number of bird species		
	2012	2013	2014
WR01	1	8	14
WR02	3	10	13

4.3.4 Microchiropteran bats

Seventeen species of bat were identified during this study, including three threatened species listed as Vulnerable under Schedule 2 of the TSC Act. The most commonly recorded species were the non-threatened *Chalinolobus gouldii* (Gould's Wattled Bat), *C. morio* (Chocolate Wattled Bat) and *Mormoptorus* (Ozimops) *planiceps* (South-eastern Freetail Bat).

Three species listed as vulnerable under the Threatened Species Conservation Act 1995 (TSC Act) were recorded. This includes numerous *Miniopterus schreibersii oceanensis* (Eastern Bentwing Bat) definite calls. Probable calls were recorded for the threatened *Myotis macropus* (Large-footed Myotis) and possible calls were recorded for the threatened *Vespadelus troughtoni* (Eastern Cave Bat). Despite there being no definite calls for either the Large-footed Myotis or the Eastern Cave Bat, they have been previously recorded in the region (ELA 2011, 2013a and 2013b).

Four 'definite' calls were recorded at W01, however it could not be determined whether these were from the threatened *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) or the common species *Scotorepens orion* (Eastern Broad-nosed Bat). *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) calls are often difficult to distinguish from the calls of *Scotorepens orion* (Eastern Broad-nosed Bat) were the species overlap. The habitat in region appears to more suitable for the Eastern Broad-nosed Bat than Eastern False Pipistrelle. The Eastern False Pipistrelle prefers wet sclerophyll and coastal mallee or tall and wet forests (Churchill 2008). Previous ELA surveys have identified both species in the region (ELA 2011, 2013a and 2013b).

There were moderate to high levels of microbat activity recorded across the five of the six survey sites. Relatively low levels of bat activity were recorded at WR01. This is likely due to the low growing nature of the rehabilitated trees that are present at this site.

Miniopterus schreibersii oceanensis (Eastern Bentwing Bat) was detected at all six sites with the highest activity recorded at W02. *Mormopterus norfolkensis* (East coast Freetail Bat) was also detected at five of the six sites with the highest activity recorded at both W02 and R02 (**Table 15**) (**Figure 7**). *Myotis macropus* (Large-footed Myotis) was recorded, in low numbers only within the two woodland sites W01 and W02. The presence of the Eastern Bentwing Bat at the relatively newly established Woodland rehabilitation site is a good indication that this area is being used and may in the future provide important habitat for this and other bat species.

Threatened bat activity varied substantially between annual surveys and between sites. Future monitoring will build on this data and begin to draw conclusions as to any trends in diversity and bat activity that may be occurring.

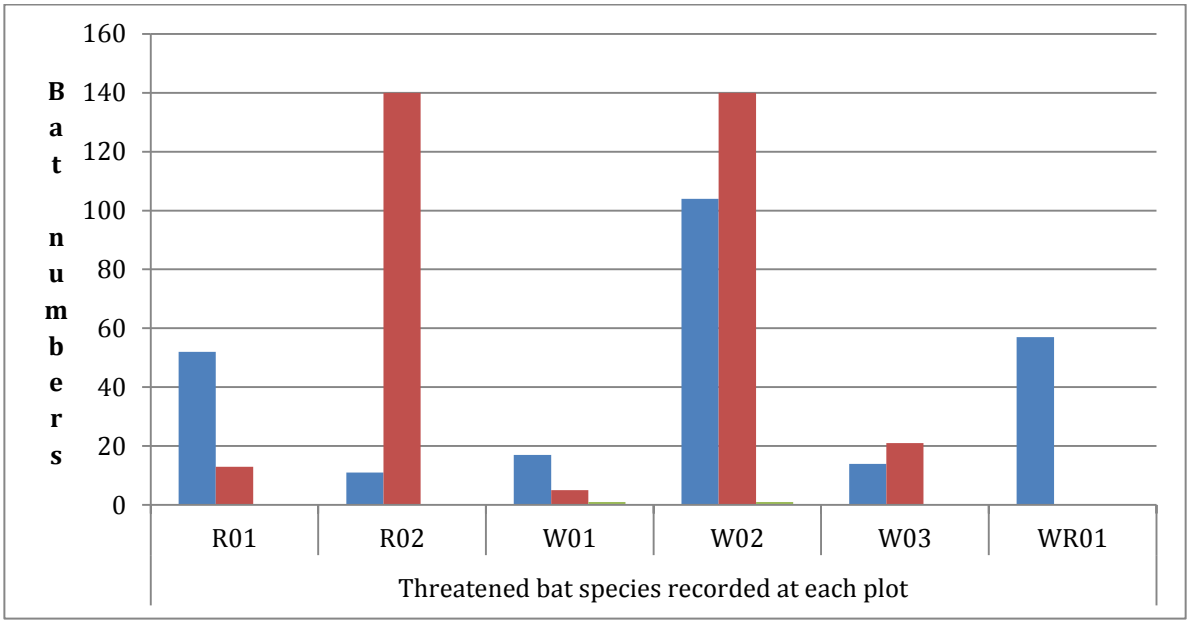

Figure 7: Threatened bat activity per site during the 2014 monitoring period. Blue represents *Miniopterus schreibersii oceanensis* (Eastern Bentwing Bat), Red represents *Mormopterus norfolkensis* (East-Coast Freetail Bat) and Green represents *Myotis macropus* (Large-footed Myotis).

Table 15: Threatened bat species activity at Woodland monitoring sites 2012-2014 and Woodland Rehabilitation site (WR01) 2014

Threatened bat species recorded at Liddell Colliery 2012-13	W01 (2012)	W01 (2013)	W01 (2014)	W02 (2012)	W02 (2013)	W02 (2014)	W03 (2014)*	WR01 (2014)
Eastern falsistrelle, *Falsistrellus tasmaniensis*	0	1	0	0	0	0	0	0
Eastern Bentwing bat, *Miniopterus schreibersii oceanensis*	30	5	17	0	151	104	14	57
East coast Freetail Bat, *Mormopterus norfolkensis*	2	0	5	0	533	140	21	0
Large-footed Myotis, *Myotis macropus*	7	0	1	0	0	1	0	0
Eastern Cave Bat, *Vespadelus troughtoni*	0	0	0	0	0	0	0	0

*Site only added in 2013 and due to heavy rainfall event and flooding Bat monitoring did not occur at this site in 2013.

Table 16: Threatened bat species activity at River monitoring sites 2012-2014 and Woodland Rehabilitation (WR01) site for 2014

Threatened bat species recorded at Liddell Colliery 2012-13	R01 (2012)	R01 (2013)	R01 (2014)	R02 (2012)	R02 (2013)	R02 (2014)
Eastern falsistrelle, *Falsistrellus tasmaniensis*	0	9	0	2	8	0
Eastern Bentwing bat, *Miniopterus schreibersii oceanensis*	10	13	52	1	54	11
East-coast Freetail Bat, *Mormopterus norfolkensis*	0	0	13	0	0	140
Large-footed Myotis, *Myotis macropus*	0	1	0	19	0	0
Eastern Cave Bat, *Vespadelus troughtoni*	11	0	0	0	0	0

4.3.5 Spotted-tailed Quoll

Spotted-tailed Quoll were not detected during the 2014 monitoring period. Spotted-tailed Quoll including a den site and two juveniles has been recorded previously during the 2012 monitoring with the den site discovered in a log jam along Bowmans Creek near R02. This particular log jam den site has since been removed due to flooding prior to the 2013 monitoring. Potentially suitable log jams are evident in the area and likely along other sections of Bowmans Creek, however, none were observed as being used by Spotted-tailed Quoll. Spotted-tail Quoll are generally solitary animals although they will live as a family unit during breeding and while joeys are young. Dens are used for both shelter and for raising young (Andrews 2005). The time of this 2014 survey, late spring / early summer, is regarded as suitable for the detection of this species whilst raising young, although this is toward the later end of the breeding cycle as young may become independent from their mother / parents at this time. An earlier survey period of October / November may be more suitable.

Spotted-tailed Quoll generally have a large home range and often low detectability, thus this result is not unexpected. Repeat surveys over a number of years are likely to be required to gather evidence as to whether this lack of detection was simply due to chance or other biological reasons, such as low population size or local extinction.

The presence of a den site at Liddell Colliery during 2012 indicates the importance of Bowmans Creek and adjacent woodland habitat to Spotted-tailed Quoll population surrounding Liddell Colliery. Bowmans creek is one of the few contiguously vegetated corridors leading from the northern forested hills to the Hunter Valley floor in this locality and as such is of significance to the Spotted-tailed Quoll for not only hunting but also shelter and breeding purposes. Threats to the survival of the Spotted-tailed Quoll are:

- Loss, fragmentation and degradation of habitat.
- Accidental poisoning during wild dog and fox control programs. Deliberate poisoning, shooting and trapping may also be an issue.
- Competition with introduced predators such as cats and foxes (OEH 2013).

4.3.6 Blue-billed Duck and other waterbirds

No Blue-billed Ducks were recorded during the 2014 survey; the species has not been recorded within the LCO site since 2009, when Dam 13 (man-made mine water storage dam) was drained and mined through. Blue-Billed Ducks had been observed on this dam during the 2005, 2006, 2007 and 2009 monitoring surveys. Dam 3 contains the most suitable Blue-billed Duck habitat on the LCO managed properties; however the species has not been recorded there.

The number of water bird species recorded has remained consistent across the three years of monitoring, with 15 different species of water bird recorded during dam surveys in 2012, 14 species in 2013, and 15 species in 2014. The mean number of species per dam also showed very little change with a mean of 6, 5.75 and 6 during 2012, 2013 and 2014 respectively (**Table 16**).

Consistent with results from 2012 and 2013, Dam 3 was found to support the most species of water birds during 2014 surveys with nine species of water bird observed. Mountain Dam had the lowest diversity, with just two species observed (**Appendix C**). This represented a decrease in diversity compared with the 2012 and 2013 monitoring periods, where six and seven species were recorded at this dam, respectively. Conversely, there was an increase in water bird species observed at the Triangle Dams in 2014 (eight species observed), compared with three species in the previous two years

of monitoring. The largest numbers of water birds were observed in Dam 3, largely driven by large numbers of *Folic art* (Eurasian Coot) and *Aythya australis* (Hardhead).

Species composition varied between years. In 2014, *Anas rhynchotis* (Australasian Shoveller) was recorded, a species which had not been recorded in waterbird monitoring surveys in either 2012 or 2013. *Tribonyx ventralis* (Black-tailed Native-hen) and *Himantopus himantopus* (Black-winged Stilt) have not been recorded since the 2012 surveys, while *Bezier locate* (Musk Duck) and *Pedicels cristaus* (Great Crested Grebe) were observed on Dam 3 in 2013 but were not observed during 2014. These observations indicate that species composition can change based on factors such as survey timing and prevailing weather conditions.

Table 17: Number of waterbird species per dam

Dam	Number of waterbird species		
	2012	2013	2014
Dam 1	6	4	6
Dam 3	9	9	9
Triangle Dams	3	3	8
Dam 6 (Mountain block dam)	6	7	2
Mean	6	5.75	6
Standard Deviation	2.45	2.75	2.94

4.3.7 Unexplained turtle deaths

During inspections of various monitoring sites across the Liddell Colliery it became evident that there were an unusually high number of fatalities for the species *Chelodina longicollis* (Eastern long-necked turtle). A number of turtles were observed to be dead and turned upside down at the woodland site (W03), one dead turtle was observed at the woodland W02 site and one also at Dam 6. It was the unusually high (60+) number of turtle deaths surrounding Dam 3 that calls for concern regarding the cause for this high number of deaths. It was observed that all dams surveyed had abundant bird life utilising the dam, as well as insects seen on the dam's surface which indicates a certain level of water quality health. No visible residue or contamination could be detected on or around the dams that could explain the high number of turtle fatalities.

4.3.8 Nest box monitoring

A summary of the nest box monitoring results is presented in **Table 18**. Only one animal *Trichosurus vulpecula* (Brush-tailed Possum) was observed to be utilising nest box 14. Nest box 20 did contain what appeared to be possible nesting material, however, no animals were observed at time of survey. No other nest boxes were occupied by fauna at the time of survey. The nest box survey was carried out in early Summer and as such may have missed detecting some nesting species. Although species such as Brush-tailed Possum would be utilising the hollows all year round. Three nest boxes require repair and one requires reinstallation.

Table 18: Summary of nest box monitoring results during 2012 and 2013. Red shading indicates that repair or reinstallation is required.

Nest box number	Type of nest box	2012	2013	2014
11	Deep Possum Box	Yes- nesting birds- Inspection camera removed from nest box before identification of occupants.	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey
12	Standard Possum Box	No- no sign of occupation at time of survey	Nesting Crimson Rosellas	No- no sign of occupation at time of survey
13	Microchiropteran Bat Box	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey. Lid missing. **Maintenance is required.**
14	Deep Possum Box	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey	Yes- Brush-tail possum identified as nesting via remote camera
15	Standard Possum Box	No- no sign of occupation at time of survey	Scratches from fauna on side of box	Broken – On ground with lid off. **Maintenance is required.**
16	Microchiropteran Bat Box	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey. Leaf litter and bark inside.
17	Standard Possum Box	No- **Lid detached, exposing inside of box to weather**	Lid remains detached	No- no sign of occupation at time of survey
18	Deep Possum Box	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey
19	Deep Possum Box	No- **Lid detached, exposing inside of**	Lid remains detached from box but placed back on top.	Lid remains detached from box but placed back on top.

Nest box number	Type of nest box	2012	2013	2014
		box to weather	**Maintenance is required.**	**Maintenance is required.**
20	Standard Possum Box	Leaf litter inside of box and scratches on trunk may indicate recent use by Possum or Glider.	Australian Owlet-nightjar roosting in box	No- no sign of occupation at time of survey. Layer of possible nesting material present.
21	Deep Possum Box	Spider webs indicate this nest box has not been used recently.	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey
22	Microchiropteran Bat Box	Spider webs indicate this nest box has not been used recently.	No- no sign of occupation at time of survey	No- no sign of occupation at time of survey
23	Standard Possum Box	No- **Nest box has fallen to ground and broken**	**Reinstallation of Possum Box Required**	**Reinstallation of Possum Box Required**
24	Standard Possum Box	No- no sign of occupation at time of survey	Lid detached from box but placed back on top. **Maintenance is required.**	Lid partially detached from box but placed back on top. **Maintenance is required.**

Table 19: GPS locations for nest boxes requiring maintenance or replacement:

Nest box number	GPS co-ordinates	
13	314875	6418378
15	314165	6417585
19	314 210	6417 913
23	315 134	6418 116
24	315 141	6418 209

4.3.9 Habitat assessment

The three woodland sites (W01, W02 and W03) continue to support a range of habitat such as fallen logs, furrowed/fallen bark, leaf litter and various flowering eucalypts. Features including seed, nectar and pollen in the grassy understorey, shrub layer and overstorey also contribute to food sources. Sites W02 and W03 also have hollow-bearing trees with a range of hollow sizes within both smooth and rough barked Eucalypts. Hollow-bearing trees are present within the larger patch of vegetation surrounding W01, but no hollow-bearing trees are present within the search area for W01 as this site is predominantly semi-mature *Allocasuarina luehmannii* (Bulloak). The larger patch of vegetation also supports a number of water bodies; however, none are within the search area for W01.

W02 is part of a small linear patch of woodland that is currently being grazed by stock and hence the size of habitat available is restrictive for many woodland species that suffer from edge effects or require a minimum patch size greater than what is available at W02. The W03 site is composed of a mix of Eucalypts and Bulloak and contains a considerable amount of fallen timber in the wider patch area which was not represented well in the plot area. Water bodies are also adjacent to the greater woodland patches at W02 and W03 and provide additional habitat.

The riparian sites (R01 and R02) both continue to support a range of habitat features for both terrestrial and aquatic fauna assemblages. The vegetated creek line forms a habitat corridor through the landscape in an area otherwise highly cleared of vegetation. Both riparian sites support log jams and fallen logs, hollow-bearing trees, water sources, aquatic resources and foraging resources. The habitat structure at both sites is impacted by flooding, historical vegetation clearing and grazing, and resulting weed invasion. At site R02 stock do have access, which may be causing a reduction in regeneration of native trees and shrubs and thus reducing habitat values.

It is noted that LCO don't specifically graze cattle along Bowmans Creek, and although cattle may have a discernable negative impact, there are limitations to the complete removal of cattle from sections of the creek, as LCO doesn't own all land adjacent to the Creek, the property boundary crosses the creek line multiple times, and as such this poses issues to maintaining boundaries due to matters such as flooding events, etc. Additionally, the majority of privately owned or managed neighbouring properties in the vicinity of Bowmans Creek are primarily utilised for grazing purposes.

4.3.10 Analysis of performance targets and actions required

Objective		Performance targets	Result	Preventative or remedial action required
3	Avoid impacts from mining operations on native fauna within Liddell Colliery (especially threatened fauna)	Diversity and structure maintained or improved when compared amongst monitoring events (unless explained by natural causes i.e. drought)	No clear trends detected	No
		No loss of habitat characteristics (especially those required by threatened species)	Habitat characteristics in woodland areas largely retained. W02 and R02 being damaged by cattle.	Yes*

* Damage in these areas is due to a temporary grazing trial which is being conducted to benefit the development of pasture rehabilitation areas.

Discussion on performance and actions required

There are no obvious adverse impacts to fauna and fauna habitat areas directly attributable to mining activities. In contrast there are some issues in regard to artificial fauna habitat (nest boxes), unexplained turtle deaths and cattle access that need to be addressed.

- Several nest boxes are in need of repair (numbers 13, 15, 19 and 24) primarily the reattachment of the lids. Note that these nest boxes in the vicinity of W02 appear to be subject to regular visits by a large Lace Monitor which lives in a natural hollow in the area. This Monitor has been observed on several occasions in and adjacent to the nest boxes, as such, the nest boxes are likely to require the lids to be fastened to the body by some form of releasable clip. Additionally, possum nest box number 23, which was observed broken on the ground in 2013 cannot be located in this area and it is required that a new box of similar make be established.

  The unusually high number of turtle deaths observed during surveys at a number of locations including Woodland and dams sites is cause for concern and further investigation into the possible causes of these deaths is recommended. No obvious indication as to the cause of the turtle deaths was evident from a visual inspection. Monitoring for any future high numbers of deaths in turtles should be carried out on a regular basis with some specimens forwarded to assess or determine the cause of death. There are numerous factors which may affect the

health of freshwater turtles including parasites, malnutrition, bacterial infection, chemical imbalance or water toxicity.

The following two actions are as per the comments expressed in Objective 2, but overlap with Objective 3.

- The remnant woodland vegetation in the vicinity of W02 (which is remnant of the Endangered Ecological Community - Central Hunter Ironbark - Spotted Gum - Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions) currently is accessed by cattle and trampling and considerable grazing of the groundcover was observed at the site and surrounding area. To ensure the long-term enhancement of the vegetation and habitat, cattle need to be fenced out of this area with a narrow pathway retained where the existing vehicular track is present to allow access east to west. Fencing should include all regrowth areas beyond the existing mature trees.
- The riparian vegetation along Bowmans Creek in the vicinity of monitoring site R02 should be considered for exclusion of stock to help enhance the habitat in the area. The area contains a good diversity of native flora and fauna species and contains numerous fauna habitats, including suitable habitat for the Spotted-tail Quoll. Exclusion fencing, in addition to weed control and potentially a planting program would help this community type to provide better habitat and greater security for the native fauna species of the Liddell Colliery site. This approach could also be extended to other sections of Bowmans Creek.

As commented in Objective 2 (Section 4.2), it is noted that LCO don't graze cattle along Bowmans Creek, although there are limitations to the complete removal of cattle from sections of the creek, as LCO doesn't own all land adjacent to the Creek, the property boundary crosses the creek line multiple times, and as such this poses issues to maintaining boundaries due to matters such as flooding events, etc. Additionally, the majority of privately owned or managed neighbouring properties in the vicinity of Bowmans Creek are primarily utilised for grazing purposes.

4.4 Objective 4: Implement revegetation program to restore disturbed areas designated for native vegetation to pre-mining condition

The performance targets for woodland mine rehabilitation is to restore native plant species richness, and native canopy, mid-storey and grass cover to within 75% of reference condition.

4.4.1 Native vegetation rehabilitation

Mean data from sites W02 and W03 was used to generate a performance target for the regeneration area, as it is these two sites that are representative of a mature eucalypt woodland. Data from W01 was not used as this site is primarily *Allocasuarina luehmannii* (Bulloak) woodland and the site will be absorbed into the mining area in the near future. Rehabilitation areas have not yet met these performance targets, with native plant species richness, native canopy, mid-storey and grass cover below 75% of woodland scores as presented in **Table 20**. Exotic plant cover within the rehabilitation area is much higher than woodland areas and conversely leaf litter cover was much reduced in the rehabilitation areas, although this is expected as canopy species are generally between 2-3 m in height. It should be noted that the two woodland rehabilitation sites have only recently been established (August 2011) and as such will be unlikely to have a final community structure and species complexity at this time. It was observed at both rehabilitation sites, that the juvenile eucalypt species, especially at WR02 site have seen considerable growth since the 2013 monitoring period.

Table 20: Comparison of species diversity and structure between rehabilitation area, performance target and remnant woodland areas

	Woodland rehabilitation site 1 (WR01)	Woodland rehabilitation site 2 (WR02)	Performance target (75% of mean woodland score)	Woodland site 02 (W02)	Woodland site 03 (W03)
* Number of native plant species	10	7	15	20	20
Native overstorey (projected foliage cover %)	0	10	15.35	25	16
Native mid-story (projected foliage cover %)	0	0	0	0	0
Native grasses (% cover)	6	0	23.25	28	34
Exotic plant (% cover)	52	88	15	20	0
Leaf litter (% cover)	24	8	33	42	46
Bare ground (% cover)	12	4	9	14	10

4.4.2 Landscape Function Analysis (LFA)

It was agreed with LCO that LFA was not to be undertaken as part of the 2014 monitoring and as such does not form part of this report.

Table 21: Assessment of performance targets for Objective 4

Objective	Performance target	Result	Preventative or remedial action required
Implement revegetation program to restore disturbed areas designated for native vegetation to pre-mining condition	Restore native plant species richness, and native canopy, mid-storey and grass cover to within 75% of reference condition	Not yet achieved	Yes

Discussion on performance and actions required

Both rehabilitation monitoring sites have not yet reached the performance targets. It should be noted that the two rehabilitation sites have only recently been established (August 2011) and as such will be unlikely to have a final vegetation community structure and overstorey species complexity at this time. The following actions provide some guidance in regard to rehabilitation enhancement.

- Exotic plant cover remains considerably high in both rehabilitation areas. Weed control undertaken at WR01 was observed as *Galenia pubescens* plants were dead or dying off. However, since spraying occurred in this area new growth of Galenia and also Thistles have occurred (**Plate 5**). Continued systematic control of weeds, with particular effort placed on the control of Galenia is highly recommended. Dead weed material should be left on site for erosion and nutrient catching purposes except where obvious seed propagules are evident.

- Information from **Table 20** (*) indicate that the rehabilitation sites comprise several native species, although low in diversity. The species at these sites comprise a combination of both locally indigenous as well as non-local Australian native species and as such is not fully representative of the species represented in the control sites of W02 and W03 (i.e. *Corymbia citriodora* (Lemon-scented Gum) has been used at both rehabilitation sites in place of *Corymbia maculata* (Spotted Gum). As such, for future revegetation purposes locally native species should be used to better recreate the local representative vegetation communities. Additionally, supplementary planting and or seed dispersal for both rehabilitation areas should increase the species diversity with a target in the vicinity of 20 different locally indigenous species from all stratum. Locally indigenous flora species suitable for rehabilitation purposes can be derived from the flora species list presented in **Appendix A**. Additional suitable native species for revegetation purposes are also presented in **Appendix D.**

Plate 5: Evidence of *Galenia pubescens* dieback from spraying and also new growth present.

4.5 Objective 5: Native revegetation supports native fauna (especially threatened species) at a similar diversity and abundance to pre-mining condition

Performance targets for the rehabilitation area state that native fauna assemblages are to be within 75% of reference abundance and diversity. Threatened fauna must be at 75% diversity of reference and to restore lengths of fallen logs per hectare to within 25% of reference condition.

Revegetation works are currently at an early stage and support a different fauna assemblage to that of nearby woodland areas. The Eastern Bentwing bat was the only threatened species detected at the rehabilitation site (W01) during both 2013 and 2014. Twenty two native fauna species were detected within both rehabilitation sites, including 18 bird species, five bat species and four mammal species. Three exotic species were also detected, being *Lepus europaeus* (European Brown Hare), *Oryctolagus cuniculus* (European Rabbit) and *Manorina melanocephala* (Noisy Minor).

Woodland sites 1, 2 and 3 combined had more than double the diversity of bats detected and just under double the diversity of birds species detected as compared with the rehabilitation sites combined. The number of birds identified at the woodland rehabilitation sites has increased from previous years which is a good indication that the rehabilitation sites will, in years to come, provide suitable habitat for bird species.

Logs were not recorded within the rehabilitation plots. In contrast, woodland sites averaged 240 metres of logs with a diameter >10cm, per ha.

Objective		Performance targets	Result	Action required
5	Native revegetation supports native fauna (especially threatened species) at similar diversity and abundance to pre-mining condition	Native fauna assemblages are within 75% of reference abundance and diversity. Threatened fauna must be at 75 % diversity of reference	Not completed	Yes
		Restore lengths of fallen logs per hectare to within 25% of reference condition	Not completed	Yes

Discussion on performance and actions required

The rehabilitation area is in an early stage of growth with trees reaching 2-3 m in height. Several actions have been recommended in **section 4.6** to improve habitat complexity to facilitate improvements in fauna diversity; however, at this early stage in the rehabilitation process, meeting the set performance target is not realistic. One specific recommendation includes:

- Importing of fallen trees, hollow logs and course woody debris from mine site clearing areas for use in the woodland rehabilitation areas should be encouraged. The use of these in the woodland rehabilitation areas will enhance habitat for native ground dwelling fauna (i.e. reptiles) and will also reduce the incidence of runoff during rainfall events by trapping soil, leaf litter and nutrients.

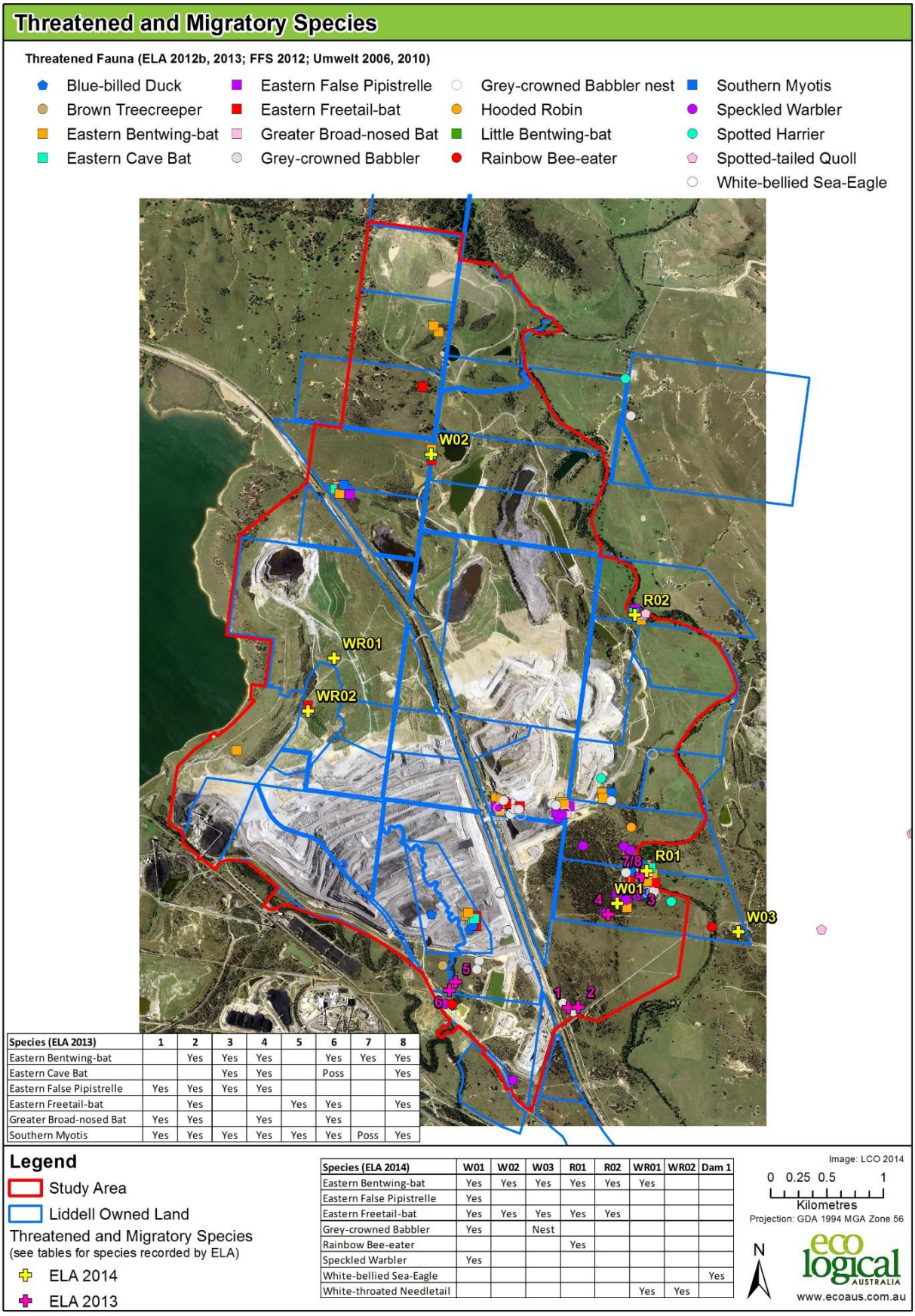

Figure 8: Threatened and migratory species across the site from all monitoring years.

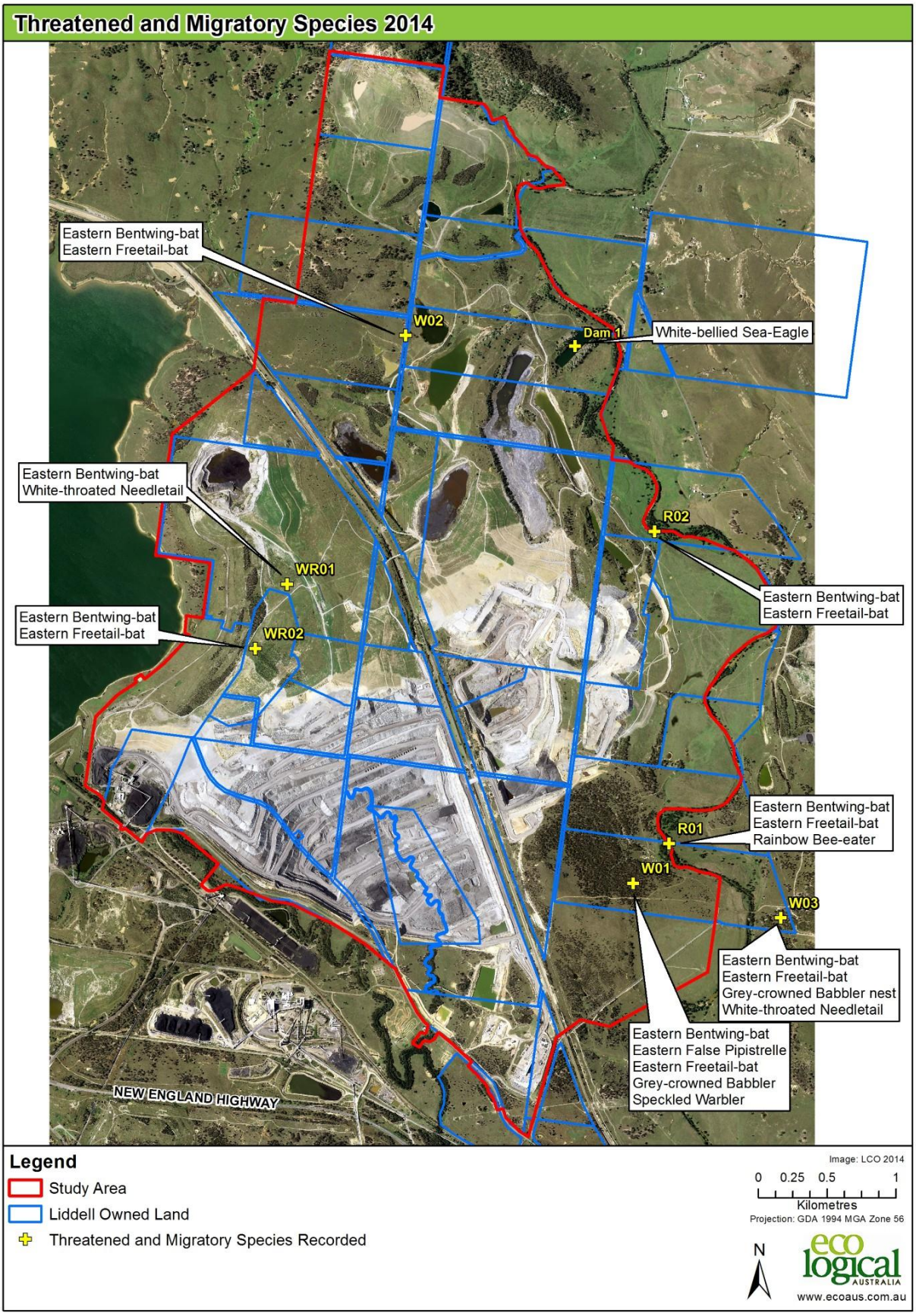

Figure 9: Threatened and migratory species 2014 only

5 Land management recommendations

5.1.1 Objective 1

The following recommendations are provided to increase habitat quality at Dam 3 and Triangle Dam for aquatic species, particularly the Blue-billed Duck:

- It is recommended that cattle be excluded from the Triangle Dam (upper and Lower) areas and further effort be made (planting of macrophytes and other fringing vegetation) to enhance these areas for the Blue-billed Duck or alternatively another dam or waterbody (e.g. Dam 6, Dam 1) be nominated the second area for which habitat is enhanced/created for this species. Should planting be undertaken this should occur during late winter/spring to enhance the chances of planting survival. Planting should be carried out in a clumping or grouping arrangement to ensure dense plant growth (i.e. eight to ten plants per sq./m) and should be done in conjunction with the woody debris placement. Suitable species for planting include: *Juncus usitatus*, *Schoenoplectus validus*, *Carex appressa*, *Typha orientalis* (Cumbungi), *Phragmites australis* (Native Reed), *Eleocharis sphacelata* (Tall Spike Rush), *Philydrum lanuginosum* (Frogs-mouth), *Alisma Plantago-aquatica* (Water Plantain) and *Lomandra longifolia* (Spiny-headed Mat-rush).

- The introduction of low density large woody debris (obtained from clearing works) to increase habitat complexity surrounding the dams and provide structure for invertebrates and algae thus enhancing habitat for the Blue-billed Duck. The addition of extra woody debris would be useful for additional habitat creation / enhancement for Blue-billed Ducks. This would include random placement of large woody debris (logs / branches) in the near edge and within the dams. The woody debris should be located within the plantings or plantings undertaken in the vicinity of the newly placed woody debris.

5.1.2 Objective 2

As for the 2012 surveys it was identified that the riparian and woodland vegetation remnants, particularly along Bowmans Creek provide an important vegetation and fauna movement corridor throughout and extending beyond the site. As little remnant vegetation remains both within Liddell Colliery and in the locality, keeping these areas in sound condition is imperative. The following recommendations have been provided to ensure riparian and woodland habitat at Liddell Colliery is maintained and enhanced.

- Grazing of the riparian zone is currently occurring at monitoring site R02. The removal of grazing from riparian zones along Bowmans creek is recommended. Installation of temporary fencing along the wooded portion of the creek edge and/or planting to allow damaged riparian areas to recover or the provision of alternative watering points may reduce the impact of stock on creek banks and vegetation.

As commented in Objective 2 (Section 4.2), it is noted that LCO do not specifically graze cattle along Bowmans Creek, although there are limitations to the complete removal of cattle from sections of the creek, as LCO doesn't own all land adjacent to the creek, the property boundary crosses the creek line

multiple times, and as such this poses issues to maintaining boundaries due to matters such as flooding events, etc. Additionally, the majority of privately owned or managed neighbouring properties in the vicinity of Bowmans Creek are primarily utilised for grazing purposes.

- Stock use, as part of the monitored grazing trial, at the Spotted Gum / Grey Box woodland (Monitoring Site W02) has resulted in trampling of fallen timber and ground hollows and created large areas of bare ground, making it difficult for plants to establish and has created an simplified structure of this community. It is recommended that this area be fenced to prevent stock access. Fencing should include all areas of new regeneration of seedlings and saplings beyond the existing narrow corridor of mature trees.

- Weed control activities targeting highly invasive species should be continued in line with strategic goals and the associated yearly action plan for long-term control. Strategies within remnant areas should be of low impact utilising techniques such as hand removal or hand application of environmentally sensitive herbicides (e.g. Roundup Biactive) where possible (particularly in areas of low weed abundance or riparian corridors).

- Damaged or degraded woodland and riparian vegetation could be enhanced by a seed collection / propagation / planting program undertaken in conjunction with the weed control activities. By introducing such a program, particularly in the vicinity of Bowmans Creek, the works would lead to increased native species richness, remnant vegetation connectivity and increase riparian value for both flora and fauna.

It is understood that LCO will be completing works to improve the biodiversity quality of Bowmans Creek in accordance with biodiversity offset conditions relating to the recent DA Mod 5.

5.1.3 Objective 3

The following recommendations have been provided to ensure fauna habitat at Liddell Colliery is maintained and enhanced:

- Repair nest boxes 13, 15,19 and 24 and reinstall nest box 23.
- Due to previous records of Spotted-tail Quoll at Liddell Colliery caution is advised when conducting feral animal baiting. Baiting methods should be sensitive to native fauna Recommendations from ELA (2012b) should be considered.
- Ensure retention of continuous vegetated habitat corridor along Bowmans Creek. Any large areas of removal of invasive weed species should be complimented by planting of native species.
- The modification of groundcover by grazing is known to impact habitat for Spotted-tailed Quoll (Andrews 2005). Grazing within remnant vegetation communities should be avoided and any grazing along Bowmans Creek should be restricted within LCO owned lands to selected access points to ensure the retention of the important habitat corridor.
- Continue management program of foxes and wild dogs across LCO, with particular emphasis on the Spotted-tailed Quoll and its breeding habitat.

5.1.4 Objective 4

The following recommendations have been provided to assist in the success of the woodland rehabilitation at the woodland rehabilitation areas:

- Continue to carry out specific weed control activities targeting highly invasive species. Strategies would ideally be of low impact utilising techniques such as hand removal or hand application of environmentally sensitive herbicides (e.g. Roundup Biactive) where possible (particularly in areas of low weed abundance or riparian corridors). Hand removal should target dense aggregations or large individuals of weeds present and competing with a favoured native species (e.g. *Eucalyptus moluccana*). This is particularly pertinent to native tree and shrub seedlings and will allow for quicker establishment. For example, hand removal of dense clumps of *Galenia pubescens* around the bases of seedlings / saplings until desirable species are 1 to 2 m in height. Note that once trees and shrubs are to a suitable height, a combination of natural shading, general competition and targeted weed herbicide application (by hand) will contribute to ongoing growth. Note that it is not necessary to remove all weeds in these areas.
- Native species richness needs to be increased at these locations, particularly in regard to the shrub and groundcover layers. Increasing species richness by way of periodic direct seeding will also help the establishing community naturally compete with weed invasion.
- The tree species *Corymbia citriodora* (which appears to have in the past been inadvertently used on site in place of *Corymbia maculata*) is not considered a suitable canopy species for the rehabilitation of natural woodland vegetation communities within Liddell Colliery. Consideration should be given to the control of Individuals of this species as soon as possible and other more suitable species (*Corymbia maculata*) should be established. If budgetary constraints do not permit the control of the species, than all future planting / seeding should ensure *Corymbia citriodora* is not used and replaced with locally sourced tree species including *Corymbia maculata.*

5.1.5 Objective 5

As per the 2012 surveys it is considered that habitat features should continue to be installed at the native rehabilitation sites to increase the habitat structure. Suitable hollow logs (coarse woody debris) obtained from clearance works at Liddell Colliery should be scattered throughout the sites.

This would help with capturing nutrient runoff as well as create habitat for log-dwelling fauna. Areas with habitat features should be targeted during weeding programs. Care must be taken to ensure weed contaminated topsoil is not introduced to the rehabilitation sites with the coarse woody debris.

5.2 Monitoring recommendations

The following recommendations have been provided to ensure the monitoring program will produce workable results to aid land management at Liddell Colliery:

- Monitoring is to be replicated in the same fashion in future monitoring events to allow comparison between years.
- Measures of abundance should be collected where ever possible particularly for threatened species to enable temporal changes in to be detected and satisfy objective 5 which requires abundance data.
- Statistical analyses should be used to assess temporal changes in fauna assemblages for Objectives 3 and 5 once adequate data has been collected.
- A review of the current monitoring methods and approaches should be undertaken to ensure methods and subsequent results are effective and performance targets and timeframes are possible to meet.

- Additional monitoring location for the Land Function Analysis (LFA) in established mature woodland vegetation should be carried out in the 2016 program to allow for more accurate assessments to be used for comparison purposes over time.

6 Conclusion

The 2014 monitoring survey has collected year two and baseline flora and fauna data for riparian and woodland habitat and woodland revegetation at Liddell Colliery. Where possible, data collected has been compared with previous years; however, the analysis has been limited by changes in study sites and differing survey methodology over time. The monitoring program has specifically targeted fauna groups with a higher chance of being impacted by current land use practises.

The dams monitored for Blue-billed Duck habitat both require management to ensure habitat, water quality and food resource (macrophytes and invertebrates) density and diversity are suitable for aquatic fauna, including Blue-billed Ducks. It is noted that the Triangle Dams currently form part of a larger temporary cattle grazing trial, and as such the Blue-Billed Duck habitat enhancement of this dam is not being actioned. The Triangle Dams (Upper and Lower) currently form part of a larger temporary cattle grazing trial, and as such the Blue-Billed Duck habitat enhancement of these dams is not being actioned.

The previous 2013 ELA monitoring report stated that "at completion of the grazing trial it is recommended that the triangle dams be reassessed for Blue-Billed Duck habitat potential. Following assessment, applicable enhancement measures should be identified for Triangle Dam and actioned or an alternative waterbody will be determined". Since the 2013 monitoring there has been little to no improvement to these dams in regard to creating functional Blue-billed duck habitat. As such, it is recommended that either cattle be excluded from these areas and further effort be made to enhance the triangle dams for the Blue-billed Duck; or alternatively another dam or waterbody (e.g. Dam 6, Dam 1) be nominated as the second area for which habitat is enhanced/created for this species. This allows the Triangle Dams, and surrounding paddocks to continue to be used for the purposes of the grazing trial. If the second option is chosen then efforts should be focused on planting and establishing suitable aquatic plant species in and around the selected site / area.

Riparian and woodland vegetation remnants, particularly along Bowmans Creek provide for an important vegetation and fauna movement corridor across and beyond the site. As little remnant vegetation remains both within Liddell Colliery and in the locality, keeping these areas in sound condition is imperative.

The woodland and riparian habitats both support a range of diurnal birds and microchiropteran bats. Management should be focused on ensuring that habitat is retained wherever possible and that sites are not impacted negatively by grazing or mining practices.

The woodland rehabilitation has not reached the reference condition, although this was expected after only three to four years since initial establishment. However, a range of management actions are recommended to ensure a successful rehabilitation program. Currently, the rehabilitated sites surveyed as part of the Annual Monitoring program contain a high proportion of weed species (~ 50%) and are in some areas still lacking soil structure to capture nutrients and enhance vegetative growth, as is expected in the early stages of rehabilitation. Fauna habitat for ground dwelling species can also be implemented at this stage in the rehabilitation to increase the complexity of the habitat.

Monitoring in 2014 will collect data to compare to the baseline data collected in 2012 and 2013. New rehabilitation areas will also be added to the program as required.

In order to achieve the environmental objectives set out in **section 1.4**, it is highly recommended that the land management actions provided in **section 5.0** be implemented.

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Appendix A: Flora species list (2014)

Species recorded from site with species recommended for revegetation purposes shaded (green). Note that additional native species suitable for revegetation purposes at LCO are presented in **Appendix D**.

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
Class FILICOPSIDA (Ferns)									
Pteridaceae	*Cheilanthes sieberi*	Mulga Fern			r		r		
Class MAGNOLIOPSIDA (Flowering plants) Subclass Magnoliidae (Dicotyledons)									
Acanthaceae	*Brunoniella australis*	Blue Trumpet			r	t	r		
Aizoaceae	*Galenia pubescens**	Galenia	t		1	1		3	2
Amaranthaceae	*Alternanthera pungens**	Khaki Weed							
Anacardiaceae	*Schinus areira**	Pepper Tree		2-3					
Asclepiadaceae	*Gomphocarpus fruticosus**	Narrow-leaved Cotton Bush				r		t	t
Asteracae	*Brachycombe multifida*	Cut-leaf Daisy			r	t	t		
	*Aster subulatus**	Wild Aster						t	t
	*Bidens pilosa**	Cobbler's Pegs	t	t		t		t	t
	Calotis cuneata	Mountain Burr-daisy					t		

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
	Calotis lappulacea	Yellow Burr-daisy			r				
	*Carthamus lanatus**	Saffron Thistle	r						
	Chrysocephalum apiculatum	Common Everlasting, Yellow Buttons			r		t		
	*Cirsium vulgare**	Spear Thistle		1				1	1
	Conyza bonariensis *	Flaxleaf Fleabane						t	t
	*Conyza Canadensis**	Canadian Fleabane		t		r		t	
	Conyza spp.*	Fleabane			r				r
	*Hypochaeris radicata**	Catsear						r	r
	*Xanthium occidentale**	Noogoora Burr							
	*Senecio madagascariensis**	Fireweed	t		t	1		t	t
	*Sigesbeckia orientalis**	Indian Weed	t	1					
	*Sonchus asper**	Prickly Sowthistle	t						t
	*Sonchus oleraceus**	Common Sowthistle		r					
	*Tagetes minuta**	Stinking Roger	1	t					
Basellaceae	*Anredera cordifolia**	Madeira Vine	t	1					

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
Boraginaceae	*Echium plantagineum**	Patterson's Curse	t	t					
	*Heliotropium amplexicaule**	Blue Heliotrope	2	1		t			
	Brassica spp.*		1						
	*Capsella bursa-pastoris**	Shepherd's Purse							t
Cactaceae	*Opuntia aurantiaca* *	Tiger Pear			t		t		
Cactaceae	*Opuntia stricta* var. *stricta**	Common Prickly Pear			t	r	1		
Casuarinaceae	*Allocasuarina luehmannii*	Bulloak			3	r	1		
	Casuarina cunninghamiana	River Oak	3	4					
Chenopodiaceae	*Einadia hastata*	Berry Saltbush				t			
	Einadia polygonoides					t			
	Einadia trigonos	Fishweed	1	1	r				r
	Enchylaena tomentosa	Ruby Saltbush			t	t		t	t
Convolvulaceae	*Dichondra repens*	Kidney Weed			t	t	r		
Crassulaceae	*Bryophyllum delagoense* (*Kalanchoe*	Mother of millions	t						

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
	delagoensis)*								
Euphorbiaceae	*Euphorbia peplus**	Petty Spurge	t	1-2					
	*Ricinus communis**	Castor Oil Plant		r					
Fabaceae (Faboideae)	*Chorizema parviflorum*	Eastern Flame Pea			r		t		
	Desmodium brachypodum	Large Tick-trefoil						t	
	Desmodium sp.	Tick-trefoil					r		
	Desmodium varians	Slender Tick-trefoil		t	r		t		
	Glycine microphylla	Love Creeper			t	t	t		
	Glycine tabacina	Glycine			t				
	*Medicago sativa**	Lucerne							t
	Pultenaea sp.						t		
Fabaceae (Mimosoideae)	*Acacia decora*	Western Golden Wattle						1	
	Acacia salicina	Cooba				r			
Flacourtiaceae	*Dovyalis caffra**	Kei-apple					t		
Lobeliaceae	*Pratia purpurascens*	Whiteroot				t	r		
Malvaceae	*Modiola caroliniana**	Red-flowered Mallow	t	t					

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
	*Sida rhombifolia**	Paddy's Lucerne	t	t	t	t	r		
	Melia azedarach	White Cedar	2						
Moraceae	*Ficus coronata*	Creek Sandpaper Fig		t					
Myoporaceae	*Eremophila debilis*	Amulla			t	t			
	Eremophila deserti	Turkeybush				t			
Myrtaceae	*Angophora floribunda*	Rough barked Apple						1	
	*Corymbia citriodora**	Lemon-scented Gum							2-3
	Corymbia maculata	Spotted Gum				3		1	
	Eucalyptus bridgesiana	Apple Box							t
	Eucalyptus crebra	Narrow-leaved Ironbark					2	1	2
	Eucalyptus moluccana	Grey Box				1-2	2-3	t	t
Oleaceae	*Olea europaea* subsp. *cuspidata**	African olive					t		
Oxalidaceae	*Oxalis perennans*	Oxalis			t				
Phyllanthaceae	*Euphorbia* sp.				r				
Plantaginaceae	*Plantago lanceolata**	Lamb's Tongues*		t	t	1	t	t	

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
	Veronica plebeia	Trailing Speedwell							
Polygonaceae	*Persicaria subsessilis*	Hairy Knotweed		t					
	Rumex brownii	Swamp Dock		t		r			
Primulaceae	*Anagallis arvensis**	Scarlet/Blue Pimpernel	t	t					
Rosaceae	*Rubus fruticosus* sp. agg.*	Blackberry complex		r					
Rubiaceae	*Asperula conferta*	Common Woodruff				t	r		
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush						t	
	Dodonaea viscosa subsp. *angustissima*	Narrow-leaved Hop-bush						t	
	Dodonaea viscosa subsp. *viscosa*	Hop-bush						1	
Solanaceae	*Solanum nigrum**	Blackberry Nightshade							t
	Solanum prinophyllum	Forest Nightshade							
	*Solanum pseudocapsicum**	Madeira Winter Cherry	t	1					
	*Solanum seaforthianum**	Climbing Nightshade	2						

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
Urticaceae	*Urtica incisa*	Stinging Nettle		t					
Verbenaceae	*Clerodendrum tomentosum*	Hairy Clerodendrum	r						
	*Verbena bonariensis**	Purpletop	1	1				1	
	*Verbena rigida**	Veined Verbena	1	2					
Class MAGNOLIOPSIDA (Flowering plants) Subclass Liliidae (Monocotyledons)									
Anthericaceae	*Caesia* spp.	Pale Grass-lily					t		
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	1	1		r			
Cyperaceae	*Carex appressa*	Tall Sedge		t					
	Cyperus polystachyos			2					
Juncaceae	*Juncus acutus**	Sharp Rush		t					
	Juncus usitatus			1					
Lomandraceae	*Lomandra multiflora*					t			
	Lomandra spp.				1		1		
Poaceae	*Aristida ramosa*	Purple Wiregrass			1	2	2-3		
	Aristida vagans	Threeawn Speargrass			1	1	t		
	Austrodanthonia spp.				1	1	t		

Class / Family	Species name	Common name	R01	R02	W01	W02	W03	WR01	WR02
	Austrostipa ramosissima	Stout Bamboo Grass			1	t			
	Austrostipa scabra					t		t	
	*Chloris gayana**	Rhodes Grass						1/2	4
	Chloris truncata	Windmill Grass			1	1	t		
	Cymbopogon refractus	Barbed Wire Grass			1	1	2		
	Cynodon dactylon	Common Couch	t	2				1/2	1
	Dichelachne micrantha	Shorthair Plumegrass			t				
	Entolasia marginata	Bordered panic		t					
	Eragrostis brownii	Brown's Lovegrass			t		t		
	Oplismenus aemulus	Australian Basket Grass	t	t					
	*Paspalum dilatatum**	Paspalum							
	*Pennisetum clandestinum**	Kikuyu Grass							1
	*Poa annua**	Winter Grass	2	1					

t Few individuals (less than 5% cover)
r Solitary, small cover (less than 5%)
1 Many individuals (less than 5% cover)
2 5 to 25% cover

3 25% to 50% cover
4 50% to 75% cover
5 greater than 75% cover
* Denotes introduced species

Appendix B: Photographs of monitoring sites

		
Plate 5 R01, looking left	**Plate 6 R01, looking centre**	**Plate 7 R01, looking right**
		
Plate 8 R02, looking left	**Plate 9 R02, looking centre**	**Plate 10 R02, looking right**

Plate 11 W01, looking left

Plate 12 W01, looking centre

Plate 13 W01, looking right

Plate 14 W02, looking left

Plate 15 W02, looking centre

Plate 16 W02, looking right

Plate 17 W03, from centre, looking left

Plate 18 W03, looking centre

Plate 19 W03, from centre, looking right

Plate 20 WR01, from centre, looking left

Plate 21 WR01, looking centre

Plate 22 WR01, from centre, looking right

Plate 23 WR02, from centre, looking left

Plate 24 WR02, looking centre

Plate 25 WR02, from centre, looking right

Plate 26 Upper Triangle Dam

Plate 27 Dam 3 planted vegetation

Appendix C: Fauna species list

The following table contains all fauna recorded during the 2014 monitoring event, represent the number of individuals observed. Where multiple surveys were completed, such as woodland bird surveys, the largest number of individuals observed during the one survey is used to avoid double counts of individuals.

Table 22: Fauna species detected during 2014 annual biodiversity monitoring at Liddell Colliery

				CONSERVATION STATUS		***MONITORING SITES***											
Fauna type	***Family***	***Scientific***	***Common Name***	***TSC ACT***	***EPBC ACT***	***R01***	***R02***	***W01***	***W02***	***W03***	***WR01***	***WR02***	***Dam 1***	***Dam 3***	***Dam 6***	***Triangle Dams***	***Opportunistic***
Bat	**Vespertilionidae**	*Chalinolobus morio*	Chocolate Wattled Bat			U	U	U	U	U							
Bat	**Molossidae**	***Mormopterus norfolkensis***	East-coast Freetail Bat	V		U	U		U	U							
Bat	**Miniopteridae**	***Miniopterus schreibersii oceanensis***	Eastern Bentwing Bat	V		U	U		U	U	U						
Bat	**Vespertilionidae**	***Falsistrellus tasmaniensis***	Eastern falsistrelle	V													
Bat	**Molossidae**	*Mormopterus ridei*	Eastern Freetail Bat			U	U	U	U	U	U						
Bat	**Molossidae**	*Mormopterus petersi*	Inland Freetail Bat			U	U	U		U							
Bat	**Molossidae**	*Mormopterus planiceps*	South-eastern Freetail Bat			U	U	U	U	U	U						
Bat	**Vespertilionidae**	*Chalinolobus gouldi*	Gould's Wattled Bat			U	U	U	U	U	U						
Bat	**Vespertilionidae**	*Scotorepens balstoni*	Inland Broad-nosed Bat			U			U	U							
Bat	**Vespertilionidae**	*Scotorepens orion*	Eastern Broad-nosed Bat					U									
Bat	**Vespertilionidae**	***Myotis macropus***	Large-footed Myotis	V													
Bat	**Vespertilionidae**	*Vespadelus vulturnus*	Little Forest Bat														
Bat	**Vespertilionidae**	*Vespadelus regulus*	Southern Forest Bat														
Bat	**Molossidae**	*Mormopterus sp.4*	Southern Freetail Bat														
Bat	**Vespertilionidae**	*Nyctophilus spp.*	Unidentified Long-eared Bat						U	U							
Bat	**Molossidae**	*Austronomus australis*	White-striped Freetail														

				CONSERVATION STATUS		MONITORING SITES											
Fauna type	**Family**	**Scientific**	**Common Name**	**TSC ACT**	**EPBC ACT**	**R01**	**R02**	**W01**	**W02**	**W03**	**WR01**	**WR02**	**Dam 1**	**Dam 3**	**Dam 6**	**Triangle Dams**	**Opportunistic**
			Bat														
Bat		*Mormopterus sp. 4*															
Bat		*Myotis macropus*															
Bat		*Nyctophilus spp.**				U	U	U									
Bat		*Scotorepens balstoni*				U		U									
Bat		*Tadarida australis*	White-striped Freetail Bat			U	U	U	U	U	U						
Bat		*Vespadelus darlingtoni*															
Bat		*Vespadelus pumilus*				U	U										
Bat		*Vespadelus regulus*															
Bat		*Vespadelus troughtoni*															
Bat		*Vespadelus vulturnus*															
Bat		*Chalinolobus gouldii*															
Bat		*Chalinolobus morio*															
Bat		*Falsistrellus tasmaniensis*															
Bat		*Miniopterus orianae oceanensis*															
Bat		*Mormopterus norfolkensis*															
Bat		*Mormopterus rideri*															
Bird	**Podicipedidae**	*Tachybaptus novaehollandiae*	Australasian Grebe											O, 5	O, 1	O, 2	
Bird	**Anatidae**	*Anas rhynchotis*	Australasian Shoveller											O, 4			
Bird	**Artamidae**	*Cracticus tibicen*	Australian Magpie			W, 2	O, 1		W, 3		O, 1	O/W, 5					
Bird	**Motacillidae**	*Anthus australis*	Australian Pipit													O, 2	
Bird	**Corvidae**	*Corvus coronoides*	Australian Raven			W, 1		W, 2	O, flyover, 1		O, flyover, 2	O/W, flyover, 3			O, flyover, 1		
Bird	**Acrocephalidae**	*Acrocephalus*	Australian Reed-											W, 2	W, 1		

				CONSERVATION STATUS		MONITORING SITES											
Fauna type	***Family***	***Scientific***	***Common Name***	***TSC ACT***	***EPBC ACT***	***R01***	***R02***	***W01***	***W02***	***W03***	***WR01***	***WR02***	***Dam 1***	***Dam 3***	***Dam 6***	***Triangle Dams***	***Opportunistic***
		australis	Warbler														
Bird	**Anatidae**	*Chenonetta jubata*	Australian Wood Duck													O, 2	
Bird	**Columbidae**	*Geopelia humeralis*	Bar-shouldered Dove				O/W, 2										
Bird	**Anatidae**	*Cygnus atratus*	Black Swan														Op
Bird	**Campephagidae**	*Coracina novaehollandiae*	Black-faced Cuckoo Shrike			W, 1	W, 2		Op	O, flyover, 2							
Bird	**Charadriidae**	*Elseyornis melanops*	Black-fronted Dotterel													O, 3	
Bird	**Accipitridae**	*Elanus axillaris*	Black-shouldered Kite						O, flyover, 1			O, 2			O, 3	O, 1	
Bird	**Falconidae**	*Falco berigora*	Brown falcon				O, 1					O, flyover, 2					
Bird	**Phasianidae**	*Coturnix ypsilophora*	Brown Quail									Op					
Bird	**Cuculidae**	*Scythrops novaehollandiae*	Channel-billed Cuckoo				Op, 2	W, 2	O, 1				O, flyover, 3				
Bird	**Columbidae**	*Phaps chalcoptera*	Common Bronzewing			O, 1	O, 1										
Bird	**Sturnidae**	*Sturnus tristis**	Common Myna*														Op
Bird	**Psittacidae**	*Platycercus elegans*	Crimson Rosella			W, 1			Op								
Bird	**Estrildidae**	*Taeniopygia bichenovii*	Double-barred Finch				O, 8										
Bird	**Rallidae**	*Gallinula tenebrosa*	Dusky Moorhen											O, 1			
Bird	**Psittacidae**	*Platycercus eximius*	Eastern Rosella						W, 1							O, 2	
Bird	**Casuariidae**	*Dromaius novaehollandiae*	Emu											Footprint			
Bird	**Rallidae**	*Fulica atra*	Eurasian Coot										O, 12	O, 15	O, 25		
Bird	**Hirundinidae**	*Petrochelidon ariel*	Fairy Martin										O, 3				
Bird	**Cacatuidae**	*Eolophus roseicapillus*	Galah				Op						O, flyover, 4				
Bird	**Cisticolidae**	*Cisticola exilis*	Golden-headed Cisticola								W, 5	O/W, 5	W, 3+		W, 3		
Bird	**Artamidae**	*Cracticus torquatus*	Grey Butcherbird			W, 2			W, 1	W, 2							

				CONSERVATION STATUS		MONITORING SITES											
Fauna type	***Family***	***Scientific***	***Common Name***	***TSC ACT***	***EPBC ACT***	***R01***	***R02***	***W01***	***W02***	***W03***	***WR01***	***WR02***	***Dam 1***	***Dam 3***	***Dam 6***	***Triangle Dams***	***Opportunistic***
Bird	**Rhipiduridae**	*Rhipidura albiscapa*	Grey Fantail				O,4			O, 2	W, 1		W, 1				
Bird	**Pachycephalidae**	*Colluricincla harmonica*	Grey shrike-thrush				O, 1			H, 1							
Bird	**Anatidae**	*Anas gracilis*	Grey Teal										O, 2	O, 2		O, 4	
Bird	**Pomatostomidae**	*Pomatostomus temporalis*	**Grey-crowned Babbler**					W, 3+		W, 2+							
Bird	**Anatidae**	*Aythya australis*	Hardhead											O, 10		O, 4	
Bird	**Podicipedidae**	*Poliocephalus poliocephalus*	Hoary-headed Grebe											O, 8		O, 6	
Bird	**Cuculidae**	*Eudynamys orientalis*	Koel cuckoo														Op
Bird	**Megaluridae**	*Megalurus gramineus*	Little Grassbird											W, 1			
Bird	**Phalacrocoracidae**	*Phalacrocorax sulcirostris*	Little Black Cormorant										O, 2				
Bird	**Cacatuidae**	*Cacatua sanguinea*	Little Corella 37				O, flyover, 4	O, flyover, 6									
Bird	**Monarchidae**	*Grallina cyanoleuca*	Magpie-lark			W, 2		W, 2		W, 2							
Bird	**Charadriidae**	*Vanellus miles*	Masked Lapwing						W, 1		O, 4					O, 2	
Bird	**Falconidae**	*Falco cenchroides*	Nankeen Kestrel									O, flyover, 2					
Bird	**Meliphagidae**	*Phiemon corniculatus*	Noisy Friarbird					W, 1		W, 2							
Bird	**Meliphagidae**	*Manorina melanocephala*	Noisy Miner			O/W, 3			W, 3	O/W, 4	W, 2						
Bird	**Oriolidae**	*Oriolus sagittatus*	Olive-backed Oriole			W, 1	W, 1			W, 1							
Bird	**Anatidae**	*Anas superciliosa*	Pacific Black Duck										O, 10	O, 6		O, 6	
Bird	**Artamidae**	*Cracticus nigrogularis*	Pied Butcherbird			W, 1		W, 1	O, 1	W, 1							
Bird	**Artamidae**	*Strepera graculina*	Pied Currawong					W, 1									
Bird	**Rallidae**	*Porphyrio porphyrio*	Purple Swamphen										O, 4				
Bird	**Meropidae**	***Merops ornatus***	**Rainbow Bee-eater**		**M**	W, 1											

				CONSERVATION STATUS		MONITORING SITES										
Fauna type	***Family***	***Scientific***	***Common Name***	***TSC ACT***	***EPBC ACT***	***R01***	***R02***	***W01***	***W02***	***W03***	***WR01***	***WR02***	***Dam 1***	***Dam 3***	***Dam 6***	***Triangle Dams***	***Opportunistic***
Bird	**Estrildidae**	*Neochmia temporalis*	Red-browed Finch				O, 2										
Bird	**Petroicidae**	*Petroica goodenovii*	Red-capped Robin					O/W, 3									
Bird	**Charadriidae**	*Erythrogonys cinctus*	Red-kneed Dotterel											O, 1			
Bird	**Psittacidae**	*Psephotus haematonotus*	Red-rumped Parrot											O, 3			
Bird	**Monarchidae**	*Myiagra inquieta*	Restless flycatcher			W, 1											
Bird	**Pachycephalidae**	*Pachycephala rufiventris*	Rufous Whistler				W, 1	W, 1		W, 1							
Bird	**Timaliidae**	*Zosterops lateralis*	Silvereye				O/W, 5+	W, 1									
Bird	**Meliphagidae**	*Gavicalis virescens*	Singing honeyeater								W, 1	W/O, 3					
Bird	**Acanthizidae**	***Chthonicola sagittata***	**Speckled Warbler**	**V**				**O, 2**									
Bird	**Pardalotidae**	*Pardalotus striatus*	Striated Pardalote								O, 1						
Bird	**Meliphagidae**	*Plectorhyncha lanceolata*	Striped Honeyeater?							W, 3+							
Bird	**Cacatuidae**	*Cacatua galerita*	Sulphur-crested Cockatoo				W, 2										
Bird	**Maluridae**	*Malurus cyaneus*	Superb Fairy-wren			O/W, 4	O/W, 14	W, 3		W, 4+	O/W, 6	O, 5	W, 3+	O, 3			
Bird	**Accipitridae**	*Circus approximans*	Swamp Harrier?								Op, 1						
Bird	**Hirundinidae**	*Petrochelidon nigricans*	Tree Martin										O, 7				
Bird	**Accipitridae**	*Aquila audax*	Wedge-tailed Eagle									O, flyover, 2					
Bird	**Acanthizidae**	*Smicrornis brevirostris*	Weebill					W, 1		O/W, 4							
Bird	**Hirundinidae**	*Hirundo neoxena*	Welcome Swallow								O, flyover, 2		O, 4				
Bird	**Accipitridae**	*Haliastur sphenurus*	Whistling kite									O, 1					
Bird	**Accipitridae**	***Haliaeetus leucogaster***	**White-bellied Sea-Eagle**		**M**								O, 2				

				CONSERVATION STATUS		MONITORING SITES											
Fauna type	***Family***	***Scientific***	***Common Name***	***TSC ACT***	***EPBC ACT***	***R01***	***R02***	***W01***	***W02***	***W03***	***WR01***	***WR02***	***Dam 1***	***Dam 3***	***Dam 6***	***Triangle Dams***	***Opportunistic***
Bird	**Ardeidae**	*Egretta novaehollandiae*	White-faced Heron										O,1				
Bird	**Apodidae**	*Hirundapus caudacutus*	White-throated Needletail		M						O, flyover, 4	O, flyover, 8					
Bird	**Corcoracidae**	*Corcorax melanorhamphos*	White-winged Chough							W, 4			W, 4				
Bird	**Rhipiduridae**	*Rhipidura leucophrys*	Willie Wagtail			O/W, 3	W, 1	O, 2		O, 2	W, 1	W, 2			O, 1		
Bird	**Acanthizidae**	*Acanthiza nana*	Yellow Thornbill					O, 3									
Bird	**Acanthizidae**	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill					W, 4			O, 2						
Non-flying Mammal	**Bovidae**	*Bos Taurus**	Cattle*														Op
Non-flying Mammal	**Macropodidae**	*Macropus robusta*	Common Wallaroo														Op
Non-flying Mammal	**Macropodidae**	*Macropus giganteus*	Eastern Grey Kangaroo			Op, 3				Op, 3	Op, 15				Op, 2		
Non-flying Mammal	**Tachyglossidae**	*Tachyglossus aculeatus*	Echidna									C					
Non-flying Mammal	**Leporidae**	*Lepus europaeus**	European Brown Hare*								Op, 1						
Non-flying Mammal	**Leporidae**	*Oryctolagus cuniculus**	European Rabbit*						Op		Op, 1						
Non-flying Mammal	**Macropodidae**	*Macropus rufogriseus*	Redneck Wallaby				Op, 1									O, 1	
Reptile	**Agamidae**	*Intellagama lesueurii*	Eastern water dragon										Op, 1				
Reptile	**Agamidae**	*Pogona barbata*	Eastern bearded dragon			Op, 1											
Reptile	**Scincidae**	*Eulamprus quoyii*	Eastern Water-skink?				Op, 1										
Reptile	**Varanidae**	*Varanus varius*	Lace Monitor														Op

				CONSERVATION STATUS		MONITORING SITES										
Fauna type	***Family***	***Scientific***	***Common Name***	***TSC ACT***	***EPBC ACT***	***R01***	***R02***	***W01***	***W02***	***W03***	***WR01***	***WR02***	***Dam 1***	***Dam 3***	***Dam 6***	***Triangle Dams***	***Opportunistic***
Reptile	**Chelodina**	*Chelodina longicollis*	Long-necked turtle						1 DEAD						Op, 2 (plus 1 dead)	O, DEAD, 60+	

O Identified from observation
F Identified from footprint
W Identified from call
O/W Identified from both observation and call
C Identified by remote camera
U Identified by Songmeter recordings of echolocation calls
V Listed as Vulnerable under Schedule 2 of the TSC Act
E Listed as Endangered under the EPBC Act
M Listed as Migratory under the EPBC Act
* * Includes *N. gouldii, N. geoffroyi, N. timoriensis* and *N. corbeni.* Note that *N. corbeni* is listed as Vulnerable under Schedule 2 of the TSC Act and under the EPBC Act.
* Exotic Species
? 'Probable' confidence category as per Mills et al. (1996)

Appendix D Additional appropriate native flora species for revegetation

Class / Family	Species name	Common name	Habit	Woodland	Riparian	Native grassland
Dicots						
Acanthaceae	*Brunoniella australis*	Blue Trumpet	H	Y		Y
Asteracae	*Brachycombe multifida*	Cut-leaf Daisy	H	Y		Y
	Calotis cuneata	Mountain Burr-daisy	H	Y		Y
	Calotis lappulacea	Yellow Burr-daisy	H	Y		Y
	Chrysocephalum apiculatum	Common Everlasting, Yellow Buttons	H	Y		Y
Casuarinaceae	*Allocasuarina luehmannii*	Bulloak	T	Y		
	Casuarina cunninghamiana	River Oak	T		Y	
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	H	Y	Y	Y
	Einadia polygonoides	-	H	Y		
	Einadia trigonos	Fishweed	H	Y		
	Enchylaena tomentosa	Ruby Saltbush	SS	Y	Y	Y
Convolvulaceae	*Dichondra repens*	Kidney Weed	H	Y	Y	Y
Fabaceae (Faboideae)	*Chorizema parviflorum*	Eastern Flame Pea	H	Y		Y
	Daviesia ulicifolia subsp. *ulicifolia*	Gorse Bitter Pea	S	Y		
	Desmodium brachypodum	Large Tick-trefoil	V	Y		
	Desmodium varians	Slender Tick-trefoil	V	Y		Y
	Glycine clandestina	Love Creeper	V	Y		
	Glycine microphylla	Love Creeper	V	Y		
	Glycine tabacina	Glycine	V	Y		Y
	Pultenea spinosa	Spiny Bush-pea	S	Y		
Fabaceae (Mimosoideae)	*Acacia decora*	Western Golden Wattle	S	Y		
	Acacia falcata	Falcate Wattle	S	Y		
	Acacia parvipinnula	Silver-stemmed Wattle	S	Y		

Class / Family	Species name	Common name	Habit	Woodland	Riparian	Native grassland
	Acacia salicina	Cooba	ST	Y	Y	
Lobeliaceae	*Pratia purpurascens*	Whiteroot	H	Y	Y	Y
Malvaceae	*Brachychiton populneus*	Kurrajong	T	Y		
Moraceae	*Ficus coronata*	Creek Sandpaper Fig	ST		Y	
Myoporaceae	*Eremophila debilis*	Amulla	H	Y		Y
	Eremophila deserti	Turkeybush	S	Y		
Myrtaceae	*Angophora floribunda*	Rough barked Apple	T	Y	Y	
	Corymbia maculata	Spotted Gum	T	Y		
	Eucalyptus crebra	Narrow-leaved Ironbark	T	Y		
	Eucalyptus fibrosa		T	Y		
	Eucalyptus moluccana	Grey Box	T	Y		
	Eucalyptus tereticornis	Forest Redgum	T	Y		
	Notelaea macrocarpa var. *microcarpa*	Native Olive	ST	Y		
Pittosporaceae	*Bursaria spinosa* subsp. *spinosa*	Blackthorn	S	Y	Y	
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush	S	Y	Y	
Polygonaceae	*Persicaria subsessilis*	Hairy Knotweed	H		Y	
Rubiaceae	*Pomax umbellata*	Pomax	H	Y		
Sapindaceae	*Dodonaea viscosa* subsp. *angustissima*	Narrow-leaved Hop-bush	S	Y		
	Dodonaea viscosa subsp. *viscosa*	Hop-bush	S	Y		
Verbenaceae	*Clerodendrum tomentosum*	Hairy Clerodendrum	S		Y	
Monocots						
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	H	Y	Y	
Cyperaceae	*Carex appressa*	Tall Sedge	H		Y	
Lomandraceae	*Juncus usitatus*		H		Y	
	Lomandra multiflora	Many-flowered Mat-rush	H	Y		Y
	Lomandra longifolia	Spiny-headed Mat-rush	H	Y	Y	

Class / Family	Species name	Common name	Habit	Woodland	Riparian	Native grassland
Phormiaceae	*Dianella revoluta* var. *revoluta*		H	Y	Y	Y
Poaceae	*Aristida ramosa*	Purple Wiregrass	G	Y		Y
	Aristida vagans	Threeawn Speargrass	G	Y		Y
	Austrostipa ramosissima	Stout Bamboo Grass	G		Y	
	Austrostipa scabra	Speargrass	G	Y		Y
	Bothriochloa decipiens	A Redleg grass	G	Y	Y	Y
	Chloris truncata	Windmill Grass	G	Y	Y	Y
	Cymbopogon refractus	Barbed Wire Grass	G	Y		Y
	Dichelachne micrantha	Shorthair Plumegrass	G	Y		Y
	Echinopogon caespitosus var. *caespitosus*	Forest Hedgehog Grass	G	Y		
	Entolasia marginata	Bordered panic	G		Y	
	Entolasia stricta	Wiry Panic	G	Y		Y
	Eragrostis brownii	Brown's Lovegrass	G	Y		Y
	Microlaena stipoides var. *stipoides*	Weeping Grass	G		Y	
	Oplismenus aemulus	Australian Basket Grass	G		Y	
	Rytidosperma sp.	Wallaby Grass	G	Y	Y	Y
	Sporobolus creber	Rats-tail Grass	G	Y		Y
	Themeda australis	Kangaroo Grass	G	Y		Y

Note: G – grass; H – Herb; V – Vine / Twiner; SS – Sub-shrub; S – Shrub; ST – Small Tree; T - Tree

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