Dendrobium

Terrestrial Ecology Monitoring Program

Annual Report for 2015

Prepared for Illawarra Coal

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Summary

This document reports on the Dendrobium Terrestrial Ecology Monitoring Program (the program) required for Dendrobium Area 2, Dendrobium Area 3A and Dendrobium Area 3B for the 2015 calendar year. This report incorporates the previous 10.5 years of the program in Dendrobium Area 2, 6.5 years in Dendrobium Area 3A and 3.5 years in Dendrobium Area 3B. Monitoring includes a minimum of two years baseline surveys for pre-impact sites within Area 2 and Area 3. Some sites within Area 3B received only one year of baseline survey due to post-approval changes in monitoring requirements. Monitoring of reference sites has been occurring for a minimum of three years for Dendrobium Area 3B and up to a maximum of 11 years for Area 2.

An introduction and background context to the program is provided in Section 1. Methods used in site selection, data collection and statistical analysis are summarised in Section 2. Section 3 summarises literature relevant to the program and presents findings following statistical analysis undertaken by The Analytical Edge Statistical Consulting (The Analytical Edge Statistical Consulting, 2016). Conclusions and recommendations for the 2015 program are in Section 4.

During the 2015 monitoring period, Longwall 11 was extracted within Dendrobium Area 3B, which follows Longwall 10 in 2014 and Longwall 9 in 2013. Dendrobium Area 2 and Area 3A were previously mined beneath by Longwalls 3, 4, 5, 6, 7 and 8. Subsidence related impacts following mining include lowering of shallow groundwater in uplands swamps and loss or alteration in the quality of pool water for first and second order streams within these areas. The following ecological features are monitored as part of the program:

- Vegetation within upland swamps in Dendrobium Area 2, Area 3A and Area 3B.
- Vegetation along one stream in Dendrobium Area 3A.
- Littlejohn's Tree Frog *Litoria littlejohni* along streams in Dendrobium Area 3A and Area 3B.

The program included monitoring and analysis of five upland swamp sites as post-mining sites (Swamp 1 (S1), Swamp 15B (S15B), Swamp 1A (S1A), Swamp 1B (S1B) and Swamp 5 (S5)). The remaining swamps were monitored and analysed as controls or pre-mining sites. Parameters analysed were Total Species Richness (TSR) and species composition as well as swamp size and the extent of groundwater dependent swamp sub-communities.

Swamp size and the extent of groundwater dependent swamp sub-communities, mapped using LiDAR data captured in 2012, 2014 and 2015, showed a global decrease across control and impacted swamps in 2014 and 2015 when compared to 2012 data. The decrease was found to be greater at impacted sites when compared to control sites suggesting some effect of mining-related impacts.

Ground-truthing of model results at several swamps in March 2016 found that, in many cases, the modelled contraction in swamp size was not a true and accurate reflection of swamp vegetation on the ground and the model tended towards over-estimation of the reduction in swamp size and extent of groundwater dependent sub-communities.

Potential causes of this observed difference in modelled and actual swamp extent include:

- Natural growth and expansion of fringing eucalypt tree crowns at the perimeter of swamps
- Inherent inaccuracies of the LiDAR data (e.g. interpolation between LiDAR strikes)
- Movement of vegetation during LiDAR capture

Caution is urged when interpreting the results of the swamp size and ecosystem functionality monitoring given that a number of factors unrelated to mining impacts may drive some of the modelled decrease in swamp size and extent of groundwater dependent sub-communities. Moreover, changes in swamp size and extent of groundwater dependent communities observed at each swamp may be the result of responses to natural phenomena such as recent and long-term climate conditions, fire patterns and stochastic events (e.g. storm damage).

Ongoing monitoring and improvements to the LiDAR swamp modelling approach are recommended in order to improve the confidence with which modelled decreases in swamp size and ecosystem functionality can be said to represent real change attributable to mining-related impacts.

All upland swamps continue to show a trending decline in TSR, indicating broader landscape scale driven changes. The declines observed each year are small but statistically significant (p-value = 0.002). In addition to the background trending decline across all sites, S15B and S1A show a small, but statistically significant decline in TSR following mining, where TSR is declining post-mining.

Regardless of treatment (impact and control), species composition is changing every year and this change is statistically significant at most sites. This change is within expected range, as some natural turnover of species occurs at sites each season and across the years monitored. When species composition is analysed at impact sites located within the vicinity of mining (the risk management zone), a statistically significant change between pre- and post-mining species composition is detected at two sites, S15A(2) (p-value = 0.004) and S1A (p-value = 0.092). This change was not detected at other sites located within a risk management zone. Further assessment of sites that had been mined beneath however revealed that there was no change in species composition, other than the natural background change, from pre- to post-mining.

There is one post-mining creek site (SC10) within Dendrobium Area 3A where monitoring is conducted as a part of the program. A graphical representation, in conjunction with formal statistical tests, identifies no significant change in the TSR when comparing pre-mining data and post-mining data. Additionally, no significant trends were detected for control sites within this area. Based on TARPs for Area 3A, Biosis recommended ceasing biannual monitoring at SC10 until at least six months prior to the extraction of Longwall 19 (Biosis 2015b), therefore data reported here is for autumn 2015 only.

Monitoring of five streams in 2015 (SC10C, DC(1), DC13, WC17 and WC21) as part of the Littlejohn's Tree Frog program were analysed as post-mining sites. Within Dendrobium Area 3A, adult Littlejohn's Tree Frogs have not been recorded at WC17 for two consecutive years following subsidence related impacts. Following an assessment of WC17 against the TARPS for terrestrial fauna - threatened frog species within the *Dendrobium Area 3 Watercourse Monitoring Trigger Action Response Plan* (TARP) (dated 12 October 2015) it was determined that a Level 3 TARP has been triggered for WC17. Following heavy rains during the breeding season Littlejohn's Tree Frog was recorded at SC10C for the first time since 2012. When assessing the presence of Littlejohn's Tree Frog at SC10C over the course of time, it is clear that despite detecting the species in 2015, a local reduction in the available breeding habitat has occurred where mining impacts have occurred. This reduction in habitat has been evident for three consecutive winter monitoring surveys and documented in stream monitoring data collected by the Illawarra Coal Environmental Field Team (data provided by Illawarra Coal Environmental Field Team January 2016). Following an assessment of SC10C against the TARPS for terrestrial fauna - threatened frog species within the *Dendrobium Area 3 Watercourse Monitoring Trigger Action Response Plan* (TARP) (dated 12 October 2015) it was determined that a Level 3 TARP had been triggered for SC10C.

Similarly for Dendrobium Area 3B, Littlejohn's Tree Frogs were recorded at DC13 for the first time since 2012 following subsidence related impacts in 2013 following the extraction of Longwall 9 (Illawarra Coal 2014). Adult frog abundance was very low (one frog) and following an assessment against the TARPS for terrestrial fauna - threatened frog species within the *Dendrobium Area 3 Watercourse Monitoring Trigger Action Response Plan* (TARP) (dated 12 October 2015) it was determined that a Level 2 TARP had been triggered for DC13.

Monitoring of upland swamps and Littlejohn's Tree Frog sites will continue throughout 2016 in Dendrobium Area 3B and Dendrobium Area 3A. It is also recommended that S1 be monitored in autumn 2016 as a biennial program for this site following observed changes in vegetation succession within upland swamp sub-communities.

The monitoring program will continue to achieve the four key outcomes:

- Ongoing monitoring of biophysical characteristics within Dendrobium Area 2 and Dendrobium Area 3.
- Determine if mining results in changes to the biological integrity of the Dendrobium mining area through comparison of baseline and control data with that collected through ongoing monitoring.
- Provide input to the design of any rehabilitation programs that may be necessary.
- Monitor the success of any remedial works.

1 Introduction

Biosis Pty Ltd was commissioned by Illawarra Coal to undertake terrestrial ecology monitoring for the Dendrobium Coal Mine in accordance with the Subsidence Management Plan (SMP) (Biosis 2003) and as required by the Dendrobium Colliery Planning Approval, originally issued in 2001, and as modified in 2008 and 2010.

The Dendrobium Coal Mine includes longwall mining of Areas 1, 2 and 3. Extraction of coal from Area 1 began in April 2005 and concluded in January 2007. Extraction of coal from Area 2 commenced in March 2007 and concluded in December 2009. A Section 75W modification, approved in December 2008, split Area 3 into Areas 3A, 3B and 3C. Extraction of coal in Area 3A commenced in February 2010 and concluded in December 2012. Extraction of coal from Area 3B commenced in February 2013 and continued through this monitoring year.

The Dendrobium Terrestrial Ecology Monitoring Program (the 'program') commenced in 2003 and is expected to continue throughout the duration of mining activities and for a period after the completion of mining within each area. Ecological monitoring in Area 1 was completed in the 2008/09 financial year, and the final report for Area 1 was completed in early 2010 (Biosis 2010). Monitoring in Areas 2, 3A and 3B are currently ongoing (refer to Section 1.1 for further details).

The aim of the program is to determine whether subsidence effects associated with longwall mining result in impacts to terrestrial ecology values located above the longwalls. In order to achieve this aim, a Before-After Control-Impact (BACI) experimental design has been established and implemented. The BACI design investigates how sites that have been mined beneath change over time (Before-After) compared with change at control sites that have not been mined beneath (Control-Impact).

As many of the terrestrial ecology values present within the study area (Section 1.1) are unlikely to be impacted as a result of mining, the program focuses on those values considered at greatest risk of impact from subsidence effects, namely those values reliant on shallow groundwater or surface water. Ecological values which are currently being monitored include vegetation communities (species and diversity) and the threatened frog, Littlejohn's Tree Frog *Litoria littlejohni*, within suitable habitats (second and third order streams) throughout the three domains.

The current report includes new monitoring data collected during 2015 and provides an analysis of data collected to date for the program.

1.1 Study area

Ecological monitoring is undertaken across four broad study areas, all of which are located within the Metropolitan Special Area and Southern Coalfield of New South Wales (Figure 1). The four study areas include three mining domains (Dendrobium Area 2, Dendrobium Area 3A and Dendrobium Area 3B) as well as control sites.

Natural features located within each of the mining domains are monitored for a minimum of two years prior to impacts. Sites are referred to as pre-impact, until the closest point of secondary extraction is located within the 400 metre risk management zone (RMZ) of the natural feature. From that point, they are then referred to as post-mining impact sites. Monitoring focusses on terrestrial ecology values within the RMZ which are sensitive to valley closure, upsidence, strains and fracturing. This is in accordance with recommendations made by the Department of Planning (2008). Given that impacts to natural features become most evident after the natural feature is mined beneath, the date the site has been mined beneath has also been considered in the assessment of trends over time.

All terrestrial ecology monitoring sites located within Dendrobium Area 2 and Dendrobium Area 3A have experienced mining within the RMZ and are therefore now considered to be post-mining impact sites (with the exception of one point at S15A(2) and one point at SC10 – see Section 1.1.2). Several monitoring sites within Dendrobium Area 3B were surveyed up until spring 2012 as pre-impact sites. Mining commenced within this area prior to the autumn 2013 season and a total of three upland swamps were classified as post-mining impact sites (or at least one monitoring point within the swamp) by the end of the 2013 monitoring period (30 November 2013) resulting in one year of baseline.

Given the length of threatened frog monitoring transects, a site can experience multiple treatments at the same time including being directly mined beneath, having the RMZ mined beneath and no mining within the RMZ. For this reason, pool mapping and records of breeding locations have been identified to identify the sections of these transects that have been impacted.

A summary of each of the study areas is provided below.

1.1.1 Dendrobium Area 2

Dendrobium Area 2 originally included a sample of natural features located above Longwalls 3, 4 and 5. Mining of Area 2 commenced in March 2007 and concluded in December 2009.

Given that no impacts to SC6 were observed following three years of post-mining impact monitoring, it was removed from the spring/autumn monitoring program following autumn 2012. This site has been retained in the program as a control site specifically to check activity levels of Littlejohn's Tree Frog during breeding season due to the presence of a significant population of the species. Although not directly mined beneath, this site is located within the RMZ of Longwall 5 in Dendrobium Area 2.

One site that has been directly mined beneath (S1) continues to be monitored biennial (every two years) as a part of this program (Figure 2).

1.1.2 Dendrobium Area 3A

Dendrobium Area 3A includes a sample of natural features located above Longwalls 6, 7, 8 and 19. Mining of Area 3A commenced in 2010 and concluded with Longwall 8 in December 2012. Mining is proposed to commence at Longwall 19 following the completion of Dendrobium Area 3B.

Natural features monitored as a part of this program include two upland swamps (S15A (2) and S15B) and one creek (SC10 (Banksia Creek)) (Figure 3). S15A (2) is located at the eastern end of the proposed Longwall 19 of Dendrobium Area 3A. Currently two monitoring points, V1 (including photo-point 1) and V3 (including photo-point 3), have experienced mining within the RMZ however monitoring point V2 (including photo-point 2) will not experience mining within the RMZ until the completion of Longwall 19. Similarly, SC10 was originally proposed to be mined beneath; however Longwall 7 was shortened to reduce impacts to the Sandy Creek Waterfall. Two of three monitoring points (V2 and V1) at SC10 fall within the RMZ of Longwall 7, while V1 will now no longer fall within the RMZ of any of the longwalls in Dendrobium Area 3B.

Following analysis of the 2014 data for SC10 it was found that no significant impacts had been detected at SC10 for 2.5 years. Based on the TARP for riparian vegetation for Dendrobium Area 3A Terrestrial Flora (Illawarra Coal 2010) and length of time until Longwall 19 is extracted, it was recommended at the completion of the 2014 monitoring period that Illawarra Coal cease bi-annual monitoring for SC10 until at least six months prior to the extraction of Longwall 19 which satisfies the Area 3A TARP. Because of this, the 2015 reporting period only encapsulates data for autumn 2015, following which, monitoring at SC10 and its control sites SC7 and DC10 have ceased temporarily.

Monitoring of Littlejohn's Tree Frog transects is undertaken in four creeks located within Dendrobium Area 3A during winter; 6CDL, SC10 (two sections), SC10C and WC17 (Figure 3). As a result of impacts to SC10C and WC17, monitoring of streams within Dendrobium Area 3A continued in 2015.

1.1.3 Dendrobium Area 3B

Dendrobium Area 3B includes natural features located above Longwalls 9 through to 18. Mining of Area 3B commenced with Longwall 9 in February 2013 and continued through 2015. Monitoring in Dendrobium Area 3B is conducted using a staged approach with new sites established as mining progresses for baseline data collection at least two years from longwall mining occurring within the RMZ of a site.

Natural features currently monitored as a part of this program in 2015 included four upland swamps (S1A, S1B, S5 and S13) along with continued monitoring of S11 which has previously been used as a control site for Dendrobium Area 3A and is yet to experience mining within the RMZ (Figure 4).

During 2015 a total of five creeks (DC(1), DC13, LA4A, WC15 and WC21) continued to be monitored for threatened species as part of the Dendrobium Area 3B program (Figure 4).

1.1.4 Control sites

A number of control sites have been established for comparison with sites that have been or will be mined beneath. Control sites for vegetation monitoring include two creeks (SC7 and DC10) and three upland swamps (S15A(1), S22 and S33;Figure 5).

S11 is included within the Dendrobium Area 3B monitoring program as the data will be used for baseline monitoring prior to the commencement of Longwall 12 in 2016. S11 will continue to be used as a control site within the 2015 monitoring programs as this site is the only adequate control site for the monitoring of S1 given the length of monitoring.

There are three additional control swamps monitored specifically for the Dendrobium Area 3B monitoring program (S88 (previously named Gallahers Creek Swamp), S87 (previously named FT15E Swamp) and S86 (previously named F T 6X Swamp)). These sites were established to ensure an even mix of impact and control sites in the BACI experimental design.

Ten control sites are surveyed as part of the Littlejohn's Tree Frog monitoring program including SC7 (two transects), SC7A, SC8, WC10, WC11, SC6, DC8, NDC, ND1 and ND2 (Figure 6).

1.2 Survey sites and monitoring periods

Sites originally proposed by Illawarra Coal for the monitoring program have been installed to collect at least two years pre-mining data. Additional monitoring sites were established closer to the mining period following the requirements of approval conditions and may not have two years of pre-mining data.

A summary of all impact sites and corresponding control sites has been provided in Table 1. In addition to site pairing, this table shows when monitoring commenced and the period when mining has been undertaken.

Table 1 Summary of monitoring sites

Area	Impact site	Monitoring commenced	Mining progress		Control sites
Vegetation monitoring					
Dendrobium Area 2	S1 (Swamp 1)	2005 – spring 2014, then 2015 (spring only)	Within mining RMZ: • V1 15/05/2008 • V2 Aug 2007 • V3 Jul 2007	Mined beneath: • V1 03/09/2009 • V2 29/08/2009 • V3 Jun 2008	S15A(1) (Swamp 15A(1)) S11 (Swamp 11)
Dendrobium Area 3A	S15B (Swamp 15B)	2003	Within mining RMZ: • V1 Aug 2011 • V2 18/09/2010 • V3 16/10/2010	Mined beneath: • V1 25/08/2012 • V2 and V3 beyond goaf	S15A(1) (Swamp 15A(1)) S11 (Swamp 11)
	S15A (2) (Swamp 15A(2))	2009	Within mining RMZ: • V1 20/10/2012 • V2 is located beyond RMZ • V3 27/10/2012	Mined beneath: • All points beyond goaf	S15A(1) (Swamp 15A(1)) S22 (Swamp 22) S33 (Swamp 33)
	SC10 (Banksia Creek)	2005 – autumn 2015	Within mining RMZ: • V1 located beyond RMZ • V2 10/12/2011 • V3 26/11/2011	Mined beneath: • All points beyond goaf	SC7 (Cascade Creek) DC10 (Donalds Castle Creek)

Area	Impact site	Monitoring commenced	Mining progress		Control sites
Dendrobium Area 3B	S1A (Swamp 1A)	2012	Within mining RMZ: • V1 23/02/2013 • V2 27/02/2013 • V3 06/04/2013	Mined beneath: • V1 7/04/2014 • V2 11/04/2013 • V3 beyond goaf	S88 (Swamp 88) S87 (Swamp 87) S86 (Swamp 86) S15A(1) (Swamp 15A(1))
	S1B (Swamp 1B)	2005-2009, then 2012-present	Within mining RMZ: • 08/02/2013	Mined beneath: • V1 19/02/2013 • V2 10/03/2013 • V3 13/02/2013	S87 (Swamp 87) S86 (Swamp 86) S15A(1) (Swamp 15A(1)) S22 (Swamp 22) S33 (Swamp 33)
	S5 (Swamp 5)	2012	Within mining RMZ: • V1 30/04/2014 • V2 18/05/2013 • V3 28/05/2013	Mined beneath: • V1 20/07/2015 • V2 14/08/2014 • V3 25/07/2013	S88 (Swamp 88) S87 (Swamp 87) S86 (Swamp 86) S15A(1) (Swamp 15A(1))
	S11	2003	Within mining RMZ: • V1 predicted Longwall 12 • V2 predicted Longwall 13 • V3 predicted Longwall 13	Mined beneath: • V1 beyond goaf • V2 predicted Longwall 14 • V3 predicted Longwall 14	S15A(1) (Swamp 15A(1)) S22 (Swamp 22) S33 (Swamp 33)
	S13 (Swamp 13)	2013 (spring only)	Within mining RMZ: • V1 predicted Longwall 13 • V2 predicted Longwall 13 • V3 predicted Longwall 14	Mined beneath: • V1 predicted Longwall 14 • V2 predicted Longwall 14 • V3 predicted Longwall 15	S88 (Swamp 88) S87 (Swamp 87) S86 (Swamp 86) S15A(1) (Swamp 15A(1))

Area	Impact site	Monitoring commenced	Mining progress		Control sites
Threatened frog breeding habitat monitoring					
Dendrobium Area 2	No longer undertaken. SC6 (Waratah Creek) is now used as a trigger site given the reliability of the Littlejohn's Tree Frog population (Section 1.1.1).				
Dendrobium Area 3A	SC10(1)	2006	Within mining RMZ: • Transect start, Pools 5A–5B outside RMZ • Pools 1–6 Dec 2011 • Pools 7–Transect End Nov 2011	Mined beneath: • All pools beyond goaf	SC6 (Waratah Creek) SC7(1) SC7A
	SC10(2)	2006	Within mining RMZ: • Transect Start and Pools 25–26F predicted Jul 2023 • Pools 12C–24 Oct 2012 • Pools 10B–12B and Transect End Nov 2011	Mined beneath: • Pools 22A–22C predicted Longwall 19 • All other pools and transect start and end beyond goaf	NDC (Native Dog Creek) SC6 (Waratah Creek) SC7(1) SC7A
	SC10C	2006	Within mining RMZ: • Transect Start–Pool 6 Nov 2011 • Pool 7 Dec 2010 • Pools 8–Transect End Oct 2010	Mined beneath: • Transect Start – Pool 2 beyond goaf • Pools 2A6 Nov 2012 • Pool 7–Transect End Oct 2012	SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7A
	6CDL	2009	Within mining RMZ: • Transect Start–Pool 5 Dec 2010 • Transect End Jan 2011	Mined beneath: • All pools beyond goaf	ND2 SC6 (Waratah Creek) SC7(2) (Cascade Creek) SC8 (Fern Tree Creek)

Area	Impact site	Monitoring commenced	Mining progress		Control sites
	WC17	2011	Within mining RMZ: Mar 2010	Mined beneath: • Transect Start and Pool 26 Apr 2011 • Pools 23 and 25 outside of goaf • Pools 20–22 and Transect End Mar 2012	NDC (Native Dog Creek) ND1 SC6 (Waratah Creek) SC8 (Fern Tree Creek) WC10 (Easement Creek) WC11
Dendrobium Area 3B	DC (1) (Donald's Castle Creek)	2013	Within mining RMZ: • Transect Start–Pool 27 Beyond RMZ • Pool 28–Transect End June 2013	Mined beneath: • All pools beyond goaf	DC8 SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7(2) (Cascade Creek) SC7A SC8 (Fern Tree Creek) WC11
	DC13	2010	Within mining RMZ: • Transect Start, End and Pools 9–12 April 2013 • Pool 1 and Pools 20–21 February 2013 • Pool 13A–Pool 19 March 2013	Mined beneath: • Transect End March 2013 • Pool 1 and Pool 18A–Pool 21 April 2013 • Transect Start and Pools 9–17 beyond goaf	SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7(2) (Cascade Creek) SC7A SC8 (Fern Tree Creek)
	LA4A (Downstream of DA3B)	2007	Within mining RMZ: • Predicted Longwall 13	Mined beneath: • All pools beyond goaf	ND1 SC6 (Waratah Creek) SC7(2) (Cascade Creek) SC8 (Fern Tree Creek)

Area	Impact site	Monitoring commenced	Mining progress		Control sites
	WC15	2011	Within mining RMZ: • Predicted Longwall 14	Mined beneath: • Transect Start–Pool 24 predicted Longwall 14 • Pool 29–Transect End predicted Longwall 15 • Pools 25–28 beyond goaf	DC8 NDC (Native Dog Creek) SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7A SC8 (Fern Tree Creek)
	WC21	2013	Within mining RMZ: • Transect Start–Pool 3 Beyond RMZ • Pools 4–5 January 2014 • Pool 6 and Pool 28 November 2013 • Pools 7–27 October 2013 • Pool 29–Transect End September 2014	Mined beneath: • Transect Start–Pool 10 and Pool 28 beyond goaf • Pools 1 –21 December 2013 • Pools 22–27 November 2014 • Pool 29–Transect End December 2015	DC8 SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7(2) (Cascade Creek) SC7A SC8 (Fern Tree Creek) WC10 (Easement Creek) WC11

1.3 Aims of this report

The aims of this monitoring report are to:

- Describe surveys undertaken in Area 2, Area 3A and Area 3B during the 2015 monitoring program.
- Discuss results of statistical analysis undertaken for 2015 survey data in the context of the results of the program since its inception.
- Report on the potential impacts of subsidence on vegetation in creek and upland swamp environments.
- Report on the potential impacts of subsidence on Littlejohn's Tree Frog populations along creek environments.
- Summarise key issues that arose during the monitoring year and how they were addressed.
- Describe future ecological monitoring to be undertaken and proposed improvements to environmental management or performance.

2 Methods

The baseline survey methodology, results of the statistical analysis and revised survey methodologies are detailed in previous Biosis annual monitoring reports (2005a, 2007a, 2007b, 2013a, 2013b, 2014 and 2015b). The following is a brief description of the survey methodology.

2.1 Survey techniques

Table 2 provides a summary of the survey method used in each of the Dendrobium monitoring programs. Timing of surveys has been developed in consultation with state and federal survey guidelines, particularly when surveying for Littlejohn's Tree Frog. This is described further in Section 2.1.3 and Table 2 below.

Table 2 Summary of survey methodology

Survey type	Area	Timing
Upland Swamp Vegetation Monitoring	Dendrobium Area 2 Dendrobium Area 3A Dendrobium Area 3B	Once in autumn and once in spring each year.
Creek Vegetation Monitoring	Dendrobium Area 3A	Once in autumn and once in spring every second year.
Littlejohn's Tree Frog Breeding Habitat Monitoring	Dendrobium Area 3A Dendrobium Area 3B	Once in winter each year.
Photo-point Monitoring	Dendrobium Area 2 Dendrobium Area 3A Dendrobium Area 3B	Once in autumn and once in spring at all flora monitoring locations.

2.1.1 Upland swamp vegetation monitoring

Detailed mapping of the boundaries of vegetation communities and sub-communities within upland swamps has been previously undertaken at eight swamps within Dendrobium Area 3B, two swamps within Dendrobium Area 3A and a further two sites beyond the Dendrobium 3A and 3B areas using the following techniques:

- Light Detection and Ranging (LiDAR) data to define the extent of upland swamps as well as areas requiring further investigation.
- Ground truthing of these areas in the field to confirm swamp boundaries and mapping of swamp sub-communities.
- Geographic Information System (GIS) to spatially represent data.

A detailed description of the LiDAR upland swamp mapping methodology has been documented previously in Biosis (2013b) and is summarised below together with a description of recent methodological updates.

LiDAR monitoring of changes to impact and reference upland swamp extent

Initial mapping of upland swamps was undertaken by Biosis in 2013 (Biosis 2013b). This included mapping of upland swamps using a modified methodology of Jenkins and Frazier (2010). Biosis subsequently amended this methodology to allow more accurate mapping of upland swamp boundaries with minimal manual adjustment, thus allowing for the use of this methodology in ongoing monitoring. The extent of upland swamps mapped in 2013 was revised using this new methodology.

Baseline (pre-mining) Light Detection and Ranging (LiDAR) data was obtained by AAM Group using Airborne Laser Scanning (ALS) from a fixed-wing aircraft on the 28 February 2012. This data was processed as outlined below.

For each LiDAR capture, raw LiDAR non-ground and ground returns were processed and converted to a continuous raster surface and then a Canopy Height Model (CHM) using methods described in Biosis (2013b). The CHM raster was then converted to polygons using the 'Raster to Polygon' geoprocessing tool and a 5 metre height threshold was applied to remove polygons or parts of polygons with height value less than 5 metres from the dataset. The application of a 5 metre height value threshold was originally based on published descriptions of height classes for upland swamp plant communities (NPWS 2003). Further manual 'cleaning' of polygons was undertaken to remove 'false positives' (i.e. obvious non-swamp patches classified by the model as swamp vegetation) and to consolidate overlapping or coincident polygon boundaries. Obvious false positives, such as man-made clearings, roads and open waterbodies, were manually removed from the dataset using aerial photo interpretation (API). Prior interrogation of the dataset for known upland swamps indicated the majority of known swamps are greater than 500 m^2 in extent. Therefore, the 'potential swamps' dataset was further processed to remove polygons with an area of less than 500 m^2. The final output of the LiDAR processing described above was a total swamp area at 2012 for each swamp within Area 3B and 3A mapped in 2013 (Biosis 2013b).

Mapping undertaken using this revised methodology identified a number of new 'potential swamp' polygons, not identified in 2013. 'Potential swamp' polygons were ground-truthed by Biosis botanists experienced in the identification of upland swamps on the Woronora Plateau. Ground-truthing was undertaken over two full field days on 10 and 12 February 2016 by two botanists. 'Potential swamp' polygons were uploaded to a GIS-enabled tablet computer and ground-truthed on-foot by field staff. At each mapped 'potential swamp' polygon, field staff confirmed the presence of upland swamp vegetation based on rapid assessment of vegetation composition, structure and topographic position and comparison of observed vegetation to published vegetation community descriptions (i.e. NPWS 2003). Where mapped polygons were confirmed as upland swamp, the sub-community type(s) were recorded and the boundary of the swamp ground-truthed using the GIS software *Collector for ArcGIS* on a tablet computer. Where boundaries obtained during the automated processing of LiDAR data did not accurately reflect swamp boundaries these boundaries were revised based on field observations, GPS readings and aerial photo interpretation (API). Spatial data collected in the field was later verified and cleaned by GIS officers using ArcMap 10. Using this methodology the boundaries of swamps mapped in 2013, were revised. A list of swamps mapped as a part of this assessment is provided in Table 3.

To determine whether subsidence associated within longwall mining had resulted in any changes to the extent of upland swamps the methodology outlined above was repeated using LiDAR data obtained in 2014 (23 February 2014) and 2015 (16 January 2015). Change in total swamp size from baseline to the most current year was investigated by comparing the total areal extent of each swamp polygon mapped using the 2014 and/or 2015 LiDAR data with the total swamp size mapped using the 2012 baseline LiDAR data.

Preliminary results generated from the above methodology were reviewed in order to validate the modelled changes in swamp size over the 2012 - 2014 and 2012 - 2015 periods. The review identified a number of areas within swamps where the LiDAR model indicated a decrease or increase in swamp which was not supported by interpretation of high resolution aerial photographs (i.e. aerial photographs from 2015, when compared with imagery from 2012, did not indicate a change in the extent of swamp had occurred). Subsequent ground-truthing of these areas determined the following:

- In all cases investigated, field assessment confirmed that modelled increases in swamp vegetation were due to stochastic impacts (e.g. storm damage) on fringing eucalypt canopy trees which had the effect of lowering the canopy height below the 5 m height threshold. These 'positive' changes were therefore not considered further in the final analyses of change in swamp extent.
- Swamp vegetation often reached well above the 5 m height threshold applied to the previous LiDAR swamp model. Individual shrubs within Banksia thicket and Tea-tree thicket often reached heights of 6 – 7 m. The growth of swamp vegetation above the 5 m threshold was therefore deemed to be the main driver of swamp area 'decrease' in swamps investigated.
- Growth of fringing eucalypt crowns at the perimeter of swamps may be a significant contributor to the observed 'contraction' of swamp boundaries from 2012 – 2014/2015. Ground-truthing of modelled 'contraction' at points within several swamps found that swamp vegetation remained but that the overarching canopy of mature eucalypts may have expanded driving an observed 'decrease' in swamp extent.

Based on the results of ground-truthing described above, the canopy height threshold was adjusted from 5 metres to 8 metres and the LiDAR swamp mapping model was reapplied across all Dendrobium Area 3A and 3B swamps.

The change in extent of groundwater dependent upland swamp sub-communities from baseline was assessed by intersecting the post-impact (i.e. 2014 and/or 2015) total swamp area with available detailed upland swamp sub-community mapping for each swamp. Groundwater dependent sub-communities include MU42, MU43, MU44a, MU44b and MU44c as described in NPWS (2003).

Eight of the 13 swamps within Dendrobium Areas 3A and 3B for which 2012 and 2014/2015 data was available had not yet been mined beneath at the time of LiDAR capture and were therefore designated as 'control' swamps for purposes of analysis. The remaining five swamps within Dendrobium Area 3B have been mined beneath and are therefore considered 'impacted' swamps (Table 3). Figure 7 presents each of the swamps considered in the LiDAR swamp mapping analysis. Seven swamps were excluded from analyses described below due to incomplete LiDAR coverage in 2014 and 2015 (Table 3).

Table 3 Upland swamps for which changes to total swamp area and extent of groundwater dependent communities between 2012 and 2014 and/or 2015 was assessed using airborne LiDAR. Upland swamps which could not be assessed due to incomplete coverage of LiDAR in 2014/2015 are also included.

Swamp name	LiDAR comparison period	Mining impact
S01a	2012 – 2014 and 2012 - 2015	Impacted
S01b	2012 – 2014 and 2012 - 2015	
S05	2012 – 2014 and 2012 - 2015	
S08	2012 – 2014 and 2012 - 2015	
S15b	2012 - 2014	
S11	2012 – 2014 and 2012 - 2015	Control
S89	2012 – 2014 and 2012 - 2015	
S90	2012 – 2014 and 2012 - 2015	
S91	2012 – 2014 and 2012 - 2015	
S92	2012 – 2014 and 2012 - 2015	
S93	2012 – 2014 and 2012 - 2015	
S95	2012 – 2014	
S96	2012 - 2014	
DC10 Swamp	Not assessed - incomplete coverage	
S13	Not assessed - incomplete coverage	
S14	Not assessed - incomplete coverage	
S15a	Not assessed - incomplete coverage	
S22	Not assessed - incomplete coverage	
S33	Not assessed - incomplete coverage	
S94	Not assessed - incomplete coverage	

Transect monitoring program

Vegetation monitoring in upland swamps is undertaken along three 15 metre transects within each swamp. The presence of all species within thirty 0.5 metre x 0.5 metre quadrats located along the 15 metre transect is recorded. A maximum score of 30 per transect for a species indicates it is present in all quadrats.

Where there is potential for misidentification, or where species cannot be reliably identified to species level in the field, species have been grouped into identification units for analysis. Each of these units is referred to as a species complex.

Surveys are undertaken once in spring and once in autumn each year.

2.1.2 Creek vegetation monitoring

Vegetation surveys within creeks are undertaken at three 20 metre x 20 metre (400 m^2) quadrats per creek. Within each quadrat, cover abundance scores were given to each species occurring within the quadrat using a modified Braun-Blanquet cover-abundance scale (defined by OEH), as outlined below:

1: <5% - 3 or less individuals

2: <5% - more than 3 sparsely scattered

3: <5% - common throughout plot

4: 5% - 25%

5: 25% - 50%

6: 50% - 75%

7: 75% - 100%

Again, where there is potential for misidentification or where plants cannot be reliably identified to species level in the field, taxa have been grouped into species complexes.

Surveys are undertaken once in spring and once in autumn each year.

2.1.3 Littlejohn's Tree Frog monitoring

Targeted surveys for Littlejohn's Tree Frog are undertaken annually in late winter to early spring, when the species is calling and therefore most detectable. The aim of these targeted surveys is to monitor known locations of this threatened frog species in order to detect any changes in extent and abundance, or impacts to habitat.

Littlejohn's Tree Frog is listed as vulnerable under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is known to breed within first and second (and occasionally third) order streams within Dendrobium Area 2, Dendrobium Area 3A and Dendrobium Area 3B.

Standardised transects have been established in breeding habitat to create repeatable survey effort that enables direct comparison of the numbers of individuals detected at each site from one year to the next. Baseline surveys prior to longwall mining within the RMZ of a stream enable a population assessment to be determined along each transect, allowing for natural population fluctuations.

Nocturnal surveys of creeks with suitable habitat are undertaken to determine the presence of adult frogs, tadpoles and egg mass. These transects are surveyed by walking down the creekline and counting all amphibians seen or heard on either side of the line. Tadpole and egg mass counts are also undertaken as part of the survey. The location of any individuals detected during the targeted nocturnal surveys or any other significant incidentals is recorded using a GPS and included in mapping provided in the reporting phase of the project. Sites are surveyed once each year or repeated if unforeseen seasonal or weather conditions result in a lack of detection of the target species.

Opportunistic sightings of other species, including threatened species such as the Giant Burrowing Frog *Heleioporus australiacus* and Red-crowned Toadlet *Pseudophryne australis* are also documented.

2.1.4 Photo-point monitoring

Photo-point monitoring is conducted at or in proximity to all vegetation monitoring sites (impact and control). Photographs are taken at each site at a fixed location and view angle. With the majority of flora sites having six or more years of photo point monitoring, presenting photos across time that capture the same vegetation view on a single page became increasingly challenging. A review of the method of presentation was discussed with Illawarra Coal during the current reporting period. At minimum photo-point monitoring tables in Appendix 2 show spring and autumn photos from a pre-mining monitoring year, a central mentoring year, the year prior to the current reporting year and the current reporting year.

Biosis reviews all photos from all seasons and years as part of our analysis to directly compare habitat condition. An interpretation of the photo-point monitoring has been provided in Section 3.2.2.

2.2 Literature review

Illawarra Coal monitors a variety of features located above Dendrobium Area 2, Area 3A and Area 3B as a part of their SMP monitoring program. In addition to ecology, features monitored include surface water, groundwater and subsidence effects. A review of data associated with these monitoring programs is presented in Section 3.1. Where relevant, data from other specialist reports have been used to explore observed changes to habitat or to identify areas of ecological features that may require further scrutiny.

2.3 Statistical analysis

2.3.1 Background to analysis

Following collection in the field, vegetation data was entered into a database and validated prior to analysis. Control sites selected for analysis were chosen for impact sites based on ecological similarity in the field and then compared using exploratory data analysis to confirm that the data were statistically suitable and available for the same period of time as impact sites.

Littlejohn's Tree Frog data was also entered into a database and validated prior to analysis. Control sites chosen for impact sites were selected on similarity of ecological features in the field.

The Analytical Edge Statistical Consulting Pty Ltd was commissioned by Biosis to undertake statistical analyses of flora and Littlejohn's Tree Frog data collected at upland swamp and creek sites (The Analytical Edge Statistical Consulting 2016). The analysis provides a statistical comparison of impact and control sites with the aim to identify, understand and manage any mining impacts.

2.3.2 Measures of analysis

Impacts to vegetation may be evidenced by a change to the number of species at different sites, or an overall change in the species composition, as some species may be less affected than others. In affected areas, these impacts may manifest as the following:

- Change in floristic TSR: the number of individual species and is calculated by summing the total number of unique species detected at each monitoring point during each season and year. This is a simple presence-absence measure and does not account for the relative abundance of each species.
- Changes in the floristic species composition: the assemblage or identity of different individual plant species that make up a vegetation community.

These indicators have been described in further detail below.

Impacts to Littlejohn's Tree Frog may be evidenced by a decline in populations or disruption of the breeding cycle following changes to key breeding habitat features. The impacts are measured quantitatively through Littlejohn's Tree Frog abundance. Adult frog abundance data was standardised across all sites by determining the number of individuals detected within a 100 metre section of creekline for each site.

Changes in frog detection may be due to mining impacts or unrelated landscape effects; for example local climate changes, bushfire etc. and as such a Before-After-Control-Impact (BACI) experimental design has been employed to increase confidence in the interpretation of observed changes. However, the ability to model the (potentially competing) influences of any long term adult frog abundance trends and after mining effects using a traditional BACI design is limited, as two out of the three post-mining impact sites within Dendrobium Area 3B lack more than one year of before mining data. To overcome these data limitations, an asymmetrical BACI design has been applied (known as a staircase design) and generalised linear mixed models and multi-variate presence-absence models used to analyse the BACI data.

2.3.3 Review of statistical analysis procedure

As part of Biosis' commitment to providing Illawarra Coal with a robust ecological monitoring program according to current best practise, The Analytical Edge Statistical Consulting were commissioned to undertake a review of the statistical analysis and data collection methodology following the completion of the 2015 program. The Analytical Edge Statistical Consulting provided Biosis with advice regarding the existing analysis techniques and recommended best practise statistical analysis to date. The results of this review are detailed below.

Upland swamp vegetation monitoring

Following review of data collection methods at swamp sites, The Analytical Edge Statistical Consulting outlined that the data collected allows for the determination of TSR and an analysis of species composition based on presence-absence data.

An important outcome of this review was that the flora data collected across all sites cannot act as a surrogate for abundance of species detected in the swamps. Data collected along transects within swamps is a value between 0 and 30, reflecting relative frequency or occupancy rather than abundance. A low cumulative total for swamp data means that the species is not widespread along each transect but may still be locally abundant (e.g. patchy species); whereas, a high score means the species may be widespread but not necessarily abundant (i.e. a single individual in each of the 30 quadrats). Consequently, following the data review it was advised that the Shannon diversity index will not be included as a part of the analysis for the swamp flora data as this method of data analysis requires abundance data and the measure recorded by current data collection methods is that of relative occupancy not relative abundance.

Similarly, the non-metric Multi-Dimensional Scaling (n-MDS) has not been included in the analysis for the 2015 statistics given the difficulty in detecting changes in species composition over time. Multi-Dimensional approaches such as n-MDS plots are typically exploratory and do not include a formal statistical test to inform a quantitative decision about the potential impact of longwall mining.

Alternatively, an 'mvabund' package has been used whereby many Generalised Linear Models (GLMs) can be fit with the response variable being the presence or absence of a species along each surveyed transect and the explanatory variables of season, year and mining status. These multiple GLMs can be correlated together to account for species interactions. This method enables the detection of change in species composition and the determination of which species are likely driving any changes. 'mvabund' is a new development in the field of species distribution modelling and is considered to be an innovative advantage in the analysis of the Dendrobium ecological monitoring data.

When analysing the species community composition of a survey point, multivariate data have been traditionally analysed within a distance-based framework, using methods like principal components analysis of non-metric multidimensional scaling (Biosis 2015a). This method however does not allow a formal framework in which to test the significance that treatment-effects (i.e. pre-mining, post-mining, mined beneath or control) influence species composition. Within the statistical field, there has been a recent trend toward model-based approaches when dealing with complex, multivariate data such as species composition. As such, multi-variate presence-absence models were fitted using the 'manyglm' function in the 'mvabund' package in the statistical program R during the data analysis herein. This allows for a finer scale assessment of change at each monitoring point and allows for the identification of the individual flora species that may be driving change within a site.

Further detail of the statistical analysis methodology is provided in Section 2.3.4.

Creek vegetation monitoring

The data at creekline sites is collected as a Braun-Blanquet score using a mixture of categorical variables. Values represent the species presence or absence at low levels; and an ordinal variable where large values represent a higher percentage cover. By collecting data through the Braun-Blanquet categories a species that is very small in size but abundant would get a low score while a single large species could have a relatively high percentage cover but a low abundance. For this reason it is not advised to use this data for calculating abundance.

As an alternative, the current dataset for creeklines within Dendrobium Area 3A has been used to determine changes in TSR as well as an analysis of species community composition based on presence-absence data.

Littlejohn's Tree Frog monitoring

The Littlejohn's Tree Frog data collected to date is technically presence-only in the sense that detectability cannot be estimated, and the ability to distinguish between a true absence record (i.e. the species does not occur at the site) and a false absence record (i.e. the species does occur at the site but was not detected) is limited.

There are possibilities to analyse presence only data within a species distribution modelling (SDM) framework such as MaxEnt, whereby habitat covariates are used to investigate long-term trends in species distribution. Further exploration into this technique is currently being investigated.

The 2015 results are displayed visually with control site data in line graphs for each mining area combined and for each individual impact site where required.

2.3.4 Data analysis procedure

The following methodology was designed and applied to the Dendrobium dataset by The Analytical Edge Statistical Consulting (2016).

Vegetation data analysis

A change in TSR or species composition following mining at an impact site that does not occur at a control site may indicate a potential impact. In order to detect changes in indicator variables, particular trends must be identified. These trends may occur suddenly, as a pulse event, or more likely, gradually over time.

TSR was calculated for swamp sites by summing up the number of species detected at each transect for each survey. At creek sites, the Braun-Blanquet scores recorded for each of the species detected along a transect were condensed into a single value: 1 if it was detected and 0 otherwise (see Section 2.3.3 for rationale). Species detections were tallied to obtain TSR at each transect at each monitoring location.

Exploratory data analysis included plotting TSR for each survey year from when monitoring first commenced up to 2015, split by mining status ('control or pre-mining', 'post-mining' or 'mined beneath' for swamps and 'control or pre mining' versus 'post mining' for creeks), representing TSR across all survey locations and sites. For swamps, this averaging process may mask individual swamp-level effects of mining status (i.e., richness at some swamps might go up, others might go down, but on average total richness appears stable). Hence the TSR in each year, across each of the three transects, for each swamp were individually plotted. The aim is to determine whether the trend in TSR pre-mining is different to the trend in TSR post-mining (or mined beneath).

Comparison of TSR between sites and years was done graphically using box plots. Box plots allow for a detailed visual of the median distribution including the underlying variability and distribution of the metrics. The box of a box plot contains the central 50 per cent of the distribution; from the first quartile to the third quartile (quartiles split the distribution into four parts, each containing one quarter, 25 per cent). Lines extending from the boxes represent the rest of the data and any points beyond these are considered outliers. Points plotted for each year are the surveys, representative of sample size.

To formally quantify whether trends detected visually represent actual changes in TSR, generalised linear mixed models (Bolker et al. 2009) were tested for all impact sites. The models tested the influence of season, year and mining status (pre, post or mined beneath) on TSR. Season allows us to look for any cyclical trends; calendar year allows us to look for trends in time across all sites; while mining status allows us to see if observed trends are different at mining and non-mining sites.

An assumption of generalised linear mixed models is that observations are independent, which here is clearly violated both temporally (since sites are visited multiple times) and spatially (since some sites within regions are closer together). That is, it would be expected that observations collected at the same swamp, regardless of year or season, would be more correlated than observations collected at different swamps; and similarly, observations collected at swamps near each other would be more similar to observations collected at swamps further away. To account for this correlation within sites and the nesting of sample points within the area, a random-effect term was included. Akiake's Information Criteria (AIC) was used to select between competing models, whereby the model with the lowest AIC was considered the 'best' of all models fitted, and models that had an AIC less than or equal to two from the AIC of the best model were considered equivalent.

All modelling and the creation of graphs was completed in the statistical software program R by The Analytical Edge Statistical Consulting (2016). Generalised linear mixed models of TSR were fitted using the 'glmer' function in the 'lme4' package.

Flora data was used to determine species composition, or community composition, at each transect for swamps and each quadrat for creeks, within each swamp or creek during each survey (i.e. a species list of all unique species detected in each visit).

The 'manyglm' function in the 'mvabund' package (in the program R), were used to fit presence-absence models to each detected species. These models correct the correlation between species (thus violating an assumption of standard generalised linear models) by using generalized estimating equations. Analysis of variance (ANOVA) was used to formally test the significance of explanatory variables (i.e., 'year', 'season' and mining status). Separate models were fitted to data collected at each swamp to account for that at some impact sites not all of the transects had been mined beneath, while for others all transects were mined beneath. If the mining status explanatory variable were found to be significant, univariate tests were completed to determine which individual species were driving the change in flora community composition.

Littlejohn's Tree Frog data analysis

Data analysis for Littlejohn's Tree Frog includes visual representation of the data and determination of trends from graphs. All data for Littlejohn's Tree Frog adult, tadpole and egg mass numbers were standardised to represent abundance within a 100 metre section of creekline. This data was then used to create line-plots of the abundance of each life stage across each of the areas and then for each impact site, split by mining status ('pre-mining/control', 'post-mining', and 'mined beneath').

Formal statistical analysis has not been undertaken as the methodology that can be applied to the data collected is still being developed by Biosis and The Analytical Edge Statistical Consulting.

2.4 Limitations

One of the greatest limitations of the ecological monitoring program is the availability of suitable impact sites to adequately conform to a BACI design. Suitable monitoring locations immediately above longwalls or with potential to be impacted are limited in extent. The loss of some sites which were planned to be mined under but were not, due to mine plan changes (for example, SC10-V1 and SC10-F1, S15A (2)-V2, SC7 and SC8), has further limited the number of sites for analysis.

Since 2011, Littlejohn's Tree Frog surveys have been refined, resulting in slight changes to how data is recorded. Subsequently, an increase in tadpole and egg mass numbers has been detected. Therefore, although historical tadpole and egg mass data has been included, it can be unreliable at detecting significant changes following impacts. As such, analyses of the current Littlejohn's Tree Frog data can only be reliably completed on adult abundance data for sites relying on pre-2011 baseline data.

The risk of human error in data collection is an inevitable reality of a long-term monitoring program and must be accounted for in the data analysis. Given the complexity that arises with cryptic flora species, such as those that are inconspicuous unless flowering or in fruit, plant species complexes have been developed that link plant species that are known to be easily confused in the field. These linked species have been treated as one in the data analysis to streamline the data and reduce the possibility of human error leading to statistical differences. Species complexes have been developed based on site specific experience over many years.

Despite best efforts to identify all individuals during a survey, Littlejohn's Tree Frog data is biased to presence-only given the inherent limitations regarding the ability to distinguish between a true absence record and a false absence record. Additionally, like many fauna surveys, the dataset is not normally distributed and is skewed by a high number of zero counts. Due to these limitations in the data, The Analytical Edge Statistical Consulting did not replicate analyses completed in previous years as determining the probability that an adult frog is present at a site, and from this a true change in abundance, is difficult because the likelihood of detection can't be determined.

In summary, ecological monitoring programs are confounded by ecological communities responding differently to environmental conditions and potential subsidence effects. It is recommended that in future programs, monitoring for each community with 'one size fits all' approach is unlikely to get the most reliable information. As such, each year Biosis is committed to the continual review of our programs to provide options for improvement and is currently in the process of refining the data collection and statistical analysis components of the program.

3 Results

Results are described in the following sections for the autumn 2015 through to spring 2015 sampling period.

3.1 Literature review

The following is a brief review of the relevant monitoring programs and specialist reports for Dendrobium Area 2, Dendrobium Area 3A and Dendrobium Area 3B, including End of Panel reporting, surface and groundwater reports and Illawarra Coal Environmental Field Team impact reports.

Pre, during and post-mining monitoring of landscape changes and pool water levels along first, second and third order streams has been conducted by the Illawarra Coal Environmental Field Team. These observations are quantified by measurements taken from installed benchmarks. The results of this monitoring at select pools are considered relevant to the ecological monitoring program and have been included herein to provide further insight into the Littlejohn's Tree Frog data analysis in Section 3.4.

During the 2015 ecological monitoring program a total of nine surface impacts were identified by the Illawarra Coal Environmental Field Team (Illawarra Coal 2016). One of these impacts was observed in a watercourse, three were observed on fire road access tracks and five were observed on a seismic track. A reduction in water levels was observed in watercourse WC21.

The shallow groundwater monitoring program documented a Level 3 TARP in relation to shallow groundwater levels (reduction and recession rates) at Borehole 05_01 within S5 following the extraction of Longwall 11 below this site (Illawarra Coal 2015a).

Surface water, groundwater and landscape impacts to Dendrobium Area 2 and Area 3A remained unchanged throughout the 2015 monitoring season with groundwater below baseline levels (Illawarra Coal 2016).

3.1.1 Dendrobium Area 2

Dendrobium Area 2 consists of the surface area above the Dendrobium Coal Mine Longwalls 3, 4 and 5 and was mined between 2007 and 2009. At the completion of 2015 a total of 9 years of flora monitoring had been completed at S1 with pre-mining flora monitoring commencing in 2005 and post-mining flora monitoring conducted for 7.5 years. Post-mining flora monitoring was undertaken at S1 during spring 2015 only. This is following the results from the 2014 reporting period specifying that due to the recorded change in species composition at one of the vegetation monitoring locations, this site will be monitored biennial (every two years) (Biosis 2015b).

No additional relevant literature is available for this area since the 2011/2012 annual report (Biosis 2013a).

3.1.2 Dendrobium Area 3A

Dendrobium Area 3A consists of the surface area above the Dendrobium Coal Mine Longwalls 6, 7, 8 and 19, with the extraction of Longwalls 6-8 from 2010 through 2012. Following the extraction of Longwall 8 on 29 December 2012, 30 subsidence related impacts had been identified by the Illawarra Coal Environmental Field Team. These included nine impacts recorded in watercourses. Subsidence impacts include rock fracturing and flow diversion within WC17 and SC10C sub-catchments, which has resulted in the draining and/or loss of water from Littlejohn's Tree Frog breeding pools. S12 and S15B experienced lower groundwater head and increased rates of shallow groundwater recession. To date, subsidence related impacts in Littlejohn's Tree Frog breeding habitat and shallow groundwater systems within upland swamps have not recovered to pre-baseline conditions.

No impacts have been detected for riparian vegetation monitoring at SC10 over the three years of post mining monitoring.

The following review details the impacts to sites monitored as part of the Dendrobium Area 3A terrestrial ecology monitoring program.

Swamp 15B

During 2015 the piezometers in S15B (located in the vicinity of the flora monitoring points S15B-V1 [Piezometer 15b_H1] and S15B-V2 [Piezometer 15b_H2]), recorded a brief recharge following significant rain but quickly returned to zero levels (Illawarra Coal Environmental Field Team data, 15 January 2016). A third piezometer, located in the vicinity of S15B-V3 (Piezometer 15b_H3) recorded below baseline levels throughout 2015 and only exhibited one small recharge event following significant rain in April 2015; however this recharge value was still below baseline values. Piezometers adjacent to flora monitoring points continued to record rates of water recession higher than baseline levels following initial subsidence impacts (Illawarra Coal Environmental Field Team data, 15 January 2016). In addition, all sites recorded values of zero for shallow groundwater following impact (Illawarra Coal Environmental Field Team data, 15 January 2016). The initial loss of shallow groundwater and increased rates of recession from these piezometers occurred between November 2011 (15b_H2 and 15b_H3) and October 2012 (15b_H1) after being mined beneath by Longwall 7 and Longwall 8 respectively (Illawarra Coal Environmental Field Team data, 15 January 2016).

Piezometers (15b_H1, 15b_H2 and 15b_H3), are located in areas of Sedgeland-Heath Complex – Cyperoid Heath and Tea-tree Thicket upland swamp sub-communities which are known to occur in locations subject to periodic inundation and on soils with impeded drainage (NPWS 2003). As noted above, subsidence related loss of shallow groundwater, which is supporting these vegetation communities, has been recorded for three consecutive years since impacts were first recorded.

In addition to the decline in shallow groundwater and decrease in measured groundwater recession rates following rain events, incidental observations by Biosis botanists noted localised areas of sedge and rush dieback from S15B-V1 through to S15B-V3 (Biosis 2013a, 2013b, 2014, 2015). Most of the areas of dieback noted in 2013 have shown no discernible increase in size since initial observations were made in 2013. Annual fluctuations in Pouched Coral Fern *Gleichenia dicarpa* cover have also been observed during monitoring and noted to correspond with antecedent rainfall (J. Carlon 2015, pers. comm., 6 February; M. Misdale 2015, pers. comm., December).

In 2014, a localised area of vegetation showing visible stress (browning of sedges and rushes) was observed south of S15B-V. During monitoring in spring 2015, the vegetation west of S15B-P2 was also showing visible stress in the form of browning of vegetation. Plate 1 below shows an example of the browning vegetation. The area of browning vegetation was approximately 40 metres long and approximately 2 to 5 metres wide (based on visual estimate in the field).

Moreover, an area containing sedges, ferns and rushes, west of S15B – V2 was noted to have a reduced cover and yellowing of vegetation during spring 2014 (Biosis 2014). A visual assessment of this area in 2015 indicated a recovery of cover and vigour during spring 2015. The observed recovery in 2015 may reflect the prevailing climatic conditions leading up to these survey periods.

Locations of vegetation dieback are monitored as part of the landscape monitoring program (completed by the Illawarra Coal Environmental Field Team) and have been reported in impact reports.

Plate 1 Browning of sedges and rushes adjacent to S15B-P2.

Sandy Creek and Sandy Creek tributaries

During 2015 no mining occurred below Sandy Creek or any of the Sandy Creek tributaries and no additional impacts were observed. Following impacts resulting from the extraction of Longwall 7 in 2011 and Longwall 8 in 2012, Pool 1, Pool 3, Pool 5 and Pool 8b have become particularly important for breeding Littlejohn's Tree Frog along SC10C. Regular water level monitoring by the Illawarra Coal Environmental Field Team at Pool 1, Pool 3 and Pool 5 has continued throughout 2015.

Graph 1 shows the hydrology of three pools along SC10C and uses the data collected by the Illawarra Coal Environmental Field Team to show the change in pool water level to a level below benchmark and pool drying at two of the three known Littlejohn's Tree Frog breeding pools along SC10C. Where benchmarks could not be installed, the following qualitative measurements of Pool Water Observations were recorded ensuring a clear graphical representation:

- -3: Dry below nail (i.e. water in pool)
- -4: Pool dry

A specialist review of SC10C was completed in 2014 by Ecoengineers (Ecoengineers 2014a) following observations consistent with the Level 3 trigger of the revised *Dendrobium Area 3A Trigger Action Response Plans* (TARP) (dated 18 October 2012). The Level 3 stream appearance trigger for SC10C is as follows:

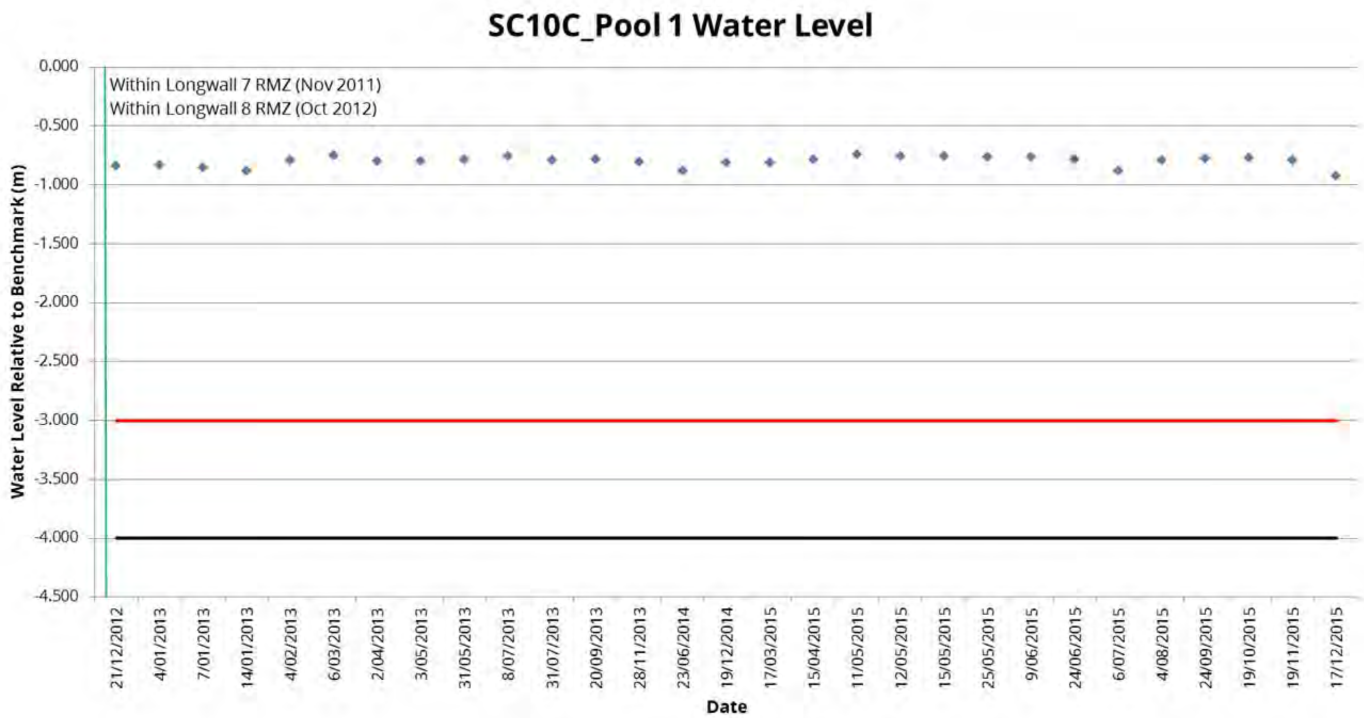
- *Pool water level or pool retention time lower than baseline in all mapped pools in any first or second order stream which is located in the mining area.*

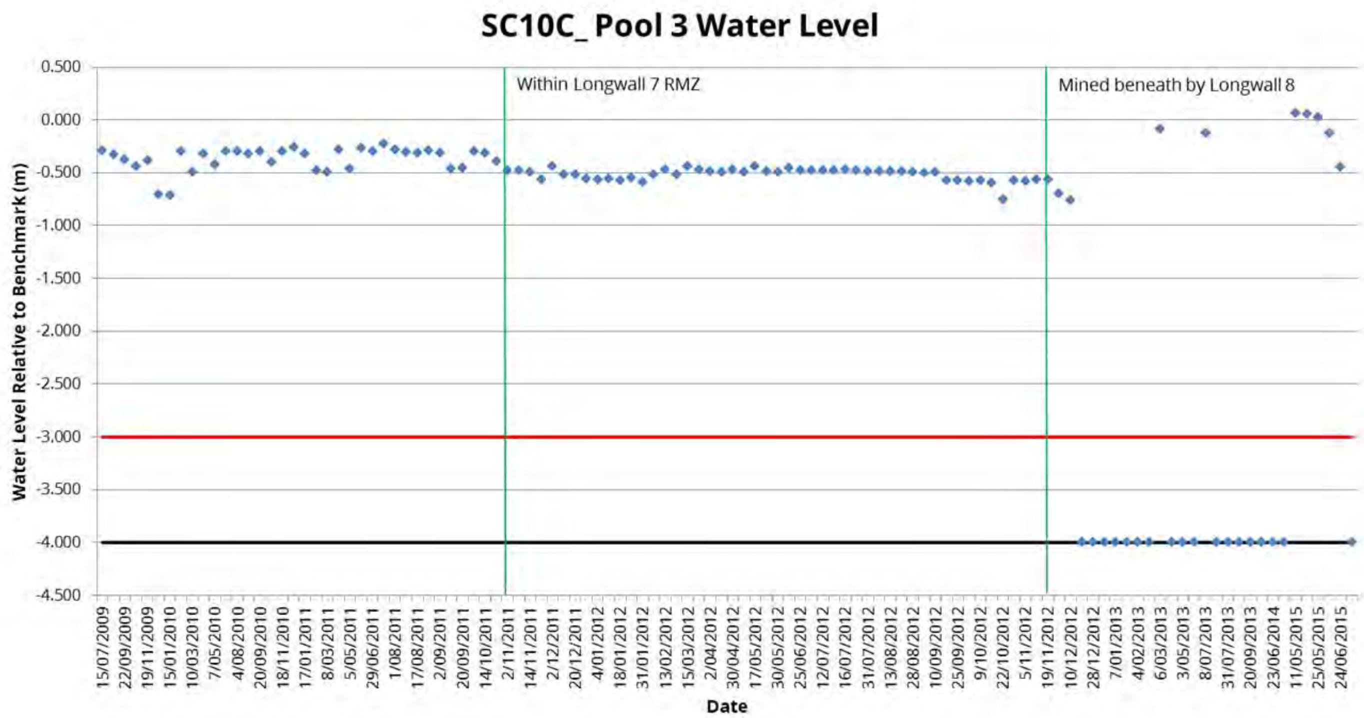
In addition, a Level 3 aquatic ecological TARP (within the revised Dendrobium Area 3A TARPs) was triggered based on the monitoring of pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat (Cardno Ecology Lab 2013). The Level 3 aquatic ecology trigger for SC10C is as follows:

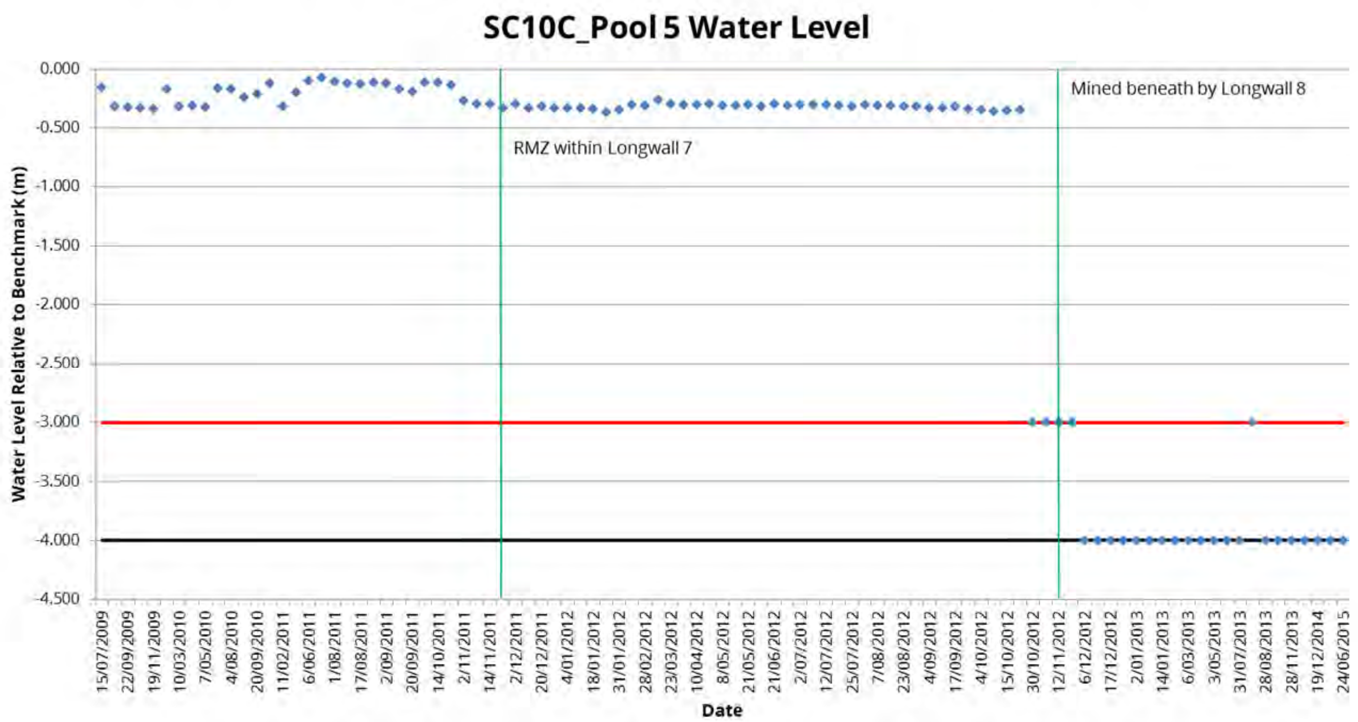
- *Reduction in aquatic habitat for an extended timeframe (> 2 seasons) or complete loss of habitat.*

Water levels in Pool 5 have not recovered in 2015, despite heavy rainfall in April and August (Graph 1). During 2015, water was present in Pool 3 during 5 of the 6 water level samples with a decreasing trend observed and was recorded to be dry in June (Graph 1). Initial pool water loss from Pool 3 and Pool 5 occurred in late 2012 following the extraction of Longwall 8. Water levels at Pool 1 remain within pre-mining levels since the extraction of Longwalls 7 and 8. Pool 1 is the only pool along SC10C that provides breeding habitat for Littlejohn's Tree Frog that has not been directly mined beneath. Pool 3 and Pool 5 have both been mined beneath by Longwall 8. Water levels at these pools rapidly fluctuate in response to rainfall and rates of water level loss are now steeper than pre-mining. This data corresponds with incidental observations by Biosis during monitoring.

Graph 1 **Water level at four pools along SC10C including three known breeding pools for Littlejohn's Tree Frog; Pool 1, Pool 3 and Pool 5 (data provided by Illawarra Coal Environmental Field Team). Red lines represent water levels below nail and black lines represent dry pool.**







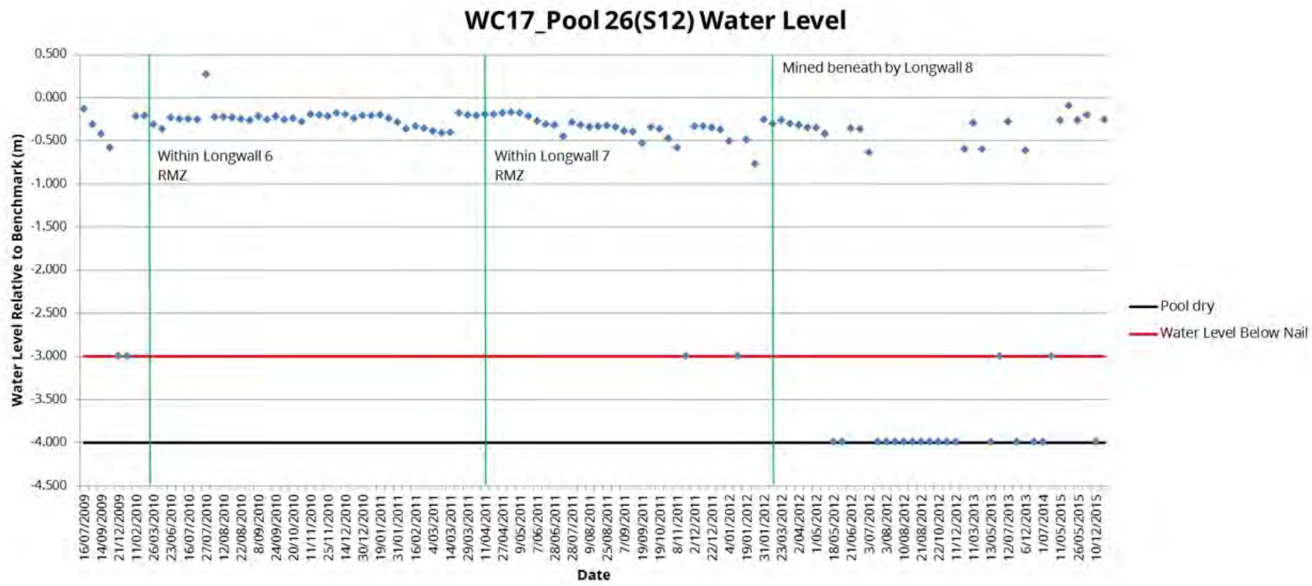
WC17

During 2015, WC17 contained water for 5 of the 6 water level samples and was recorded to be dry once during this time as observed in Graph 2 (data provided by Illawarra Coal Environmental Field Team January 2016). Incidental observations by Biosis during winter 2015 found that the entire monitoring transect along WC17 was full of water following approximately 43 millimetres of rainfall in the month prior to survey. This contrasts the observations of 2014 monitoring season where the entire length of the transect was dry at the time of survey. Iron flocculent coverage was present throughout the entire monitoring transect in 2015.

One pool, P26(S12) (Illawarra Coal WC17_Pool 11), has previously been identified as important Littlejohn's Tree Frog breeding habitat (Biosis 2012). The first substantial loss of pool water level for Pool 26(S12) was recorded in May 2012 following the extraction of Longwall 8 and water levels in this pool continued to fluctuate through 2015. Since this time the pool has been dry for months at a time, with intermittent spikes in water levels which rapidly drop to below the previously recorded baseline levels (Graph 2). Low water levels are consistent with Level 2 of the revised Dendrobium Area 3A TARP, being:

- *Pool water level or pool retention time lower than baseline in the majority of mapped pools in any first or second order stream which is located in the mining area.*

Graph 2 Water level record for WC17-Pool 26(S12), a known breeding pool for Littlejohn's Tree Frog (data provided by Illawarra Coal Environmental Field Team)



3.1.3 Dendrobium Area 3B

At the completion of extraction of Longwall 10 on 20 January 2015, 23 impacts had been identified by the Illawarra Coal Environmental Field Team. These included 13 impacts recorded along WC21 and the increase in three existing impacts from the extraction of Longwall 9 within this watercourse. Reductions in pool water levels were observed in pools associated with these impacts. Reduced shallow groundwater levels and increased rates of shallow groundwater recession were observed in S1A, S1B and S5 (Illawarra Coal Environmental Field Team data, 15 January 2016).

During the 2015 monitoring period, an additional nine surface impacts associated with Longwall 11 were identified within Dendrobium Area 3B. Rock fracturing of the sandstone along watercourse WC21 was one of these impacts and included multiple fractures along a 30 metre section, upstream of Pool 30. These observations were specific to the section of WC21 above Longwall 11 and are in addition to the observed fractures along this creekline during the extraction of Longwall 9 and Longwall 10. During field assessments the Illawarra Coal Environmental Field Team noted that water flow was absent in locations where it was previously recorded (Illawarra Coal 2016). Longwall 11 was extracted beneath the upper section of watercourse WC21 during December 2015.

The following is a summary of literature associated with sites monitored as part of the 2015 for the program.

Swamp 1A

Piezometer 01a_01 (located in the vicinity of S1A-V1) exhibited a steep rate of water recession following the extraction of Longwall 11 in May 2015 (Illawarra Coal Environmental Field Team data, 15 January 2016). A change in water hydrology at Piezometer 01a_01 was first detected following the extraction of Longwall 10 in April 2014 beneath the site and included an increased rate of water recession and complete loss of water head (Ecoengineers 2015). A brief recovery of head was recorded between August and September 2014, April and May 2015 and again in September 2015 before returning to zero within two months of significant rains (Ecoengineers 2015, Illawarra Coal Environmental Field Team data, 15 January 2016). In addition to this, it is evident that the piezometer located in the vicinity of S1A-V2 (Piezometer 01a_4) continues to have only brief recharge events following significant rain and an increased rate of groundwater recession since the extraction of Longwall 9 when compared to baseline rates (Ecoengineers 2015).

Both Piezometer 01a_01 and Piezometer 01a_4 are located within upland swamp sub-communities, Sedgeland-Heath Complex – Cyperoid Heath and Tea-tree Thicket. At the completion of the 2015 monitoring program, rapid recession rates and the loss of shallow groundwater within S1A had been evident for a total of 2 years and 8 months since subsidence impacts were first recorded.

In addition to the change in shallow groundwater retention throughout S1A, during spring 2015 Biosis observed an area approximately 50 m by 50 m in the centre of S1A, east of S1A-V2 and above Longwall 9, where Needlebush *Hakea teretifolia* was exhibiting signs of stress through visible yellowing (Plate 2). Needlebush is commonly found in or near wetter locations (Harden 2002) and is a characteristic species or floristically common within all of the upland swamp communities on the Woronora plateau (NPWS 2003). The area of Needlebush stress is within an area previously mapped as Upland Swamp - Sedgeland-Heath Complex: Restioid Heath. The occurrence of this species within Restioid Heath is described as low shrubs within a low open heath (NPWS 2003). The shrubs encountered were over 1.5 m in height and were becoming characteristic of a transition towards Upland Swamp – Banksia Thicket, a natural progression within upland swamp (Keith 2006). Chlorotic stress has the potential to be a transitory event based on climatic influences at the time, further observations are required to confirm any trends. The area is located approximately 100 m to the south east of V2 and not within close proximity to any of the piezometers within this swamp.

Additional observations from annual flora monitoring are presented in Section 3.2.

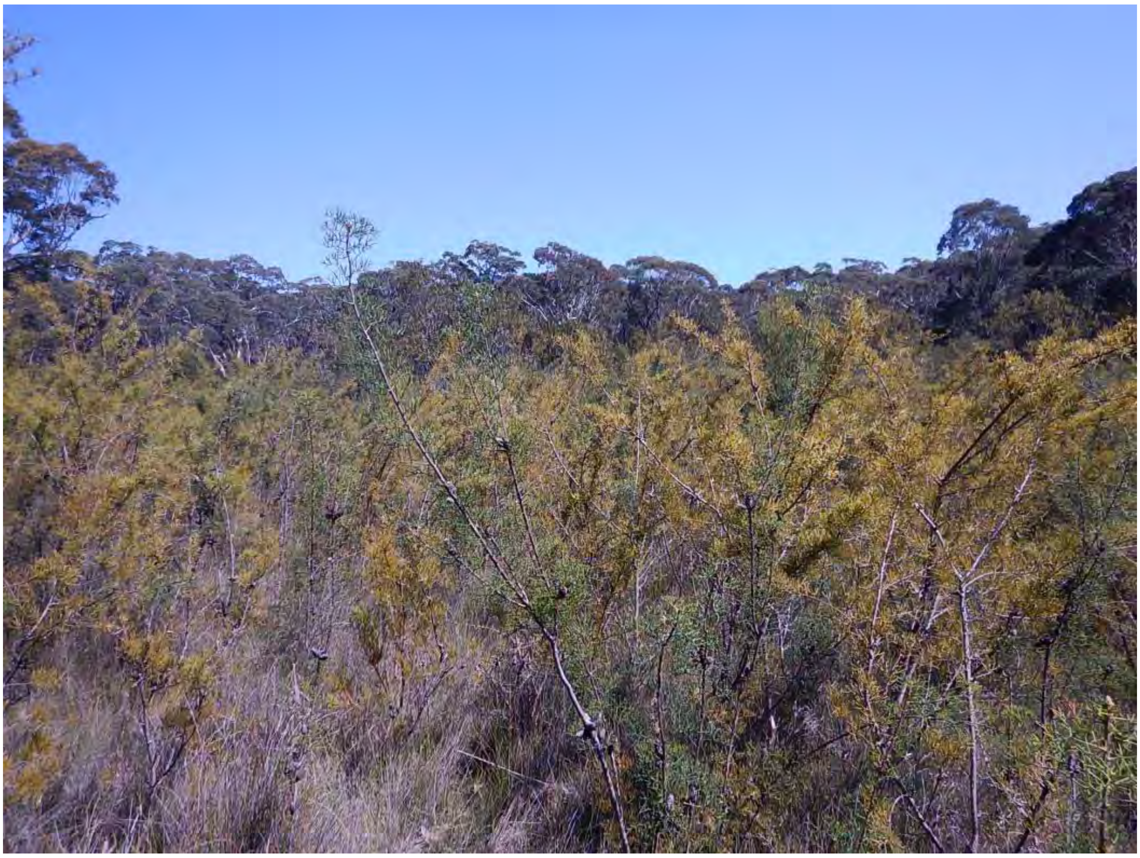


Plate 2 Area of Needlebush within S1A showing signs of vegetation stress (yellowing foliage in foreground) in spring 2015

Swamp 1B

Water recession rates at Piezometer 1b_02, within the vicinity of S1B-V2, has continued to exceed baseline rates during 2015 (Illawarra Coal Environmental Field Team data, 15 January 2016). Changes in the rate of water recession was first recorded when this site was mined beneath in early 2013 following the extraction of Longwall 9 (Illawarra Coal 2014; Ecoengineers 2015). This is the only piezometer within Swamp 1B that has comparable baseline data prior to the extraction of Longwall 9.

One of the additional piezometers within S1b, Piezometer 01b_01, is located beyond the goaf of all longwalls in the area and therefore not mined beneath. Water recession rates at this site remain consistent since monitoring began in early 2012.

Piezometer 01b_02 is located within the upland swamp sub-community, Sedgeland-Heath Complex – Cyperoid Heath, known to be supported on soils with impeded drainage while Piezometer 01b_01 is located within the upland swamp sub-community, Sedgeland-Heath Complex – Restioid Heath, known to occupy the drier soils within the swamp complex. Both vegetation communities are however subject to periodic inundation (NPWS 2003). At the completion of the 2015 monitoring program, rapid recession rates and loss of shallow groundwater within S1B had been recorded for a total of 2 years and 8 months since subsidence impacts were first recorded (Illawarra Coal Environmental Field Team data, 15 January 2016).

Additional observations from annual flora monitoring are presented in Section 3.2.

Swamp 5

The piezometer located within the vicinity of the flora monitoring site S5-V1 (Piezometer 05_01) was mined beneath by Longwall 11 in July 2015. This resulted in an increased rate of recession for shallow groundwater with short periods of water head recovery during rain events through the remainder of 2015 (Illawarra Coal Environmental Field Team data, 15 January 2016). During 2015 a level 3 groundwater TARP was triggered for S5 following the extraction of Longwall 11 (Illawarra Coal 2015b). Changes in the rate of water recession within S5 was first recorded following the extraction of Longwall 9 in 2013 when water level recession at Piezometer 05_03, located within the vicinity of S5-V3 exceeded the rate recorded prior to being mined beneath (Illawarra Coal 2014).

Piezometers within S5 (05_02 and 05_03) are located within or adjacent to the upland swamp sub-communities, Sedgeland-Heath Complex – Cyperoid Heath and Tea-tree Thicket, which are known to be supported on soils with impeded drainage and subject to periodic inundation (NPWS 2003). At the completion of the 2015 monitoring program, the loss of shallow groundwater levels within S5 had been evident for a total of 2.5 years since subsidence impacts were first recorded.

Additional incidental observations of holes within the soil of the swamp previously identified in 2014 were again observed in spring 2015.

Additional observations from annual flora monitoring are presented in Section 3.2.

Donald's Castle Creek and Donald's Castle Creek tributaries

During 2015 the upper reaches of Donald's Castle Creek, within S5, were mined beneath by Longwall 11. None of the Donald's Castle Creek tributaries experienced additional impacts during 2015.

Over the past three years of monitoring three important frog breeding pools have been identified along Donald's Castle Creek (DC(1)), including Pool 20, Pool 32 and Pool 34. Following the extraction of Longwall 9, changes in pool water levels at DC(1) were recorded by the Illawarra Coal Environmental Field Team and have continued for 2.5 years. The top of DC(1) is within the RMZ of Longwall 9 and changes to the hydrology of pools along this transect is a result of impacts that occurred upstream and within S5.

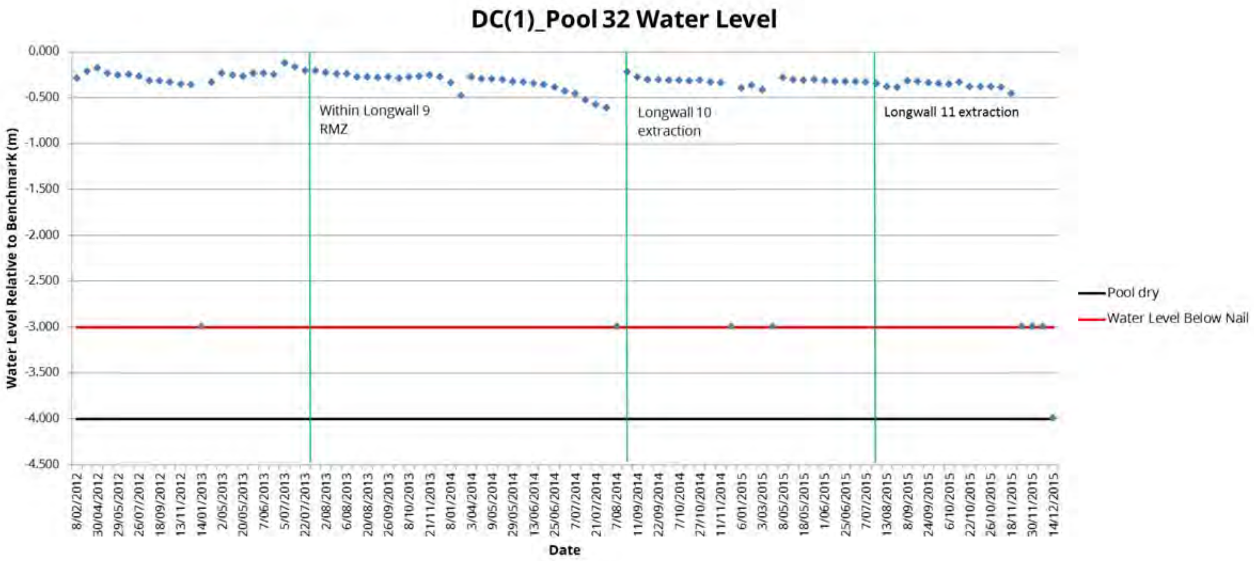
Of the three important breeding pools along DC(1), Pool 20 remains hydrologically similar to that recorded pre-impact and the pool has not been recorded dry since monitoring began in 2013.

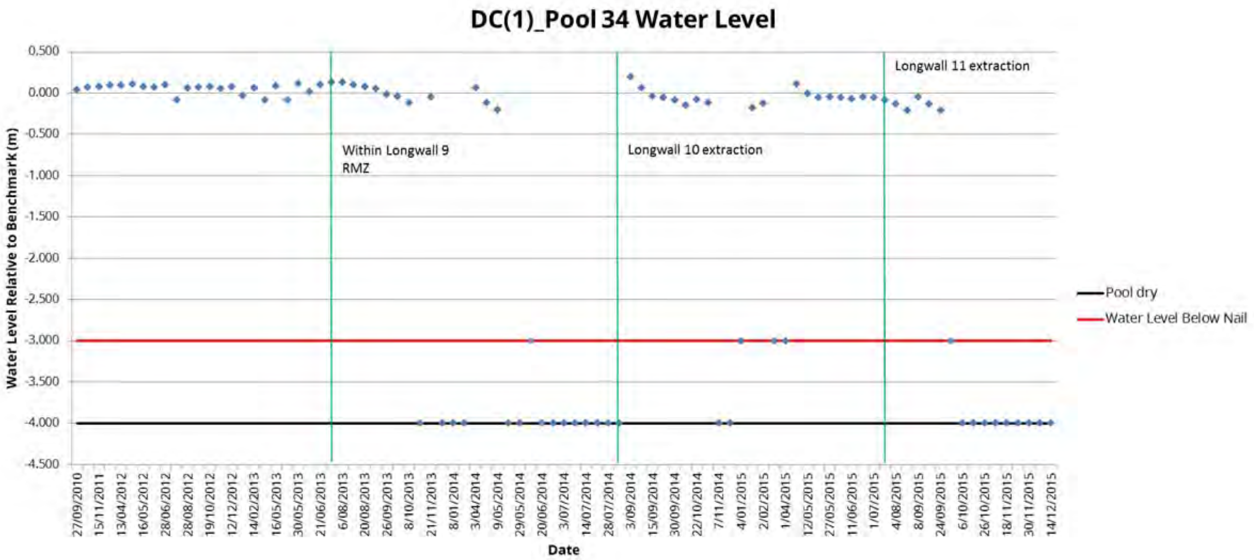
Graph 3 illustrates pool level change for Pool 32 and Pool 34, following the extraction of Longwall 9, 10 and 11. Pool 32 has contained water for the majority of time and drops in water level were infrequent up until the pool was recorded dry for the first time in late 2015 following the extraction of Longwall 11. Extended periods of pool water loss with increases in the rate of pool water level loss have been detected at Pool 34 following the fracturing of the upstream Rockbar 33 in May 2013. Pool 34 has previously been identified as Littlejohn's Tree Frog breeding habitat (Biosis 2013a).

A loss of flow and a reduction in pool water from the DC(1) Littlejohn's Tree Frog transect was observed between Pool 32 and Pool 35 during the 2015 winter surveys by Biosis.

No additional impacts to Donald's Castle Creek were observed by the Illawarra Coal Environmental Field Team over the past 2 years following the extraction of Longwalls 10 and 11.

Graph 3 Water level record for two pools along DC(1) known to provide Littlejohn's Tree Frog breeding habitat (data provided by Illawarra Coal Environmental Field Team)





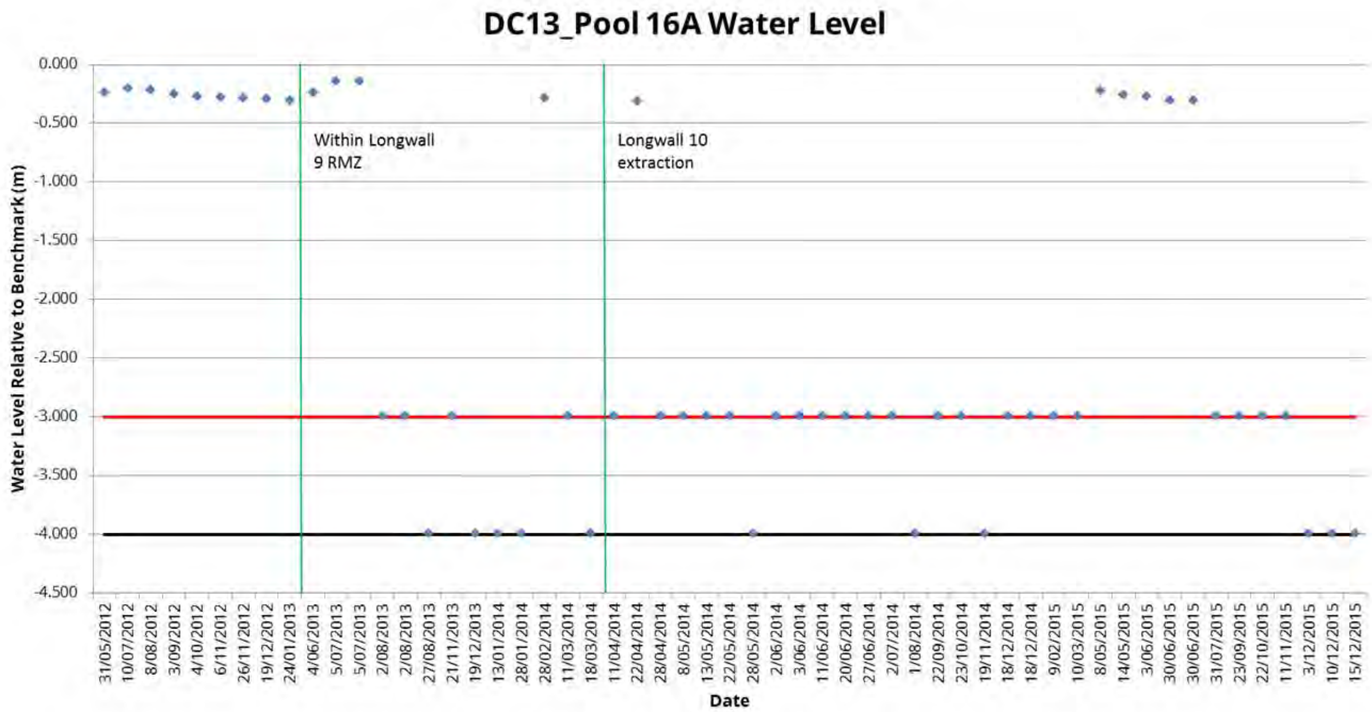
Declines in water level were still evident during 2015 along the DC13 Littlejohn's Tree Frog monitoring transect. No water was present upstream of Pool 18A during the 2015 survey and limited water was present at 7 pools from Pool 13A to Pool 17. Since monitoring began in 2012, 12 of the 17 pools along DC13 have been identified important for breeding Littlejohn's Tree Frog. The six pools above and including Pool 18A were impacted through a reduction of water in April 2013 during Longwall 9 extraction (Illawarra Coal 2014) and four of these were known to provide Littlejohn's Tree Frog breeding habitat (Biosis 2013b). None of these pools were utilised for breeding in 2015 and Graph 4 shows the change in water retention at two known breeding impact areas following the extraction of Longwall 9; Pool 19 and Pool 21 and two pools downstream of the impacted area; Pool 16A and 16B.

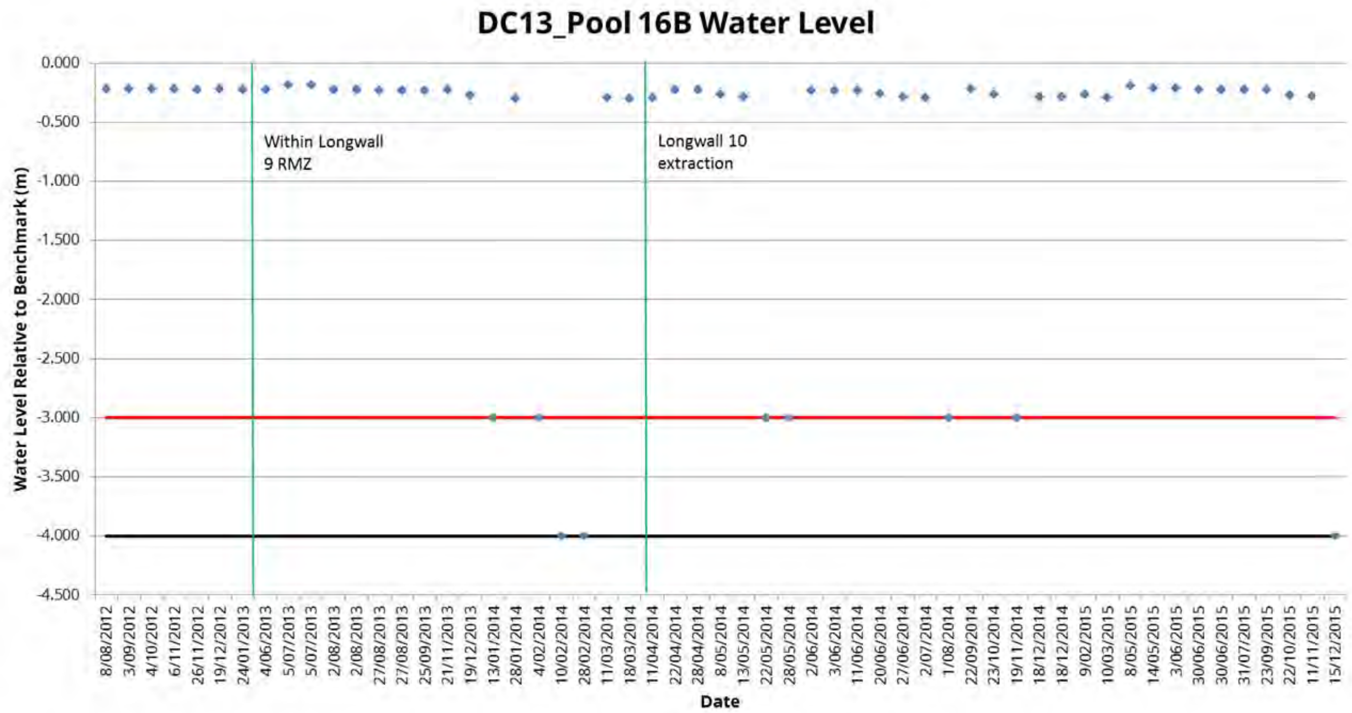
Post-impact, Pool 19 and Pool 21 have been consistently dry on the days it was monitored and this has persisted for approximately 2.5 years (Graph 4). Although Pool 19 has had water present on occasion following rain, water levels have not returned to baseline measurements. Pool 16A appears to be able to retain water for a short period of time following rain however water retention capacity has been reduced as post-mining rates of loss are steeper than pre-mining baseline levels. Pool 16B contains water for the majority of the survey dates however, water levels at this pool have consistently dropped below pre-impact values and has been dry on occasion (Graph 4).

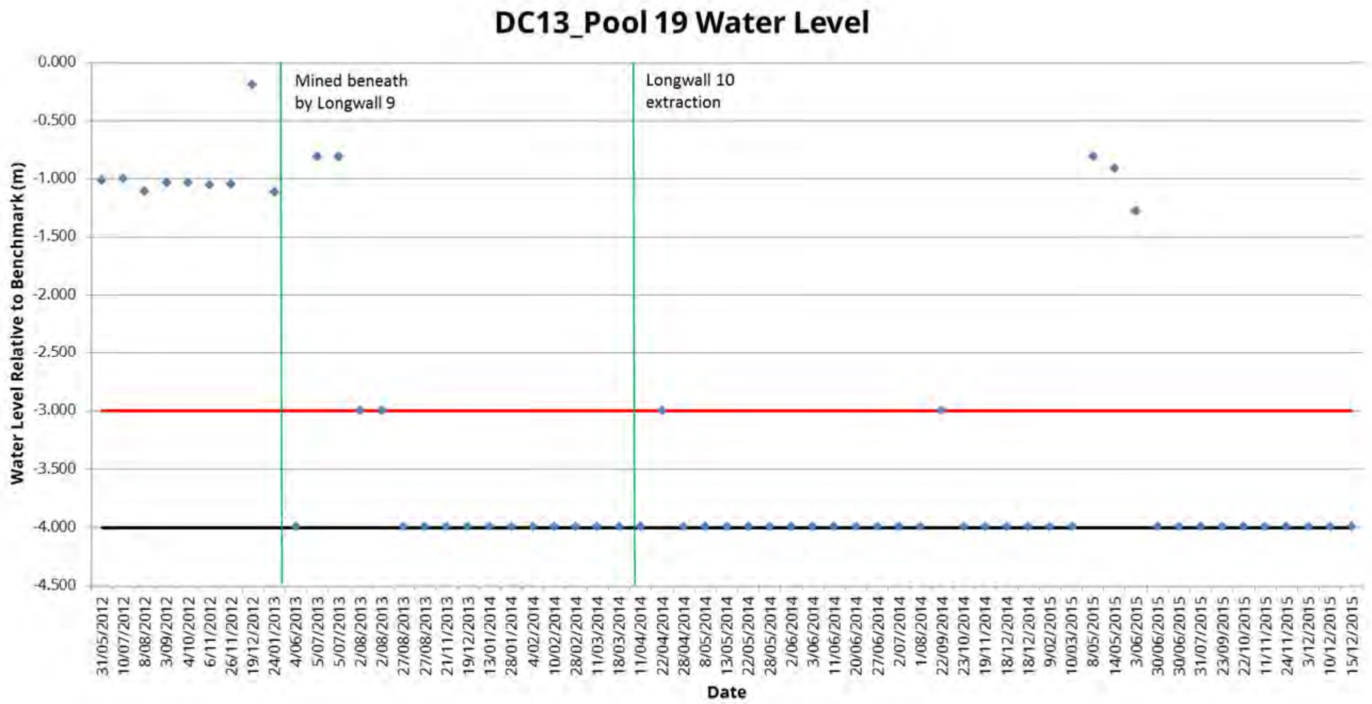
No additional impacts to Donald's Castle Creek were observed by the Illawarra Coal Environmental Field Team over the past two years following the extraction of Longwalls 10 and 11.

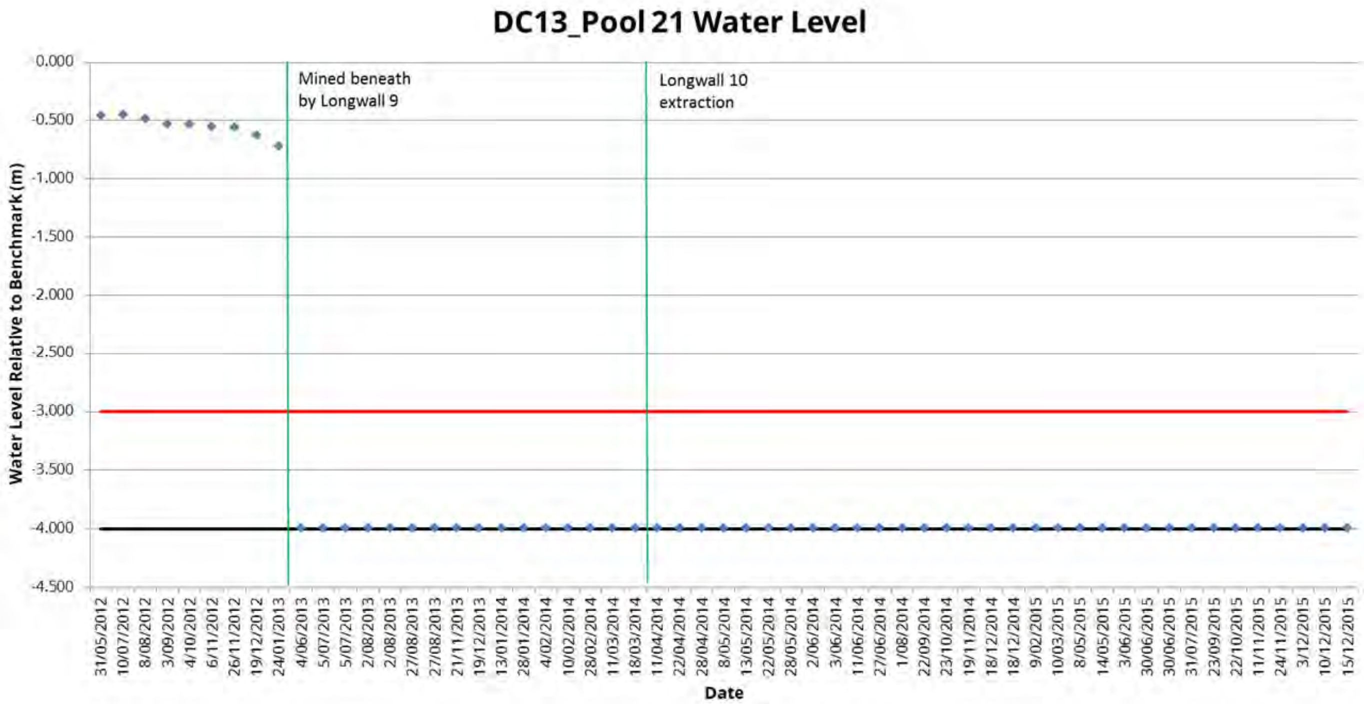
While no habitat assessment or targeted survey has been undertaken immediately downstream of the Donald's Castle Creek monitoring section, the species is known to occur in at least two tributaries of Donald's Castle Creek downstream of the site. Littlejohn's Tree Frog have previously been recorded at DC10 and DC8, both of which are not located within a subsidence RMZ and not experienced any mining impacts.

Graph 4 **Water level records for four pools along DC13 known to provide habitat for Littlejohn's Tree Frog. Red lines represent water levels below nail and black lines represent dry pool.**









WC21

Watercourse impacts following the extraction of Longwall 11 in 2015 included rock fractures up to 2 metres long within a 30 metre section of the watercourse above Pool 30. Reductions in pool water level within the creek were also noted (Illawarra Coal 2016).

During the 2015 Littlejohn's Tree Frog survey, iron flocculent coverage was again recorded between Pool 10 and the confluence of WC21 and Wongawilli Creek. This was previously recorded by Illawarra Coal (2014d) and Biosis (2015a) during 2014. Observations upstream of Pool 10 included reduced water flow between Pool 11 and Pool 24 and clear flowing water from Pool 25 to the transect end. These observations however were prior to the creek being impacted by Longwall 11 and the End of Panel report for Longwall 11 will provide further details on the impacts to WC21.

Watercourse impacts reported by the Illawarra Coal Environmental Field Team (2014, 2014a, 2014b, 2014c, 2014d) following the extraction of Longwall 10 in 2014 include fracturing of several rockbars and pool base uplift within the WC21 Littlejohn's Tree Frog monitoring transect. Following initial subsidence related impacts in late 2013, the cumulative effects of fracturing from Longwall 9, 10 and 11 include localised surface flow diversion, reductions in surface flows and loss of pool water from at least 17 pools (Illawarra Coal 2016). Littlejohn's Tree Frog had been recorded in three of these pools (Pool 10, Pool 16 and Pool 4) previously (Biosis 2013b). During winter 2015 additional locations along this stream were identified as known breeding locations, including Pool 17 and potholes on the bedrock between Pool 14 and Pool 15.

Surveys for the species were undertaken in 2006 downstream of WC21, along the main channel of Wongawilli Creek. No individuals were located and habitat is considered to be sub-optimal for the species, with steep terrain, large, deep pools and high flowing water. It is likely that the species does use Wongawilli Creek as a dispersal corridor linking suitable habitats located in the tributaries associated with the creek.

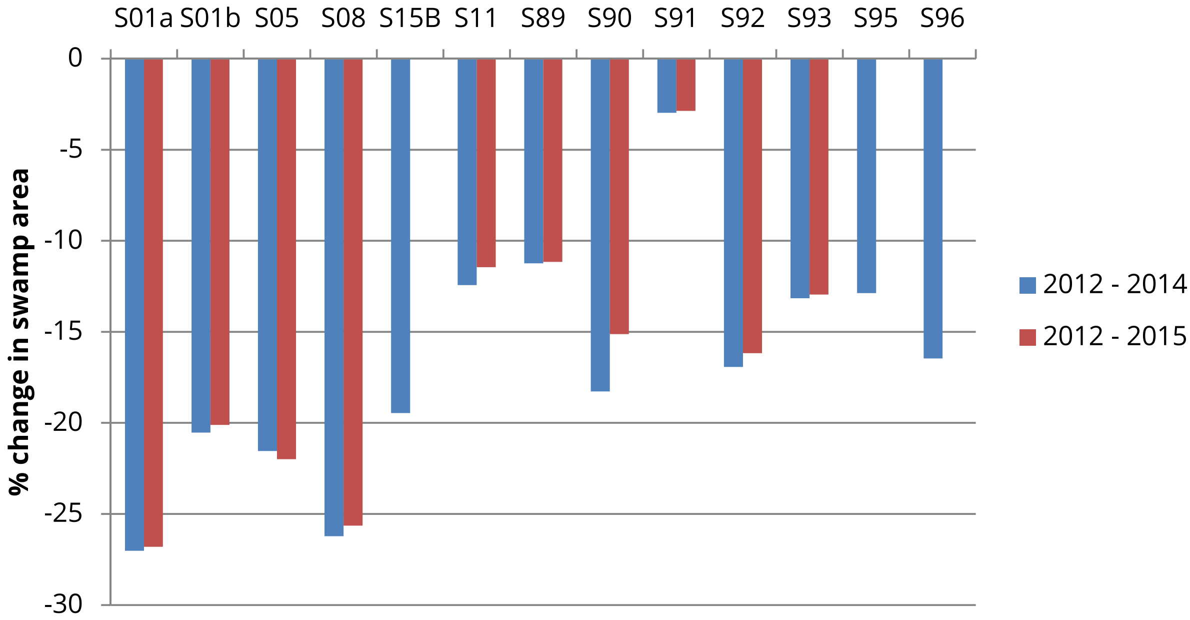
3.2 Vegetation

Data from vegetation monitoring collected as part of the 2015 monitoring program is provided in Appendix 1.

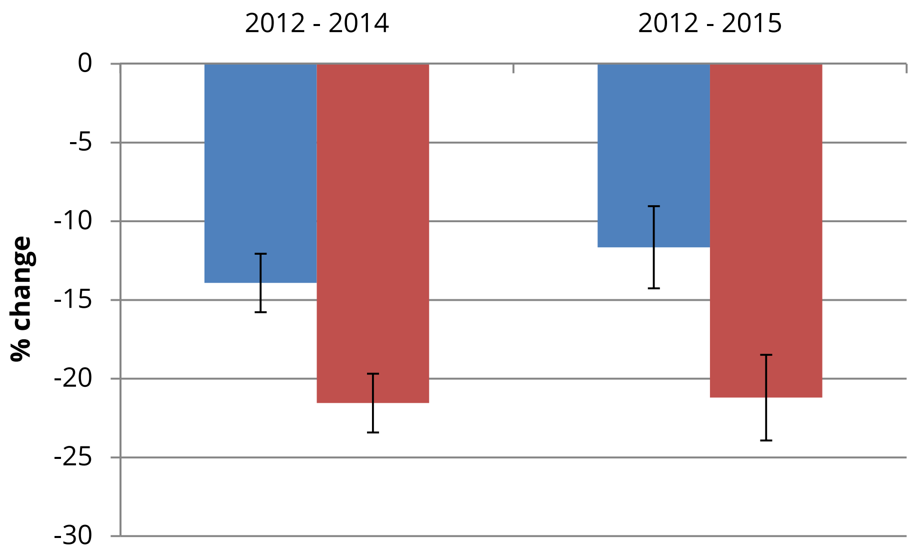
3.2.1 Upland swamp vegetation monitoring

LiDAR mapping of total upland swamp area

Swamp area has been assessed based on a differential canopy height of 8 metres to determine swamp margins. The total area of swamp decreased (relative to baseline) at all impacted and reference swamps assessed (Graph 5). The greatest reduction in swamp area was observed at impacted swamps S01a (27.0% from 2012 to 2014) and S08 (26.21% from 2012 to 2014) (Graph 5). Substantial declines in total swamp area were also observed in control swamps with 18.3% and 16.9% declines recorded at S90 and S92 respectively from 2012 to 2014 (Graph 5). Across control swamps the decline in total swamp area relative to baseline ranged from 2.9% at S91 in 2014 to 18.3% at S90 in 2014 with a mean (±SE) percentage decline relative to baseline of 13.9% (±1.9%) in 2014 and 11.7% (±1.9) in 2015 (Graph 6). At impacted swamps, the decline in total swamp area relative to baseline ranged from 11.4% at S11 in 2015 to 27.0% at S01A in 2014 with a mean (±SE) percentage decline relative to baseline of 21.5% (±2.6) in 2014 and 21.2 (± 2.7) in 2015 (Graph 6).

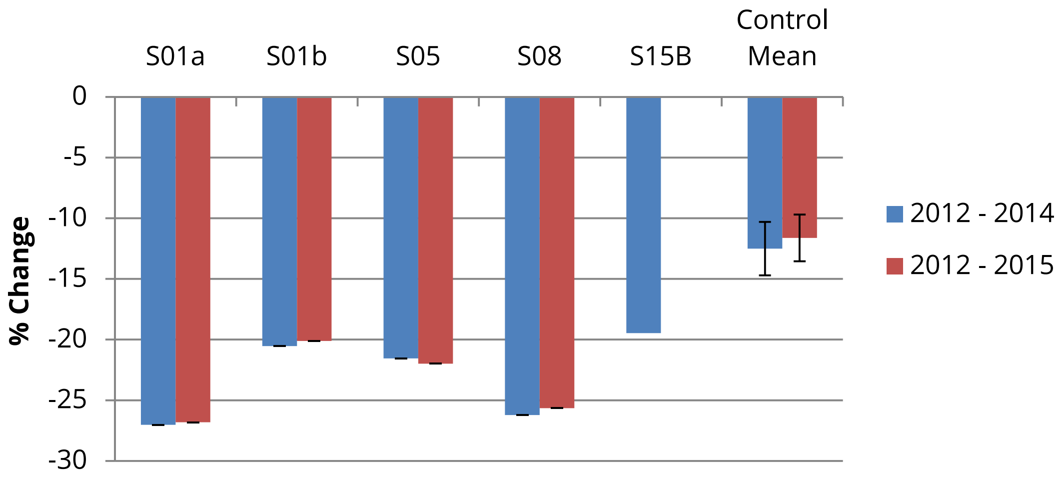


Graph 5 **Percent decline in total swamp area at all swamps assessed in 2014 and 2015 relative to baseline total swamp area recorded in 2012.**



Graph 6 **Mean (±SE) change in total swamp area of control swamps and impacted swamps within the Dendrobium 3A and 3B areas in 2014 and 2015 relative to baseline total swamp area recorded in 2012.**

Swamps for which 2014 and 2015 LiDAR data were available showed a very slight increase in swamp extent from 2014 to 2015 (Graph 7). An exception was Swamp S5 where a slight decrease was detected from 2014 to 2015 (Graph 7). The observed decrease in swamp extent at impacted swamps was greater than the mean (±SE) of the swamp extent at control swamps for both the 2012 – 2014 and 2012 – 2015 periods (Graph 7).



Graph 7 **Percent change in swamp extent from 2012 – 2014 and 2012 – 2015 at impacted swamps and mean (±SE) change in swamp extent from 2012 – 2014 and 2012 – 2015 at control sites.**

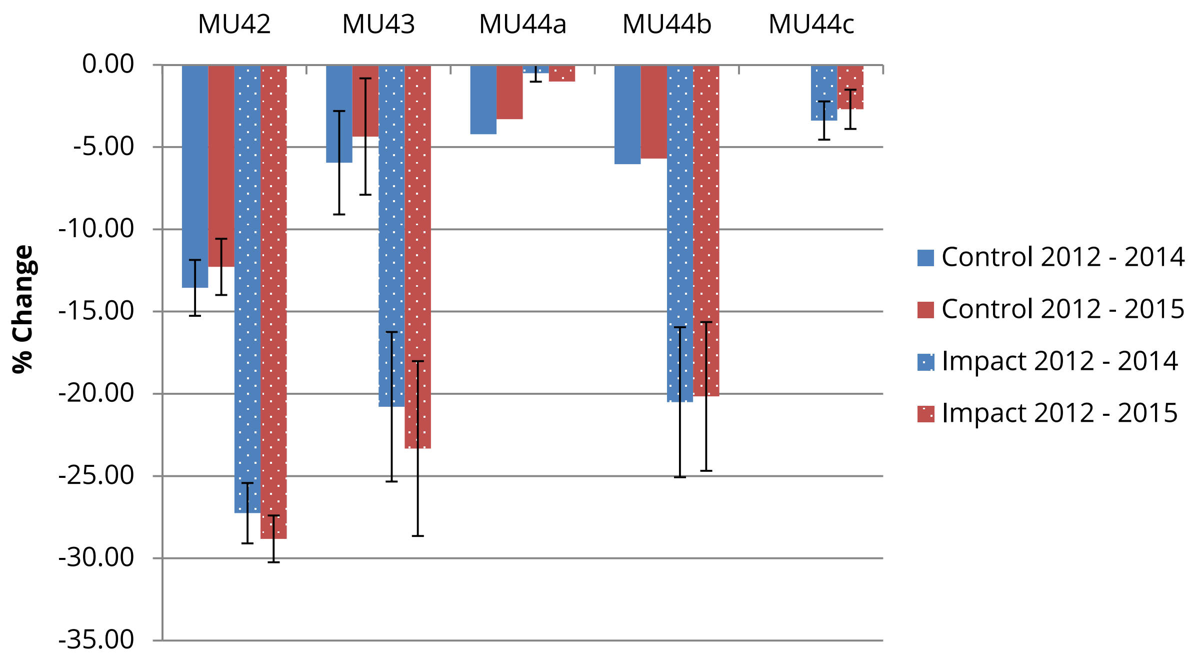
LiDAR mapping of individual groundwater dependent communities within swamps

The mean (±SE) extent of all swamp sub-communities declined across control and impacted swamps in the comparison periods 2012 – 2014 and 2012 – 2015 (Graph 8). No control swamps contained swamp sub-community MU44c therefore a comparison of losses between control and impacted swamps for this sub-community was not possible. In some cases a sub-community was found at only one swamp (e.g. MU44a and MU44b). The percentage decline presented for these sub-communities in Graph 8 below are absolute rather than mean values and no standard error value could be calculated.

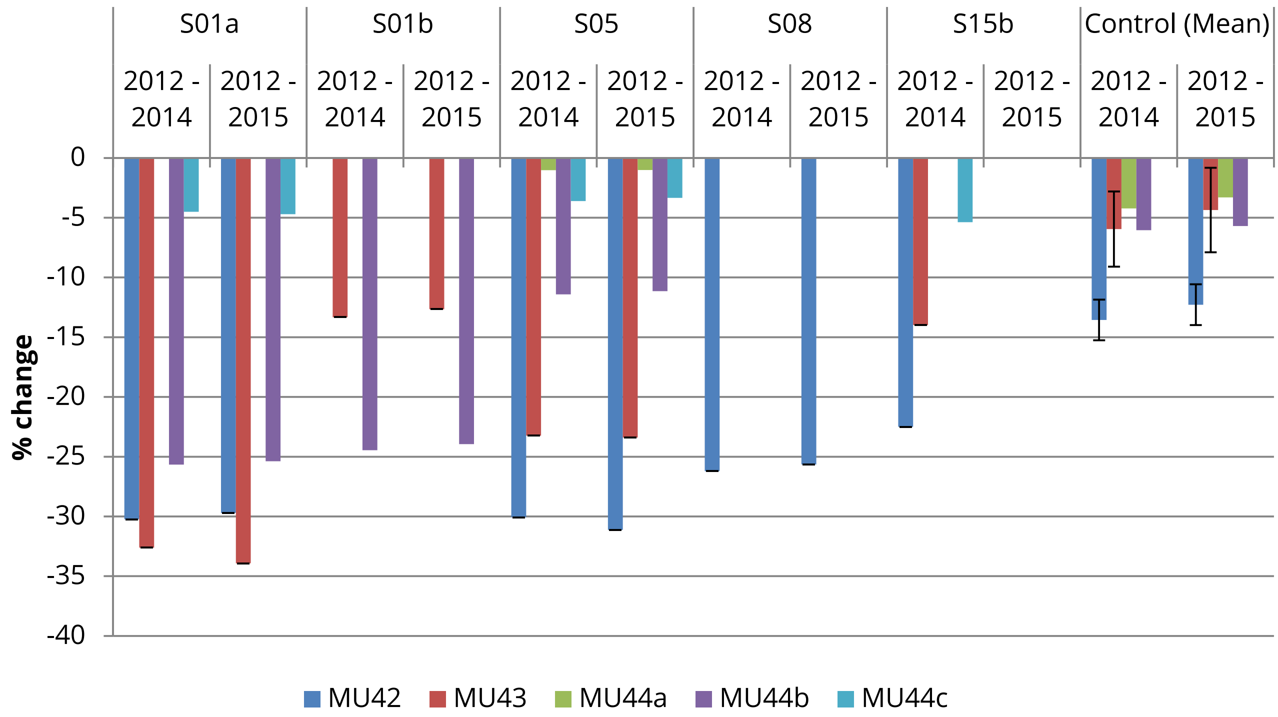
The mean (±SE) decline in sub-community extent was greater at impacted swamps than at control swamps for all sub-communities except MU44a (Graph 8). Swamp sub-community MU42 (Banksia Thicket) showed the greatest decline across both control and impacted swamps with a mean (±SE) decrease of 27.3% (2014) and 28.8% (2015) at impacted swamps and decreased of 13.6% (2014) and 12.3%) (2015) at control swamps (Graph 8). The relative large decline in MU42 sub-community reflects the fact that, at all swamps, decrease in swamp vegetation occurred primarily at the margins of the swamp where this sub-community most commonly occurs. MU43 (Tea-Tree Thicket) and MU44b (Sedgeland – Heath Complex (Restioid Heath)) also showed marked decline in 2014 and 2015 relative to their 2012 mapped extent (Graph 8).

All swamp sub-communities at all impacted swamps were found to have declined to a greater extent than the decrease recorded for corresponding sub-communities within control swamps (

Graph 9). MU44a was the only exception to this as the decline in extent of MU44a was 1% at S05 in 2014 and 2015 compared with 4.2% and 3.3% in 2014 and 2015 respectively among the control swamps (Graph 9).



Graph 8 **Mean (±SE) decrease in swamp sub-community extent at impacted and control swamps across the Dendrobium 3A and 3B Areas during the periods 2012 – 2014 and 2012 - 2015.**

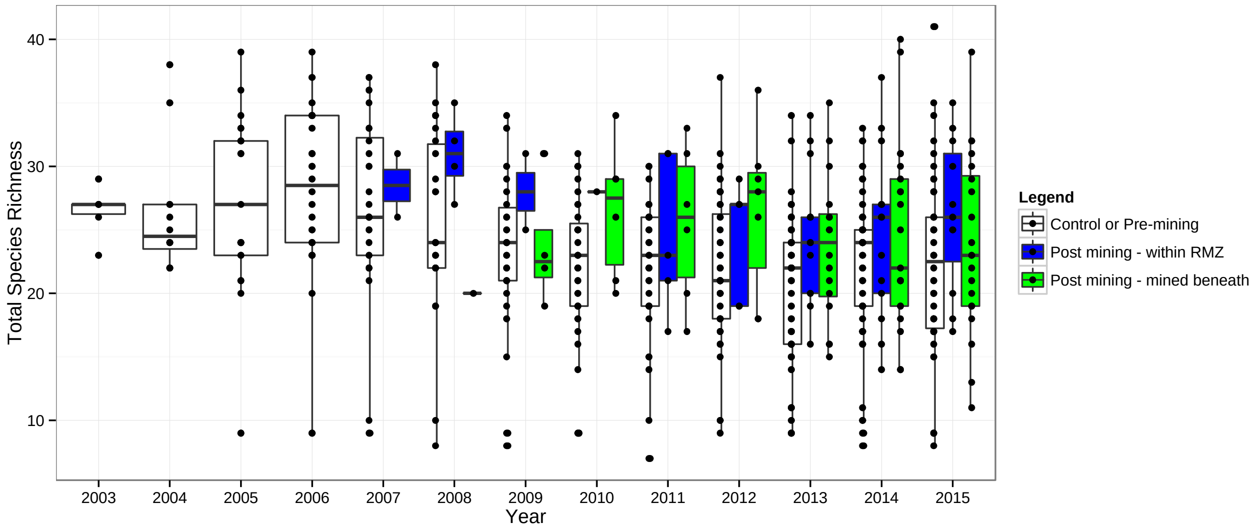


Graph 9 **Decrease in swamp sub-community extent at impacted swamps across the Dendrobium 3A and 3B Areas during the periods 2012 – 2014 and 2012 - 2015 compared against the mean (±SE) decrease in swamp sub-community across all control swamps for the same periods.**

Total Species Richness (TSR)

Exploratory analysis of the TSR data collected at each swamp, suggests that richness is highly variable between years and in response to mining status (control or pre-mining, post-mining or mined beneath; Graph 10). When pooled across all monitored swamps in all Dendrobium Areas, it appears TSR is highly variable regardless of year or mining status. TSR may be slightly greater and have less variability in post-mining areas than pre-mined areas (Graph 10). When sites that have been mined beneath are investigated there appears to be more variation and a drop in TSR from 2013 to 2015 (Graph 10).

Graph 10 Boxplot of total Total Species Richness for swamp sites by mining status, for all transects within each year at Dendrobium Area 2, Dendrobium Area 3A, and Dendrobium Area 3B and associated control sites



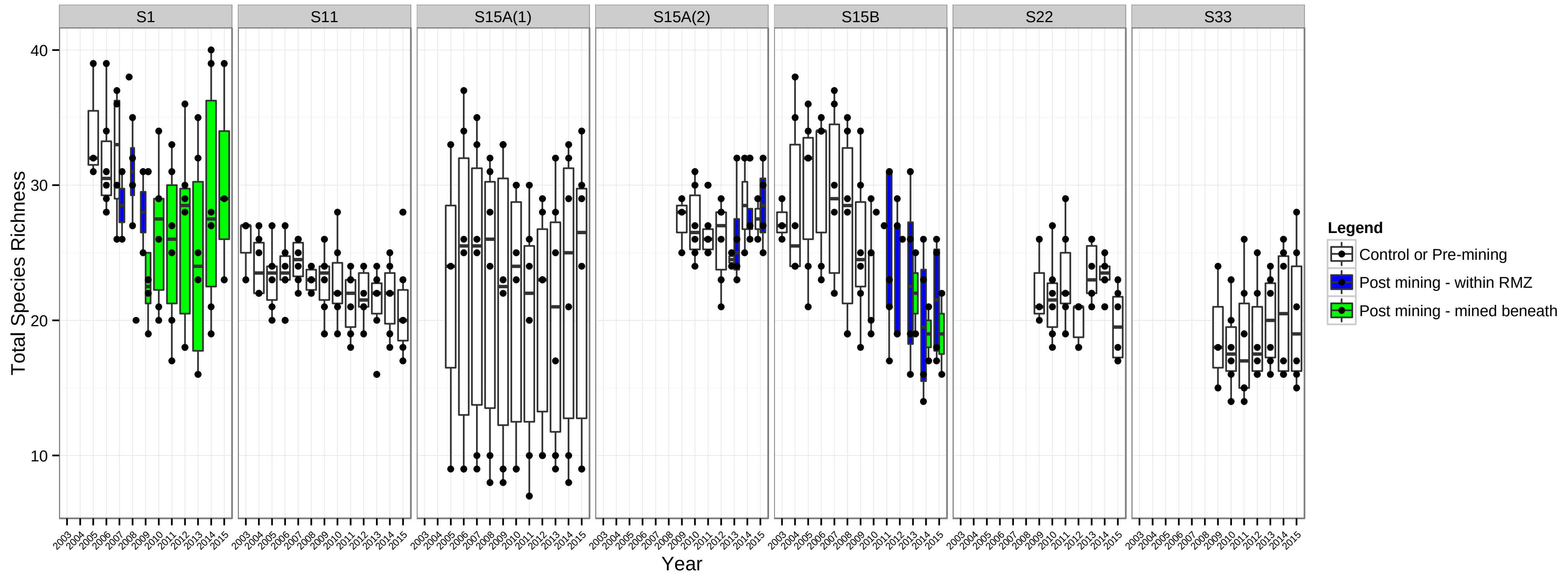
To further investigate trends in TSR, sites were analysed on a site-by-site basis. When accounting for TSR within each individual swamp within Dendrobium Area 2 and 3A (Graph 11) and Area 3B (Graph 12), variability within and between swamps is large, regardless of year effects or mining status.

It is visually evident that within Dendrobium Area 2 and 3A (Graph 11), TSR has declined at two impact sites (S1 and S15B) following impact, but potentially not the third impact site (S15A(2)). Declines in TSR at S1 were observed between 2008 and 2013 and were followed by an increase in TSR during 2014 and 2015. TSR has been gradually declining at S15B since 2008, however these trends pre-date mining at this site (between 2008 and 2010). While trends in TSR observed at S1 and S15B could be attributable to natural, non-anthropogenic factors, trends at these sites differ from the broadly stable pattern of TSR observed across all control and pre-mining sites during the same time (Graph 11).

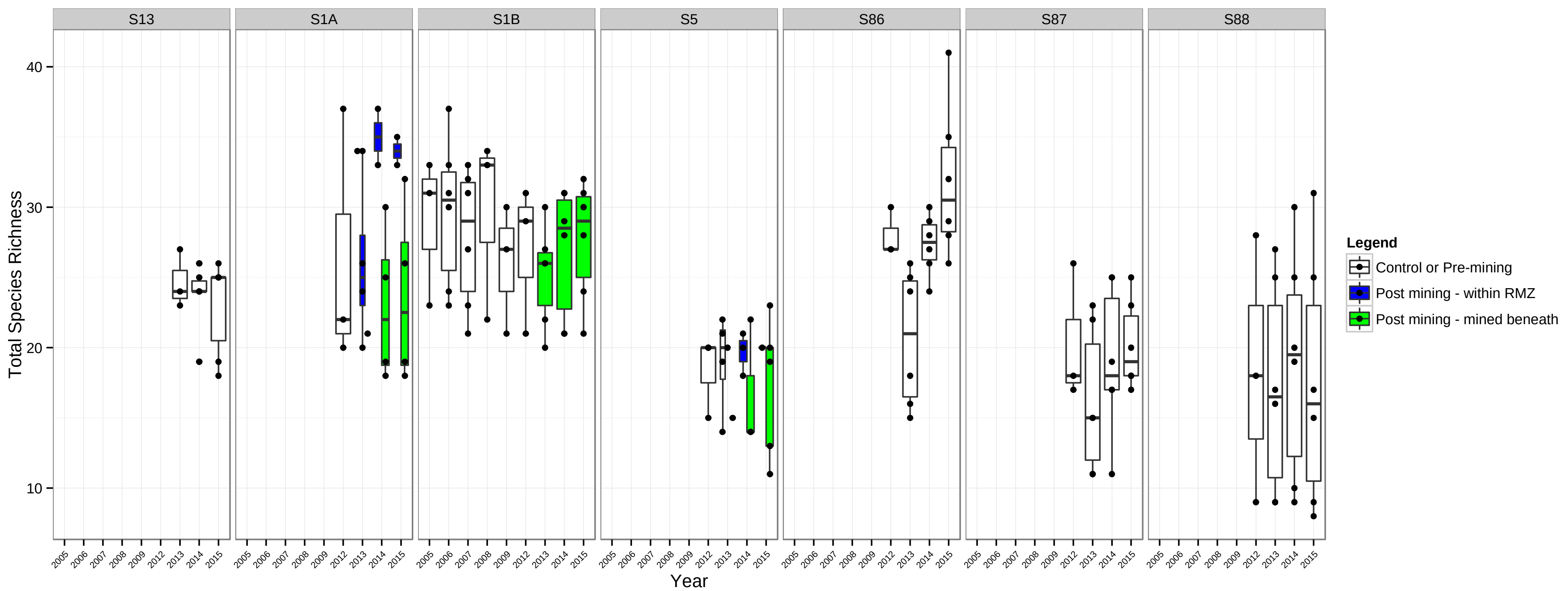
Similarly, within Dendrobium Area 3B (Graph 12), TSR was lower for sites that had been mined beneath (S1A, S1B, and S5). However, for sites that were classified as post-mining within an RMZ but not mined beneath, richness was found to be higher. This is particularly clear in 2014 and 2015 at S1A (Graph 12). In Graph 12, no consistent trends across the sites are evident when assessed visually; however, it is apparent that the control site, S86, showed a large transitory change in TSR in 2013. This drop in TSR is associated with bushfires that burnt S86 prior to monitoring that year and demonstrates the power of these graphs in detecting a visual change in vegetation.

Future analysis of monitoring in 2016 will provide further insight into these trends within Dendrobium Area 3B.

Graph 11 Box plots of the total Total Species Richness for each swamp within Dendrobium Area 2, Area 3A and associated reference swamps, within each year, split by mining status (boxes shaded white are points before mining commenced or control sites, shaded blue is after mining commenced, and shaded green are transects that are mined beneath). Solid black points are the observations



Graph 12 Box plots of the total Total Species Richness for each swamp within Dendrobium Area 3B and associated reference swamps, within each year, split by mining status (boxes shaded white are sites before mining commenced or control sites, shaded blue is after mining commenced, and shaded green are points within the site that are mined beneath). Solid black points are the observations



Five generalised linear mixed models (GLMs) were fit to the TSR data for the three Dendrobium Areas (Table 4).

Table 4 Model selection results for the generalised linear mixed models fit to the TSR data, collected at all swamps. (df is the degrees of freedom of the model, AIC is the Akiake's Information Criteria, and ΔAIC is the difference in AIC when compared to the model with the lowest AIC).

Model	df	AIC	ΔAIC
M3: PrePost + year	9	3084.85	0
M4: PrePost * year	10	3085.53	0.68
M2: Year	8	3085.71	0.86
M1: PrePost	8	3091.95	7.10
M0: Null	7	3108.44	23.59

GLMs suggested that both the mining status and year influenced the TSR in a swamp, with this most likely to be an additive affect (i.e. the affect of post-mining is the same for each year) as this model had the lowest AIC of those tested (Table 4). However, high uncertainty surrounded the model structure, as the next two best fitting models had a difference in AIC of less than 2, suggesting these top three models (M3, M4, and M2) are essentially equivalent (Burnham and Anderson, 2003).

Based on M3, it was found that a small but statistically significant decline in TSR is occurring over time (est. = -0.01, s.e. = 0.004, p-value = 0.002). This background declining trend was first observed in 2010-11 and has been observed each year since (Biosis 2013a, 2013b, 2014 and 2015b). As this trend occurs across all sites, regardless of treatment, it suggests that there is a broad decline in TSR related to landscape scale factors.

The overall decline in TSR observed at all sites is likely indicative of landscape scale factors, such as climate, natural succession of swamp vegetation or the effect of succession following bushfire on upland swamp vegetation. The most recent recorded fire within Dendrobium Area 2 and Area 3A occurred in 2001/02 and burnt across both control and impact sites. Whilst vegetation dynamics associated with fire may explain observed declines in richness and diversity at all sites, it is unlikely to have been the only factor contributing to the changes observed at post-mining sites.

In addition to the background decline, when all post-mining sites are pooled, TSR shows a statistically significant declining trend at the α =0.1 level (est. = -0.055, s.e. = 0.033, p-value = 0.09). This decline is first evident in 2012/13 and has been observed for 3.5 years (Biosis 2013a).

When all reference swamps are pooled, GLMs fitted to TSR data indicate a five year period of stable or increasing TSR from 2010 to 2015. The best fit model indicated a statistically non-significant yearly increase in TSR of 0.02 (s.e.= 0.012, p-value=0.133) however there was large model selection uncertainty (Table 1) as the difference in AIC between M2 (the 'best' fitting model) and M0 (the null model) is less than 2 (i.e., can be considered equivalent).

Table 5 **Model selection results for the GLMM fit to the Total Species Richness data, collected at all Control swamps. df is the degrees of freedom of the model, AIC is the Akiake's Information Criteria, and dAIC is the difference in AIC when compared to the model with the lowest AIC**

Model	df	AIC	dAIC
M2	3	1291.5	0
M0	2	1291.8	0.26

The trend in TSR at impacted swamps, when assessed individually against the identified 5 year period of stability at control swamps (2010 – 2015), varied with some impacted swamps showing a stable or increasing trend in TSR and others showing a small but statistically significant decline in TSR. TSR at S1 (mined beneath since 2008) showed a non-statistically significant yearly increase of 0.04 (s.e.= 0.02, p-value=0.143) however there was considerable uncertainty in the magnitude and direction of this effect (95% CI overlaps zero: -0.01, 0.096) (Table 4). TSR within S1B and S5 was stable with no yearly increasing or decreasing trend detected over the period 2013 – 2015 during which time all or some monitoring transects had been mined beneath. There was no detectable change in TSR at S15A(2) during the period from 2012 – 2015 during which time transects V1 and V3 fell within the RMZ. There was uncertainty when fitting GLMs to TSR data from S1B, S15A(2) and S5 with the best fitting null-model and next best fitting model considered equivalent (Table 4).

A statistically significant yearly decrease in TSR of -0.06 was detected at S15B over the 2013 – 2015 period (s.e.= 0.02, p-value=0.0256, 95% CI: -0.11, -0.007) during which time a single transect had been mined beneath (Table 4). However, whether the observed yearly decrease in TSR was caused by mining impacts, or was a continuation of an observed pre-mining trend of decreasing TSR at the swamp is uncertain (see Graph 11). As discussed previously, TSR at S1A was found to be higher during the 'post-mining - within RMZ' phase. However, when considering TSR data from transects 'post-mining - mined beneath' (i.e. transects V1 and V2) a statistically significant decrease in TSR of -0.24 (s.e.= 0.08, p-value=0.0044) (95% CI: -0.42, -0.07) was observed (Table 4). This decrease was observed over a two year period (2013 – 2015) during which time at least one flora monitoring transect had been mined beneath.

When assessing the results of monitoring against the Dendrobium 3B TARP for terrestrial flora, the decline in species richness each year at impacted swamps over the identified period of stability in TSR among the control swamps was found to be very small. As such, it was not considered ecologically or statistically relevant to express the decline in percentage terms. Rather, the statistical significance of models fit to TSR data is used as the primary means of identifying a declining trend in TSR across impacted swamps.

Table 6 Model selection results for the GLM fit to the Total Species Richness data, collected at impacted swamps. df is the degrees of freedom of the model, AIC is the Akiake's Information Criteria, and dAIC is the difference in AIC when compared to the model with the lowest AIC.

Swamp	Model	df	AIC	dAIC
S1	M2	2	191.7	0
	M0	1	191.85	0.15
S15A(2)	M0	1	164.74	0
	M2	2	166.02	1.28
S15B	M2	2	180.35	0
	M3	2	184.27	3.92
	M0	1	183.34	2.99
S1A	M3	2	109.18	0
	M0	1	115.31	6.13
	M2	2	116.85	7.67
S1B	M0	1	105.05	0
	M2	2	106.34	1.29
S5	M0	1	78.54	0
	M3	2	78.92	0.38
	M2	2	80.54	2

M0 - null model

M2 - yearly effects

M3 - undermining effects

Piezometric data indicates changes in shallow groundwater levels at S15B and S1 following extraction of longwalls in Dendrobium Area 2 and 3a and more recently at S1A, S1B and S5 in Dendrobium Area 3B; therefore, it is possible that a decline in TSR richness is coincident with declines in shallow groundwater.

All swamp impact sites for Dendrobium Areas 2, 3A and 3B have been assessed against the TARP triggers for upland swamps (Section 4.1.1) as set out in Attachment 1 of South32 (2015)).

Species composition

All data for each monitoring site was combined to analyse changes in flora species composition over time using a multivariate presence-absence model. It was found that since the initial baseline survey a large number of additional species were detected at each swamp throughout the period of monitoring. S88, a control site, had the lowest total number of new species recorded throughout time with 44 additional species detected since the initial baseline survey (Appendix 2). S15B, an impact site, had the highest total number at 100 additional species detected since the initial baseline survey (Appendix 2). Often, species were only detected once within a swamp with 5% to15% of these additional species detected once at any site. An exception to this was S86, a control swamp, were 30% of all species recorded were detected once (Appendix 2). Although it is likely human error accounts for some of these results, it shows that the floristic composition of these systems is naturally dynamic.

A statistical significance of yearly, and occasionally seasonal, trends in species composition was detected in most sites, regardless of area (Dendrobium Area 2, 3A or 3B) or treatment (control or impact sites) when using a conservative 0.1alpha threshold. Natural turnover of species at sites is not an unexpected trend with seasonal and yearly variation.

In addition to the year and season trends across all sites, a statistically significant change in species composition from pre-mining data to post-mining data was found at two of the six sites; S15A(2) (p-value = 0.004) and S1A (p-value = 0.092). Specifically for S1A, this is consistent with field observations from botanists since impact as well as changes in groundwater at piezometer sites (see Section 3.1). At the remaining sites there is little to distinguish between pre-mining and post-mining species composition. When a comparison of species composition was made between post-mining sites that are within an RMZ, to those sites that have been mined beneath, there was no statistically significant difference.

S15A(2) is located within Dendrobium Area 3A and although none of the monitoring points in this swamp have been mined beneath, Longwall 8 is within the RMZ of the site. The key species driving change in this swamp are *Almaleea paludosa*, *Cassytha glabella f. glabella* and Leafless Globe-pea *Sphaerolobium vimineum*. *Almaleea paludosa* and Leafless Globe-pea which are commonly supported in a range of habitats which include swamps and swampy places (Harden 1992), these species have not been included within the species characteristic of any vegetation types found within the Woronora Plateau (NPWS 2003). *Cassytha glabella f. glabella* is a widespread species (Harden 2000) and is a characteristic of Rock plate Heath-mallee, Upland Swamp – Banksia Thicket and Upland Swamp -Sedgeland Heath complex: restioid heath sub-communities.

Sub-communities in S15(A)2 include Upland Swamp -Sedgeland Heath complex: cyperioid heath and Upland Swamp – Banksia Thicket. The Cyperioid heath areas are surrounded by Banksia Thicket and encroachment at the edges may be occurring across time. Changes in these species are likely to be linked to or facilitated by incremental changes in vegetation driven by post fire succession of Heath-leaved Banksia *Banksia ericifolia* which occurred during 2001 which is within expected transitions within the upland swamp sub-communities. Therefore a change in the presence of *Almaleea paludosa, Cassytha glabella f. glabella* and Leafless Globe-pea *Sphaerolobium vimineum* doesn't indicate that the swamp is transitioning into a woodland and it is more likely a result of climatic and landscape influences. In support of this conclusion piezometer data for S15A(2) shows that shallow groundwater retention rates are the same or similar to pre-mining (Illawarra Coal Environmental Field Team data, 15 January 2016).

S1A is a Dendrobium Area 3B impact site and was first mined beneath by Longwall 9 in 2013 and then by Longwall 10 in 2014. Although a culmination of species were found to be driving changes in species composition in S1A, one key species driving change was Heath-leaved Banksia *Banksia ericifolia subsp. Ericifolia*. A change in vegetation composition of upland swamps from Cyperoid Heath to Banksia Thicket driven by Heath-leaved Banksia is an expected trend under climatic drying periods (Keith et al 2006). Shallow groundwater recession rates have increased following mining and this swamp is not retaining shallow groundwater to the extent that it was pre-mining (see section 3.1.3). This loss of shallow groundwater has the potential to manifest as a similar trend in areas where these two communities are found adjacent.

Observational data recorded by Biosis at S1 in Dendrobium Area 2 over the past two years involves the establishment of species more commonly representative of rainforest or wet sclerophyll forest vegetation types rather than upland swamps. During 2014, Biosis recorded three new seedlings from species not previously recorded within transects S1-V2 and S1-V3 for S1, two of which were again recorded in 2015. The species recorded were Native Daphne *Pittosporum undulatum* (Present in on transect in V3 in 2014 and V2 and V3 in 2015), Wonga Vine *Pandorea pandorana* (recorded in V2 in 2014 but not recorded in 2015) and Sweet Morinda *Morinda jasminoides* (recorded in V3 in 2014 and again in 2015). Additional observations for S1-V3 during 2015 also included the presence of Coachwood *Ceratopetalum apetalum*, Lilly Pilly *Acmena smithii* and Pencil Cedar *Polyscia murrayi*. All of these species are representative of rainforest or tall wet sclerophyll forest vegetation types. The recruitment and establishment of such species have the potential to be forward indicators of long-term changes in shallow groundwater.

A formal statistical test using the multivariate presence-absence model on data for all years at S1 found a statistically significant change in species composition from year to year (p-value = 0.066). It is important to note that this trend was present pre-mining and is also occurring at control sites, so these trends cannot be attributed to impacts from mining. Additionally, the rainforest species detected within the swamp in more recent years don't appear to be key species driving changes in species composition at this swamp. The persistence of these wet sclerophyll species indicate that periods of inundation that would prevent establishment of such species have not occurred recently which may be due to loss of shallow groundwater following mining.

Key species driving changing in S1 include *Xyris* species complex and *Goodenia dimorpha stelligera* species complex (The Analytical Edge Statistical Consulting 2016). The species within the *Xyris* species complex are strongly associated with groundwater dependent communities within upland swamps or wet heath (Harden 1993). The *Goodenia dimorpha stelligera* complex is characteristic of shallow, free draining heath and mallee-heath within the Woronora plateau (NPWS 2003) and swamps (Harden 1992). This shows that the changes detected in species composition are likely natural transitions, as was detected across the majority of swamps. The colonisation of non-swamp species such as Coachwood, Lilli-pilli, Sweet Pittosporum and Sweet Morinda may be the beginning of a trend within this swamp but the presence of these species are not considered a significant change in species composition.

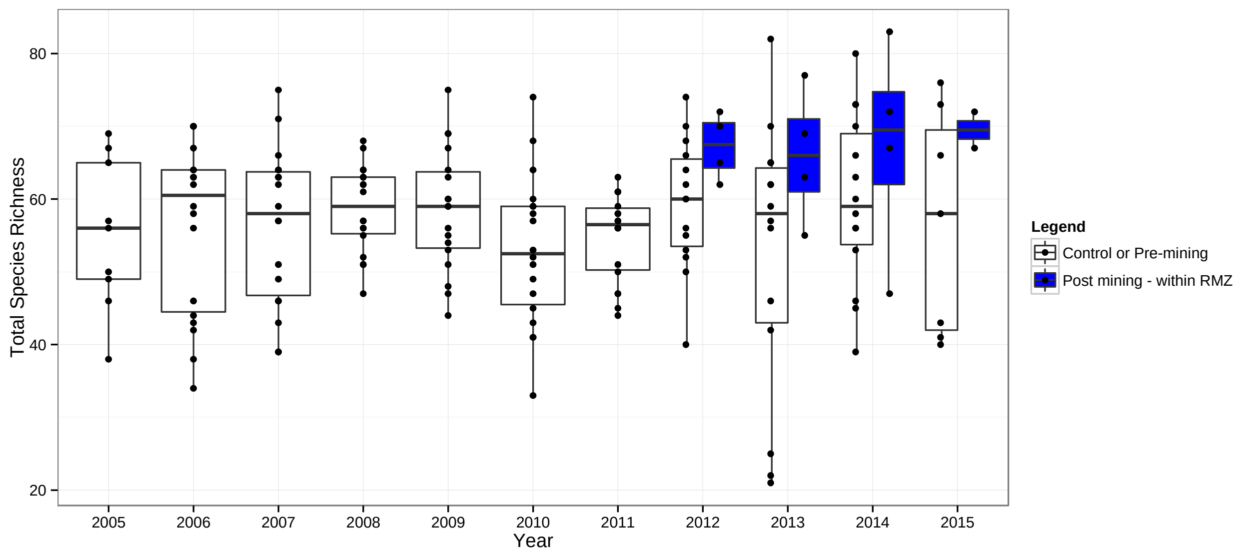
Previously recorded changes in species abundance at S1 and S15B (Biosis 2015b) were not analysed in current statistical analysis techniques. The current methods of data analysis show that no out of the ordinary changes in TSR or species composition has been detected at these sites.

3.2.2 Stream point monitoring

Total Species Richness (TSR)

Exploratory analysis of the TSR data collected at three sites along streams, suggests that richness is highly variable between years and mining status (Graph 13). When data from all sites are combined, TSR is slightly greater, and has less variability, at the single post-mining site, SC10, when compared to pre-mining data and control site data (Graph 13). It cannot be ascertained whether this finding is an artefact of the sample size (one impact and two control sites) or a true trend using exploratory analysis.

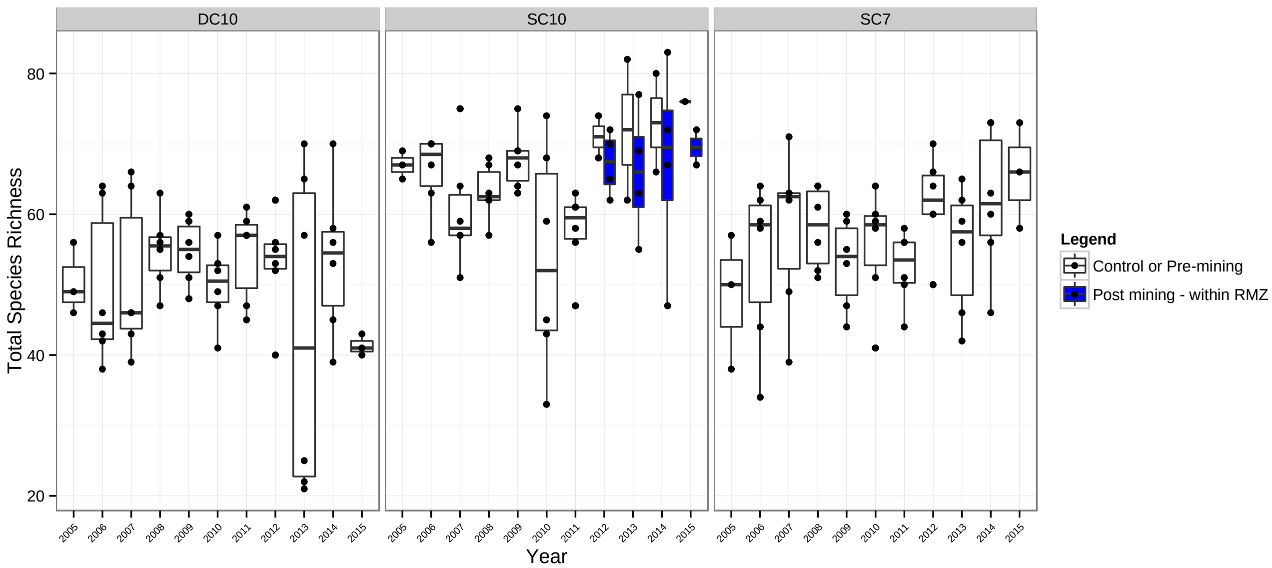
Graph 13 Boxplot of total Total Species Richness for creekline sites with SC10 (post-mining) and grouped control sites compared (reference or pre-mining) for each year of monitoring



No strong patterns emerged over time when the average TSR was investigated at each stream. Any change in TSR at SC10 from before mining commenced, to after mining commenced, was very small and visually undetectable. This may be due to an artefact of sampling as there are more pre-mining/control sites than post-mining sites. In addition, while the RMZ of one impact site (SC10) has experienced mining, the site has not been directly mined beneath and the upstream extent also has not been impacted. Graph 14 shows the breakdown of stream vegetation TSR at the only post-mining stream, SC10 compared to the two control sites. The overall TSR is increasing across years in SC10 and SC7 while TSR at DC10 has remained relatively consistent throughout time.

It is noted that a monitoring point at the control site DC10 displays an irregularly low richness for 2013 (Graph 14). This was a direct result of the spring 2013 surveys being undertaken following a fire through the site and post-fire regeneration was limited. A reduction in the TSR was also noted again in 2015 which may be a result of the natural succession of riparian vegetation post-fire. The fire did not burn monitoring points at SC10 and these trends are not visible.

Graph 14 Boxplot of the average Total Species Richness at each stream site, within each year, split by mining status (black is before mining commenced, and blue is after mining commenced).



A total of four generalised linear mixed models were tested against the data (Table 7).

Table 7 Model selection results for generalised linear mixed models fit to the Total Species Richness data, collected at streams

Model	df	AIC	dAIC
M1: PrePost	8	1328.18	0
M3: PrePost + year	9	1329.66	1.48
M2: year	8	1333.19	5.00
M0: null	7	1334.55	6.37

Based on M1 having the lowest AIC of those tested, mining status (pre-mining/control and post-mining) influences the TSR in the monitored streams. When mining status was the only explanatory variable in the model it was found that TSR is significantly higher at post mining sites (est.=0.11, s.e.=0.04, p-value=0.004) and is visually seen in Graph 13 above.

Species composition

When investigating species composition for stream sites, it was found that a large number of unique species were detected at each stream. SC10 had the lowest number of unique species since monitoring began with a total of 97 and SC7 had the highest unique species recorded since monitoring began with a total of 218. At SC10 the percentage of species recorded once since monitoring began was low at 8.1% and the site that had the highest percentage of species recorded once since monitoring began was DC10 with 19.5%.

A statistically significant trend in species composition was detected at all sites, regardless of treatment (control or impact sites) when using a 0.05 alpha level (p-values = 0.001). Natural turnover of species is expected each season and across years at each of the sites, so this result is not surprising. In addition to the yearly trends across all sites, a statistically significant change in species composition from pre-mining to post-mining was found at SC10 (p-value = 0.006).

Species change at SC10 was primarily driven by Spiny-headed mat-rush *Lomandra longifolia* a woodland species characteristic of a Sandstone Gully Peppermint Forest vegetation type (NPWS 2003) and common to numerous woodland vegetation types. The vegetation adjacent to SC10 is mapped as MU26 Sandstone Gully Peppermint Forest (NPWS 2003) so changes in the presence of this species are likely to represent natural transitions over time and unlikely to represent changes driven by mining impacts. Other species also contributing to observed changes in species composition at SC10 were *Poranthera ericifolia* and *Hibbertia circumdans*, both species occur within a number of vegetation types across the Woronora Catchment (NPWS 2003) making it difficult to attribute a causal factor to the observed changes.

3.3 Photo-point monitoring

Photo-point monitoring has been conducted at Dendrobium Area 2, Dendrobium Area 3A and associated control sites since spring 2009; and, at Dendrobium Area 3B and associated control sites since spring 2012 (and spring 2009 at S11). Photo-points have been displayed in Appendix 3.

Overall photo-points collected for swamp monitoring points tend to be represented within four visual trends:

- Minimal change.
- Increased woody shrub density and height.
- Dieback, bare patches and/or browning of vegetation.
- Post-bushfire recovery.

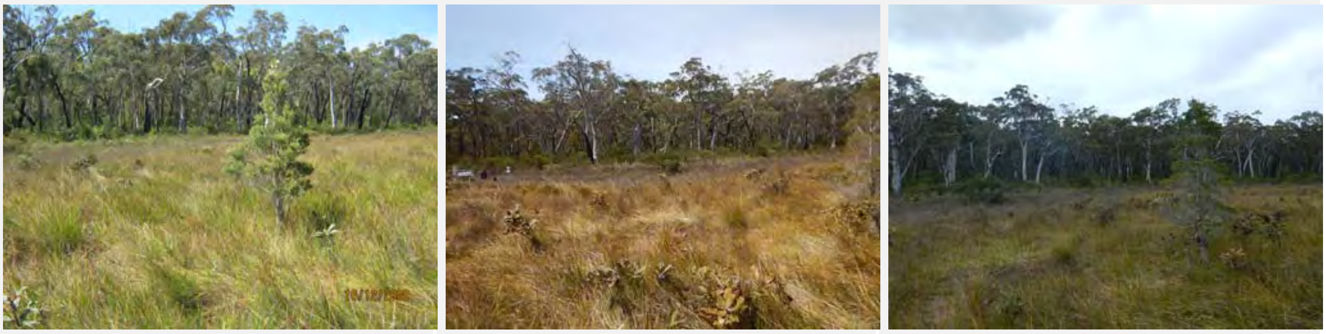
A number of photo-point monitoring points within upland swamps display minimal visual changes within photo-records from the start of monitoring to current photos. Points displaying minimal change include four impact sites (S1-F1, S15A(2)-F1, S5-all and S1B-all), two pre-mining sites (S11-F3, S11-F5, S13-F1 and S13-F3) and two control sites (S15A(1)-F2 and S22-all).

Photo-point monitoring points that show increases in height and density of the shrub layer species were typical of the sub-community MU42 Banksia Thicket. These monitoring points were located at four impact sites (S1-F2, S1-F3, S15A(2)-F2, S15A(2)-F3, S1A-F and S15B-F5), two pre-mining sites (S13-F2 and parts of S11-F1) and two control sites (S15A(1)-F3 and S33-all). This type of successional species progression occurs naturally within upland swamp vegetation communities and has been attributed to environmental factors such as the prolonged lengths of time between fire and periods of drought which are more favourable to species such as Heath-leafed Banksia *Banksia ericifolia* and Needlebush *Hakea teretifolia* (Keith 2006). This conclusion is confirmed by the statistically significant change in species composition within swamps as discussed in Section 3.2.1. The control monitoring point, S15A(1)-F1, continues to exhibit an increasing density of shrubs, *Leptospermum* spp., which are characteristic of MU43 Tea-tree Thicket. This trend has been gradually occurring since monitoring began in 2009 and may be attributed to the normal background change within this upland swamp vegetation sub-community detected in the statistical analysis.

Visual colour changes or noticeable browning documented in 2014 for at least one direction at all photo point monitoring locations in three impact sites (S1A, S1B and S5) and two control swamp sites (S87and S88) was not observed during 2015. Examples of this are shown in Plate 3 of S1B-F2 and in Plate 4 of S88-F1. Consecutive high temperatures (above 35°C) and a dry period in October 2014 were likely to contribute to vegetation stress and most likely to have exacerbated any seasonal water stress at control or impact sites that may have caused browning within upland swamps detected during the spring 2014 monitoring season. Vegetation at these sites appears to have recovered from these temporal variations following rainfall experienced throughout 2015.

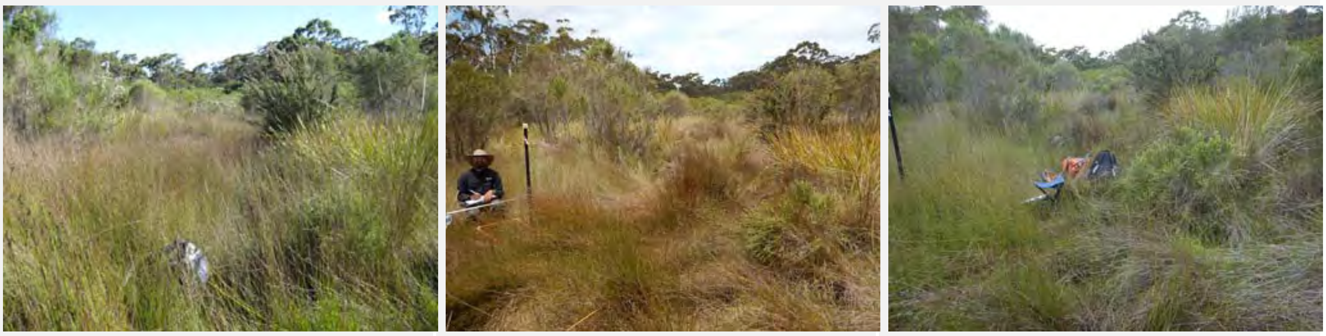
Photo-point monitoring of S86 continues to document the recovery of groundcover vegetation by obligate re-sprouting plants following the fire that occurred in October 2013 at all monitoring points.

Overall, the four visual trends shown within photo-point records between 2009 and 2015 (Appendix 2), have recorded variations that were displayed at both impact and control sites, with no changes recorded that were only recorded at post-mining upland swamp photo-point monitoring sites.



Spring 2009	Spring 2014	Spring 2015

Plate 3 Comparison of vegetation colouration at S1B-F2 South between spring 2009, spring 2014 and spring 2015.



Spring 2009	Spring 2014	Spring 2015

Plate 4 Comparison of vegetation colouration at Control Swamp S88-F1 South between spring 2009 and spring 2014 and then 2015.

Similarly, photo-point monitoring of the SC10 site has not demonstrated any change to the vegetation structure or pools since they were established in spring 2009. A visual change in condition however has been noted at SC10-F1, SC10-F2 and SC10-F3 monitoring points with the presence of iron flocculent increasing following the extraction of Longwall 8 upstream in 2012. Iron flocculent has also been detected at control site DC10 and the source of this is unknown (Appendix 2). No visual change in vegetation at SC7 has been detected throughout the course of monitoring and the only changes observed at the DC10 control site were associated with a large scale fire that occurred in October 2013 (Biosis 2014), however this site appears to be regenerating well in 2014 and autumn 2015.

3.4 Littlejohn's Tree Frog transect monitoring

Littlejohn's Tree Frog was detected in at least one lifecycle stage (i.e. adult, tadpole or egg mass) at seven of the eight post-mining impact sites (6CDL, DC(1), DC13, SC10C, WC21, SC10(1) and SC10(2)) monitored as part of the threatened frog surveys in winter 2015. The species was also detected at one of the two pre-impact sites and at ten of the eleven control sites. All three lifecycle stages were detected at seven control sites (ND1, SC6, SC7(2), SC7A, SC8, WC10 and WC11). Littlejohn's Tree Frog has not been recorded at the pre-mining site LA4A since 2010 and control site ND2 since 2012.

First and second order streams within the Sandy Creek catchment continued to be a stronghold for the population with 77 adults (54% of the total) recorded along SC10C, SC10(1), SC10(2), SC6, SC7(1), SC7(2), SC7A and SC8. During the 2015 surveys the numbers of adults recorded across streams in this catchment were evenly distributed between the tributaries. Overall during 2015, Littlejohn's Tree Frog breeding pools were again recorded in high numbers throughout the Sandy Creek catchment.

At post-mining sites that have experienced subsidence related impacts, survey data shows a declining trend in abundance (or at least a reduction in detection) of all Littlejohn's Tree Frog life stages. This trend has been evident at SC10C, WC17, DC(1), DC13 and WC21, where the post-mining detection of Littlejohn's Tree Frog has remained lower than that recorded pre-mining. Although a small increase in various life stage at some impact sites was observed in 2015, in particular egg mass, detection events have not returned to those recorded pre-mining.

A summary of the results from 2015 are provided in Table 8 and the records have been mapped in Figure 8. An analysis of sites that have experienced direct impact from mining in Dendrobium Area 3A and Dendrobium Area 3B has been provided in Section 3.4.1 and 3.4.2 below.

Table 8 Summary of the results from the winter 2015 threatened frog monitoring

Mining status	Site	Survey date	Life stage			No. breeding pools
			Adult	Egg mass	Tadpoles	
Pre-mining sites	LA4A	06/08/2015	0	0	0	0
	WC15	11/08/2015	10	13	36	10
Post-mining sites (Mined beneath)	DC13	06/08/2015	2	30	36	8
	SC10C	08/09/2015	4	28	0	2
	WC17	04/08/2015	0	0	0	0
	WC21	12/08/2015	0	4	148	3
Post-mining sites (Within RMZ)	6CDL	12/08/2015	1	13	149	6
	DC(1)	30/07/2015	2	7	0	2
	SC10(1)	13/08/2015	8	65	0	3
	SC10(2)	29/07/2015	13	40	22	11
Control sites	DC8	18/08/2015	17	39	0	7
	ND1	08/09/2015	7	36	5	14
	ND2	03/08/2015	0	0	0	0
	NDC	03/08/2015	10	0	11	6
	SC6	10/08/2015	7	37	51	12
	SC7(1)	10/08/2015	7	45	0	11
	SC7(2)	28/07/2015	15	71	80	13
	SC7A	10/08/2015	22	167	127	23
	SC8	05/08/2015	1	9	260	4
	WC10	04/08/2015	13	95	21	12
	WC11	12/08/2015	4	22	7	3

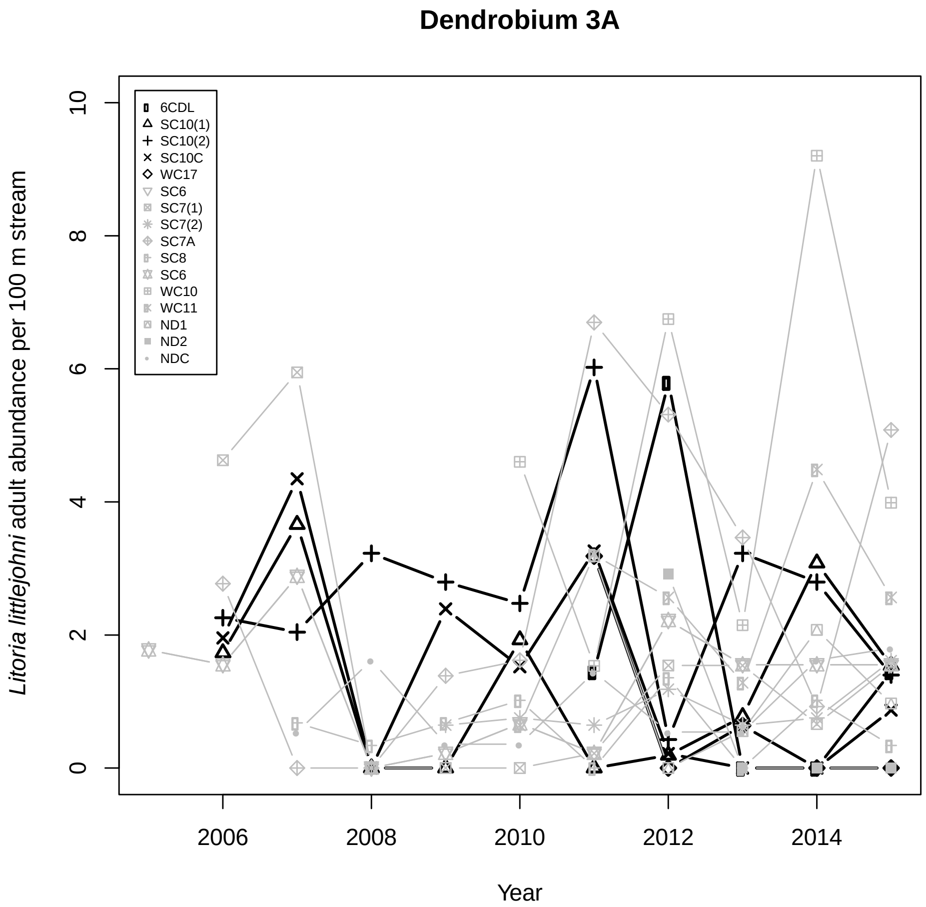
3.4.1 Dendrobium Area 3A

In 2015 the abundance of adults across Dendrobium Area 3A declined across the majority of impact sites, though these values remained within the abundance range of control sites (Graph 15).

Declines in the abundance of adult Littlejohn's Tree Frog was observed following 2011 at three impact sites (SC10C, 6CDL and WC17) which have experienced physical mining related impacts (Graph 15). Declines in adult numbers at SC10C and 6CDL were first observed in 2012 and continued through to 2014 with adults recorded again in 2015. Declines in adult numbers were also recorded in 2012 at WC17 where adult frogs have not been recorded during monitoring two consecutive years (2014 and 2015 surveys).

The abundance of adult frogs at control sites continues to fluctuate across time with abundance between zero and five per 100 metres of stream (Graph 15).

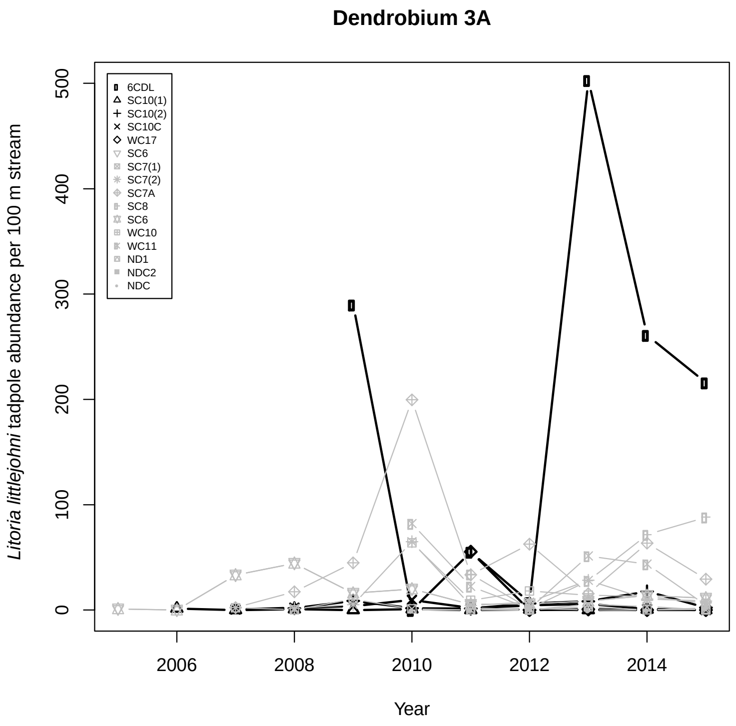
Graph 15 Abundance of Littlejohn's Tree Frog adults within 100 metre section of creekline at all Dendrobium Area 3A impact and control sites over the years of monitoring*



** Solid black lines represent impact sites and grey shade lines represent control sites.*

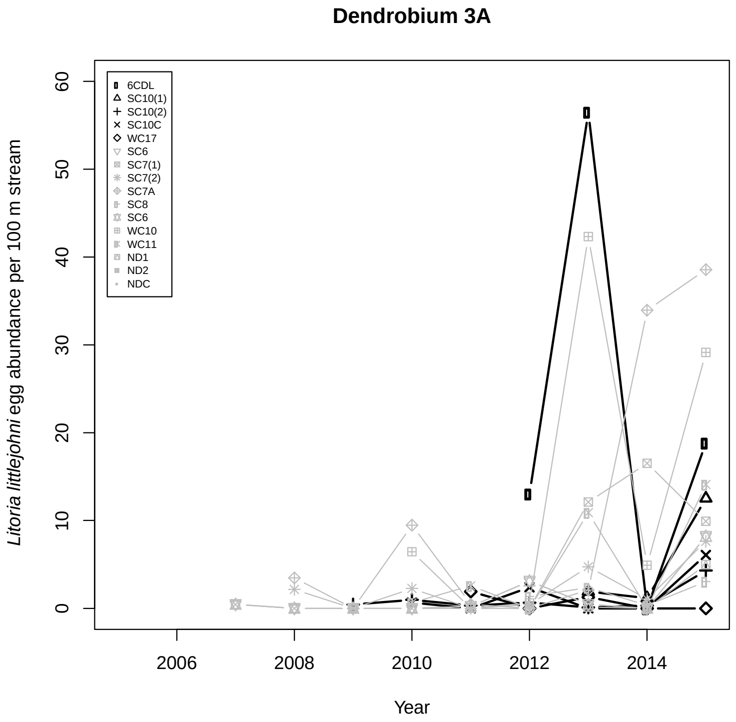
The detection of tadpoles continued to decline in 2015 at impact sites across Dendrobium Area 3A. Tadpole detection at control sites has fluctuated across time, including the 2015 sample (Graph 16). The detection of egg mass across the majority of impact sites in 2015 increased from 2014, a trend also observed at the majority of control sites. The number of egg mass between impact and control sites during 2015 do not appear to differ when analysed visually (Graph 17).

Graph 16 Abundance of Littlejohn's Tree Frog tadpoles within 100 metre section of creekline at all Dendrobium Area 3A impact and control sites over the years of monitoring*



** Solid black lines represent impact sites and grey shade lines represent control sites.*

Graph 17 Abundance of Littlejohn's Tree Frog egg mass within 100 metre section of creekline at all Dendrobium Area 3A impact and control sites over the years of monitoring*



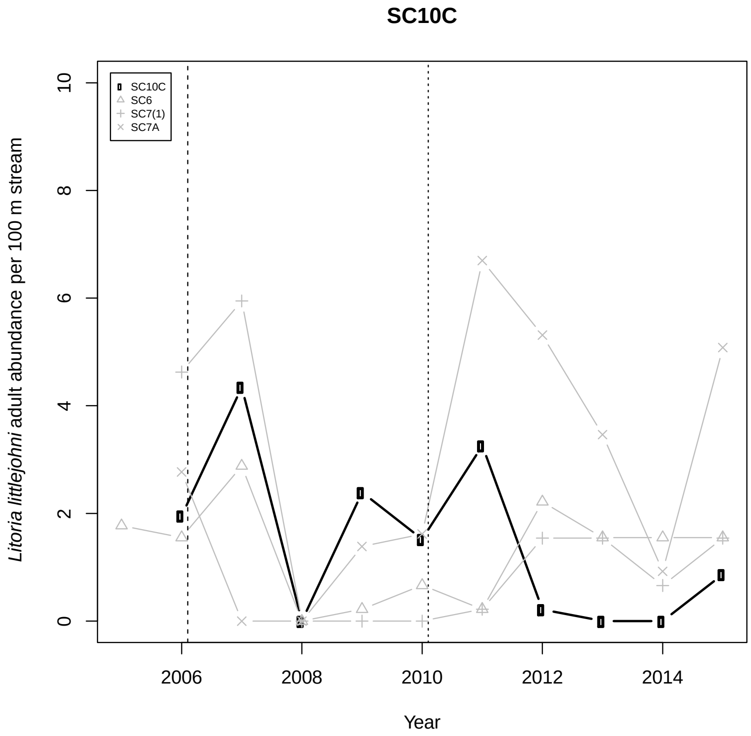
** Solid black lines represent impact sites and grey shade lines represent control sites.*

Sandy Creek and tributaries

Sandy Creek and its tributaries form part of a large and significant population of Littlejohn's Tree Frog. This sub-population is located within the catchment of Sandy Creek and includes the creek as well as a number of tributaries including SC10, SC10C (below S15A), SC6, SC7, SC7A and SC8. These waterways are interconnected and it is likely that the species moves throughout this area in response to a number of environmental variables.

Calculated as a standardised abundance measure of frogs per 100 metre of stream, the abundance of Littlejohn's Tree Frog along SC10C is less than recorded at control sites. The abundance of frogs at control sites fluctuated among years within the same time period but overall no discernible increasing or decreasing trend was observed (Graph 18).

Graph 18 Adult abundance of Littlejohn's Tree Frog detected at SC10C (black line), contrasted against matched Control sites (grey lines). The dashed vertical line represents monitoring start date and the dotted vertical line represents comencment of mining within the RMZ.



Although SC10C became an impact site when Longwall 6 was within the RMZ in 2010, data from the Littlejohn's Tree Frog surveys shows that changes to the abundance of the species were not recorded until the transect was mined beneath by Longwall 7. A decline in the abundance of adult frogs was observed following subsidence impacts detected at SC10C and S15B following extraction of Longwall 7 and Longwall 8 during 2011 and 2012 (Graph 18). Previous declines in the presence of Littlejohn's Tree Frog adults at SC10C has correlated with reductions in pool water levels along the transect.

During 2015 an increase in adults along this transects appears to be in response to rainfall of approximately 260 millimetres at the end of August 2015 (rainfall data provided by Illawarra Coal Environmental Field Team). Rain during the monitoring season resulted in an increase of water levels within the transect at the time of year to facilitate a breeding however abundance values remain below pre-mining values. Biosis observed that Pool 1 through to Pool 4 and Pool 8b were full of water while Pool 5 through to Pool 7 were dry and Pool 8 had limited water with two small pools on the sandstone, approximately six centimetres deep. As has been recorded in previous years, iron flocculent was present within the lower third of the monitoring transect, coating egg mass in Pool 1. The loss of pool water and increased rates of pool water loss from SC10C has impacted three known breeding pools for Littlejohn's Tree Frogs (Biosis 2013a and 2013b).

Plate 5 below shows one of the adult Littlejohn's Tree Frog recorded at SC10C during winter 2015.

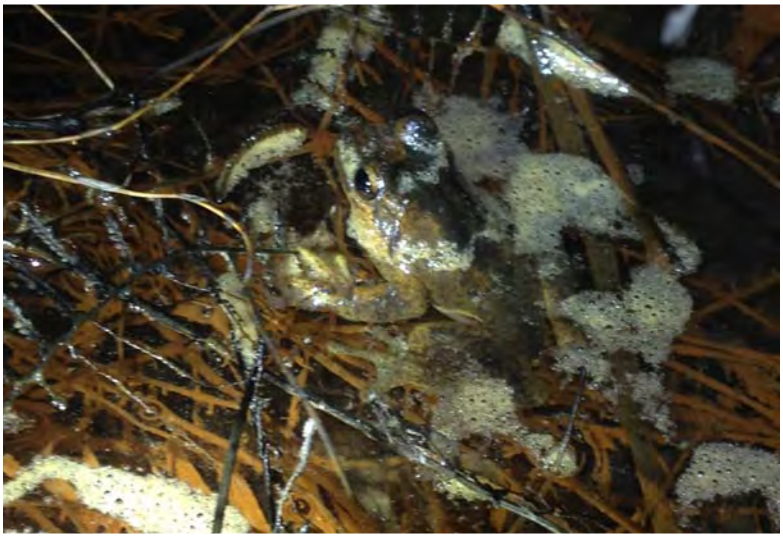
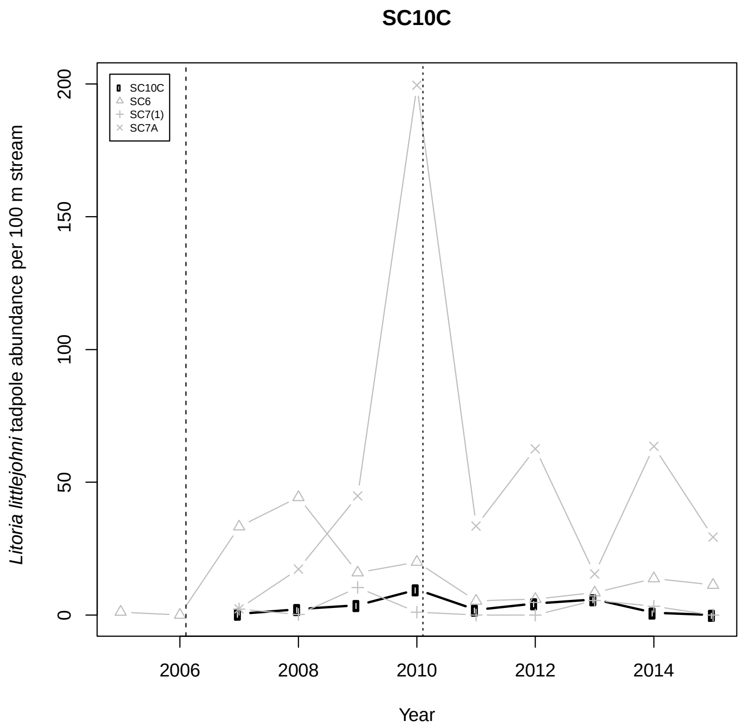


Plate 5 Littlejohn's Tree Frog adult recorded in winter 2015 at SC10C.

No tadpoles were recorded at SC10C during 2015, a new low for this site since monitoring began in 2007 (Graph 19). Comparatively, tadpole abundance across control sites during the same period remained stable with tadpole abundances within a 100 metre section of stream between zero and 40 tadpoles.

Graph 19 Tadpole abundance of Littlejohn's Tree Frog detected at SC10C, contrasted against matched Control Sites (grey lines). The dashed vertical line represents monitoring start date and the vertical dotted line represents when mining commenced within the RMZ.

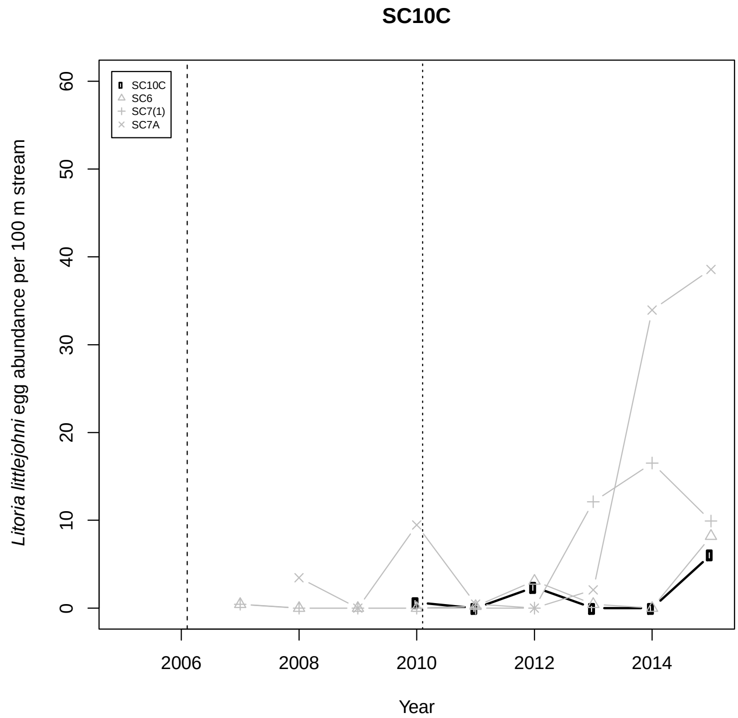


Following a low tadpole count in 2014 and again in 2015, Biosis recommended undertaking tadpole surveys at SC10C during summer 2015/2016 due to the presence of egg mass in winter 2015. These additional surveys showed that tadpoles were successfully metamorphosing at Pool 1 and although tadpoles were detected in a pool on the sandstone between Pool 8 and Pool 8b metamorphosis was not detected at this pool; individuals were not detected at other pools inspected.

Egg mass were detected along SC10C during 2015 for the first time since 2012 (Graph 20). All egg mass recorded were split across two breeding pools along SC10C with 25 egg mass recorded in Pool 1 and three recorded in Pool 8B, the highest number of egg mass recorded at this site since monitoring began in 2007. This follows a stochastic pattern of egg mass presence between 2009 and 2012 and then two years with no egg mass following direct impacts to the creekline in 2012 (Graph 20).

Again, this increase in breeding activity in 2015 is likely related to the rainfall prior to surveys resulting in water flow and pool level rise throughout the transect. An increase in egg mass abundance was also observed across control sties during 2015 (Graph 20). Some but not all egg mass detected at SC10C during 2015 were coated by iron flocculent (Plate 6).

Graph 20 Egg mass abundance of Littlejohn's Tree Frog detected at SC10C, contrasted against matched Control Sites (grey lines). The dashed vertical line represents monitoring start date and the vertical dotted line represents when mining commenced within the RMZ. Results are standardized per 100 m of creekline surveyed.



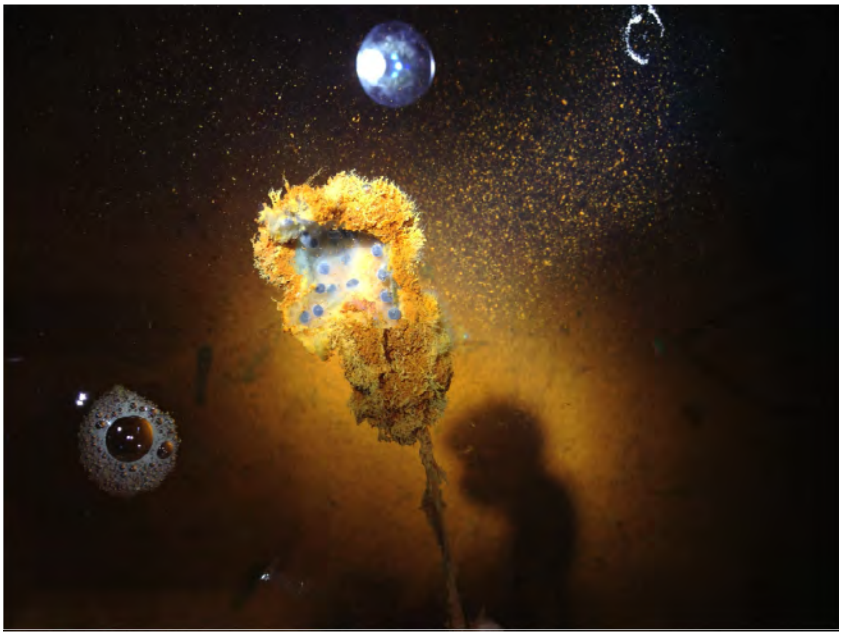


Plate 6 Littlejohn's Tree Frog egg mass recorded in winter 2015 at SC10C covered in iron floculent. The gelatinous parts of the eggs appeared white and the condition of the eggs were unknown but may have been desiccated.

Following the analysis of Littlejohn's Tree Frog presence at SC10C over the course of time, it is clear that a reduction in the available Littlejohn's Tree Frog breeding habitat has occurred where mining impacts have occurred and this effect has persisted for three consecutive winter monitoring surveys. Further assessment of these results against the TARPs has been provided in Section 4.

The abundance of Littlejohn's Tree Frog at SC10(1) and SC10(2) continue to fluctuate, as observed in the long-term data trends. During 2015, a decline in the abundance of adult frogs and tadpoles was recorded at both SC10(1) and SC10(2), while egg mass abundance increased. In comparison to previous years data across the stream as a whole, adult numbers are similar to historical pre-mining data and both transects are returning to baseline levels following a significant drop in adult frog numbers in 2012; an event which was observed across the entire Sandy Creek catchment.

A slight reduction in the number of tadpoles was observed in 2015; however, values were in line with historical records. Egg mass numbers increased during 2015, with 105 egg mass clusters detected along the stream. Overall, the detection of all three life stages along SC10 has remained relatively consistent since monitoring began. In this time the only mining related impacts that have been recorded includes the presence of iron flocculent downstream of the intersection of SC10C within SC10(1) (beyond the goaf for Longwalls 7 and 8).

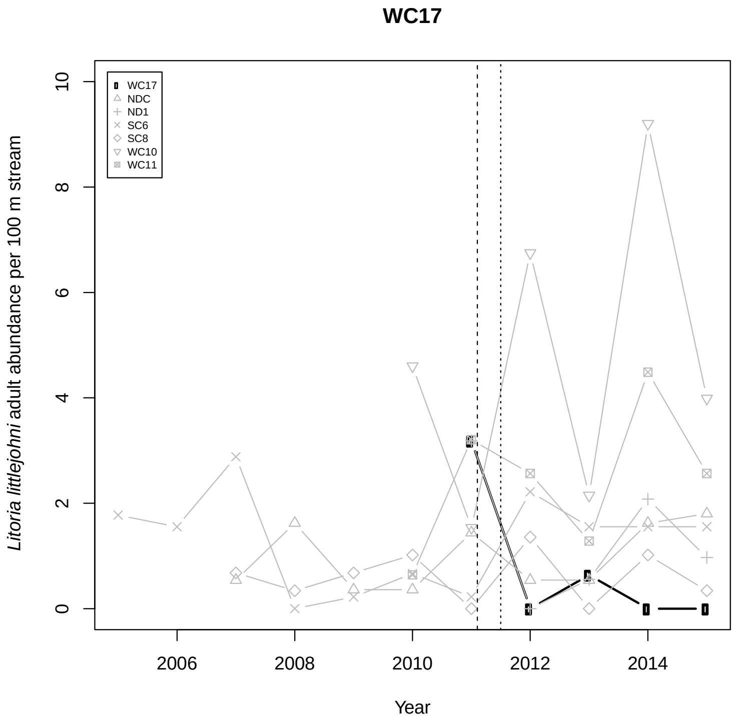
WC17

As with the Sandy Creek catchment, Wongawilli Creek and its tributaries form a second large and significant sub-population of the Littlejohn's Tree Frog in the study area. The species is known to occur along a number of first and second order streams associated with Wongawilli Creek (WC2, WC4, WC7, WC10, WC11, WC15, WC17 and WC21), as well as the upper reaches of Wongawilli Creek itself. Again, these waterways are interconnected and it is likely that the species moves throughout this area in response to a number of environmental and seasonal variables.

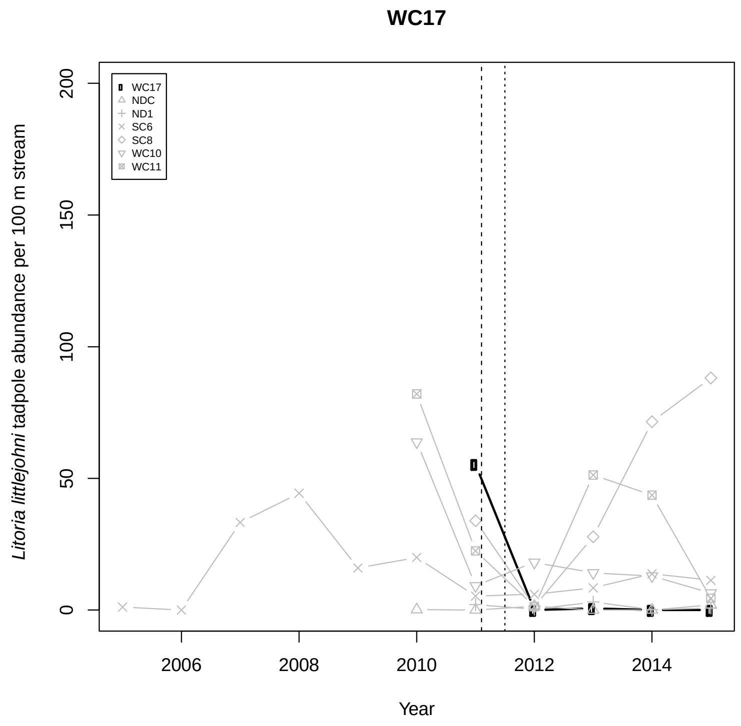
During 2015, Littlejohn's Tree Frog was not recorded within the WC17 transect for the second consecutive year. This follows a decline in adult and tadpole numbers for this species from 2011 to 2013 post-impact

(Graph 21 and Graph 22). Egg mass abundances however have historically been below average compared to control sites and this trend continued during 2015 (Graph 23). A decline in the presence of Littlejohn's Tree Frog at WC17 occurred when an important Littlejohn's Tree Frog breeding pool (Pool 26) was first observed to be dry in 2012 (Illawarra Coal Environmental Field Team). Surveys at WC17 in 2012 failed to detect the species, however in the following year (2013) water was present during monitoring and one adult frog, one tadpole and two egg mass clusters were detected at the pool. Despite not detecting the species, this pool did contain water during the 2015 surveys.

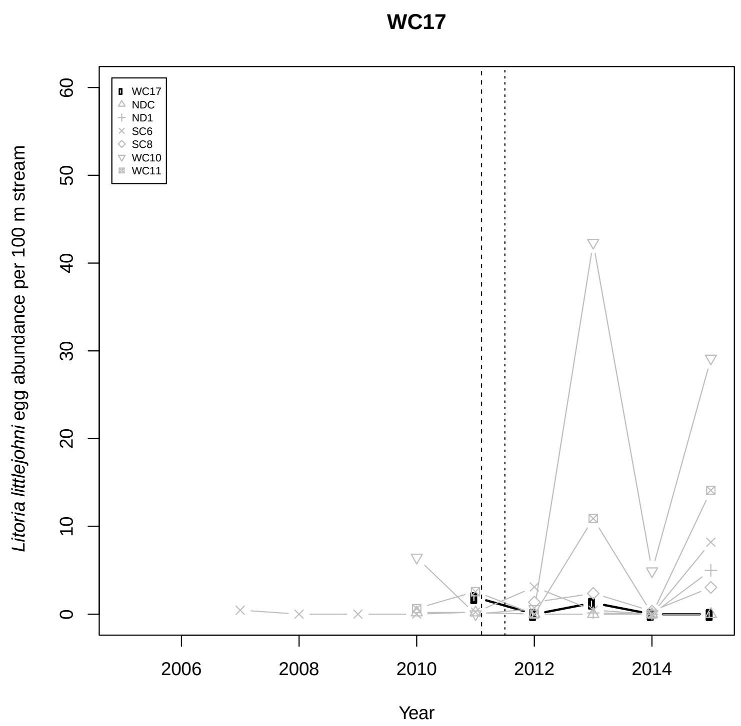
Graph 21 Adult abundance of Littlejohn's Tree Frog detected at WC17, contrasted against matched Control Sites (grey lines). The dashed vertical line represents monitoring start date and the vertical dotted line represents when mining commenced within the RMZ.



Graph 22 Tadpole abundance of Littlejohn's Tree Frog detected at WC17, contrasted against matched Control Sites (grey lines).



Graph 23 Eggmass abundance of Littlejohn's Tree Frog detected at WC17, contrasted against matched Control Sites (grey lines).



Following a count of zero for Littlejohn's Tree Frog during 2015 targeted surveys at WC17 Biosis recommended conducting tadpole surveys during summer to determine if breeding had occurred at WC17 at the end of the season following rainfall during late August. These surveys detected immature tadpoles in Pool 26 at the end of November however this pool was subsequently recorded to be dry in mid December by the Illawarra Coal Environmental Field Team. Following the drying of this pool in December no tadpoles were detected.

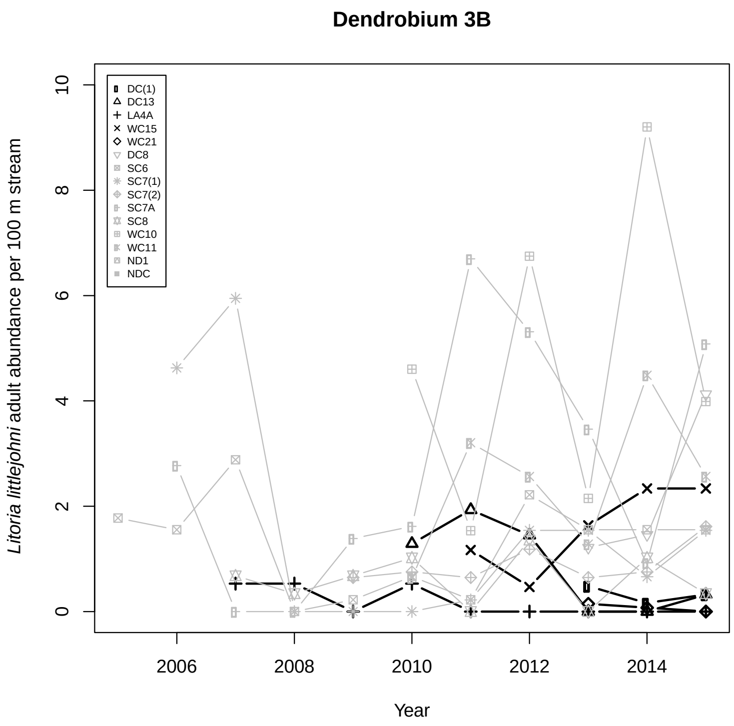
Littlejohn's Tree Frog is known to respond to rainfall events which are likely to have facilitated a breeding event in Pool 26. Water level data indicates that Pool 26 no longer has a stable water holding capacity and is often recorded to be dry for months at a time (see Graph 2 in section 3.1.2). Littlejohn's Tree Frog tadpoles are known to metamorphose within four and a half months of laying (Anstis 2013); however, with immature tadpoles recorded in the end of November and the pool recorded to be dry in mid December 2015 it is unlikely that metamorphosis was successful. This result shows that the 143m transect at WC17 may have been used opportunistically in 2015 while water persisted. Although high site fidelity has not been documented for this species in the literature, if this is true for Littlejohn's Tree Frog, the pool will continue to be used opportunistically if the correct conditions are present at the right time of year.

A reduction in habitat and the presence of Littlejohn's Tree Frog has been recorded across four monitoring periods over three years including 2012-2013, 2013-2014 and 2014-2015. Additionally, targeted surveys for the species during 2014 and 2015 have resulted in a zero count for the species along this transect. Therefore the species has been absent from this site for two monitoring periods (one year). Further assessment of these results against the TARPs has been provided in Section 4.

3.4.2 Dendrobium Area 3B

In 2015 the abundance of adults at impact sites across Dendrobium Area 3B was lower than control sites and pre-impact data. The abundance of Littlejohn's Tree Frog adults have been gradually declining across impact sites since 2011 while the abundance at control and pre-impact sites (WC15) have continued to fluctuate between years but across time have not shown an increasing or decreasing trend (Graph 24).

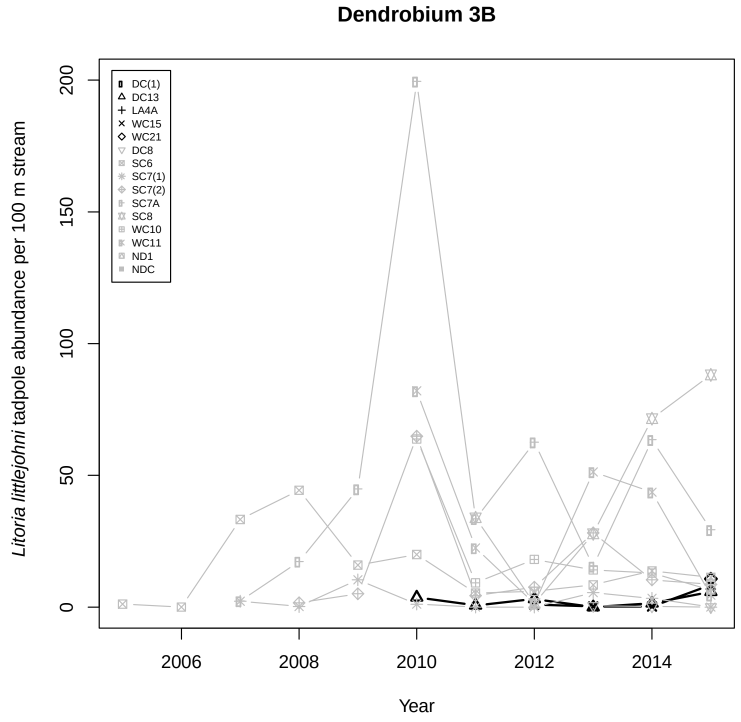
Graph 24 Abundance of Littlejohn's Tree Frog adults within 100 metre section of creekline at all Dendrobium Area 3B impact and control sites over the years of monitoring*



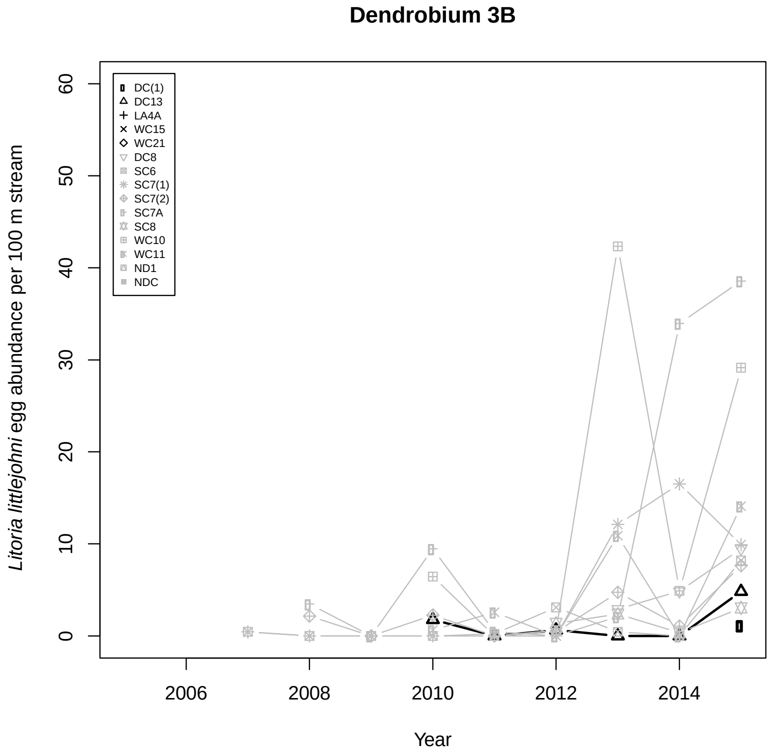
** Solid black lines represent impact sites and grey shade lines represent control sites.*

Tadpole and egg mass abundance in 2015 across Dendrobium Area 3B impact sites increased slightly following declines in previous years (Graph 25). Tadpoles and egg mass were recorded for the first time since monitoring began at two of the post-impact sites DC(1) and WC21 during 2015. Historical records for tadpole and egg mass abundance in Dendrobium Area 3B have been representative of DC13 only, and the abundance of tadpoles at this site have been typically lower than that observed at control and pre-mining sites. During 2015 tadpole abundance increased at impact sites and numbers were comparable to that observed at the majority of control sites (Graph 25). Egg mass abundances also increased at impact sites in 2015; however, abundances were still below that recorded at the majority of control sites (Graph 26). Historically tadpoles and egg mass abundances at impact sites have been low with values below the majority of control sites. Tadpole and egg mass abundances at control sites continue to fluctuate during the same time period.

Graph 25 Abundance of Littlejohn's Tree Frog tadpoles within 100 metre section of creekline at all Dendrobium Area 3B impact and control sites over the years of monitoring*



Graph 26 Abundance of Littlejohn's Tree Frog eggmass within 100 metre section of creekline at all Dendrobium Area 3B impact and control sites over the years of monitoring*



** Solid black lines represent impact sites and grey shade lines represent control sites.*

WC21

As detailed above, Wongawilli Creek and its tributaries form a second large and significant sub-population of Littlejohn's Tree Frog within the study area and WC21 is a part of this catchment area. No adults were detected along the WC21 transect (Pool 1 to Pool 29) during 2015 following consistently low numbers in previous years.

In 2014, a single adult frog was recorded between Pool 9 and Pool 10, located directly downstream of Longwall 9, while in 2013 two adult frogs were detected along WC21, one at Pool 12 and the other at Pool 18. Pool 12 and Pool 18 are located above Longwall 9 and were mined beneath during December 2013 and no adults, tadpoles or egg mass have been subsequently detected.

Both Egg mass and tadpoles were recorded during 2015 along WC21. Four egg mass and 148 tadpoles were detected along the WC21 transect for the first time since the current monitoring program commenced in 2013. The tadpoles and egg mass were recorded in pot holes on the sandstone between Pool 14 and Pool 15. One egg mass was also recorded in Pool 17. The section of stream is located above Longwall 9. Historical data for this stream from an unrelated survey during 2010 recorded nine Littlejohn's Tree Frog egg mass clusters between Pool 10 and Pool 25. Although this historical survey was not a part of the current monitoring program for the species, it shows that in the past a population of Littlejohn's Tree Frog was present and successfully breeding at WC21.

Impacts to WC21 between Pool 22 and Pool 27 were detected following the extraction of Longwall 10 in 2014, however these impacts occurred following the winter 2014 monitoring season (Ecoengineers 2014b). All Littlejohn's Tree Frog records since commencing the current monitoring program in 2013 have been located within the stream downstream of Longwall 10.

Although additional impacts to the upper extent of WC21 have subsequently occurred following the completion of Longwall 11 (Illawarra Coal 2016), these impacts occurred following the winter 2015 monitoring season. The 2016 survey of this site will provide future insight into the effects of stream impacts to the Littlejohn's Tree Frog numbers along WC21.

When assessing WC21 against the TARPs for terrestrial fauna - threatened frog species within the Dendrobium Area 3 Watercourse Monitoring Trigger Action Response Plan (TARP) (dated 12 October 2015) it was determined that a Level 1 TARP has been triggered for WC21. A reduction in Littlejohn's Tree Frog habitat during the breeding season was first observed along WC21 in 2014 (Biosis 2015a; Biosis 2015b). Disruptions to water flow along approximately 35% of the monitoring transect was observed by Biosis during the 2015 Littlejohn's Tree Frog surveys (between Pool 11 and Pool 24). Subsequent impacts upstream of Pool 30 have been recorded following the extraction of Longwall 11 (Illawarra Coal 2016). Therefore a reduction in habitat has been recorded at WC21 for two monitoring periods (one year), triggering a Level 1 TARP.

Donald's Castle Creek and tributaries

A smaller, disjunct sub-population of Littlejohn's Tree Frog occurs along Donald's Castle Creek and its tributaries. Although the species has been known to occur in DC13 since 2010, new locations of Littlejohn's Tree Frog were recorded in the upper reaches of Donald's Castle Creek and at DC8 (used as a control site) in winter 2013.

Low numbers of adult Littlejohn's Tree Frog at DC(1) continued in 2015 with two adults detected along the transect. Both adults were located in Pool 32 where the species has been recorded previously. This follows a count of one adult in 2014 at Pool 20. Monitoring for Littlejohn's Tree Frog began at DC(1) in 2013 with three adults detected across Pools 32, 34 and 35 in the upper reaches of the transect. During 2015 egg mass was recorded along DC(1) for the first time since monitoring began, with three egg mass located in Pool 32 (Plate 7), while four egg mass were recorded in a small pool on the sandstone above Pool 33. Tadpoles are yet to be recorded at this site.

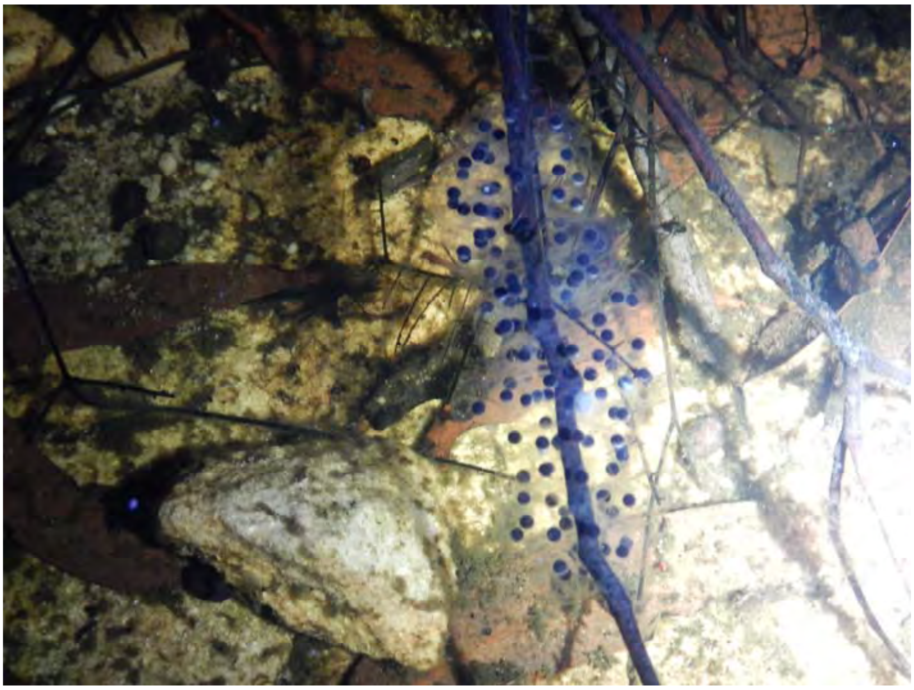


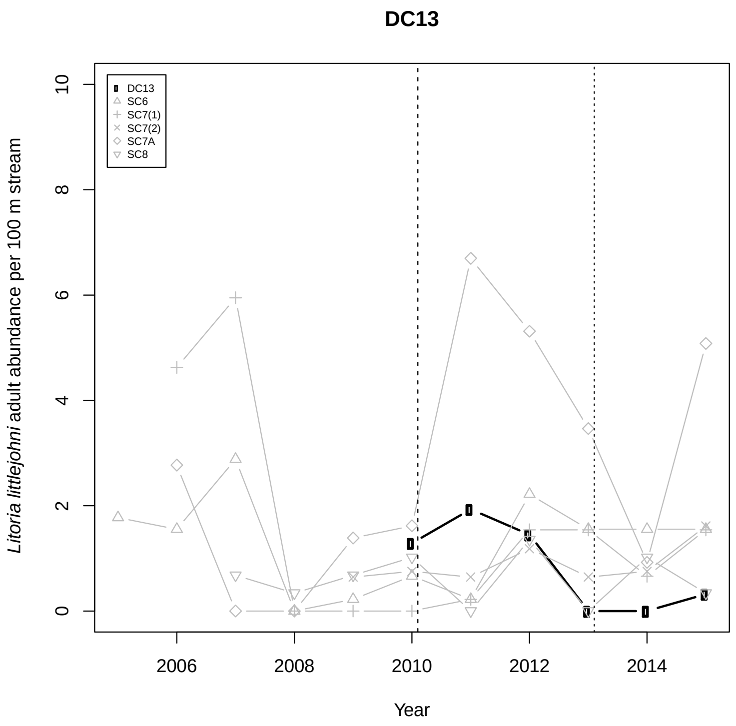
Plate 7 Littlejohn's Tree Frog egg mass recorded in pool 32 during winter 2015 at DC(1)

As discussed in Section 3.1.3, the upstream section of this transect has been impacted, altering the water regime in two known breeding pools of the DC(1) transect. During winter 2015 water was present along the majority of DC(1) and limited water was noted upstream of Pool 32. Although water was present in Pool 32, there was no in-flow or out-flow during monitoring. DC(1) has now been monitored for three years, however the transect was not monitored prior to Pools 30–35 being impacted (impact date was 3/6/2013 and the survey date was 11/6/2013). Signs of occupancy have been recorded during 2015, although adult numbers continue to be low and future surveys will assist in determining to what extent the species continues to utilise this stream following mining.

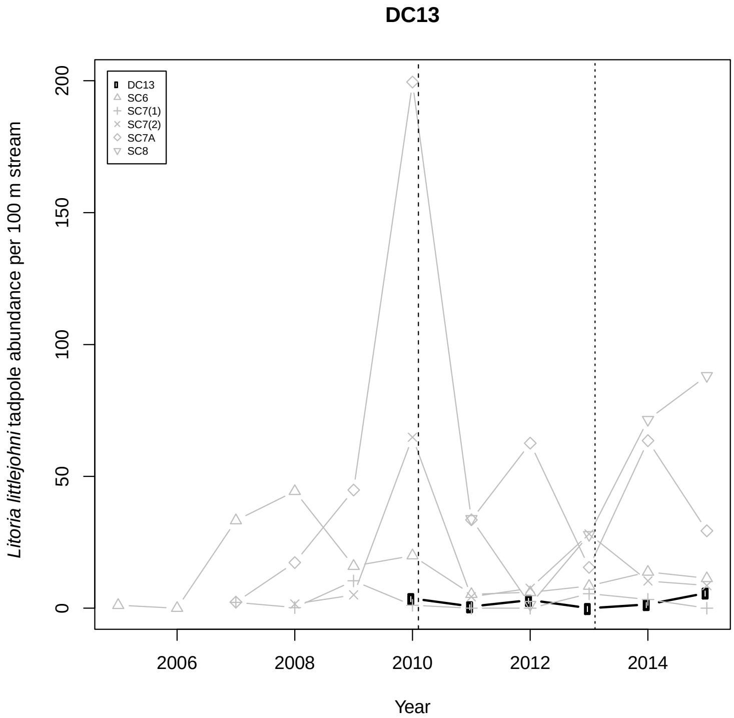
Littlejohn's Tree Frog adults and egg mass were recorded at DC13 for the first time in 2015 since 2012 (Graph 26 and Graph 29). One adult was recorded in Pool 12, and 30 egg mass were recorded across seven breeding pools from Pool 11 through to some pot holes in the sandstone below Pool 17. Adult detection remains below that recorded pre-impact.

An increase in tadpole numbers has been recorded along DC13 in 2015 with a total of 36 tadpoles recorded across five breeding pools between Pool 16A and Pool 17 (Graph 28). During 2014, only nine tadpoles were recorded across three breeding pools (Pools 11, 16B and 17) and no tadpoles were recorded in 2013. Following this result, Biosis recommended conducting summer tadpole surveys to determine if breeding was successful along this stream. By the completion of these additional surveys, successful metamorphosis had been observed in two pot holes on the sandstone between Pools 16B and 17.

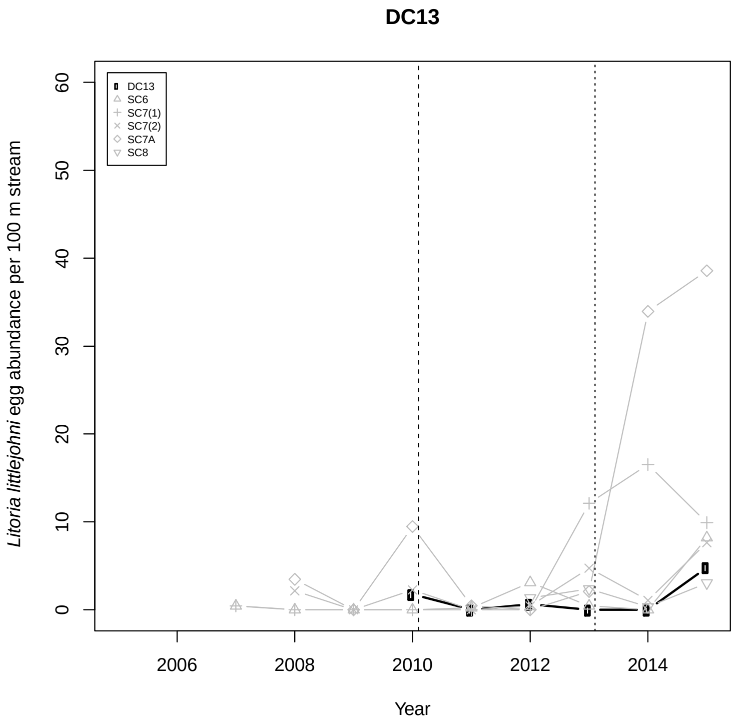
Graph 27 Adult abundance of Littlejohn's Tree Frog detected at DC13, contrasted against matched Control Sites (grey lines). The dashed vertical line represents monitoring start date and the vertical dotted line represents when mining commenced within the RMZ.



Graph 28 Tadpole abundance of Littlejohn's Tree Frog detected at DC13, contrasted against matched Control Sites (grey lines). The dashed vertical line represents monitoring start date and the vertical dotted line represents when mining commenced within the RMZ.



Graph 29 Eggmass abundance of Littlejohn's Tree Frog detected at DC13, contrasted against matched Control Sites (grey lines).



When assessing DC13 against the TARPS for terrestrial fauna - threatened frog species within the *Dendrobium Area 3 Watercourse Monitoring Trigger Action Response Plan* (TARP) (dated 12 October 2015) it was determined that a Level 2 TARP has been triggered for DC13. Pools that were previously utilised by the species to breed (Pools 18A through to the transect end) were recorded to have minimal to no water in 2013, 2014 and 2015. This represents a reduction in breeding habitat across three monitoring periods over two years. Following a review of the Environmental Field Team's water level data, pools where tadpoles and egg mass were recorded along DC13 in 2015 have a faster rate of water level recession.

3.5 Incidental threatened species observations

A number of Littlejohn's Tree Frog were recorded outside of the monitoring transects in Dendrobium areas during winter 2015 (Table 9). In addition the Giant Burrowing Frog was incidentally recorded at several sites during the Littlejohn's Tree Frog monitoring program in tadpole form. No additional incidental threatened flora or fauna were recorded in Dendrobium Area 3A or 3B during 2015.

Table 9 Littlejohn's Tree Frog adults incidentally heard in Dendrobium impact and control sites during winter 2015

Survey Date	Location in relation to monitoring transects	Number of Littlejohn's Tree frog heard
4/8/2015	Downstream of WC17	1
29/7/2015	Upstream of SC10(2)	2
29/7/2015	Downstream of SC10(2) along SC10C	2
8/9/2015	Downstream of SC10C along SC10(1)	4

Giant Burrowing Frog tadpoles have been recorded sporadically across a number of impact and control sites that are monitored as part of the Littlejohn's Tree Frog program and during 2015 numerous tadpoles were recorded at SC6 and WC11 (Table 10). Most records for this species across the area have been single sighting events throughout the program; however, consistent records at SC6 may indicate the importance of this site for the species. Giant Burrowing Frog tadpoles were first recorded at SC6 in 2008 and have been recorded at this site each year with the exception of 2013 (Table 10). During the 2015 threatened frog monitoring, tadpoles were again recorded at SC6 in large numbers across eleven breeding pools. Large numbers of tadpoles were also detected at WC11 which is a control site. This species was not recorded at any of the current impact sites during 2015.

Table 10 Giant Burrowing Frog historical tadpole records throughout the Dendrobium impact and control sites from the commencement of monitoring

Site status	Site	Monitoring year							
		2008	2009	2010	2011	2012	2013	2014	2015
Impact	6CDL	-	0	0	4	0	0	0	0
	DC13	-	-	0	0	0	70	0	0
	SC10(1)	0	0	0	1	0	0	0	0
	SC10C	10	0	0	0	11	0	0	0
Control	NDC	-	48	0	0	0	0	0	0
	DC8	-	-	-	-	-	1	0	0
	SC6	23	251	84	3	11	0	52	90
	SC7(1)	0	0	0	1	0	0	0	0
	SC7(2)	0	0	0	7	0	0	0	0
	WC11	-	-	0	4	3	0	0	108

4 Conclusion and recommendations

At the completion of the 2015 ecological monitoring program, 10.5 years of data has been collected for Dendrobium Area 2; 6.5 to 11.5 years of data has been collected for Dendrobium Area 3A; and 3.5 years of data collected for the majority of Dendrobium Area 3B (aside from S11 where monitoring has been undertaken for 12.5 years).

To align with the requirements of the NSW Government *Annual Review Guideline* (NSW Government 2015) the following section provides a summary analysis of the terrestrial ecology monitoring program for the 2015 period, including:

- A summary and conclusion of trends in the data as detailed in Section 3 herein (Section 4.1).
- A comparison of the data to predictions made in the Environmental Impact Statement (Section 4.1).
- Identification of any management implications and proposed improvements to environmental management or performance (Section 4.2).

4.1 Assessment against performance measures

4.1.1 Upland swamp vegetation monitoring

LiDAR mapping of upland swamps

The comparison of pre-mining and post-mining swamp size and extent of groundwater dependent communities within swamps of the Dendrobium 3A and 3B areas showed a decline in both measures across control and impacted swamps. For both measures, the observed decline was larger for impacted than for control swamps.

Terrestrial flora - total swamp size TARP

The *Dendrobium Area 3B Swamp Monitoring – Terrestrial Flora: Composition and Distribution of Species* (Illawarra Coal 2015c) sets out the following trigger levels for swamp size:

- **Level 1**: A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for two consecutive monitoring periods, greater than observed in the Control Group, and exceeding the standard error (SE) of the Control Group.
- **Level 2**: A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for three consecutive monitoring periods, greater than observed in the Control Group, and exceeding the standard error (SE) of the Control Group.
- **Level 3**: A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for four consecutive monitoring periods, greater than observed in the Control Group, and exceeding the standard error (SE) of the Control Group.
- **Exceeding prediction**: Mining results in a trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for five consecutive monitoring periods, greater than observed in the Control Group, and exceeding the standard error (SE) of the Control Group.

The results of LiDAR mapping indicate that a Level 1 TARP was triggered at swamps S01A, S01B, S5 and S8 as at these swamps there has been two consecutive years of decline in swamp size relative to baseline and the observed decline is greater than the decline in the control group and exceeds the standard error of the control group. Swamp S15B also showed a decline in size greater than the mean (±SE) of the control group for 2014 however there are no specific TARPs relating to swamp size for impacted swamps within Dendrobium Area 3A.

Terrestrial flora – ecosystem functionality TARP

The *Dendrobium Area 3B Swamp Monitoring – Terrestrial Flora: Composition and Distribution of Species* (Illawarra Coal 2015c) sets out the following trigger levels for Ecosystem Functionality:

- **Level 1:** A trending decline in the extent of any individual groundwater dependent community within a swamp for two consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.
- **Level 2:** A trending decline in the extent of any individual groundwater dependent community within a swamp for three consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.
- **Level 3:** A trending decline in the extent of any individual groundwater dependent community within a swamp for four consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.

  Exceeding Prediction: Mining results in a trending decline in the extent of any individual groundwater dependent community within a swamp for five consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.

Each sub-community within impacted swamps declined to a greater extent than the decrease recorded at corresponding sub-communities within control swamps. This declining trend was evident in 2014 and 2015 for those swamps where LiDAR data for 2012, 2014 and 2015 was available. These results indicate a Level 1 ecosystem functionality TARP was triggered at swamps S01A, S01B, S05 and S08 as a trending decline in the extent of individual groundwater dependent communities within those swamps was observed for two consecutive monitoring periods and is greater than the observed decline at control swamps and exceeding the standard error of the control groups.

As is the case for the swamp size TARP above, swamp S15B showed a greater decline in extent of groundwater dependent sub-communities than the mean (±SE) of the control group for 2014 however there are no specific TARPs relating to swamp size for impacted swamps within Dendrobium Area 3A.

The mean decrease in total swamp size was greatest where mining had occurred suggesting some influence of mine subsidence on the observed swamp size decrease and decrease in groundwater dependent sub-communities. However, marked decreases in both measures were also observed at control swamps suggesting a broader natural background trend of decreasing swamp area across the Dendrobium area.

Across all swamps, the modelled decrease in swamp extent in 2014 and 2015 was driven largely by the inward contraction of the swamp perimeter in the order of 1 – 5 meters from the 2012 mapped extent. The contraction of swamp vegetation and encroachment of fringing eucalypt woodland may be expected following subsidence-related impacts to swamp hydrology and hydrogeology and as such, the decline in swamp size and extent of groundwater dependent swamp sub-communities presented here warrant further investigation.

Ground-truthing of model results at several swamps in March 2016 found that the modelled contraction in swamp size, in many cases, was not a true and accurate reflection of swamp vegetation on the ground and the model tended towards over-estimate of the reduction in swamp size and extent of groundwater dependent sub-communities. Potential causes of this observed difference in modelled and actual swamp extent include:

- Natural growth and expansion of fringing eucalypt tree crowns at the perimeter of swamps
- Inherent inaccuracies of the LiDAR data (e.g. interpolation between LiDAR strikes)
- Movement of vegetation during LiDAR capture

Caution is urged when interpreting the results of the swamp size and ecosystem functionality monitoring given that a number of factors unrelated to mining impacts may drive some of the modelled decrease in swamp size and extent of groundwater dependent sub-communities. Moreover, changes in swamp size and extent of groundwater dependent communities observed at each swamp may be the result of responses to natural phenomena such as recent and long-term climate, fire patterns and stochastic events (e.g. storm damage, etc.). The observed decreases at control swamps suggest that at least a proportion of the observed decrease at impacted swamps may be due to factors unrelated to mining impacts.

Ongoing monitoring and improvements to the LiDAR swamp modelling approach are recommended in order to improve the confidence with which modelled decreases in swamp size and ecosystem functionality can be said to represent real change attributable to mining-related impacts.

An assessment of the results of the 2015 analysis against the Dendrobium 3A and 3B TARPS is presented below in Table 11.

Table 11 Assessment of Dendrobium Area 3A and 3B impact swamps against the Swamp Size and Ecosystem Function TARPs.

Swamp	Predicted impact	Results and TARP justification	TARP	Recommendations
S15B	No prediction made at EIS	TARPS relating to swamp size and extent of groundwater dependent sub-communities do not currently apply to swamps within Dendrobium Area 3A	None	Continue monitoring S15B to determine trend in change to swamp extent and the extent of sub-communities within swamps.
S1A **S1B** **S5** **S8**	No prediction made at EIS	Two monitoring periods of decline in swamp size relative to baseline in which the decline is greater than the observed decline in the control group and exceeds the standard error of the control group. Two monitoring periods of decline in groundwater dependent swamp sub-communities relative to baseline in which the decline is greater than the observed decline in the control group and exceeds the standard error of the control group.	Swamp Size: Level 1 TARP. Ecosystem Function: Level 1 TARP.	Continue monitoring each year. Incorporate ground-truthing as necessary to validate LiDAR mapping.

Total species richness and species composition

Impacts on the distribution of local vegetation within a swamp, as well as changes in water levels, were predicted as a result of mining beneath swamps (Illawarra Coal 2012). Specifically, localised water diversion and lowering of the shallow groundwater table within S1A, S1B and S5 was predicted (Illawarra Coal 2012).

Data analysis continues to show that TSR across all sites irrespective of mining status is highly variable however a period of stability in TSR between 2010 and 2015 is discernible when considering pooled TSR data from control swamps. During this period of stability, a statistically significant decline in TSR was detected at two impact swamps S1A (Dendrobium Area 3B) and S15B (Dendrobium 3A). Declines in TSR were observed pre-mining and continued through 2015 at S15B while TSR at S1A had decreased at transects which had been mined beneath whilst increasing markedly at a transect not undermined (i.e. transect V3).

Yearly and occasionally seasonal changes in species composition were detected in most sites, regardless of area or treatment. Seasonal and yearly variation at sites due to natural turnover of species is not unexpected. When accounting for the yearly effects, a statistically significant change in species composition in post-mining data to pre-mining data was found at S15A(2) and S1A.

The *Dendrobium Area 3B Swamp Monitoring – Terrestrial Flora: Composition and Distribution of Species* (Illawarra Coal 2015c) sets out the following trigger levels for terrestrial flora within upland swamps:

- Level 1 - A 2% or otherwise statistically significant decline in species richness or diversity during a period of species richness/diversity stability or increase in a reference swamp for two consecutive years.
- Level 2 - A 5% or otherwise statistically significant decline in species richness or diversity during a period of species richness/diversity stability or increase in a reference swamp for three consecutive years.
- Level 3 – An 8% or otherwise statistically significant decline in species richness or diversity during a period of species richness/diversity stability or increase in a reference swamp for four consecutive years.
- Exceeding prediction - Mining results in a >10% or otherwise statistically significant decline in species richness or diversity during a period of species richness/diversity stability or increase in a reference swamp for five consecutive years.

Additionally, the following trigger levels have been set for terrestrial flora within upland swamps of Dendrobium Area 3A:

- Level 1 - Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period.
- Level 2 - Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period; and statistically significant difference of species richness and species diversity between Before After Control Impact sites as a result of mining.
- Level 3 - Subsidence causes erosion of the surface or changes in ecosystem functionality of the swamp Vegetation impacted by mining that is not responding to CMAs.

An assessment of the results of the 2015 analysis against the Dendrobium 3A and 3B TARPS is presented below in Table 12.

Table 12 Assessment of impact swamps in Dendrobium Area 2, 3A and 3B against the TARPs.

Swamp	Predicted impact	Results and TARP justification	TARP	Recommendations
S1	Level 1, 2 or 3 TARP.	Visual trends in TSR at S1post mining included 6 years of a decline in TSR to 2013 followed by a subsequent increase in TSR from 2013 to 2015. Analysis showed a non-significant increase in TSR at S1 during a five year period of stability at control swamps. No significant change in species composition was detected at S1. Results indicate no trigger has been reached at S1.	No TARP trigger.	Due to the fluctuating nature of the TSR at this site it is recommended that monitoring continue at the biennial basis.
S15A(2)	Level 1, 2 or 3 TARP.	No visual decline in TSR was detected at S15A(2) (Graph 11) and there was no statistically significant trend in TSR when the best-fitting GLM was interrogated. A significant change in Species Composition was detected at S15A(2) during the 3 year post-mining period (p-value = 0.004) indicating a Level 2 TARP had been triggered.	Level 2 TARP.	Continue monitoring S15A(2) in spring and autumn each year.
S15B	Level 1, 2 or 3 TARP.	TSR showed a declining trend at S15B; a trend which has been evident since pre-mining. A statistically significant decline in TSR was detected post-mining (see section 3.2.1) during the period 2012 – 2015 . No significant change in Species Composition was found post mining at S15B. A decline in TSR has occurred for 4 years (2012 – 2015) so a Level 2 TARP has been triggered for S15B.	Level 2 TARP.	Continue monitoring S15B in spring and autumn each year and investigate reasons for the exceedance. Consult with technical specialists to identify need and type of CMA required and implement any agreed CMA.
S1A	Level 1, 2 or 3 TARP.	TSR at S1A was found to be higher during the 'post-mining - within RMZ' phase. However, when considering TSR data from transects 'post-mining - mined beneath' a statistically significant decrease in TSR was observed. A significant change in Species Composition has been detected at S1A post-mining (p-value = 0.092) which, given post-mining for 3 years, corresponding with the change in species composition. Therefore a Level 2 TARP has been triggered for S1A. The significant decrease in TSR and change in species composition was observed over a three year post-mining period (2013 – 2015) indicating a Level 2 TARP has been triggered.	Level 2 TARP.	Continue monitoring S1A in spring and autumn each year.

Swamp	Predicted impact	Results and TARP justification	TARP	Recommendations
S1B	Level 1, 2 or 3 TARP.	TSR within S1B was stable with no yearly increasing or decreasing trend detected over the period 2013 – 2015 during which time all monitoring transects had been mined beneath. Additionally, no significant change in Species Composition was found post mining so no TARP has been triggered for S1B.	No TARP trigger.	Continue monitoring.
S5	Level 1, 2 or 3 TARP.	TSR within S5 was stable with no yearly increasing or decreasing trend detected over the period 2013 – 2015 during which time all monitoring transects had been mined beneath. Additionally, no significant change in Species Composition was found post mining so no TARP has been triggered for S5.	No TARP trigger.	Continue monitoring.

Creek point monitoring

Analysis of the 2015 creek data found that TSR is significantly higher at SC10 post-mining. SC10 species composition is also significantly different post-mining compared to pre-mining. Changes in TSR and species composition are also observed at control sites and there is no statistically significant difference of species richness and species diversity between Before After Control Impact sites as a result of mining. No stressed or dead vegetation has been observed at SC10.

4.1.2 Littlejohn's Tree Frog monitoring

It was predicted that mining within Dendrobium Area 3A and 3B would have a significant impact to one or more local populations of Littlejohn’s Tree Frog (Biosis 2007b; Niche 2012). Analysis of adult Littlejohn's Tree Frog standardised abundance for the combined Dendrobium Area 3A and Area 3B programs indicates that the abundance of adult frogs is lower at impact sites than control sites. Subsidence related impacts appear to be the most likely agent causing declines in Littlejohn's Tree Frog populations at Dendrobium Area 3A and 3B post-mining sites.

Fracturing of the bedrock and resultant pool water level loss in SC10C and WC17 has resulted in impacts to breeding habitat for Littlejohn's Tree Frog. The revised *Dendrobium Area 3A TARPS* (dated 18 October 2012) relating to ecology do not include triggers specific to threatened fauna and therefore do not stipulate specific actions to be undertaken following the detection of impacts to Littlejohn's Tree Frog habitat during Littlejohn's Tree Frog surveys. It is understood that Pool Water Level / Flow and Appearance triggers identified in the in the Dendrobium Area 3A Watercourse TARP have, however, been reached and Corrective Management Actions (CMAs) are being considered.

Littlejohn's Tree Frog transects within Dendrobium Area 3B have been assessed against the *Dendrobium Area 3B Watercourse TARP* (dated 12 October 2015) which include the following trigger levels for Threatened Frog Species:

- Level 1 - Reduction in habitat for 1 year.
- Level 2 - Reduction in habitat for 2 years following the active subsidence period.
- Level 3 - Reduction in habitat for >2 years or complete loss of habitat following the active subsidence period.

Biosis has defined a reduction or complete loss of habitat for the Littlejohn's Tree Frog as the following:

- A reduction in habitat is:
  - A reduction in potential breeding habitat, shown by dry pools along the transect during the breeding season. This prevents adults from laying egg mass in some portion of the habitat.
  - A reduction in breeding habitat for egg mass and tadpole life stages, as shown by breeding pools recorded to be consistently dry during the breeding season or unable to hold water for a sufficient time to allow for full development to occur. This results in the unsuccessful hatching and completion of metamorphosis of egg mass and tadpoles.
  - A significant reduction in the presence of Littlejohn's Tree Frog (all life stages) from a site where successful breeding occurred pre-mining.
- A complete loss of habitat is:
  - A reduction in potential breeding habitat, shown by dry pools along the transect during the breeding season. This prevents adults from laying egg mass in the entire section of habitat.
  - The absence of the species (all life stages) from a site where successful breeding occurred pre-mining.

Table 13 assesses impact sites in Dendrobium Area 3B against the TARPs using the definitions outlined above.

Table 13 Assessment of Littlejohn's Tree Frog monitoring results at impacted sites within the Dendrobium Area 3A against Dendrobium Area 3A TARPs

Stream	Predicted impact	Results and TARP justification	TARP	Recommendations
Dendrobium Area 3A Watercourse Monitoring TARP (dated 18 October 2012)				
SC10C	Significant impacts to the Littlejohn's Tree Frog.	No trigger relates specifically to threatened fauna species, therefore observed impacts to Littlejohn's Tree Frog habitat have not triggered a TARP. The following Level 3 triggers relating to watercourse monitoring have been observed: • Stream appearance at SC10C. • Aquatic ecology including pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat at SC10C.	No threatened frog TARP triggered.	The Dendrobium Area 3A TARP does not specify actions to be undertaken for threatened fauna in watercourses. CMAs for related watercourse TARPs may address some impacts to threatened frog habitats.
WC17	Significant impacts to the Littlejohn's Tree Frog.	No trigger relates specifically to threatened fauna species, therefore observed impacts to Littlejohn's Tree Frog habitat have not triggered a TARP. A Level 2 trigger relating to watercourse monitoring has been observed for WC17 as the majority of pools monitored showed water level or pool retention time lower than baseline.	No threatened frog TARP triggered.	The Dendrobium Area 3A TARP does not specify actions to be undertaken for threatened fauna in watercourses. CMAs for related watercourse TARPs may address some impacts to threatened frog habitats.

Table 14 Assessment of Littlejohn's Tree Frog monitoring results at impact sites within the Dendrobium Area 3B against Dendrobium Area 3B TARPs

Stream	Predicted impact	Results and TARP justification	TARP	Recommendations
Dendrobium Area 3B Watercourse Monitoring TARP (dated 12 October 2015)				
DC13	Significant impacts to the Littlejohn's Tree Frog.	Following the 2015 survey at DC13, pools that were previously utilised by the species to breed (Pools 18A through to the transect end) were recorded to have minimal to no water for three consecutive years (2013, 2014 and 2015). This represents a reduction in breeding habitat across three monitoring periods and two years following impacts; therefore a level 2 TARP has been triggered for DC13.	Level 2 trigger.	Continue monitoring as a part of the terrestrial monitoring program. Additional tadpole surveys were conducted by Biosis in summer 2015/2016 (Biosis in prep) and additional pool water level monitoring was conducted by Illawarra Coal.
WC21	Significant impacts to the Littlejohn's Tree Frog.	A reduction in habitat for two monitoring periods (one year) has been recorded at WC21 following the extraction of Longwall 9 and Longwall 10. Approximately 35% of the potential breeding habitat along this stream was experiencing a reduction in water levels (between Pool 11 and Pool 24) including three confirmed breeding pools (observations by Biosis during monitoring in 2015). Therefore, a level 1 TARP has been triggered for WC21.	Level 1 trigger.	Continue monitoring. Illawarra Coal has developed a rehabilitation plan for WC21 which is with Government for review.
DC(1)	Significant impacts to the Littlejohn's Tree Frog.	A TARP has not been triggered for DC(1) as water levels at important breeding pools along this transect do contain water for extended periods of time (see section 3.1.3); therefore, no TARP has been triggered for DC(1).	No TARP trigger.	Continue monitoring.

In response to the impacts to WC17, DC13 and SC10C, water level monitoring and tadpole surveys were undertaken during summer 2015/2016 to determine if metamorphosis was occurring.

4.2 Site specific recommendations

4.2.1 S1 vegetation monitoring

Observational data recorded by Biosis at S1 over the past two years has identified the establishment of several mesic species more commonly encountered within rainforest or tall wet sclerophyll forest vegetation types and generally not considered typical of upland swamps. The species were first recorded at S1 in 2014 and individuals of two of these species were recorded again in 2015. Species composition at S1 was statistically different from year to year and these trends were observed in pre-mining data as well as post-mining data.

The mesic species were not shown to be key species responsible for driving trends in compositional dissimilarity between years within S1, rather, common upland swamp flora species were found to be driving changes in species composition between years within S1. None the less, the establishment of these species may be a forward indicator of hydrological changes, in particular, a reduction in seasonal inundation that would usually prevent such species from establishing.

There is the potential that these seedlings have established due to temporarily favourable micro-habitats being intermittently present as part of natural climatic fluctuations and/or mining impacts. The future persistence and maturation of mesic non-swamp species in future years would be indicative of a transition towards a vegetation community uncharacteristic of coastal upland swamp.

Previously it has been recommended that S1 be monitored biennially (i.e. once every two years) given the observed incremental successional changes which may be attributable to natural turnover or a longer term trend attributable to changes in shallow groundwater levels (Biosis 2015b).

4.2.2 S15A(2) and S15B upland swamp terrestrial flora monitoring

The triggering of a Dendrobium Area 3A Swamp – Terrestrial Flora Level 2 TARP for S15A(2) and S15B (South32 2015) requires the following actions:

- Continue monitoring program.
  - Biosis will continue to monitoring all of these sites as part of the 2016 monitoring program.
- Review monitoring frequency.
- Report in the End of Panel Report.
- Summarise all actions and monitoring in AEMR by due date.
- Notify relevant technical specialists and seek advice on any CMA required.
- Implement agreed CMAs as approved.

4.2.3 S1AB upland swamp terrestrial flora monitoring

The triggering of a Level 2 TARP for S1A Dendrobium Area 3B Swamp – Terrestrial Flora (South32 2015) requires consideration of the following actions:

- Investigation and review.
- Continuation of monitoring program.
  - Biosis will continue to monitoring all of these sites as part of the 2016 monitoring program.
- Implementation of CMAs such as water spreading, seeding/planting/weeding, fire management, grouting of controlling rockbars and bedrock base and/or use of other remediation techniques.
- Update future predictions based on the outcomes of the investigation.

4.2.4 Swamp size and ecosystem functionality monitoring

The triggering of a Dendrobium Area 3B Swamp – Monitoring Level 2 TARP for swamp size and ecosystem functionality at S1A, S1B. S5 and S8 (South32 2015) requires consideration of the following actions:

- Investigation and review.
- Continuation of monitoring program.
  - Biosis will continue to monitoring all of these sites as part of the 2016 monitoring program.
- Implementation of CMAs such as water spreading, seeding/planting/weeding, fire management, grouting of controlling rockbars and bedrock base and/or use of other remediation techniques.

- Update future predictions based on the outcomes of the investigation.

4.2.5 SC10 terrestrial flora monitoring

Based on the length of time until Longwall 19 is extracted, Biosis recommends ceasing biannual monitoring for SC10 until at least six months prior to the extraction of Longwall 19. The resumption of monitoring will be as per the SMP (Illawarra Coal 2010). This would include discontinuing the monitoring at DC10 and SC7 control sites until the resumption of monitoring at SC10 occurs.

4.2.6 WC17 and SC10C Littlejohn's Tree Frog monitoring

The revised Dendrobium Area 3A TARPS (dated 18 October 2012) relating to ecology do not include triggers specific to threatened fauna and therefore do not stipulate specific actions to be undertaken following the detection of impacts to Littlejohn's Tree Frog habitat. Pool Water Level / Flow and Appearance triggers identified in the in the Dendrobium Area 3A Watercourse TARP have however been triggered and Corrective Management Actions (CMAs) are being considered (e.g. grouting and repair of surface water controlling features and beds of streams).

4.2.7 WC21 Littlejohn's Tree Frog monitoring

The triggering of a *Dendrobium Area 3B Watercourse – Terrestrial Fauna: Threatened Frog Species* Level 1 TARP for WC21 (South32 2015) required the following actions. Biosis has also provided the appropriate managed actions response undertaken following the triggering of the TARP:

- Continue monitoring program.
  - Biosis will continue to monitoring WC21 as part of the 2016 monitoring program.
- Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other.
  - May be included in the Longwall 11 End of Panel Report.
- Report in the End of Panel Report.
  - May be included in the Longwall 11 End of Panel Report.
- Summarise actions and monitoring in AEMR.

4.2.8 DC13 Littlejohn's Tree Frog monitoring

The triggering of a *Dendrobium Area 3B Watercourse – Terrestrial Fauna: Threatened Frog Species* Level 2 TARP for DC13 (South32 2016) required the following actions. Biosis has also provided the appropriate managed actions response undertaken following the triggering of the TARP:

- Continue monitoring program.
  - Biosis will continue to monitoring DC13 as part of the 2016 monitoring program.
- Review monitoring frequency.
  - Biosis conduced additional tadpole monitoring during summer 2015/2016 to determine tadpole success and metamorphosis (Biosis in prep).
- Submit an Impact Report to OEH, D&PE, DPI, SCA and other relevant resource managers.
  - Completed in the Longwall 10 End of Panel Terrestrial Ecology Report (Biosis 2015a).
- Report in the End of Panel Report.

- Completed in the Longwall 10 End of Panel Terrestrial Ecology Report (Biosis 2015a). May be included in the Longwall 11 End of Panel Report.
- Summarise actions and monitoring in AEMR.
  - Completed in the Longwall 10 End of Panel Report – to be included in the AEMR (Illawarra Coal 2015). Continue monitoring program.
- Summarise actions and monitoring in AEMR.
- Notify relevant technical specialists and seek advice on any CMA required.
- Implement agreed CMAs as approved (subject to stakeholder feedback).

4.3 Conclusion

Following the 2015 terrestrial monitoring it was found that an ecological response had been detected at impact sites within Dendrobium Areas 2, 3A and 3B where physical impacts have been documented. The documented impacts remain within predicted impact levels identified within relevant Environmental Impact Statements for Dendrobium Areas 2, 3A and 3B. However, observed ecological responses of upland swamps and threatened frogs at some monitoring locations do trigger TARPs for Dendrobium Areas 2, 3A and 3B. Management responses are required in these areas to better understand the impacts and, where appropriate, minimise and ameliorate impacts driving observed ecological change.

Biosis is committed to the continual review of the terrestrial programs for Dendrobium Areas 2, 3A and 3B and are constantly looking to provide options for improvement. Biosis is currently in the process of refining the data collection and statistical analysis components of the program. Data analysis has moved to new methods using species distribution modelling, considered an innovative approach in the analysis of the Dendrobium ecological monitoring. Data collected in 2016 will provide further insight into trends detected in 2015.

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Figures

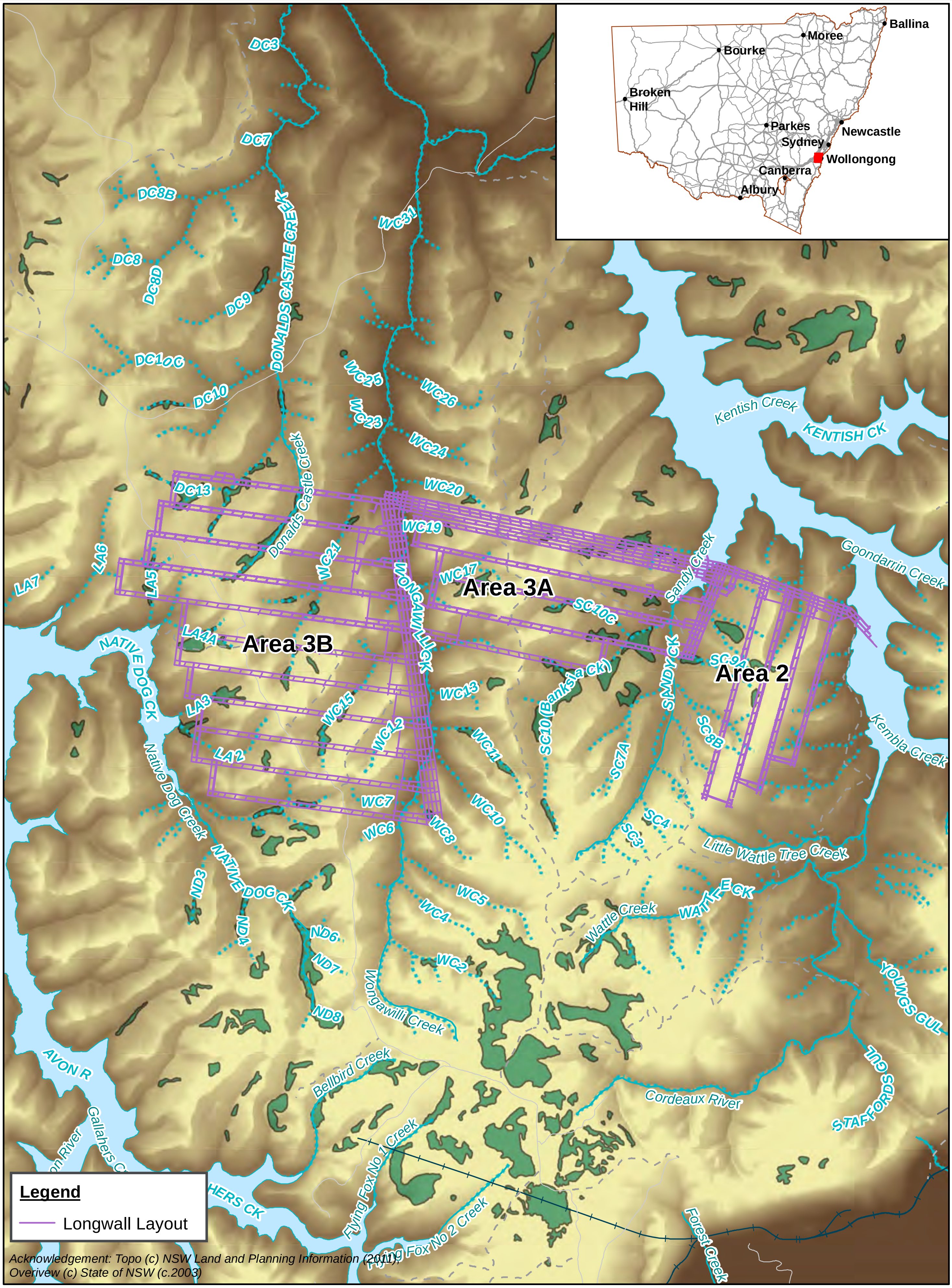

Figure 1: Location of the study area in a regional context

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Newcastle, Sydney, Wangaratta & Wollongong

Matter: 20489/20490/20491
Date: 14 April 2016,
Checked by: CFV, Drawn by: ANP, Last edited by: apritchard
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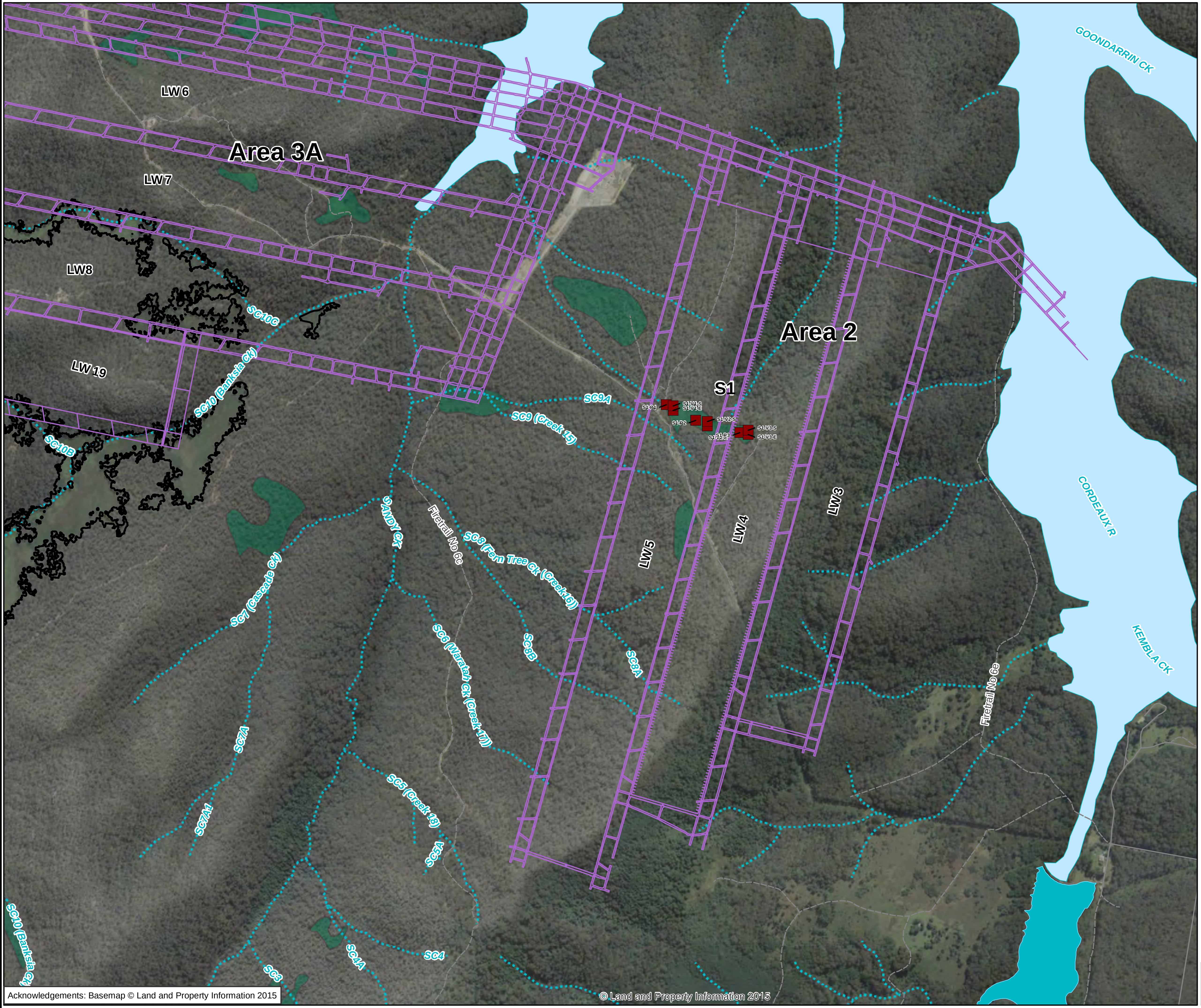

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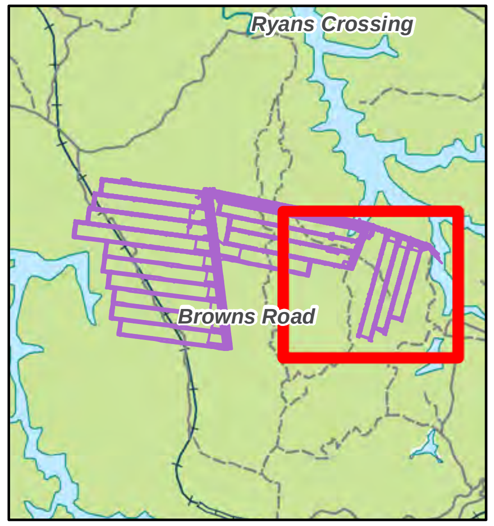

Legend

Monitoring Locations

- Flora upland swamp impact site
- Upland swamp boundary (Biosis)

Survey Area

- Longwall Layout
- IC Creekline
- Upland swamp boundary (NPWS)

Figure 2: Location of 2015 impact monitoring sites surveyed in Dendrobium Area 2

0 200 400 600
Metres
Scale: 1:12,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

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Matter: 20489/20490/20491
Date: 15 April 2016,
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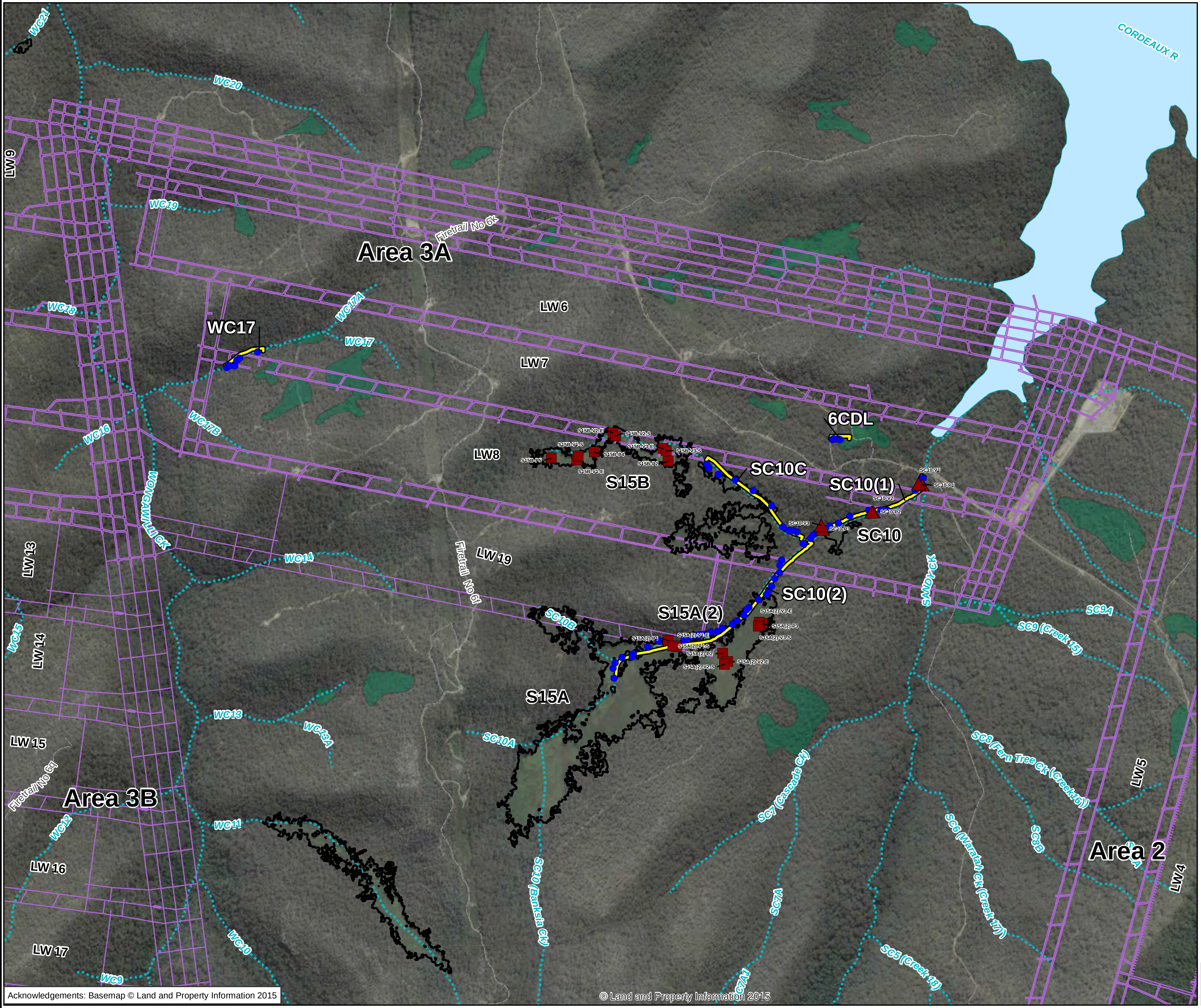

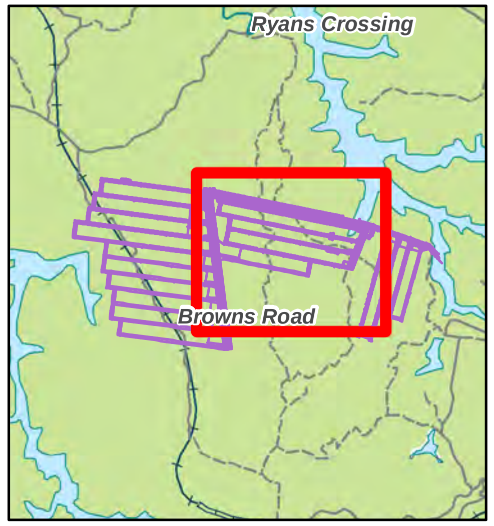

Legend

Monitoring Locations

- Flora creek impact site
- Flora upland swamp impact site
- Threatened frog monitoring impact transect
- Threatened frog monitoring breeding pool
- Upland swamp boundary (Biosis)

Survey Area

- Longwall Layout
- IC Creekline
- Upland swamp boundary (NPWS)

Figure 3: Location of 2015 monitoring impact sites surveyed in Dendrobium Area 3A

0 200 400 600

Metres

Scale: 1:13,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 20489/20490/20491
Date: 15 April 2016,
Checked by: CVF, Drawn by: ANP, Last edited by: apritchard
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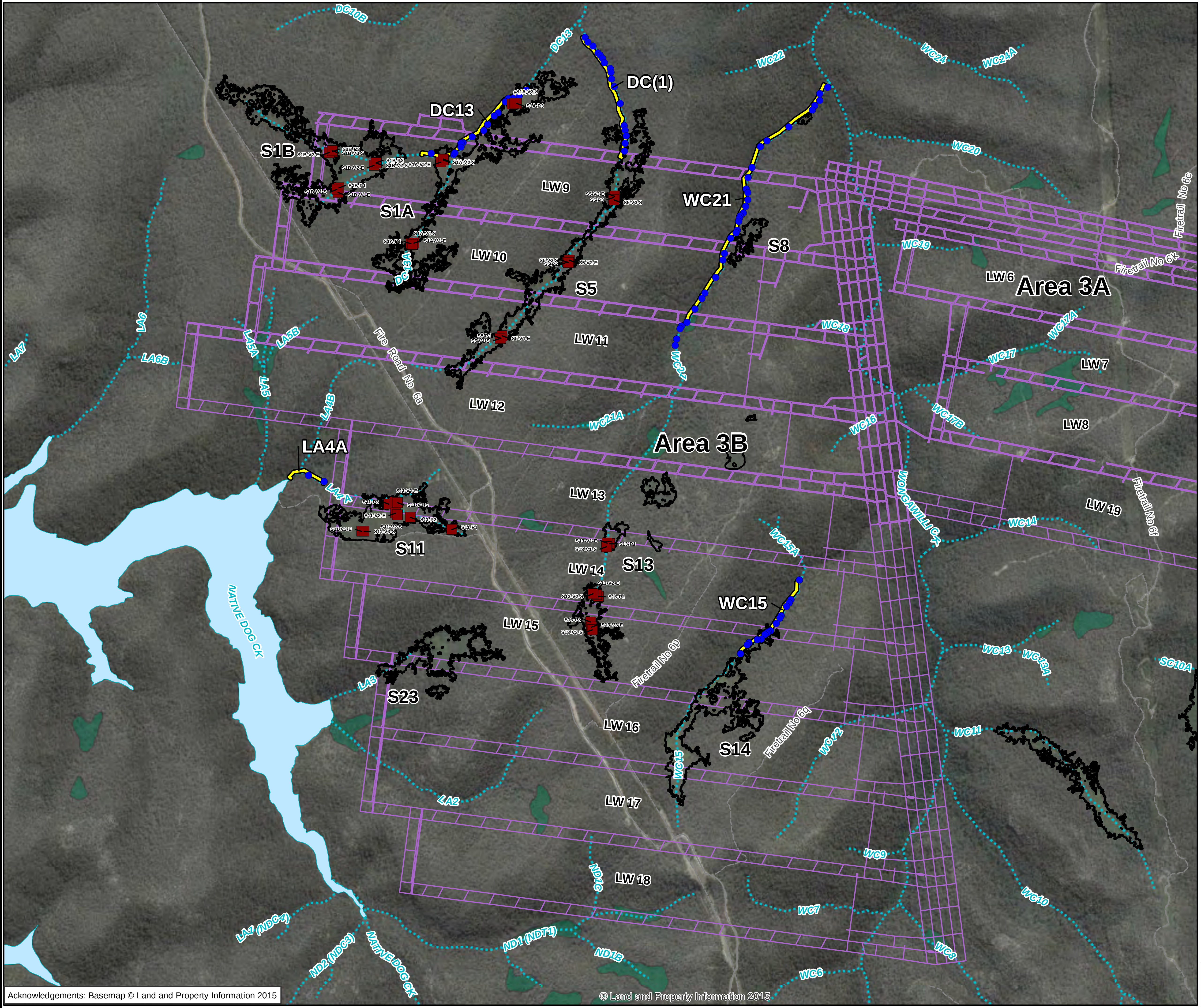

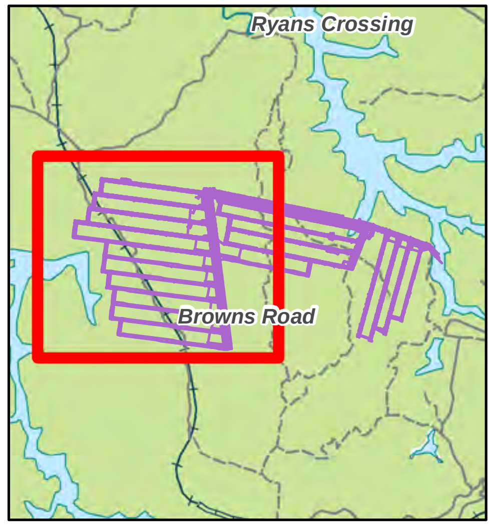

Legend

Monitoring Locations

- Flora upland swamp impact site
- Threatened frog monitoring impact transect
- Threatened frog monitoring breeding pool
- Upland swamp boundary (Biosis)

Survey Area

- Longwall Layout
- IC Creekline
- Upland swamp boundary (NPWS)

0 200 400 600 800

Metres

Scale: 1:16,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

Figure 4: Location of 2015 monitoring impact sites surveyed in Dendrobium Area 3B

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Location:P:\20400s\20489 - Dend Area 2 FFM\Mapping\Annual Reports\20489_AR_F4_DendArea3b_Impact

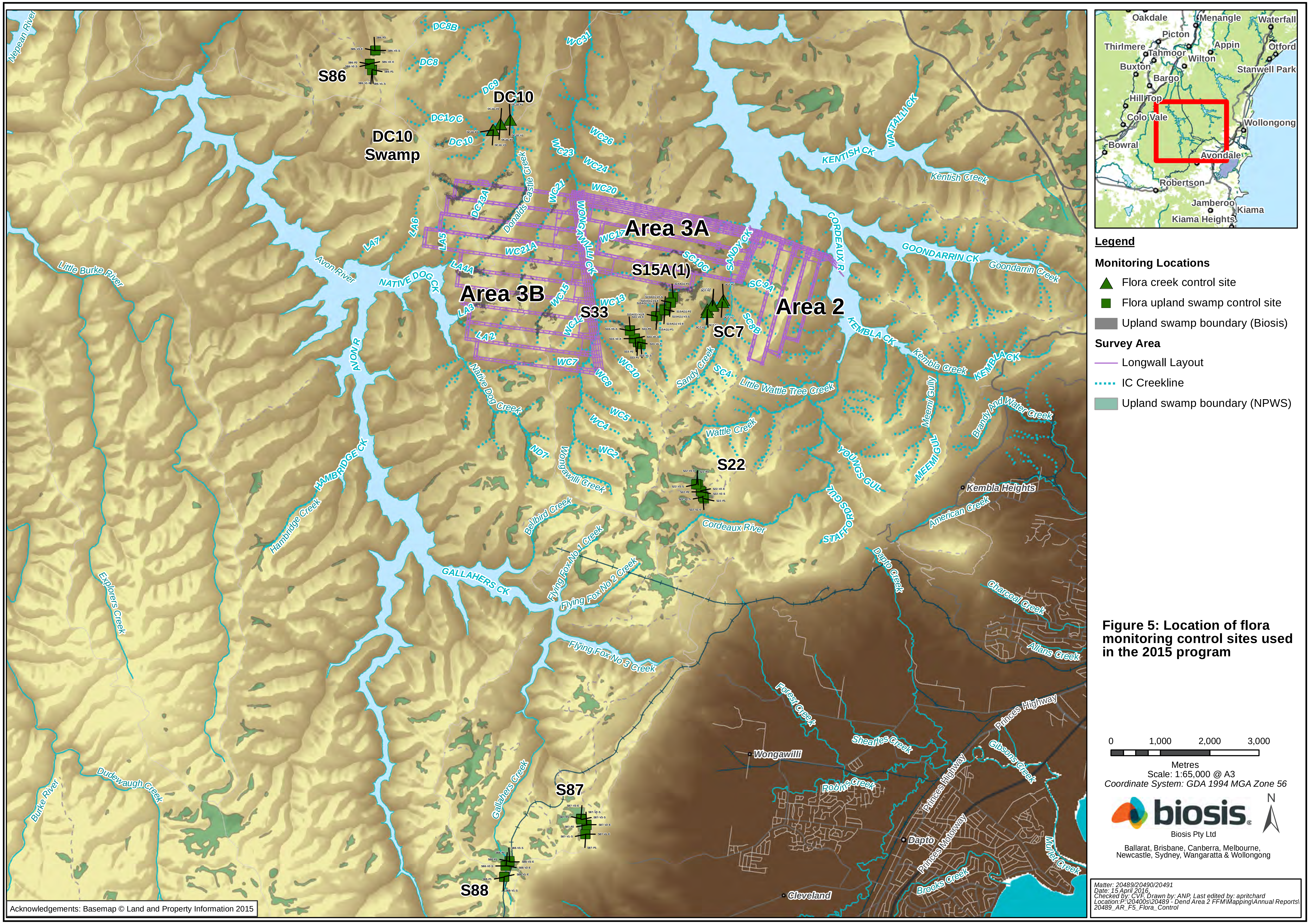

Figure 5: Location of flora monitoring control sites used in the 2015 program

Legend

Monitoring Locations

- Threatened frog monitoring control transect
- Threatened frog monitoring breeding pool
- Upland swamp boundary (Biosis)

Survey Area

- Longwall Layout
- IC Creekline
- Upland swamp boundary (NPWS)

Figure 6: Location of threatened frog monitoring control transects used in the 2015 program

0 300 600 900 1,200 1,500
Metres
Scale: 1:30,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

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Matter: 20489/20490/20491
Date: 15 April 2016,
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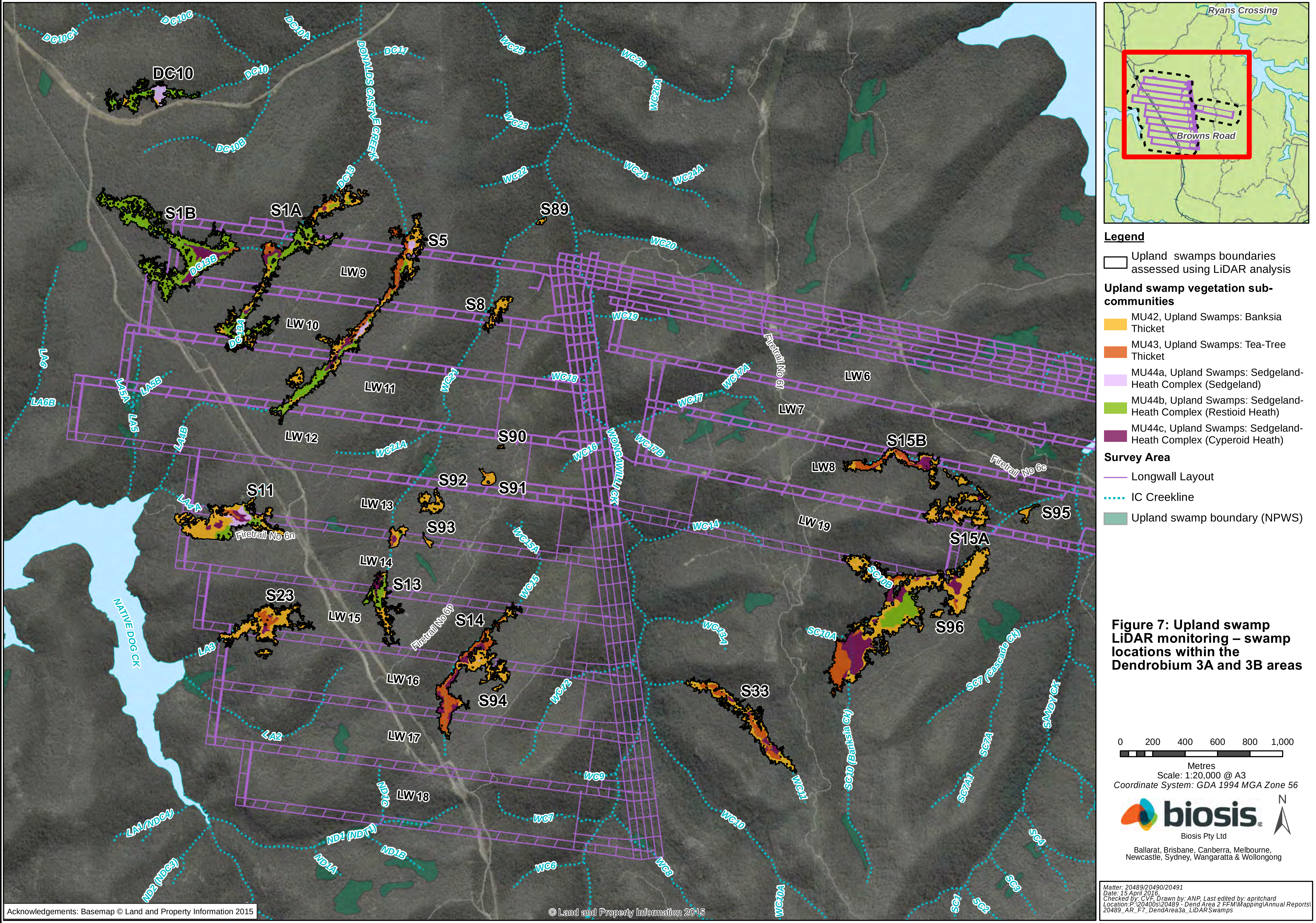
Location:P:\20400s\20489 - Dend Area 2 FFM\Mapping\Annual Reports\20489_AR_F6_TFM_Control



Legend

Upland swamps boundaries assessed using LiDAR analysis

Upland swamp vegetation sub-communities

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

Survey Area

- Longwall Layout
- IC Creekline
- Upland swamp boundary (NPWS)

Figure 7: Upland swamp LiDAR monitoring – swamp locations within the Dendrobium 3A and 3B areas

0 200 400 600 800 1,000
Metres
Scale: 1:20,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

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Matter: 20489/20490/20491
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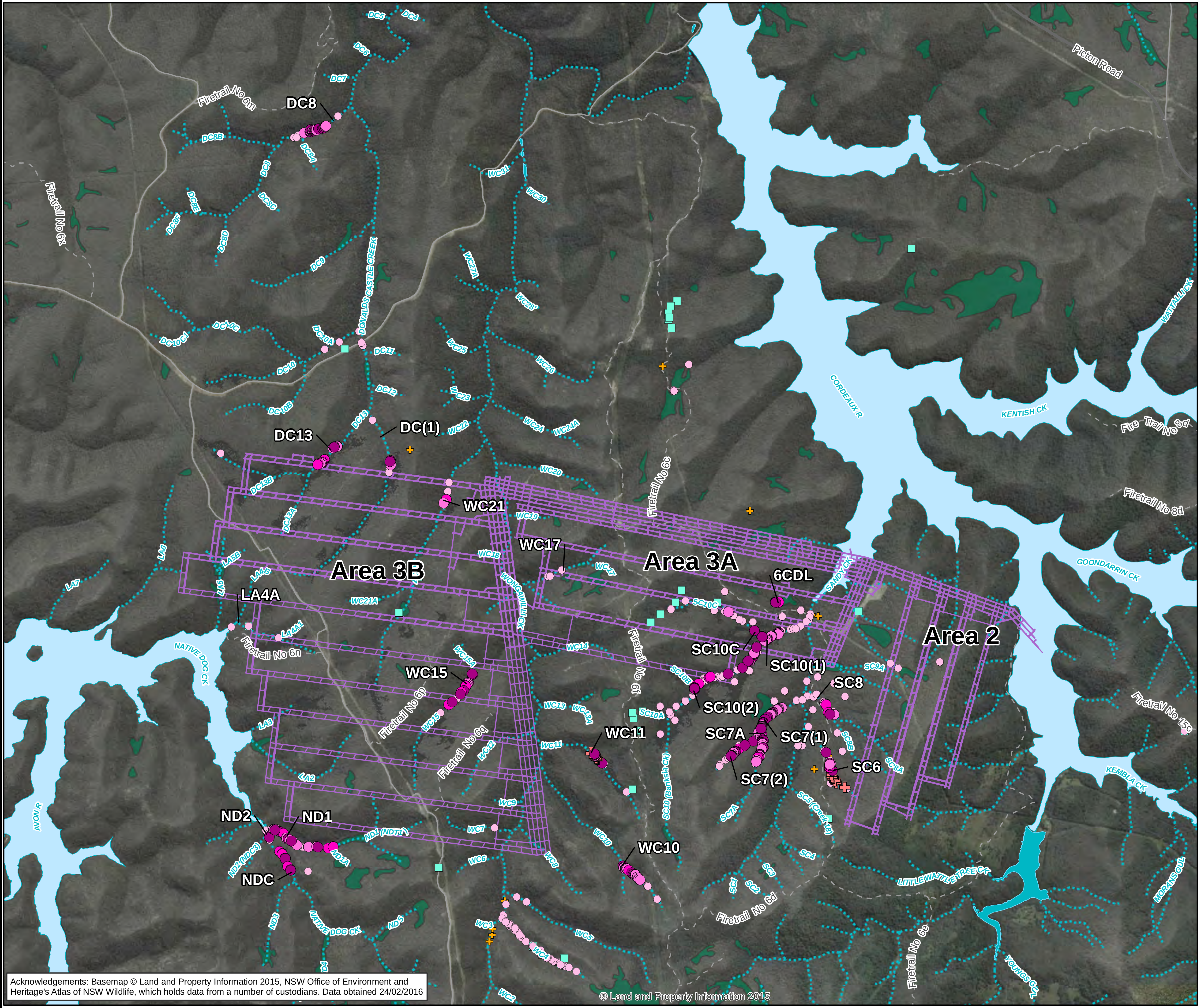
Location:P:\20400s\20489 - Dend Area 2 FFM\Mapping\Annual Reports\20489_AR_F7_DendArea3a_LiDARSwamps



Legend

Threatened Frogs Located by Biosis 2015

- Giant Burrowing Frog - Tadpoles
- Littlejohn's tree frog - Adult
- Littlejohn's tree frog - Tadpoles
- Littlejohn's tree frog - Eggmass

Previous Records - OEH

- Giant Burrowing Frog
- Littlejohn's Tree Frog
- Red-crowned Toadlet

Survey Area

- Longwall Layout
- IC Creekline
- Upland swamp boundary (NPWS)
- Upland swamp boundary (Biosis)

Figure 8: Location of Threatened Frogs recorded during 2015 surveys and previous records (Biosis and OEH 2015)

0 500 1,000 1,500
Metres
Scale: 1:35,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

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Matter: 20489/20490/20491
Date: 15 April 2016,
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Location:P:\20400s\20489 - Dend Area 2 FFM\Mapping\Annual Reports\20489_AR_F8_TFM_Frogs

Appendices

Appendix 1 Vegetation data

Table 15 Dendrobium area 3A impact and control creek sites 2015 vegetation data (SC10, DC10 & SC7)

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control
Point	SC10-V1	SC10-V2	SC10-V3	DC10-V1	DC10-V2	DC10-V3	SC7-V1	SC7-V2	SC7-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Aut	Aut	Aut	Aut	Aut	Aut	Aut	Aut
Acacia binervata							3		
Acacia linifolia	2	2	2	2	3	2			2
Acacia myrtifolia			2						
Acacia obtusifolia	3				3		3		2
Acacia suaveolens		2							
Acacia terminalis	3		2	2	2	3		3	3
Acacia ulicifolia	1				3			2	2
Acianthus sp.			3				3		
Actinotus minor	3		3					3	2
Allocasuarina littoralis	3				2	2	2		
Amperea xiphoclada var. xiphoclada	2	2	2		2	3			2
Anisopogon avenaceus	3	3	3			3	2	2	2
Astroloma pinifolium	2								
Astrotricha longifolia	3	3	2	3		2		2	4
Baeckea linifolia			2						
Baloskion gracile	3	3	2						3
Banksia ericifolia subsp. ericifolia	5	5	5					4	2
Banksia marginata				2					
Banksia paludosa subsp. paludosa	3	3	2						1
Banksia serrata	4	3	3		2			3	2
Banksia spinulosa var. spinulosa	2	2	2		2	3			
Bauera rubioides	3	3						3	4
Billardiera scandens var. scandens	3	2	3			3	3	3	
Blandfordia nobilis						2			
Boronia ledifolia	3	2	3						1
Bossiaea heterophylla				3	3	3		2	
Bossiaea obcordata	3	3	2	2	2				2
Bossiaea scolopendria				3				2	
Brunoniella australis							3		

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control
Point	**SC10-V1**	**SC10-V2**	**SC10-V3**	**DC10-V1**	**DC10-V2**	**DC10-V3**	**SC7-V1**	**SC7-V2**	**SC7-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**
Callistemon citrinus	2			2					
Calochlaena dubia							3		
Cassytha glabella f. glabella	3	3					3	3	
Ceratopetalum gummiferum							2	2	2
Chiloglottis sp.							3		
Clematis aristata							2		
Conospermum tenuifolium	3	3	3	3		2			
Corybas sp.		2	3				3	2	
Corymbia gummifera			2					2	4
Cryptostylis erecta			2						
Cryptostylis leptochila									3
Cryptostylis sp.							3		
Cyathochaeta diandra		3				3		3	3
Dampiera purpurea							3		
Dampiera stricta	3	3	3	4	2	3		2	
Darwinia grandiflora	3								
Daviesia corymbosa	2	3							
Dianella caerulea var. caerulea					2	2			
Dianella caerulea var. producta				3			3		
Dianella revoluta var. revoluta	3			3	2				3
Dillwynia floribunda	2	3	3					2	3
Dodonaea camfieldii									2
Dodonaea triquetra	2						4		4
Empodisma minus	3	3	3		4	2		3	3
Entolasia marginata						3	2		
Entolasia stricta	3	3	3	4	4	2	2	3	3
Epacris microphylla var. microphylla			2						3
Epacris pulchella	3	2	2		2		2	3	3
Eriostemon australasius	2	2	2					2	
Eucalyptus piperita	4	4	4	3	5	4	5		5
Eucalyptus racemosa	4	4	5	3	1	4		5	4

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control
Point	**SC10-V1**	**SC10-V2**	**SC10-V3**	**DC10-V1**	**DC10-V2**	**DC10-V3**	**SC7-V1**	**SC7-V2**	**SC7-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**
Gahnia species complex							2		3
Gleichenia dicarpa	3	2	2					2	3
Gompholobium glabratum		3							2
Gompholobium grandiflorum	3		3					3	
Gompholobium minus	2	2						2	
Gonocarpus tetragynus		2							
Gonocarpus teucrioides	3	2	3		2	3	3	2	3
Goodenia bellidifolia subsp. bellidifolia			2						
Goodenia hederacea		2				2			
Goodenia stelligera		3						2	2
Grevillea mucronulata	3				1		3	3	3
Grevillea oleoides	3	3	2					2	
Grevillea sphacelata	2							3	
Haemodorum planifolium				3					
Hakea dactyloides	3	3	3	3	3	3		3	3
Hakea salicifolia subsp. salicifolia							3		
Hakea sericea	2					3			2
Hakea teretifolia subsp. teretifolia		2	2					2	2
Hardenbergia violacea					3				
Hemarthria uncinata var. uncinata	2	2							
Hibbertia aspera subsp. aspera							3		3
Hibbertia bracteata								3	
Hibbertia circumdans	3								
Hibbertia riparia	3	3	3		3	3		2	3
Hovea linearis			2						
Hovea linearis/longifolia/purpurea complex									2
Hovea longifolia							3		
Isopogon anemonifolius	3	3	2	2	2	3		3	
Kennedia rubicunda					2		2		
Lambertia formosa		3	2	3	2	2		3	2
Laxmannia gracilis	2								

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control
Point	SC10-V1	SC10-V2	SC10-V3	DC10-V1	DC10-V2	DC10-V3	SC7-V1	SC7-V2	SC7-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Aut	Aut	Aut	Aut	Aut	Aut	Aut	Aut
Lepidosperma filiforme								2	2
Lepidosperma laterale				2			1		
Leptocarpus tenax	3	3	2	2				3	2
Leptomeria acida	3		3					3	3
Leptospermum arachnoides								2	
Leptospermum juniperinum									2
Leptospermum polygalifolium subsp. polygalifolium	2		2		2	2	2	4	3
Leptospermum trinervium	3	3	2	3		2		3	3
Lepyrodia scariosa	3	3	3					3	3
Leucopogon amplexicaulis			3						
Leucopogon ericoides					2	3			
Leucopogon lanceolatus var. lanceolatus	2						3		
Lindsaea linearis		3	3					3	3
Lindsaea microphylla							2		
Logania albiflora	3						3		2
Lomandra brevis				2					
Lomandra cylindrica	3		3		3	2		3	2
Lomandra filiformis subsp. coriacea			3					3	3
Lomandra filiformis subsp. filiformis			3		3				
Lomandra glauca	3	2	3	3		2		2	2
Lomandra gracilis							2		
Lomandra longifolia	3	3	2	3	4	3	3	2	3
Lomandra multiflora subsp. multiflora	3	2	2		3			3	2
Lomandra obliqua	3	2	3	3	3	3		3	2
Lomatia silaifolia	2	3	2	3	3		3		3
Lycopodium deuterodensum			3						
Marsdenia suaveolens							2		
Microlaena stipoides var. stipoides				2	1	2			
Mirbelia rubiifolia		3				2		3	
Mitrasacme polymorpha					2				
Monotaxis linifolia				2					

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control
Point	**SC10-V1**	**SC10-V2**	**SC10-V3**	**DC10-V1**	**DC10-V2**	**DC10-V3**	**SC7-V1**	**SC7-V2**	**SC7-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**	**Aut**
Monotoca scoparia	3	2						2	
Nematolepis squamea subsp. squamea							3		
Opercularia aspera							2	2	
Opercularia diphylla			3						
Opercularia diphylla aspera species complex		2							
Patersonia glabrata	3	2	3				2	2	
Patersonia sericea	2		2			3		3	3
Persoonia lanceolata		2	2						
Persoonia levis	2		2		3			2	
Persoonia linearis				3	2		3		
Petrophile pulchella	3	3	3			3		3	3
Petrophile pulchella sessilis complex							2		
Petrophile sessilis		3							
Phyllanthus hirtellus							3	3	
Pimelea linifolia subsp. linifolia	3	2	3	3			3	3	3
Platylobium formosum subsp. formosum	3		3						
Platysace linearifolia			3	3		2		2	2
Pomaderris intermedia	2						3		
Pteridium esculentum	3	3	2	3	2		3		2
Pterostylis pedoglossa							3		
Ptilothrix deusta								3	
Pultenaea daphnoides				3			3		
Pultenaea flexilis							3		
Pultenaea linophylla									3
Rhytidosporum procumbens				1					
Scaevola ramosissima		2							2
Schelhammera undulata							2		
Schoenus melanostachys				4		3	2		2
Selaginella uliginosa	3	3	3	3		3		3	
Smilax glyciphylla							2		
Sowerbaea juncea						2		1	2

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control
Point	SC10-V1	SC10-V2	SC10-V3	DC10-V1	DC10-V2	DC10-V3	SC7-V1	SC7-V2	SC7-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Aut	Aut	Aut	Aut	Aut	Aut	Aut	Aut
Stylidium lineare			2						
Styphelia laeta subsp. laeta									2
Telopea speciosissima	2								2
Tetrarrhena juncea	3		3			2	3		3
Tetrarrhena turfosa		3							
Thelymitra sp.					2				
Thysanotus juncifolius		1		3	2				
Tristaniopsis collina							3		
Tylophora barbata							1		
Viola hederacea							2		
Viola sieberana		2							3
Xanthorrhoea media		3		2					
Xanthosia dissecta	3	3	3						
Xanthosia pilosa								2	3
Xanthosia spp.							3		
Xanthosia tridentata	3	3	3	2		2		3	3
Zieria smithii	2						2		

Table 16 Dendrobium area 2 impact and control swamp sites 2015 vegetation data (S1, S11 & S15A(1))

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	S1-V1	S1-V2	S1-V3	S11-V1	S11-V1	S11-V2	S11-V2	S11-V3	S11-V3	S15A(1)-V1	S15A(1)-V1	S15A(1)-V2	S15A(1)-V2	S15A(1)-V3	S15A(1)-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Spr	Spr	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Acacia rubida					1										
Acmena smithii			2												
Almaleea paludosa							1	5	6			5	7		
Anisopogon avenaceus	2														
Baeckea imbricata	13	15	5			30	30	29	24			8	12	18	22
Baeckea linifolia												9	10		
Banksia ericifolia subsp. ericifolia	1		5	3	3	10	5	13	9					4	2
Banksia robur	2	1		2	3					3	5	1	1		
Bauera microphylla							5					1	4		
Baumea rubiginosa	3	5	8	10						24	3	8	10		1
Baumea teretifolia										11	29			1	3
Blandfordia nobilis							1		1						
Boronia parviflora		7				2	4		1			2	4	4	13
Burchardia umbellata	7						10		1			2	3		
Cassytha glabella f. glabella		3	1		1									2	3
Ceratopetalum apetalum			2												
Chorizandra cymbaria	15			28		17		9		23				3	
Chorizandra sphaerocephala					25		17		8						
Cissus antarctica			1												
Dampiera stricta	11	10										3	3		
Dianella caerulea var. caerulea			2												
Drosera binata	5			9	26							2	5	6	24
Drosera peltata	4														
Drosera spatulata						27	29	20	12			3	1		1
Empodisma minus	24	21	8	25	18	7		14	3	10	30	26	30	28	27
Entolasia stricta	19	8	7				1					5	1	1	
Epacris microphylla	2														
Epacris obtusifolia				9	7	17	20	14	14			19	18	25	25
Epacris paludosa										8	7				

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	S1-V1	S1-V2	S1-V3	S11-V1	S11-V1	S11-V2	S11-V2	S11-V3	S11-V3	S15A(1)-V1	S15A(1)-V1	S15A(1)-V2	S15A(1)-V2	S15A(1)-V3	S15A(1)-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Spr	Spr	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Gleichenia dicarpa				10	13					28	30				
Gonocarpus tetragynus	2	3					1		1				2		2
Goodenia stelligera	3		2										1		2
Grevillea patulifolia							4								
Grevillea sericea subsp. sericea						3									
Gymnoschoenus sphaerocephalus								22	21			22	20	23	19
Hakea teretifolia subsp. teretifolia	22	21	7	1			1							1	1
Hibbertia riparia	1														
Lepidosperma filiforme						14	2								
Lepidosperma limicola				30	29			11	12			22	19	23	27
Lepidosperma neesii		1						1	1						
Lepidosperma urophorum	7	10	12									1			
Leptocarpus tenax	14	18	10	11	14	27	30	12	12			14	12	21	19
Leptospermum juniperinum	3	6		10	9					18	16	1	1	2	1
Leptospermum polygalifolium subsp. Polygalifolium	8	1	3						1						
Leptospermum polygalifolium trinervium complex														1	1
Leptospermum trinervium	2														
Lepyrodia cryptica									27						
Lepyrodia muelleri															1
Lepyrodia scariosa	11	5		8	8	22	30	22	3			9	9	19	16
Lindsaea linearis	11	1					4								
Melaleuca linariifolia		1													
Mitrasacme species complex												3			
Monotaxis linifolia	17	1											3		
Morinda jasminoides			3												
Panicum simile	8														
Parsonsia straminea			2												
Patersonia sericea	2												3		
Petrophile pulchella	7	1													
Pittosporum undulatum		1	11												
Polyscias murrayi	1		17												

Treatment	Impact	Impact	Impact	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	**S1-V1**	**S1-V2**	**S1-V3**	**S11-V1**	**S11-V1**	**S11-V2**	**S11-V2**	**S11-V3**	**S11-V3**	**S15A(1)-V1**	**S15A(1)-V1**	**S15A(1)-V2**	**S15A(1)-V2**	**S15A(1)-V3**	**S15A(1)-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Spr**	**Spr**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Pterostylis sp.	1	11													
Ptilothrix deusta	19	18	16			30	30	17	15			13	5		
Pultenaea divaricata				3	4						3	23	21		
Schizaea bifida	3						3								1
Schoenus brevifolius	10	16	9	23	29	27	26	23	28			11	10	22	19
Schoenus lepidosperma							1								
Schoenus paludosus							8								
Selaginella uliginosa	2	4			2								3	3	3
Sowerbaea juncea		2										1	2		1
Sphaerolobium vimineum				3	6					2	2		1	2	2
Sprengelia incarnata	1	1		12	8	18	10	7	3			6	5	3	3
Stylidium lineare							22								
Tetraria capillaris	8					3		2							
Tetrarrhena turfosa	2	5	2	30	19							17	17	19	11
Thelymitra cyanea							3								
Thelymitra sp.													1		1
Viola species	3														
Xanthosia tridentata	1	1													
Xyris gracilis			8	6		20	1	27	1			14	8	22	7
Xyris operculata				1	11	5	21	1	28			20	16	14	27

Table 17 Dendrobium area 3A impact and control swamp sites 2015 vegetation data (S15B, S15A(2) & S11)

Treatment	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact
Point	S15B-V1	S15B-V1	S15B-V2	S15B-V2	S15B-V3	S15B-V3	S15A(2)-V1	S15A(2)-V1	S15A(2)-V2	S15A(2)-V2	S15A(2)-V3	S15A(2)-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Acacia terminalis	2	2										
Allocasuarina littoralis											1	1
Almaleea paludosa								2	5	3		
Anisopogon avenaceus											1	
Baeckea imbricata							2	2	3	3	1	1
Baeckea linifolia	4	5	6	6	8	9	8	12				
Baloskion gracile											3	4
Banksia ericifolia subsp. ericifolia			4	6	2	1	7	8			5	4
Banksia robur					5	5	6					
Bauera microphylla					1			3	7	7	2	3
Bauera rubioides			1								9	8
Baumea rubiginosa	7	7	4	4			5	9				
Baumea teretifolia		1					2	3				
Boronia parviflora					1	1	4	4	6	3		
Burchardia umbellata				1					1	3	3	7
Caesia parviflora var. parviflora												1
Caladenia species complex		1										
Cassytha glabella f. glabella			2	1			5				1	3
Chorizandra cymbaria			6	6								
Cryptandra ericoides											5	10
Dampiera stricta											8	3
Dillwynia floribunda		13		5							20	20
Drosera binata		22	2	15			17	21	6	6		
Drosera peltata												10
Empodisma minus	29	30	22	20	28	30	30	28	30	23	27	22
Entolasia stricta		1					1		3	3	13	12
Epacris microphylla	1	2										
Epacris obtusifolia	1	1			2	3	4	1	24	22		
Eucalyptus piperita		1										

Treatment	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact
Point	S15B-V1	S15B-V1	S15B-V2	S15B-V2	S15B-V3	S15B-V3	S15A(2)-V1	S15A(2)-V1	S15A(2)-V2	S15A(2)-V2	S15A(2)-V3	S15A(2)-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Eucalyptus sp.	3		1	3								
Gleichenia dicarpa	30	27	23	22	28	30	14	16				
Gonocarpus tetragynus								1		2		
Goodenia dimorpha												3
Goodenia stelligera											5	
Gymnoschoenus sphaerocephalus					21	21	20	14	14	14		
Hakea dactyloides											2	2
Hakea teretifolia subsp. teretifolia							3	2	6	6		1
Hibbertia riparia											18	18
Lepidosperma forsythii					1	2	4	5	1			
Lepidosperma limicola	7	8	9	10	15	14	25	25	17	15		
Lepidosperma neesii	2	3				5					28	1
Lepidosperma urophorum											4	26
Leptocarpus tenax	3	4	8	8	10	9	1		22	21	24	21
Leptospermum juniperinum	1	1	6	4	3	4		1				
Leptospermum polygalifolium subsp. Polygalifolium		1	1									1
Leptospermum polygalifolium trinervium complex								1				
Lepyrodia scariosa			1	2				1	1	7	24	13
Lepyrodia sp.									2			
Lindsaea linearis			5	6					1	1	21	18
Lomandra cylindrica											8	
Mitrasacme polymorpha											2	3
Monotaxis linifolia			1	1			2	5				
Persoonia glaucescens			1									
Persoonia levis			1	1								
Petrophile pulchella			1	1								
Petrophile sessilis											1	2
Platysace linearifolia		1									1	
Ptilothrix deusta							4	2	10	7	30	21
Pultenaea divaricata	15	5	6		8	5	14	8	8	9		
Schoenus brevifolius	2	4	11	8	2		15	8	9	6	28	24

Treatment	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact
Point	S15B-V1	S15B-V1	S15B-V2	S15B-V2	S15B-V3	S15B-V3	S15A(2)-V1	S15A(2)-V1	S15A(2)-V2	S15A(2)-V2	S15A(2)-V3	S15A(2)-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Selaginella uliginosa			1	2					1	4		
Sowerbaea juncea									1			
Sphaerolobium vimineum					1	3			3	1		
Sprengelia incarnata									12	7		
Stylidium lineare											2	5
Tetraria capillaris			1	1								
Tetrarrhena turfosa	16	21	24	18	4	5	20	25	29	27		
Thysanotus juncifolius											1	4
Xanthorrhoea media									2			
Xanthorrhoea resinosa									7	14		
Xyris gracilis				9			10	5	24	9		
Xyris operculata			3	1	12	8	4	15	15	17		
Xyris species complex	2											2

Table 18 Dendrobium areas 3A and 3B shared control swamp sites 2015 vegetation data (S15A(1), S22 & S33)

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	S15A(1)-V1	S15A(1)-V1	S15A(1)-V2	S15A(1)-V2	S15A(1)-V3	S15A(1)-V3	S22-V1	S22-V1	S22-V2	S22-V2	S22-V3	S22-V3	S33-V1	S33-V1	S33-V2	S33-V2	S33-V3	S33-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Acacia terminalis																	3	
Almaleea paludosa			5	7						1								
Baeckea imbricata			8	12	18	22							19	13				
Baeckea linifolia			9	10			20	18	16	15	24	15						
Banksia ericifolia subsp_ ericifolia					4	2							6	11	4	2	12	5
Banksia robur	3	5	1	1			5	6	13	8	11	10						
Bauera microphylla			1	4									17	21			8	11
Bauera rubioides															15	14	19	14
Baumea rubiginosa	24	3	8	10		1			3							4		
Baumea teretifolia	11	29			1	3	5	2									4	
Boronia parviflora			2	4	4	13							4	16				
Burchardia umbellata			2	3							2							
Cassytha glabella f_ glabella					2	3	4	2					1	2	1	1	2	2
Chorizandra cymbaria	23				3		25	21	23	15	15	14						
Dampiera stricta			3	3									5	5				
Dillwynia floribunda													17	20			2	
Drosera binata			2	5	6	24		3	1	1	3	2	2	10	6	11	4	14
Drosera spatulata			3	1		1		1				2						
Empodisma minus	10	30	26	30	28	27	28	24	30	26	27	27	27	27	30	30	27	28
Entolasia stricta			5	1	1													
Epacris microphylla																	1	1
Epacris obtusifolia			19	18	25	25	11	13	9	11	16	19	7	8	6	7		
Epacris paludosa	8	7																
Eurychorda complanata											3	9						
Gleichenia dicarpa	28	30													22	23	25	27
Gonocarpus tetragynus				2		2								1				
Goodenia bellidifolia														1				
*Goodenia sp_*													1					
Goodenia stelligera				1		2												
Gymnoschoenus sphaerocephalus			22	20	23	19	23	16	18	17	19	17	7	7	19	23	17	23

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	**S15A(1)-V1**	**S15A(1)-V1**	**S15A(1)-V2**	**S15A(1)-V2**	**S15A(1)-V3**	**S15A(1)-V3**	**S22-V1**	**S22-V1**	**S22-V2**	**S22-V2**	**S22-V3**	**S22-V3**	**S33-V1**	**S33-V1**	**S33-V2**	**S33-V2**	**S33-V3**	**S33-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Hakea dactyloides													1					
Hakea teretifolia subsp_ teretifolia					1	1	2	2			2	2	14	13			1	
Lepidosperma filiforme													5	5				
Lepidosperma limicola			22	19	23	27	25	15	21	16	26	18	26	27	16	21	25	21
Lepidosperma urophorum			1															
Leptocarpus tenax			14	12	21	19	6	8	18	15	24	26	9	5	7	4	2	4
Leptospermum juniperinum	18	16	1	1	2	1		1	4	4	1	2		1	2	2		
Leptospermum lanigerum							9											
Leptospermum polygalifolium trinervium complex					1	1												
Leptospermum squarrosum													16	18			1	
Leptospermum trinervium								10										
Lepyrodia muelleri						1												
Lepyrodia scariosa			9	9	19	16		2	2	2	3	3	11	16				
Mitrasacme species complex			3															
Monotaxis linifolia				3														
Patersonia sericea				3														
Pittosporum undulatum														1				
Ptilothrix deusta			13	5				1		1								
Pultenaea divaricata		3	23	21			13	9	7	5	10	10		1	12	8	3	4
Schizaea bifida						1												
Schoenus brevifolius			11	10	22	19	7	1	7		13		3	21	3	5	10	12
Selaginella uliginosa				3	3	3					1	2						
Sowerbaea juncea			1	2		1												
Sphaerolobium vimineum	2	2		1	2	2				3		3						4
Sporadanthus gracilis																		2
Sprengelia incarnata			6	5	3	3	3	2	1	2	1	3	22	18				
Stylidium lineare													3	1				
Symphionema paludosum													1	2				
Tetrarrhena turfosa			17	17	19	11	28	15	30	24	22	17	21	30	11	8	13	19
Thelymitra sp_				1		1												
Xanthorrhoea media											6	7						

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	**S15A(1)-V1**	**S15A(1)-V1**	**S15A(1)-V2**	**S15A(1)-V2**	**S15A(1)-V3**	**S15A(1)-V3**	**S22-V1**	**S22-V1**	**S22-V2**	**S22-V2**	**S22-V3**	**S22-V3**	**S33-V1**	**S33-V1**	**S33-V2**	**S33-V2**	**S33-V3**	**S33-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Xyris gracilis			14	8	22	7	2	1	16		14	3	10				3	
Xyris operculata			20	16	14	27		2		13		6		6	17	11	9	3

Table 19 Dendrobium area 3B impact swamp sites 2015 vegetation data (S1B & S5)

Treatment	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact
Point	S1B-V1	S1B-V1	S1B-V2	S1B-V2	S1B-V3	S1B-V3	S5-V1	S5-V1	S5-V2	S5-V2	S5-V3	S5-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Almaleea paludosa	4	5	13	15	1		5	3	8	13		
Anisopogon avenaceus			3									
Baeckea diosmifolia								18				
Baeckea imbricata									29	24		
Baeckea linifolia							15					
Banksia ericifolia subsp. ericifolia									4	2		
Banksia oblongifolia					9	8						
Banksia robur	5	4	2	2			4	4	6	6	2	1
Bauera microphylla	15	17	29	29	18	14	23	26	30	29		
Baumea rubiginosa											1	
Blandfordia nobilis			5	7						1		
Boronia parviflora	1	1	21	20	7	5	8	11	10	16		
Burchardia umbellata			6	23		2				2		
Caesia parviflora var. parviflora			7	7	3	4		1				
Cassytha glabella f. glabella			13	6						1		
Chorizandra cymbaria	4						25	25		2	22	24
Chorizandra sphaerocephala		3	12	11	18	15						
Comesperma sphaerocarpum	1											
Dampiera stricta			6	2	1	1			1	10		
Dillwynia floribunda			2	2			3	1				
Drosera binata												4
Drosera peltata						1						
Drosera spatulata			18	16	1	1	1		4	3		
Empodisma minus	17	19								1	27	17
Entolasia stricta	17	16	21	23	19	15	4	11	7	22		
Epacris obtusifolia	2	2	15	13								
Gleichenia dicarpa											30	28
Gonocarpus tetragynus	3	4										
Goodenia bellidifolia subsp. bellidifolia									1	2		

Treatment	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact
Point	S1B-V1	S1B-V1	S1B-V2	S1B-V2	S1B-V3	S1B-V3	S5-V1	S5-V1	S5-V2	S5-V2	S5-V3	S5-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Goodenia stelligera	1		3	6	8	7						
Grevillea oleoides									1			
Grevillea patulifolia	4	6	7	8	13			13		14		
Grevillea sericea							19		14			
Grevillea.sericea/speciosa/patulifolia complex						16						
Gymnoschoenus sphaerocephalus											15	10
Hemarthria uncinata var. uncinata					3	3						
Hypericum gramineum					1	1						
Lagenifera stipitata					1							
Lepidosperma limicola	15	17	1	2	15	15	16	15			17	15
Lepidosperma neesii	12	7			15	15	7	5				
Lepidosperma urophorum		5	23	10	15	14						
Leptocarpus tenax	26	28	26	28	30	29	29	29	29	29	7	8
Leptospermum juniperinum					3	2					1	1
Leptospermum polygalifolium subsp. Polygalifolium					1	1	3	7				
Lepyrodia muelleri	1											
Lepyrodia scariosa			23	22	7	9	1	5	17	22		
Lindsaea linearis					8	8						
Melaleuca thymifolia							18	21				
Mitrasacme pilosa var. pilosa			3	3	1							
Monotaxis linifolia			1	2								
Patersonia sericea					1	1						
Ptilothrix deusta	18	22	30	30	19		30	29	29	30		
Pultenaea divaricata					1	2					8	6
Schoenus brevifolius	26	27	26	27	29	25	29	29	29	29	7	3
Schoenus paludosus					3							
Selaginella uliginosa	5	5	15	15	2	2						
Sowerbaea juncea			20	18								
Sphaerolobium vimineum	1		1	3			2	2	2	14		1
Stackhousia nuda			7		1							

Treatment	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact	Impact
Point	**S1B-V1**	**S1B-V1**	**S1B-V2**	**S1B-V2**	**S1B-V3**	**S1B-V3**	**S5-V1**	**S5-V1**	**S5-V2**	**S5-V2**	**S5-V3**	**S5-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Stylidium graminifolium									3			
Stylidium lineare			8	5						5		
Tetraria capillaris	12	8										
Tetrarrhena turfosa	9	12	2	2	26	28	27	30				
Thysanotus juncifolius						1						
Xanthorrhoea resinosa	15	15										
Xyris gracilis	23	25	17	20					21			2
Xyris operculata										21		

Table 20 Dendrobium area 3B impact swamp sites 2015 vegetation data (S13 & S1A)

Treatment	Control	Control	Control	Control	Control	Control	Impact	Impact	Impact	Impact	Impact	Impact
Point	S13-V1	S13-V1	S13-V2	S13-V2	S13-V3	S13-V3	S1A-V1	S1A-V1	S1A-V2	S1A-V2	S1A-V3	S1A-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Acacia rubida	2	2							11	7		
Almaleea paludosa			1	1			9	7				
Baeckea imbricata			12	6	10	10	18	17			12	11
Baeckea linifolia											22	21
Baloskion gracile												1
Banksia ericifolia	7	4			1	1						
Banksia ericifolia subsp. ericifolia											21	20
Banksia marginata				1	6	7						
Banksia robur	5	3	6	5			1		4	4		1
Bauera microphylla			29	29			27	29	8	9	21	22
Baumea rubiginosa	5	2										
Billardiera scandens var. scandens											1	
Blandfordia nobilis					2	6	1	3				
Boronia parviflora			6	11	3	6	17	19	3	2		
Brunoniella species complex							1					
Burchardia umbellata					7	14		1				3
Caesia parviflora var. parviflora							3	4				
Cassytha glabella f. glabella	7		5	7	5	3	15	11			1	3
Chorizandra cymbaria	19	17	7	7					19	16	14	12
Dampiera stricta	2	2	11	8	26	26	9	9	2	2	2	2
Dianella longifolia var. longifolia					2	7						
Dillwynia floribunda	3	2	4	3	20	21	2	2			19	19
Drosera binata	15	24							9	10	1	5
Drosera spatulata						1	12	10				
Empodisma minus	30	29	13	15					28	27	3	29
Entolasia stricta			17	11	11	10	17	14			11	7
Epacris obtusifolia									5	7	2	
Eucalyptus sieberi		1										
Eucalyptus sp.							1					

Treatment	Control	Control	Control	Control	Control	Control	Impact	Impact	Impact	Impact	Impact	Impact
Point	**S13-V1**	**S13-V1**	**S13-V2**	**S13-V2**	**S13-V3**	**S13-V3**	**S1A-V1**	**S1A-V1**	**S1A-V2**	**S1A-V2**	**S1A-V3**	**S1A-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Gleichenia dicarpa	22	19							8	10		
Gonocarpus teucrioides					1	4						
Goodenia bellidifolia subsp. bellidifolia							19	20				
Goodenia sp.					22	18						
Grevillea patulifolia						5		14				
Grevillea sericea					7							
Grevillea sphacelata							12					
Gymnoschoenus sphaerocephalus									1	1	5	7
Hakea teretifolia subsp. teretifolia			10	14			9	6			11	9
Lepidosperma filiforme urophorum complex			24	24	30	15	1	27			2	
Lepidosperma limicola	28	24	26	23					25	26	15	17
Lepidosperma neesii			6	4								
Lepidosperma sp.												3
Leptocarpus tenax	13	10	21	18	28	26	30	30	11	9	20	16
Leptomeria acida											2	2
Leptospermum juniperinum			2	2			2	1	5	5	7	3
Leptospermum polygalifolium subsp. Polygalifolium		2			1	1						1
Leptospermum trinervium					1							
Lepyrodia scariosa					22	25	29	29			9	6
Lindsaea linearis					13	13					13	10
Lomandra cylindrica								5				
Melaleuca thymifolia			3	3			2	3				
Mitrasacme polymorpha							1	1				
Monotaxis linifolia							1					
Olax stricta											1	1
Panicum simile							3	1				
Persoonia levis							1					
Petrophile pulchella					2	4						
Petrophile sessilis	10	12	1	2			1				4	4
Ptilothrix deusta			4	4	30	28	30	30			18	21

Treatment	Control	Control	Control	Control	Control	Control	Impact	Impact	Impact	Impact	Impact	Impact
Point	**S13-V1**	**S13-V1**	**S13-V2**	**S13-V2**	**S13-V3**	**S13-V3**	**S1A-V1**	**S1A-V1**	**S1A-V2**	**S1A-V2**	**S1A-V3**	**S1A-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Pultenaea divaricata	2	4	4	9					18	15		
Schizaea bifida					2	1						
Schoenus brevifolius	12	15	30	30	30	26	29	30	26	23	26	23
Selaginella uliginosa											11	6
Sphaerolobium vimineum					1	2	5	4	4	3	2	1
Sprengelia incarnata											10	11
Stackhousia nuda							2					
Stylidium graminifolium											3	2
Symphionema paludosum											5	7
Tetraria capillaris			21	13								
Tetrarrhena turfosa	29	27	28	25					20	23	22	20
Xyris operculata	2	8	5	4			29			1		
Xyris species complex											25	23

Table 21 Dendrobium area 3B specific control swamp sites 2015 vegetation data (FT6XS, FT15ES & GCS)

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	FT6XS-V1	FT6XS-V1	FT6XS-V2	FT6XS-V2	FT6XS-V3	FT6XS-V3	FT15ES-V1	FT15ES-V1	FT15ES-V2	FT15ES-V2	FT15ES-V3	FT15ES-V3	GCS-V1	GCS-V1	GCS-V2	GCS-V2	GCS-V3	GCS-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Acacia terminalis															2	1		
Almaleea paludosa	7	28	13	24	5	12				2								
Anisopogon avenaceus						7												
Austrostipa pubescens					3													
Baeckea diosmifolia	13	25			13	17												
Baeckea imbricata																	5	
Baeckea linifolia	2	1									7	7	3	2	2	1	1	4
Banksia ericifolia						1												
Banksia ericifolia subsp. ericifolia																	18	22
Banksia robur	1	2	12	15	1	1	1	1	6	4	7	7			1	1	4	4
Banksia spinulosa var. spinulosa	19	22																
Bauera microphylla			25	22	7	30			13	17							7	22
Baumea acuta				3														
Baumea rubiginosa	21	13	4	4	14			1					2	7	10	20		
Baumea teretifolia			1															
Blandfordia nobilis		7		9	13	19				2								1
Blandfordia sp.			3															
Boronia parviflora	11	25	20	29	14	26											1	
Brunoniella pumilio						4												
Burchardia umbellata		2				4		6		8								
Caesia parviflora var. parviflora		2		1	2	19		2										
Cassytha glabella f. glabella									21	18	12	18						8
Chorizandra cymbaria		2					2			5		22	3	6	23	18	7	8
Chorizandra sp.											18							
Comesperma sphaerocarpum							2											
Dampiera stricta	2	5	8	4	14	7	16	19	12	16							3	5
Dianella longifolia var. longifolia						1												
Dillwynia floribunda	9	19		9		8												

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	FT6XS-V1	FT6XS-V1	FT6XS-V2	FT6XS-V2	FT6XS-V3	FT6XS-V3	FT15ES-V1	FT15ES-V1	FT15ES-V2	FT15ES-V2	FT15ES-V3	FT15ES-V3	GCS-V1	GCS-V1	GCS-V2	GCS-V2	GCS-V3	GCS-V3
Year	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Season	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr
Dillwynia sp.			4		5													
Drosera binata							2	1	10	21	10	14			2	4	3	8
Drosera peltata																		1
Drosera pygmaea						2												
Drosera spatulata		4	25	24	19	21												
Empodisma minus	16	8	11	11			30	30	30	30	30	28	21	23	28	26	30	28
Entolasia stricta	2	6	12	6	22	29	2	1					14	11	2	2		3
Epacris obtusifolia									19	12	9	12					23	12
Eucalyptus sp.				1														
Eurychorda complanata											5	4						
Genoplesium apostasioides							5											
Gleichenia dicarpa															30	29		
Gonocarpus micranthus subsp. micranthus	23	28	22	27	3	25												
Goodenia bellidifolia subsp. bellidifolia							10											
Goodenia sp.	6	15	7	23	8	15												
Gymnoschoenus sphaerocephalus									2	2	21	15			6	7	1	
Haemodorum sp.						8												
Hakea sericea		9			2	2												
Hakea teretifolia subsp. teretifolia	11																2	5
Hemarthria uncinata var. uncinata		13		4														
Hybanthus monopetalus		1																
Hypericum japonicum		2				6												
Lepidosperma filiforme urophorum complex	1	12	20	14	24	29												
Lepidosperma limicola									28	28	26	26			19	15	30	28
Lepidosperma neesii	24	24	3	3							3							
Lepidosperma urophorum							3											
Leptocarpus tenax	23	29	24	25	25	29	30	30	11	20	22	22	30	30	1	3	6	11
Leptospermum juniperinum	10	14				1			2		2	2	1		2	1	3	5

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	**FT6XS-V1**	**FT6XS-V1**	**FT6XS-V2**	**FT6XS-V2**	**FT6XS-V3**	**FT6XS-V3**	**FT15ES-V1**	**FT15ES-V1**	**FT15ES-V2**	**FT15ES-V2**	**FT15ES-V3**	**FT15ES-V3**	**GCS-V1**	**GCS-V1**	**GCS-V2**	**GCS-V2**	**GCS-V3**	**GCS-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Leptospermum lanigerum																	9	
Leptospermum polygalifolium subsp. Polygalifolium		1	1	2														1
Leptospermum sp.	14		5															
Leptospermum squarrosum																	3	1
Leptospermum trinervium																		7
Lepyrodia anarthria										4		2						
Lepyrodia scariosa	1		28	19	30	30			1									1
Lindsaea linearis		2	2	1			16	27	6	19								
Lomandra cylindrica						3												
Melaleuca thymifolia	19	19	17	10	6	9												
Micrantheum ericoides						4												
Microtis sp.								3										
Mitrasacme polymorpha				3		7												
Panicum simile					18	20												
Patersonia sericea					1	8												
Patersonia sp.	2																	
Persoonia sp.						1												
Petrophile sessilis	15	24			4	21												
Petrophile sp.				1														
Plinthanthesis paradoxa																		2
Pterostylis parviflora									2									
Ptilothrix deusta	22	29	22	29	26	30	27	30	27	30							2	11
Pultenaea divaricata							18	12	13	15	10	3			3	1	25	21
Schizaea bifida		3				1												
Schoenus brevifolius							30	30	24	27	6	10	3	12	1	13	24	26
Selaginella uliginosa	7	23	3	2			13	12	4	16	1	2					5	7
Sowerbaea juncea								3		1								
Sphaerolobium vimineum	1	11			2	3		1	1								1	1
Sprengelia incarnata	1																	1

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Point	**FT6XS-V1**	**FT6XS-V1**	**FT6XS-V2**	**FT6XS-V2**	**FT6XS-V3**	**FT6XS-V3**	**FT15ES-V1**	**FT15ES-V1**	**FT15ES-V2**	**FT15ES-V2**	**FT15ES-V3**	**FT15ES-V3**	**GCS-V1**	**GCS-V1**	**GCS-V2**	**GCS-V2**	**GCS-V3**	**GCS-V3**
Year	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**
Season	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**	**Aut**	**Spr**
Tetrarrhena turfosa	25	30	13	27	17	30	30	29	26	29	9	17	30	30		15	23	27
Thysanotus juncifolius				1	1	1		11	1	6								
Tricoryne elatior					16	2												
Viminaria juncea				1														
Viola sieberana						12												
Xanthorrhoea media									6	7								
Xanthosia tridentata																		1
Xyris gracilis	3							24								2		
Xyris operculata			20	15					17	7	22	23					23	16

Appendix 2 Multivariate model summary results

Table 22 Multivariate model summary results for swamp control and pre-mining sites. The unique number of species detected at each swamp is provided, and the number of species detected only once (in parenthesis).

Region	Site	Unique species	ANOVA test of full model
3B Pre-mining	S11	90 (14.4%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 74 Year 73 1 17.008 0.001 *** Season 72 1 5.884 0.956
Control	S15A(1)	72 (4.1%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 62 Year 61 1 14.643 0.001 *** Season 60 1 6.996 0.549
Control	S22	68 (19.1%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 38 Year 37 1 11.511 0.001 *** Season 36 1 6.353 0.061 .
Control	S33	59 (13.5%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 38 Year 37 1 11.839 0.001 *** Season 36 1 6.537 0.190
Control	S86	85 (30.5%)	Multivariate test: Res.Df Df.diff Dev Pr(>Dev) (Intercept) 20 Year 17 3 290.1 0.132 Season 16 1 144.6 0.043 *
Control	S87	49 (14.2%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 20 Year 19 1 4.699 0.280 Season 18 1 4.207 0.471
Control	S88	44 (13.6%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 20 Year 19 1 3.624 0.360 Season 18 1 3.497 0.507
3B Pre-mining	S13	57 (12.3%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 14 Year 13 1 4.975 0.043 * Season 12 1 3.384 0.523

Table 23 Multivariate model summary results for swamp impact sites. The unique number of species detected at each swamp is provided, and the number of species detected only once (in parenthesis).

Region	Site	Unique species	ANOVA test of full model
3A	S15A(2)	93 (6.5%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 38 as.numeric(Year) 37 1 13.904 0.001 *** Season 36 1 7.953 0.112 Pre.Post.Mining 35 1 8.630 0.004 **
3A	S15B	100 (12%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 59 as.numeric(Year) 58 1 15.020 0.001 *** Season 57 1 5.862 0.878 Pre.Post.Mining 56 1 7.275 0.115 Is.Undermined 55 1 2.622 0.736
3B	S1A	68 (10.2%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 20 as.numeric(Year) 19 1 6.298 0.038 * Season 18 1 5.798 0.104 Pre.Post.Mining 17 1 4.983 0.092 . Is.Undermined 16 1 5.703 0.318
3B	S1B	78 (14.1%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 41 as.numeric(Year) 40 1 12.988 0.001 *** Season 39 1 5.890 0.461 Is.Undermined 38 1 4.488 0.792
3B	S5	49 (10.2%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 20 as.numeric(Year) 19 1 4.999 0.078 . Season 18 1 4.847 0.099 . Pre.Post.Mining 17 1 3.540 0.592 Is.Undermined 16 1 4.237 0.304
2	S1	49 (10.2%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 20 as.numeric(Year) 19 1 5.175 0.066 . Season 18 1 4.969 0.076 . Pre.Post.Mining 17 1 3.594 0.568 Is.Undermined 16 1 4.335 0.324

Table 24 Multivariate model summary results for Flora – creek survey data. The unique number of species detected at each swamp is provided, and the number of species detected only once (in parenthesis).

Treatment	Site	Unique species	ANOVA test of full model
Control	DC10	215 (19.5%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 59 as.numeric(Year) 58 1 21.37 0.001 *** Season 57 1 10.96 0.239
Control	SC7	218 (10%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 59 as.numeric(Year) 58 1 23.27 0.001 *** Season 57 1 12.08 0.102
Impact	SC10	97 (8.1%)	Multivariate test: Res.Df Df.diff wald Pr(>wald) (Intercept) 59 as.numeric(Year) 58 1 24.04 0.001 *** Season 57 1 13.08 0.010 ** Pre.Post.Mining 56 1 12.68 0.006 **

Appendix 3 Photo-point monitoring

Table 25 Dendrobium Area 3A creek sites 2015 photo point monitoring

SC10 – F1 Upstream Autumn 2010	SC10 – F1 Upstream Autumn 2012	SC10 – F1 Upstream Autumn 2014	SC10 – F1 Upstream Autumn 2015
			
SC10 – F1 Upstream Spring 2010	**SC10 – F1 Upstream Spring 2012**	**SC10 – F1 Upstream Spring 2014**	**SC10 – F1 Upstream Spring 2015**
			**No longer monitored**

SC10 – F1 Downstream Autumn 2010	SC10 – F1 Downstream Autumn 2012	SC10 – F1 Downstream Autumn 2014	SC10 – F1 Downstream Autumn 2015
			
SC10 – F1 Downstream Spring 2010	**SC10 – F1 Downstream Spring 2012**	**SC10 – F1 Downstream Spring 2014**	**SC10 – F1 Downstream Spring 2015**
			No longer monitored

SC10 – F2 Upstream Autumn 2010	SC10 – F2 Upstream Autumn 2012	SC10 – F2 Upstream Autumn 2014	SC10 – F2 Upstream Autumn 2015
			
SC10 – F2 Upstream Spring 2010	**SC10 – F2 Upstream Spring 2012**	**SC10 – F2 Upstream Spring 2014**	**SC10 – F2 Upstream Spring 2015**
			No longer monitored

SC10 – F2 Downstream Autumn 2010	SC10 – F2 Downstream Autumn 2012	SC10 – F2 Downstream Autumn 2014	SC10 – F2 Downstream Autumn 2015
			
SC10 – F2 Downstream Spring 2010	**SC10 – F2 Downstream Spring 2012**	**SC10 – F2 Downstream Spring 2014**	**SC10 – F2 Downstream Spring 2015**
			Still to be reported on

SC10 – F3 Upstream Autumn 2010	SC10 – F3 Upstream Autumn 2012	SC10 – F3 Upstream Autumn 2014	SC10 – F3 Upstream Autumn 2015
			
SC10 – F3 Upstream Spring 2010	**SC10 – F3 Upstream Spring 2012**	**SC10 – F3 Upstream Spring 2014**	**SC10 – F3 Upstream Spring 2015**
			No longer monitored

SC10 – F3 Downstream Autumn 2010	SC10 – F3 Downstream Autumn 2012	SC10 – F3 Downstream Autumn 2014	SC10 – F3 Downstream Autumn 2015
			
SC10 – F3 Downstream Spring 2010	**SC10 – F3 Downstream Spring 2012**	**SC10 – F3 Downstream Spring 2014**	**SC10 – F3 Downstream Spring 2015**
			**No longer monitored**

Table 26 Dendrobium Area 3A control creek sites 2015 photo point monitoring

DC10 – F1 Upstream Autumn 2010	DC10 – F1 Upstream Autumn 2012	DC10 – F1 Upstream Autumn 2014	DC10 – F1 Upstream Autumn 2015
			
DC10 – F1 Upstream Spring 2010	**DC10 – F1 Upstream Spring 2012**	**DC10 – F1 Upstream Spring 2014**	**DC10 – F1 Upstream Spring 2015**
			**No longer monitored**

DC10 – F1 Downstream Autumn 2010	DC10 – F1 Downstream Autumn 2012	DC10 – F1 Downstream Autumn 2014	DC10 – F1 Downstream Autumn 2015
			
DC10 – F1 Downstream Spring 2010	**DC10 – F1 Downstream Spring 2012**	**DC10 – F1 Downstream Spring 2014**	
			**No longer monitored**

DC10 – F2 Upstream Autumn 2010	DC10 – F2 Upstream Autumn 2013	DC10 – F2 Upstream Autumn 2014	DC10 – F2 Upstream Autumn 2015
			
DC10 – F2 Upstream Spring 2010	**DC10 – F2 Upstream Spring 2013**	**DC10 – F2 Upstream Spring 2014**	**DC10 – F2 Upstream Spring 2015**
			**No longer monitored**

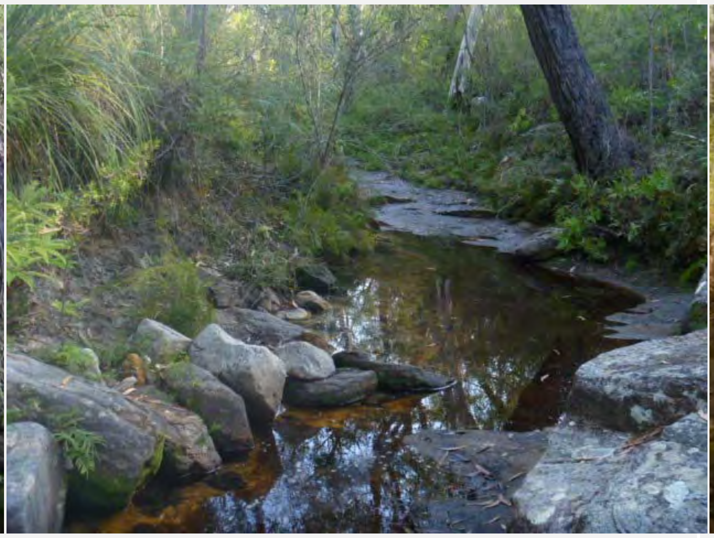
DC10 – F2 Downstream Autumn 2010	DC10 – F2 Downstream Autumn 2013	DC10 – F2 Downstream Autumn 2014	DC10 – F2 Downstream Autumn 2015
			
DC10 – F2 Downstream Spring 2010	**DC10 – F2 Downstream Spring 2013**	**DC10 – F2 Downstream Spring 2014**	**DC10 – F2 Downstream Spring 2015**
			

DC10 – F3 Upstream Autumn 2010	DC10 – F3 Upstream Autumn 2013	DC10 – F3 Upstream Autumn 2014	DC10 – F3 Upstream Autumn 2015
			
DC10 – F3 Upstream Spring 2010	**DC10 – F3 Upstream Spring 2013**	**DC10 – F3 Upstream Spring 2014**	**DC10 – F3 Upstream Spring 2015**
			**No longer Monitored**

DC10 – F3 Downstream Autumn 2010	DC10 – F3 Downstream Autumn 2013	DC10 – F3 Downstream Autumn 2014	DC10 – F3 Downstream Autumn 2015
			
DC10 – F3 Downstream Spring 2010	**DC10 – F3 Downstream Spring 2013**	**DC10 – F3 Downstream Spring 2014**	**DC10 – F3 Downstream Spring 2015**
			**No longer monitored**

SC7 – F1 Upstream Autumn 2010	SC7 – F1 Upstream Autumn 2013	SC7 – F1 Upstream Autumn 2014	SC7 – F1 Upstream Autumn 2015
			
SC7 – F1 Upstream Spring 2010	**SC7 – F1 Upstream Spring 2013**	**SC7 – F1 Upstream Spring 2014**	**SC7 – F1 Upstream Spring 2015**
			**No longer monitored**

SC7 – F1 Downstream Autumn 2010	SC7 – F1 Downstream Autumn 2013	SC7 – F1 Downstream Autumn 2014	SC7 – F1 Downstream Autumn 2015
			
SC7 – F1 Downstream Spring 2010	**SC7 – F1 Downstream Spring 2013**	**SC7 – F1 Downstream Spring 2014**	**SC7 – F1 Downstream Spring 2015**
			**No longer monitored**

SC7 – F2 Upstream Autumn 2010	SC7 – F2 Upstream Autumn 2013	SC7 – F2 Upstream Autumn 2014	SC7 – F2 Upstream Autumn 2015
			
SC7 – F2 Upstream Spring 2010	**SC7 – F2 Upstream Spring 2013**	**SC7 – F2 Upstream Spring 2014**	**SC7 – F2 Upstream Spring 2015**
			

SC7 – F2 Downstream Autumn 2010	SC7 – F2 Downstream Autumn 2013	SC7 – F2 Downstream Autumn 2014	SC7 – F2 Downstream Autumn 2015
			
SC7 – F2 Downstream Spring 2010	**SC7 – F2 Downstream Spring 2013**	**SC7 – F2 Downstream Spring 2014**	**SC7 – F2 Downstream Spring 2015**
			**No longer monitored**

SC7 – F3 Upstream Autumn 2010	SC7 – F3 Upstream Autumn 2013	SC7 – F3 Upstream Autumn 2014	SC7 – F3 Upstream Autumn 2015
			
SC7 – F3 Upstream Spring 2010	**SC7 – F3 Upstream Spring 2013**	**SC7 – F3 Upstream Spring 2014**	**SC7 – F3 Upstream Spring 2015**
			**No longer monitored**

SC7 – F3 Downstream Autumn 2010	SC7 – F3 Downstream Autumn 2013	SC7 – F3 Downstream Autumn 2014	SC7 – F3 Downstream Autumn 2015
			
SC7 – F3 Downstream Spring 2010	**SC7 – F3 Downstream Spring 2013**	**SC7 – F3 Downstream Spring 2014**	**SC7 – F3 Downstream Spring 2015**
			**No longer monitored**

Table 27 Dendrobium Area 2 impact swamp sites 2015 photo point monitoring

S1 – F1 Upstream Autumn 2010	S1 – F1 Upstream Autumn 2013	S1 – F1 Upstream Autumn 2014	S1 – F1 Upstream Autumn 2015
			Site not monitored
S1 – F1 Upstream Spring 2010	**S1 – F1 Upstream Spring 2013**	**S1 – F1 Upstream Spring 2014**	**S1 – F1 Upstream Spring 2015**
			

S1 – F1 Downstream Autumn 2010	S1 – F1 Downstream Autumn 2013	S1 – F1 Downstream Autumn 2014	S1 – F1 Downstream Autumn 2015
			**Site not monitored**
S1 – F1 Downstream Spring 2010	**S1 – F1 Downstream Spring 2013**	**S1 – F1 Downstream Spring 2014**	**S1 – F1 Downstream Spring 2015**
			

S1 – F2 North Autumn 2010	S1 – F2 North Autumn 2013	S1 – F2 North Autumn 2014	S1 – F2 North Autumn 2015
			Site not monitored
S1 – F2 North Spring 2009	**S1 – F2 North Spring 2013**	**S1 – F2 North Spring 2014**	**S1 – F2 North Spring 2015**
			

S1 – F2 East Autumn 2010	S1 – F2 East Autumn 2013	S1 – F2 East Autumn 2014	S1 – F2 East Autumn 2015
			**Site not monitored**
S1 – F2 East Spring 2009	**S1 – F2 East Spring 2013**	**S1 – F2 East Spring 2014**	**S1 – F2 East Spring 2015**
			

S1 – F2 South Autumn 2010	S1 – F2 South Autumn 2013	S1 – F2 South Autumn 2014	S1 – F2 South Autumn 2015
			**Site not monitored**

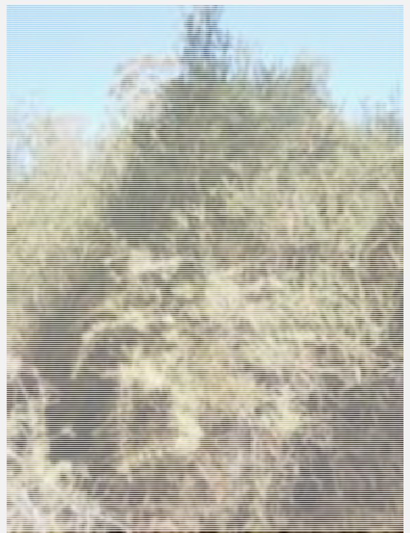
S1 – F2 South Spring 2009	S1 – F2 South Spring 2013	S1 – F2 South Spring 2014	S1 – F2 South Spring 2015
			

S1 – F2 West Autumn 2010	S1 – F2 West Autumn 2013	S1 – F2 West Autumn 2014	S1 – F2 West Autumn 2015
			**Site not monitored**
S1 – F2 West Spring 2009	**S1 – F2 West Spring 2013**	**S1 – F2 West Spring 2014**	**S1 – F2 West Spring 2015**
			

S1 – F3 North Autumn 2010	S1 – F3 North Autumn 2011	S1 – F3 North Autumn 2013	S1 – F3 North Autumn 2015
			**Site not monitored**

S1 – F3 North Spring 2009	S1 – F3 North Spring 2011	S1 – F3 North Spring 2013	S1 – F3 North Spring 2015
			

S1 – F3 East Autumn 2010	S1 – F3 East Autumn 2013	S1 – F3 East Autumn 2014	S1 – F3 East Autumn 2015
			Site not monitored
S1 – F3 East Spring 2010	**S1 – F3 East Spring 2013**	**S1 – F3 East Spring 2014**	**S1 – F3 East Spring 2015**
			

S1 – F3 South Autumn 2010	S1 – F3 South Autumn 2013	S1 – F3 South Autumn 2014	S1 – F3 South Autumn 2015
			**Site not monitored**
S1 – F3 South Spring 2009	**S1 – F3 South Spring 2013**	**S1 – F3 South Spring 2014**	**S1 – F3 South Spring 2015**
			

S1 – F3 West Autumn 2011	S1 – F3 West Autumn 2013	S1 – F3 West Autumn 2014	S1 – F3 West Autumn 2015
			Site not monitored
S1 – F3 West Spring 2009	**S1 – F3 West Spring 2013**	**S1 – F3 West Spring 2014**	**S1 – F3 West Spring 2015**
			

Table 28 Dendrobium Area 3A impact swamp sites 2015 photo point monitoring

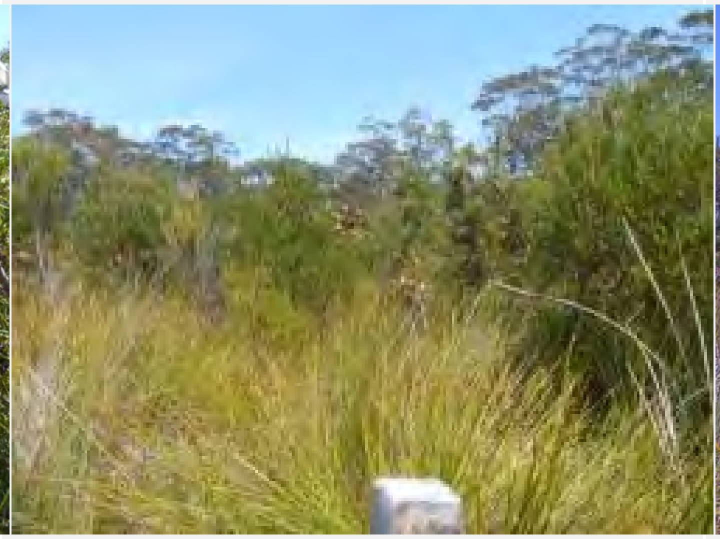
S15A(2) – F1 Upstream Autumn 2011	S15A(2) – F1 Upstream Autumn 2013	S15A(2) – F1 Upstream Autumn 2014	S15A(2) – F1 Upstream Autumn 2015
			
S15A(2) – F1 Upstream Spring 2011	**S15A(2) – F1 Upstream Spring 2013**	**S15A(2) – F1 Upstream Spring 2014**	**S15A(2) – F1 Upstream Spring 2015**
			

S15A(2) – F1 Downstream Autumn 2011	S15A(2) – F1 Downstream Autumn 2013	S15A(2) – F1 Downstream Autumn 2014	S15A(2) – F1 Downstream Autumn 2015
			
S15A(2) – F1 Downstream Spring 2011	**S15A(2) – F1 Downstream Spring 2013**	**S15A(2) – F1 Downstream Spring 2014**	**S15A(2) – F1 Downstream Spring 2015**
			

S15A(2) – F2 North Autumn 2011	S15A(2) – F2 North Autumn 2013	S15A(2) – F2 North Autumn 2014	S15A(2) – F2 North Autumn 2015
			
S15A(2) – F2 North Spring 2011	**S15A(2) – F2 North Spring 2013**	**S15A(2) – F2 North Spring 2014**	**S15A(2) – F2 North Spring 2015**
Photo not available			

S15A(2) – F2 East Autumn 2011	S15A(2) – F2 East Autumn 2013	S15A(2) – F2 East Autumn 2014	S15A(2) – F2 East Autumn 2015
			
S15A(2) – F2 East Spring 2011	**S15A(2) – F2 East Spring 2013**	**S15A(2) – F2 East Spring 2014**	**S15A(2) – F2 East Spring 2015**
			

S15A(2) – F2 South Autumn 2011	S15A(2) – F2 South Autumn 2013	S15A(2) – F2 South Autumn 2014	S15A(2) – F2 South Autumn 2015
			
S15A(2) – F2 South Spring 2011	**S15A(2) – F2 South Spring 2013**	**S15A(2) – F2 South Spring 2014**	**S15A(2) – F2 South Spring 2015**
			

S15A(2) – F2 West Autumn 2011	S15A(2) – F2 West Autumn 2013	S15A(2) – F2 West Autumn 2014	S15A(2) – F2 West Autumn 2015
			
S15A(2) – F2 West Spring 2011	**S15A(2) – F2 West Spring 2013**	**S15A(2) – F2 West Spring 2014**	**S15A(2) – F2 West Spring 2015**
			

S15A(2) – F3 North Autumn 2011	S15A(2) – F3 North Autumn 2013	S15A(2) – F3 North Autumn 2014	S15A(2) – F3 North Autumn 2015
			
S15A(2) – F3 North Spring 2011	**S15A(2) – F3 North Spring 2013**	**S15A(2) – F3 North Spring 2014**	**S15A(2) – F3 North Spring 2015**
			

S15A(2) – F3 East Autumn 2011	S15A(2) – F3 East Autumn 2013	S15A(2) – F3 East Autumn 2014	S15A(2) – F3 East Autumn 2015
			
S15A(2) – F3 East Spring 2011	**S15A(2) – F3 East Spring 2013**	**S15A(2) – F3 East Spring 2014**	**S15A(2) – F3 East Spring 2015**
			

S15A(2) – F3 South Autumn 2011	S15A(2) – F3 South Autumn 2013	S15A(2) – F3 South Autumn 2014	S15A(2) – F3 South Autumn 2015
			
S15A(2) – F3 South Spring 2011	**S15A(2) – F3 South Spring 2013**	**S15A(2) – F3 South Spring 2014**	**S15A(2) – F3 South Spring 2015**
			

S15A(2) – F3 West Autumn 2011	S15A(2) – F3 West Autumn 2013	S15A(2) – F3 West Autumn 2014	S15A(2) – F3 West Autumn 2015
			
S15A(2) – F3 West Spring 2011	**S15A(2) – F3 West Spring 2013**	**S15A(2) – F3 West Spring 2014**	**S15A(2) – F3 West Spring 2015**
			

S15B – F2 Upstream Autumn 2010	S15B – F2 Upstream Autumn 2012	S15B – F2 Upstream Autumn 2014	S15B – F2 Upstream Autumn 2015
			
S15B – F2 Upstream Spring 2010	**S15B – F2 Upstream Spring 2012**	**S15B – F2 Upstream Spring 2014**	**S15B – F2 Upstream Spring 2015**
			

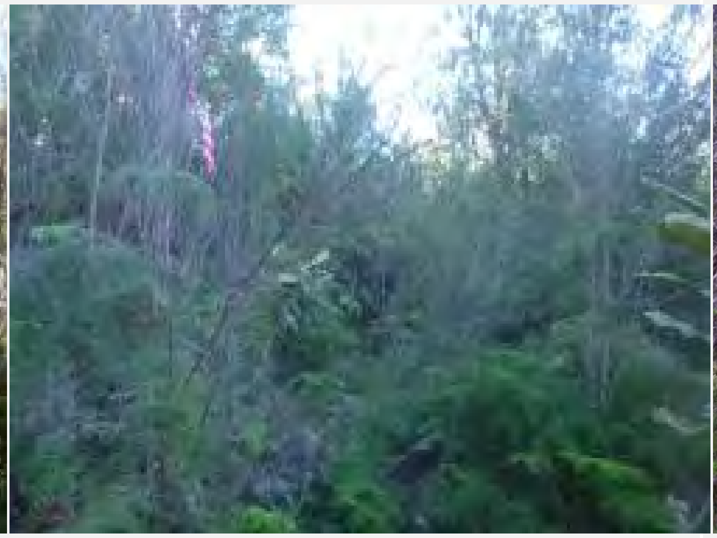
S15B – F2 Downstream Autumn 2010	S15B – F2 Downstream Autumn 2012	S15B – F2 Downstream Autumn 2014	S15B – F2 Downstream Autumn 2015
			
S15B – F2 Downstream Spring 2010	**S15B – F2 Downstream Spring 2012**	**S15B – F2 Downstream Spring 2014**	**S15B – F2 Downstream Spring 2015**
			

S15B – F4 North Autumn 2010	S15B – F4 North Autumn 2012	S15B – F4 North Autumn 2014	S15B – F4 North Autumn 2015
			
S15B – F4 North Spring 2010	**S15B – F4 North Spring 2012**	**S15B – F4 North Spring 2014**	**S15B – F4 North Spring 2015**
			

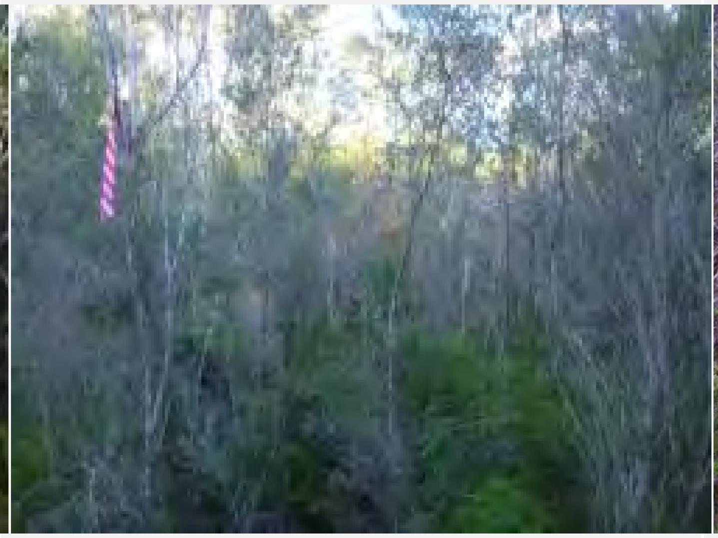
S15B – F4 East Autumn 2010	S15B – F4 East Autumn 2012	S15B – F4 East Autumn 2014	S15B – F4 East Autumn 2015
			
S15B – F4 East Spring 2010	**S15B – F4 East Spring 2012**	**S15B – F4 East Spring 2014**	**S15B – F4 East Spring 2015**
Photo not available			

S15B – F4 South Autumn 2010	S15B – F4 South Autumn 2012	S15B – F4 South Autumn 2014	S15B – F4 South Autumn 2015
			
S15B – F4 South Spring 2010	**S15B – F4 South Spring 2012**	**S15B – F4 South Spring 2014**	**S15B – F4 South Spring 2015**
			

S15B – F4 West Autumn 2010	S15B – F4 West Autumn 2012	S15B – F4 West Autumn 2014	S15B – F4 West Autumn 2015
			
S15B – F4 West Spring 2010	**S15B – F4 West Spring 2012**	**S15B – F4 West Spring 2014**	**S15B – F4 West Spring 2015**
			

S15B – F5 North Autumn 2010	S15B – F5 North Autumn 2012	S15B – F5 North Autumn 2014	S15B – F5 North Autumn 2015
			
S15B – F5 North Spring 2010	**S15B – F5 North Spring 2012**	**S15B – F5 North Spring 2014**	**S15B – F5 North Spring 2015**
			

S15B – F5 East Autumn 2010	S15B – F5 East Autumn 2012	S15B – F5 East Autumn 2014	S15B – F5 East Autumn 2015
			
S15B – F5 East Spring 2010	**S15B – F5 East Spring 2012**	**S15B – F5 East Spring 2014**	**S15B – F5 East Spring 2015**
			

S15B – F5 South Autumn 2010	S15B – F5 South Autumn 2012	S15B – F5 South Autumn 2014	S15B – F5 South Autumn 2015
			
S15B – F5 South Spring 2010	**S15B – F5 South Spring 2012**	**S15B – F5 South Spring 2014**	**S15B – F5 South Spring 2015**
			

S15B – F5 West Autumn 2010	S15B – F5 West Autumn 2012	S15B – F5 West Autumn 2014	S15B – F5 West Autumn 2015
			
S15B – F5 West Spring 2010	**S15B – F5 West Spring 2012**	**S15B – F5 West Spring 2014**	**S15B – F5 West Spring 2015**
			

Table 29 Dendrobium Area 2 and 3A control swamp sites 2015 photo point monitoring.

S15A(1) – F1 North Autumn 2010	S15A(1) – F1 North Autumn 2012	S15A(1) – F1 North Autumn 2014	S15A(1) – F1 North Autumn 2015
			
S15A(1) – F1 North Spring 2010	**S15A(1) – F1 North Spring 2012**	**S15A(1) – F1 North Spring 2014**	**S15A(1) – F1 North Spring 2015**
			

S15A(1) – F1 East Autumn 2010	S15A(1) – F1 East Autumn 2012	S15A(1) – F1 East Autumn 2014	S15A(1) – F1 East Autumn 2015
			
S15A(1) – F1 East Spring 2010	**S15A(1) – F1 East Spring 2012**	**S15A(1) – F1 East Spring 2014**	**S15A(1) – F1 East Spring 2015**
			

S15A(1) – F1 South Autumn 2010	S15A(1) – F1 South Autumn 2012	S15A(1) – F1 South Autumn 2014	S15A(1) – F1 South Autumn 2015
			
S15A(1) – F1 South Spring 2010	**S15A(1) – F1 South Spring 2012**	**S15A(1) – F1 South Spring 2014**	**S15A(1) – F1 South Spring 2015**
			

S15A(1) – F1 West Autumn 2010	S15A(1) – F1 West Autumn 2012	S15A(1) – F1 West Autumn 2014	S15A(1) – F1 West Autumn 2015
			
S15A(1) – F1 West Spring 2010	**S15A(1) – F1 West Spring 2012**	**S15A(1) – F1 West Spring 2014**	**S15A(1) – F1 West Spring 2015**
			

S15A(1) – F2 North Autumn 2010	S15A(1) – F2 North Autumn 2012	S15A(1) – F2 North Autumn 2014	S15A(1) – F2 North Autumn 2015
			
S15A(1) – F2 North Spring 2010	**S15A(1) – F2 North Spring 2012**	**S15A(1) – F2 North Spring 2014**	**S15A(1) – F2 North Spring 2015**
			

S15A(1) – F2 East Autumn 2010	S15A(1) – F2 East Autumn 2012	S15A(1) – F2 East Autumn 2014	S15A(1) – F2 East Autumn 2015
			
S15A(1) – F2 East Spring 2010	**S15A(1) – F2 East Spring 2012**	**S15A(1) – F2 East Spring 2014**	**S15A(1) – F2 East Spring 2015**
			

S15A(1) – F2 South Autumn 2010	S15A(1) – F2 South Autumn 2012	S15A(1) – F2 South Autumn 2014	S15A(1) – F2 South Autumn 2015
			
S15A(1) – F2 South Spring 2010	**S15A(1) – F2 South Spring 2012**	**S15A(1) – F2 South Spring 2014**	**S15A(1) – F2 South Spring 2015**
			

S15A(1) – F2 West Autumn 2010	S15A(1) – F2 West Autumn 2012	S15A(1) – F2 West Autumn 2014	S15A(1) – F2 West Autumn 2015
			
S15A(1) – F2 West Spring 2010	**S15A(1) – F2 West Spring 2012**	**S15A(1) – F2 West Spring 2014**	**S15A(1) – F2 West Spring 2015**
			

S15A(1) – F3 Upstream Autumn 2010	S15A(1) – F3 Upstream Autumn 2012	S15A(1) – F3 Upstream Autumn 2014	S15A(1) – F3 Upstream Autumn 2015
			
S15A(1) – F3 Upstream Spring 2010	**S15A(1) – F3 Upstream Spring 2012**	**S15A(1) – F3 Upstream Spring 2014**	**S15A(1) – F3 Upstream Spring 2015**
			

S15A(1) – F3 Downstream Autumn 2010	S15A(1) – F3 Downstream Autumn 2012	S15A(1) – F3 Downstream Autumn 2014	S15A(1) – F3 Downstream Autumn 2015
			
S15A(1) – F3 Downstream Spring 2010	**S15A(1) – F3 Downstream Spring 2012**	**S15A(1) – F3 Downstream Spring 2014**	**S15A(1) – F3 Downstream Spring 2015**
			

S22 – F1 North Autumn 2011	S22 – F1 North Autumn 2012	S22 – F1 North Autumn 2014	S22 – F1 North Autumn 2015
			
S22 – F1 North Spring 2011	**S22 – F1 North Spring 2012**	**S22 – F1 North Spring 2014**	**S22 – F1 North Spring 2015**
			

S22 – F1 East Autumn 2011	S22 – F1 East Autumn 2012	S22 – F1 East Autumn 2014	S22 – F1 East Autumn 2015
			
S22 – F1 East Spring 2011	**S22 – F1 East Spring 2012**	**S22 – F1 East Spring 2014**	**S22 – F1 East Spring 2014**
			

S22 – F1 South Autumn 2011	S22 – F1 South Autumn 2012	S22 – F1 South Autumn 2014	S22 – F1 South Autumn 2015
			
S22 – F1 South Spring 2011	**S22 – F1 South Spring 2012**	**S22 – F1 South Spring 2014**	**S22 – F1 South Spring 2015**
			

S22 – F1 West Autumn 2011	S22 – F1 West Autumn 2012	S22 – F1 West Autumn 2014	S22 – F1 West Autumn 2015
			
S22 – F1 West Spring 2011	**S22 – F1 West Spring 2012**	**S22 – F1 West Spring 2014**	**S22 – F1 West Spring 2015**
			

S22 – F2 North Autumn 2011	S22 – F2 North Autumn 2012	S22 – F2 North Autumn 2014	S22 – F2 North Autumn 2015
			
S22 – F2 North Spring 2011	**S22 – F2 North Spring 2012**	**S22 – F2 North Spring 2014**	**S22 – F2 North Spring 2015**
			

S22 – F2 East Autumn 2011	S22 – F2 East Autumn 2012	S22 – F2 East Autumn 2014	S22 – F2 East Autumn 2015
			
S22 – F2 East Spring 2011	**S22 – F2 East Spring 2012**	**S22 – F2 East Spring 2014**	**S22 – F2 East Spring 2014**
			

S22 – F2 South Autumn 2011	S22 – F2 South Autumn 2012	S22 – F2 South Autumn 2014	S22 – F2 South Autumn 2015
			
S22 – F2 South Spring 2011	**S22 – F2 South Spring 2012**	**S22 – F2 South Spring 2014**	**S22 – F2 South Spring 2015**
			

S22 – F2 West Autumn 2011

S22 – F2 West Autumn 2012

S22 – F2 West Autumn 2014

S22 – F2 West Autumn 2015

S22 – F2 West Spring 2011

S22 – F2 West Spring 2012

S22 – F2 West Spring 2014

S22 – F2 West Spring 2015

S22 – F3 North Autumn 2011	S22 – F3 North Autumn 2012	S22 – F3 North Autumn 2014	S22 – F3 North Autumn 2015
			
S22 – F3 North Spring 2011	**S22 – F3 North Spring 2012**	**S22 – F3 North Spring 2014**	**S22 – F3 North Spring 2015**
			

S22 – F3 East Autumn 2011	S22 – F3 East Autumn 2012	S22 – F3 East Autumn 2014	S22 – F3 East Autumn 2015
			
S22 – F3 East Spring 2011	**S22 – F3 East Spring 2012**	**S22 – F3 East Spring 2014**	**S22 – F3 East Spring 2015**
			

S22 – F3 South Autumn 2011	S22 – F3 South Autumn 2012	S22 – F3 South Autumn 2014	S22 – F3 South Autumn 2015
			
S22 – F3 South Spring 2011	**S22 – F3 South Spring 2012**	**S22 – F3 South Spring 2014**	**S22 – F3 South Spring 2015**
			

S22 – F3 West Autumn 2011	S22 – F3 West Autumn 2012	S22 – F3 West Autumn 2014	S22 – F3 West Autumn 2015
			
S22 – F3 West Spring 2011	**S22 – F3 West Spring 2012**	**S22 – F3 West Spring 2014**	**S22 – F3 West Spring 2015**
			

S33 – F1 North Autumn 2010

S33 – F1 North Autumn 2012

S33 – F1 North Autumn 2014

S33 – F1 North Autumn 2015

S33 – F1 North Spring 2010

S33 – F1 North Spring 2012

S33 – F1 North Spring 2014

S33 – F1 North Spring 2015

S33 – F1 East Autumn 2010	S33 – F1 East Autumn 2012	S33 – F1 East Autumn 2014	S33 – F1 East Autumn 2015
			
S33 – F1 East Spring 2010	**S33 – F1 East Spring 2012**	**S33 – F1 East Spring 2014**	**S33 – F1 East Spring 2015**
			

S33 – F1 South Autumn 2010	S33 – F1 South Autumn 2012	S33 – F1 South Autumn 2014	S33 – F1 South Autumn 2015
			
S33 – F1 South Spring 2010	**S33 – F1 South Spring 2012**	**S33 – F1 South Spring 2014**	**S33 – F1 South Spring 2015**
			

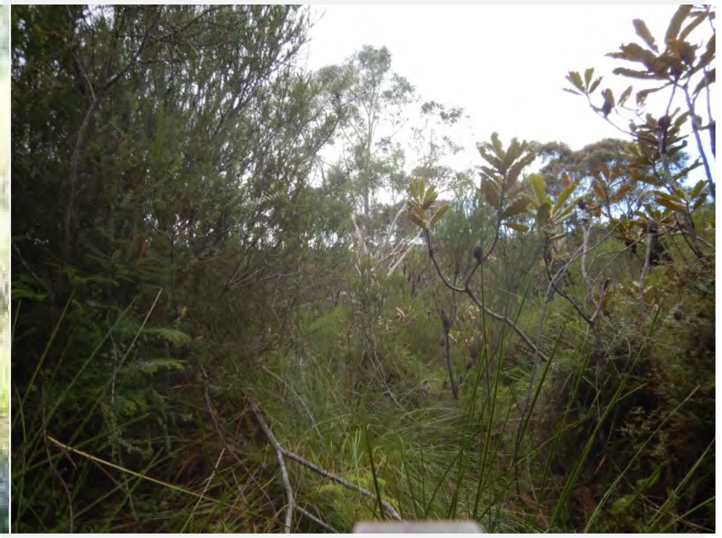
S33 – F1 West Autumn 2010	S33 – F1 West Autumn 2012	S33 – F1 West Autumn 2014	S33 – F1 West Autumn 2015
			
S33 – F1 West Spring 2010	**S33 – F1 West Spring 2012**	**S33 – F1 West Spring 2014**	**S33 – F1 West Spring 2015**
			

S33 – F2 North Autumn 2010	S33 – F2 North Autumn 2012	S33 – F2 North Autumn 2014	S33 – F2 North Autumn 2015
			
S33 – F2 North Spring 2010	**S33 – F2 North Spring 2012**	**S33 – F2 North Spring 2014**	**S33 – F2 North Spring 2015**
			

S33 – F2 East Autumn 2010	S33 – F2 East Autumn 2012	S33 – F2 East Autumn 2014	S33 – F2 East Autumn 2015
			
S33 – F2 East Spring 2010	**S33 – F2 East Spring 2012**	**S33 – F2 East Spring 2014**	**S33 – F2 East Spring 2015**
			

S33 – F2 South Autumn 2010	S33 – F2 South Autumn 2012	S33 – F2 South Autumn 2014	S33 – F2 South Autumn 2015
			
S33 – F2 South Spring 2010	**S33 – F2 South Spring 2012**	**S33 – F2 South Spring 2014**	**S33 – F2 South Spring 2015**
			

S33 – F2 West Autumn 2010	S33 – F2 West Autumn 2012	S33 – F2 West Autumn 2014	S33 – F2 West Autumn 2015
			
S33 – F2 West Spring 2010	**S33 – F2 West Spring 2012**	**S33 – F2 West Spring 2014**	**S33 – F2 West Spring 2015**
			

S33 – F3 North Autumn 2010	S33 – F3 North Autumn 2012	S33 – F3 North Autumn 2014	S33 – F3 North Autumn 2015
			
S33 – F3 North Spring 2010	**S33 – F3 North Spring 2012**	**S33 – F3 North Spring 2014**	**S33 – F3 North Spring 2015**
			

S33 – F3 East Autumn 2010	S33 – F3 East Autumn 2012	S33 – F3 East Autumn 2014	S33 – F3 East Autumn 2015
			
S33 – F3 East Spring 2010	**S33 – F3 East Spring 2012**	**S33 – F3 East Spring 2014**	**S33 – F3 East Spring 2015**
			

S33 – F3 South Autumn 2010	S33 – F3 South Autumn 2012	S33 – F3 South Autumn 2014	S33 – F3 South Autumn 2015
			
S33 – F3 South Spring 2010	**S33 – F3 South Spring 2012**	**S33 – F3 South Spring 2014**	**S33 – F3 South Spring 2015**
			

S33 – F3 West Autumn 2010	S33 – F3 West Autumn 2012	S33 – F3 West Autumn 2014	S33 – F3 West Autumn 2015
			
S33 – F3 West Spring 2010	**S33 – F3 West Spring 2012**	**S33 – F3 West Spring 2014**	**S33 – F3 West Spring 2015**
			

S11 – F1 North Autumn 2010	S11 – F1 North Autumn 2011	S11 – F1 North Autumn 2014	S11 – F1 North Autumn 2015
			
S11 – F1 North Spring 2010	**S11 – F1 North Spring 2011**	**S11 – F1 North Spring 2014**	**S11 – F1 North Spring 2015**
			

S11 – F1 East Autumn 2010	S11 – F1 East Autumn 2011	S11 – F1 East Autumn 2014	S11 – F1 East Autumn 2015
			
S11 – F1 East Spring 2010	**S11 – F1 East Spring 2011**	**S11 – F1 East Spring 2014**	**S11 – F1 East Spring 2015**
			

S11 – F1 South Autumn 2010	**S11 – F1 South Autumn 2011**	**S11 – F1 South Autumn 2014**	**S11 – F1 South Autumn 2015**
			
S11 – F1 South Spring 2010	**S11 – F1 South Spring 2011**	**S11-F1 South Spring 2014**	**S11-F1 South Spring 2015**
			

S11 – F1 West Autumn 2010	S11 – F1 West Autumn 2011	S11 – F1 West Autumn 2014	S11 – F1 West Autumn 2015
			
S11 – F1 West Spring 2010	**S11 – F1 West Spring 2011**	**S11 – F1 West Spring 2014**	**S11 – F1 West Spring 2015**
			

S11 – F3 North Autumn 2010	S11 – F3 North Autumn 2011	S11 – F3 North Autumn 2014	S11 – F3 North Autumn 2015
			
S11 – F3 North Spring 2010	**S11 – F3 North Spring 2011**	**S11 – F3 North Spring 2014**	**S11 – F3 North Spring 2014**
			

S11 – F3 East Autumn 2010	S11 – F3 East Autumn 2011	S11 – F3 East Autumn 2014	S11 – F3 East Autumn 2015
			
S11 – F3 East Spring 2010	**S11 – F3 East Spring 2011**	**S11 – F3 East Spring 2014**	**S11 – F3 East Spring 2015**
			

S11 – F3 South Autumn 2010	S11 – F3 South Autumn 2011	S11 – F3 South Autumn 2014	S11 – F3 South Autumn 2015
			
S11 – F3 South Spring 2010	**S11 – F3 South Spring 2011**	**S11 – F3 South Spring 2014**	**S11 – F3 South Spring 2015**
			

S11 – F3 West Autumn 2010	S11 – F3 West Autumn 2011	S11 – F3 West Autumn 2014	S11 – F3 West Autumn 2015
			
S11 – F3 West Spring 2010	**S11 – F3 West Spring 2011**	**S11 – F3 West Spring 2014**	**S11 – F3 West Spring 2015**
			

S11 – F5 North Autumn 2010

S11 – F5 North Autumn 2011

S11 – F5 North Autumn 2014

S11 – F5 North Autumn 2015

S11 – F5 North Spring 2010

S11 – F5 North Spring 2011

S11 – F5 North Spring 2014

S11 – F5 North Spring 2015

S11 – F5 East Autumn 2010

S11 – F5 East Autumn 2011

S11 – F5 East Autumn 2014

S11 – F5 East Autumn 2015

S11 – F5 East Spring 2010

S11 – F5 East Spring 2011

S11 – F5 East Spring 2014

S11 – F5 East Spring 2015

S11 – F5 South Autumn 2010	S11 – F5 South Autumn 2011	S11 – F5 South Autumn 2014	S11 – F5 South Autumn 2015
			
S11 – F5 South Spring 2010	**S11 – F5 South Spring 2011**	**S11 – F5 South Spring 2014**	**S11 – F5 South Spring 2015**
			

S11 – F5 West Autumn 2010	S11 – F5 West Autumn 2011	S11 – F5 West Autumn 2014	S11 – F5 West Autumn 2015
			
S11 – F5 West Spring 2010	**S11 – F5 West Spring 2011**	**S11 – F5 West Spring 2014**	**S11 – F5 West Spring 2015**
			

Table 30 Dendrobium Area 3B impact swamp sites 2015 photo point monitoring

S1A – F1 North Autumn 2012	S1A – F1 North Autumn 2013	S1A – F1 North Autumn 2014	S1A – F1 North Autumn 2015
Not monitored			
S1A – F1 North Spring 2012	**S1A – F1 North Spring 2013**	**S1A – F1 North Spring 2014**	**S1A – F1 North Spring 2015**
			

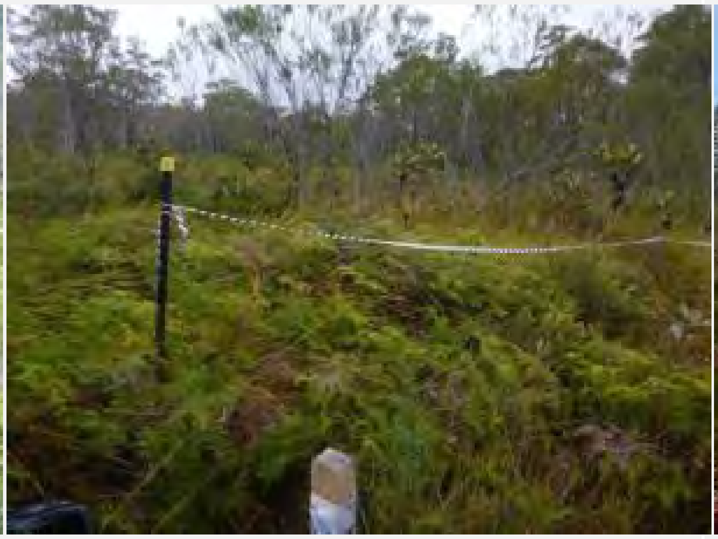
S1A – F1 East Autumn 2012	S1A – F1 East Autumn 2013	S1A – F1 East Autumn 2014	S1A – F1 East Autumn 2015
Not monitored			
S1A – F1 East Spring 2012	**S1A – F1 East Spring 2013**	**S1A – F1 East Spring 2014**	**S1A – F1 East Spring 2015**
			

S1A – F1 South Autumn 2012	S1A – F1 South Autumn 2013	S1A – F1 South Autumn 2014	S1A – F1 South Autumn 2015
Not monitored			
S1A – F1 South Spring 2012	**S1A – F1 South Spring 2013**	**S1A – F1 South Spring 2014**	**S1A – F1 South Spring 2015**
			

S1A – F1 West Autumn 2012	S1A – F1 West Autumn 2013	S1A – F1 West Autumn 2014	S1A – F1 West Autumn 2015
Not monitored			
S1A – F1 West Spring 2012	**S1A – F1 West Spring 2013**	**S1A – F1 West Spring 2014**	**S1A – F1 West Spring 2015**
			

S1A – F2 North Autumn 2012	S1A – F2 North Autumn 2013	S1A – F2 North Autumn 2014	S1A – F2 North Autumn 2015
Not monitored			
S1A – F2 North Spring 2012	**S1A – F2 North Spring 2013**	**S1A – F2 North Spring 2014**	**S1A – F2 North Spring 2015**
			

S1A – F2 East Autumn 2012	S1A – F2 East Autumn 2013	S1A – F2 East Autumn 2014	S1A – F2 East Autumn 2015
Not monitored			
S1A – F2 East Spring 2012	**S1A – F2 East Spring 2013**	**S1A – F2 East Spring 2014**	**S1A – F2 East Spring 2015**
			

S1A – F2 South Autumn 2015	S1A – F2 South Autumn 2013	S1A – F2 South Autumn 2014	S1A – F2 South Autumn 2015
Not monitored			
S1A – F2 South Spring 2012	**S1A – F2 South Spring 2013**	**S1A – F2 South Spring 2014**	**S1A – F2 South Spring 2015**
			

S1A – F2 West Autumn 2012	S1A – F2 West Autumn 2013	S1A – F2 West Autumn 2014	S1A – F2 West Autumn 2015
Not monitored			
S1A – F2 West Spring 2012	**S1A – F2 West Spring 2013**	**S1A – F2 West Spring 2014**	**S1A – F2 West Spring 2015**
			

S1A – F3 North Autumn 2012	S1A – F3 North Autumn 2013	S1A – F3 North Autumn 2014	S1A – F3 North Autumn 2015
Not monitored			
S1A – F3 North Spring 2012	**S1A – F3 North Spring 2013**	**S1A – F3 North Spring 2014**	**S1A – F3 North Spring 2015**
			

S1A – F3 East Autumn 2012	S1A – F3 East Autumn 2013	S1A – F3 East Autumn 2014	S1A – F3 East Autumn 2015
Not monitored			
S1A – F3 East Spring 2012	**S1A – F3 East Spring 2013**	**S1A – F3 East Spring 2014**	**S1A – F3 East Spring 2015**
			

S1A – F3 South Autumn 2012	S1A – F3 South Autumn 2013	S1A – F3 South Autumn 2014	S1A – F3 South Autumn 2015
Not monitored			
S1A – F3 South Spring 2012	**S1A – F3 South Spring 2013**	**S1A – F3 South Spring 2014**	**S1A – F3 South Spring 2015**
			

S1A – F3 West Autumn 202	S1A – F3 West Autumn 2013	S1A – F3 West Autumn 2014	S1A – F3 West Autumn 2015
Not monitored			
S1A – F3 West Spring 2012	**S1A – F3 West Spring 2013**	**S1A – F3 West Spring 2014**	**S1A – F3 West Spring 2015**
			

S1B – F1 North Autumn 2010	S1B – F1 North Autumn 2013	S1B – F1 North Autumn 2014	S1B – F1 North Autumn 2015
			
S1B – F1 North Spring 2009	**S1B - F1 North Spring 2013**	**S1B - F1 North Spring 2014**	**S1B - F1 North Spring 2015**
			

S1B – F1 East Autumn 2010

S1B – F1 East Autumn 2013

S1B – F1 East Autumn 2014

S1B – F1 East Autumn 2015

S1B – F1 East Spring 2009

S1B - F1 East Spring 2013

S1B - F1 East Spring 2014

S1B - F1 East Spring 2015

S1B – F1 South Autumn 2010

S1B – F1 South Autumn 2013

S1B – F1 South Autumn 2014

S1B – F1 South Autumn 2015

S1B – F1 South Spring 2009

S1B - F1 South Spring 2013

S1B - F1 South Spring 2014

S1B - F1 South Spring 2015

S1B – F1 West Autumn 2010

S1B – F1 West Autumn 2013

S1B – F1 West Autumn 2014

S1B – F1 West Autumn 2015

S1B – F1 West Spring 2009

S1B - F1 West Spring 2013

S1B - F1 West Spring 2014

S1B - F1 West Spring 2015

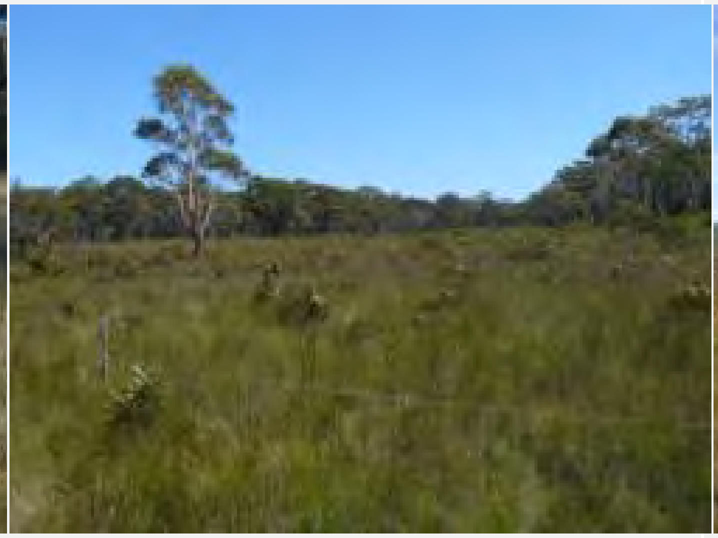
S1B – F2 North Autumn 2010	S1B – F2 North Autumn 2013	S1B – F2 North Autumn 2014	S1B – F2 North Autumn 2015
			
S1B – F2 North Spring 2009	**S1B – F2 North Spring 2013**	**S1B – F2 North Spring 2014**	**S1B – F2 North Spring 2015**
			

S1B – F2 East Autumn 2010	S1B – F2 East Autumn 2013	S1B – F2 East Autumn 2014	S1B – F2 East Autumn 2015
			
S1B – F2 East Spring 2009	**S1B – F2 East Spring 2013**	**S1B – F2 East Spring 2014**	**S1B – F2 East Spring 2015**
			

S1B – F2 South Autumn 2010	S1B – F2 South Autumn 2013	S1B – F2 South Autumn 2014	S1B – F2 South Autumn 2015
			
S1B – F2 South Spring 2009	**S1B – F2 South Spring 2013**	**S1B – F2 South Spring 2014**	**S1B – F2 South Spring 2015**
			

S1B – F2 West Autumn 2010

S1B – F2 West Autumn 2013



S1B – F2 West Autumn 2014

S1B – F2 West Autumn 2015

S1B – F2 West Spring 2009

S1B – F2 West Spring 2013

S1B – F2 West Spring 2014

S1B – F2 West Spring 2015

S1B – F3 North Autumn 2010	S1B - F3 North Autumn 2013	S1B - F3 North Autumn 2014	S1B - F3 North Autumn 2015
			Photo not available
S1B – F3 North Spring 2009	**S1B – F3 North Spring 2013**	**S1B – F3 North Spring 2014**	**S1B – F3 North Spring 2015**
			

S1B – F3 East Autumn 2010	S1B – F3 East Autumn 2013	1B – F3 East Autumn 2014	S1B – F3 East Autumn 2015
			Photo not available
S1B – F3 East Spring 2009	**S1B – F3 East Spring 2013**	**S1B – F3 East Spring 2014**	**S1B – F3 East Spring 2015**
			

S1B – F3 South Autumn 2010	S1B – F3 South Autumn 2013	S1B – F3 South Autumn 2014	S1B – F3 South Autumn 2015
			Photo not available
S1B – F3 South Spring 2009	**S1B – F3 South Spring 2013**	**S1B – F3 South Spring 2014**	**S1B – F3 South Spring 2015**
			

S1B – F3 West Autumn 2010	S1B – F3 West Autumn 2013	S1B – F3 West Autumn 2014	S1B – F3 West Autumn 2015
			Photo not available
S1B – F3 West Spring 2009	**S1B – F3 West Spring 2013**	**S1B – F3 West Spring 2014**	**S1B – F3 West Spring 2015**
			

S5 – F1 North Autumn 2012	S5 – F1 North Autumn 2013	S5 – F1 North Autumn 2014	S5 – F1 North Autumn 2015
Not monitored			
S5 – F1 North Spring 2012	**S5 – F1 North Spring 2013**	**S5 – F1 North Spring 2014**	**S5 – F1 North Spring 2015**
			

S5 – F1 East Autumn 2012	S5 – F1 East Autumn 2013	S5 – F1 East Autumn 2014	S5 – F1 East Autumn 2015
Not monitored			
S5 – F1 East Spring 2012	**S5 – F1 East Spring 2013**	**S5 – F1 East Spring 2014**	**S5 – F1 East Spring 2015**
			

S5 – F1 South Autumn 2012	S5 – F1 South Autumn 2013	S5 – F1 South Autumn 2014	S5 – F1 South Autumn 2015
Not monitored			
S5 – F1 South Spring 2012	**S5 – F1 South Spring 2013**	**S5 – F1 South Spring 2014**	**S5 – F1 South Spring 2015**
			

S5 – F1 West Autumn 2012	S5 – F1 West Autumn 2013	S5 – F1 West Autumn 2014	S5 – F1 West Autumn 2015
Not monitored			
S5 – F1 West Spring 2012	**S5 – F1 West Spring 2013**	**S5 – F1 West Spring 2014**	**S5 – F1 West Spring 2015**
			

S5 – F2 North Autumn 2012	S5 – F2 North Autumn 2013	S5 – F2 North Autumn 2014	S5 – F2 North Autumn 2015
Not monitored			
S5 – F2 North Spring 2012	**S5 – F2 North Spring 2013**	**S5 – F2 North Spring 2014**	**S5 – F2 North Spring 2014**
			

S5 – F2 East Autumn 2012	S5 – F2 East Autumn 2013	S5 – F2 East Autumn 2014	S5 – F2 East Autumn 2015
Not monitored			
S5 – F2 East Spring 2012	**S5 – F2 East Spring 2013**	**S5 – F2 East Spring 2014**	**S5 – F2 East Spring 2015**
			

S5 – F2 South Autumn 2012	S5 – F2 South Autumn 2013	S5 – F2 South Autumn 2014	S5 – F2 South Autumn 2015
Not monitored			
S5 – F2 South Spring 2012	**S5 – F2 South Spring 2013**	**S5 – F2 South Spring 2014**	**S5 – F2 South Spring 2015**
			

S5 – F2 West Autumn 2012	S5 – F2 West Autumn 2013	S5 – F2 West Autumn 2014	S5 – F2 West Autumn 2015
Not monitored			
S5 – F2 West Spring 2012	**S5 – F2 West Spring 2013**	**S5 – F2 West Spring 2014**	**S5 – F2 West Spring 2015**
			

<table>
<tr><th>S5 – F3 North Autumn 2012</th><th>S5 – F3 North Autumn 2013</th><th>S5 – F3 North Autumn 2014</th><th>S5 – F3 North Autumn 2015</th></tr>
<tr><td>Not monitored</td><td></td><td></td><td></td></tr>
<tr><th>S5 – F3 North Spring 2012</th><th>S5 – F3 North Spring 2013</th><th>S5 – F3 North Spring 2014</th><th>S5 – F3 North Spring 2015</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

S5 – F3 East Autumn 2012	**S5 – F3 East Autumn 2013**	**S5 – F3 East Autumn 2014**	**S5 – F3 East Autumn 2015**
Not monitored			
S5 – F3 East Spring 2012	**S5 – F3 East Spring 2013**	**S5 – F3 East Spring 2014**	**S5 – F3 East Spring 2015**
			

S5 – F3 South Spring 2012	S5 – F3 South Autumn 2013	S5 – F3 South Autumn 2014	S5 – F3 South Autumn 2015
Not monitored			
S5 – F3 South Spring 2012	**S5 – F3 South Spring 2013**	**S5 – F3 South Spring 2014**	**S5 – F3 South Spring 2015**
			

S5 – F3 West Autumn 2012	S5 – F3 West Autumn 2013	S5 – F3 West Autumn 2014	S5 – F3 West Autumn 2015
			
S5 – F3 West Spring 2012	**S5 – F3 West Spring 2013**	**S5 – F3 West Spring 2014**	**S5 – F3 West Spring 2015**
			

S13 – F1 North Autumn 2013	S13 – F1 North Autumn 2014	S13 – F1 North Autumn 2015
Not monitored		
S13 – F1 North Spring 2013	**S13 – F1 North Spring 2014**	**S13 – F1 North Spring 2015**
		

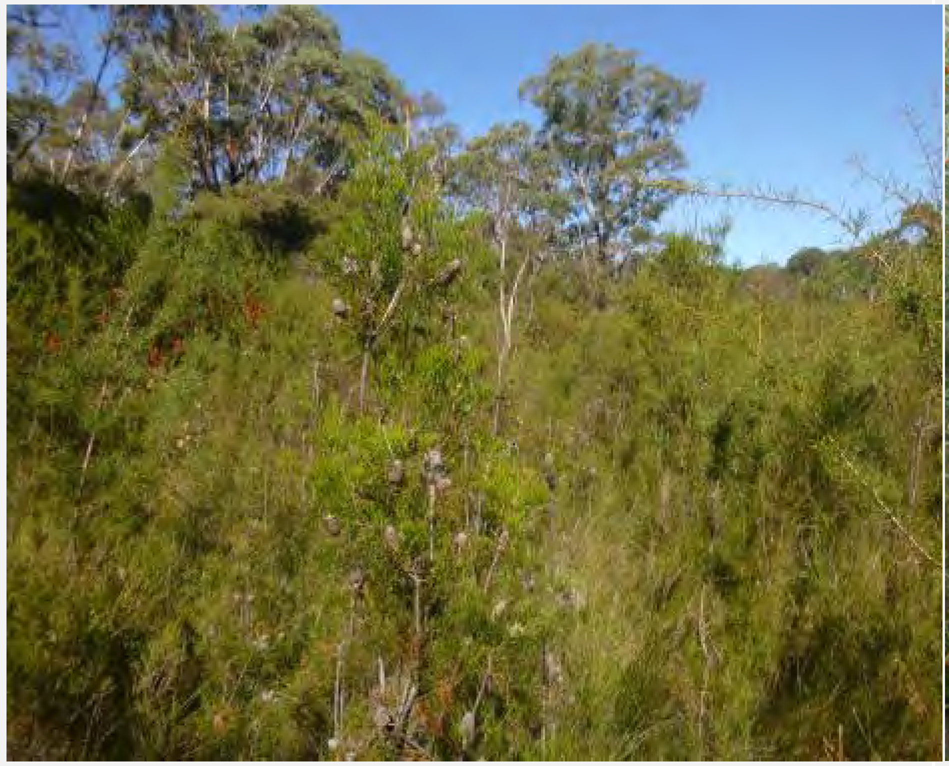
S13 – F1 East Autumn 2013	S13 – F1 East Autumn 2014	S13 – F1 East Autumn 2015
Not monitored		
S13 – F1 East Spring 2013	**S13 – F1 East Spring 2014**	**S13 – F1 East Spring 2015**
		

S13 – F1 South Autumn 2013	S13 – F1 South Autumn 2014	S13 – F1 South Autumn 2015
Not monitored		
S13 – F1 South Spring 2013	**S13 – F1 South Spring 2014**	**S13 – F1 South Spring 2015**
		

S13 – F1 West Autumn 2013	S13 – F1 West Autumn 2014	S13 – F1 West Autumn 2015
		
S13 – F1 West Spring 2013	**S13 – F1 West Spring 2014**	**S13 – F1 West Spring 2015**
		

S13 – F2 North Autumn 2013	S13 – F2 North Autumn 2014	S13 – F2 North Autumn 2015
Not monitored		
S13 – F2 North Spring 2013	**S13 – F2 North Spring 2014**	**S13 – F2 North Spring 2015**
		

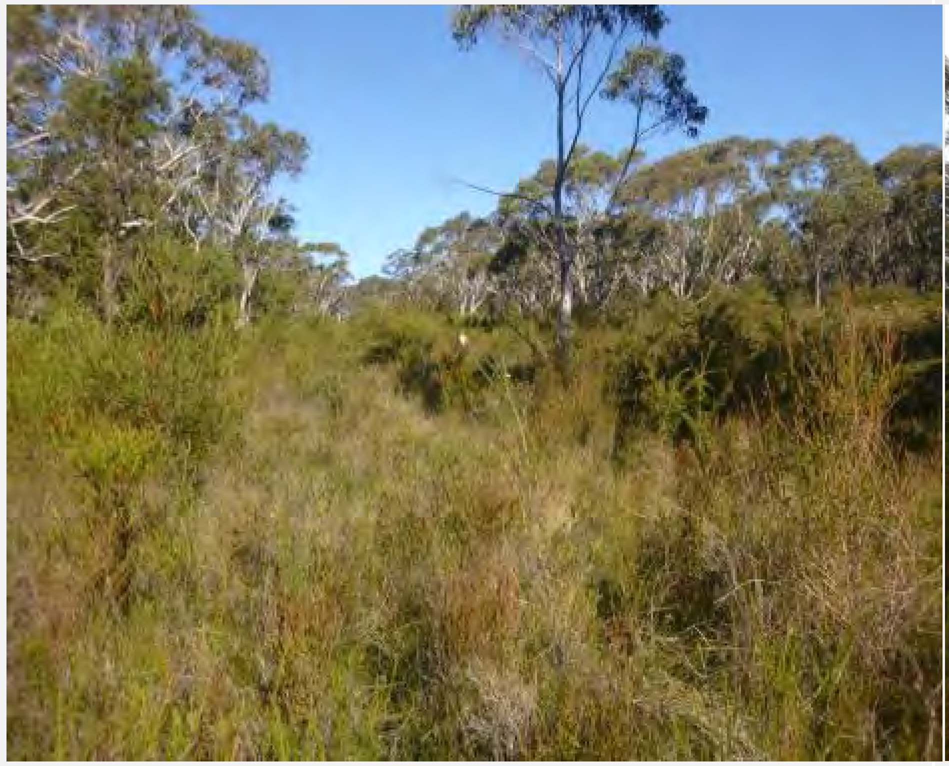
S13 – F2 East Autumn 2013	S13 – F2 East Autumn 2014	S13 – F2 East Autumn 2015
Not monitored		
S13 – F2 East Spring 2013	**S13 – F2 East Spring 2014**	**S13 – F2 East Spring 2015**
		

S13 – F2 South Autumn 2013	S13 – F2 South Autumn 2014	S13 – F2 South Autumn 2015
Not monitored		
S13 – F2 South Spring 2013	**S13 – F2 South Spring 2014**	**S13 – F2 South Spring 2015**
		

S13 – F2 West Autumn 2013	S13 – F2 West Autumn 2014	S13 – F2 West Autumn 2015
Not monitored		
S13 – F2 West Spring 2013	**S13 – F2 West Spring 2014**	**S13 – F2 West Spring 2015**
		

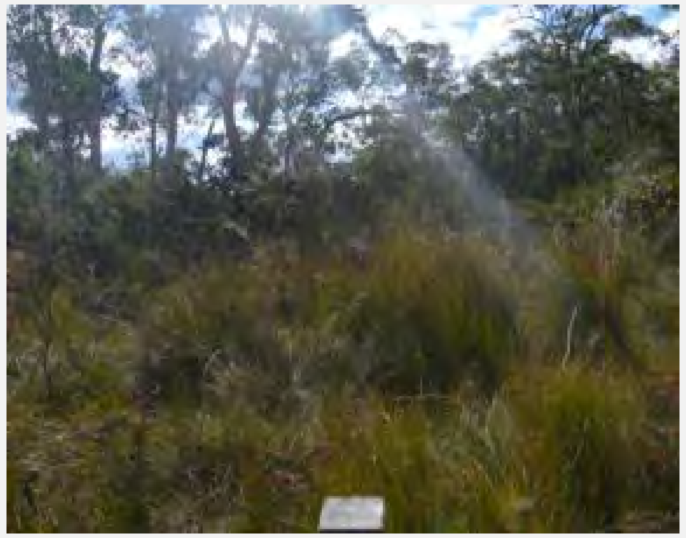
S13 – F3 North Autumn 2013	S13 – F3 North Autumn 2014	S13 – F3 North Autumn 2015
Not monitored		
S13 – F3 North Spring 2013	**S13 – F3 North Spring 2014**	**S13 – F3 North Spring 2015**
		

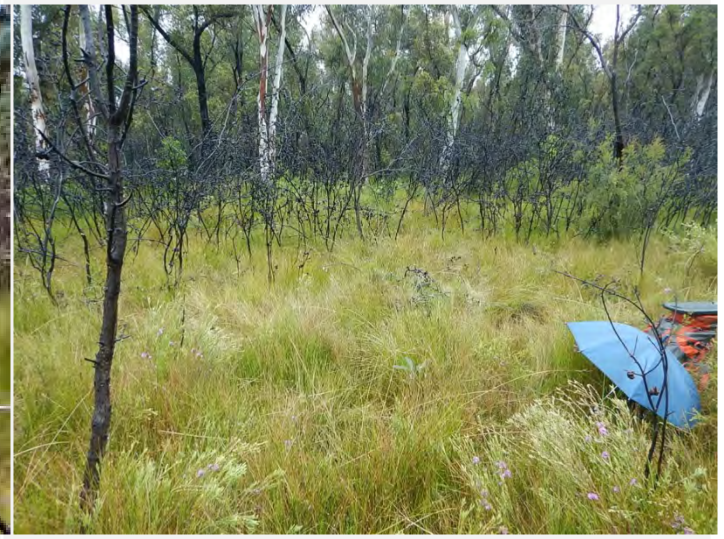
S13 – F3 East Autumn 2013	S13 – F3 East Autumn 2014	S13 – F3 East Autumn 2015
Not monitored		
S13 – F3 East Spring 2013	**S13 – F3 East Spring 2014**	**S13 – F3 East Spring 2015**
		

S13 – F3 South Autumn 2013	S13 – F3 South Autumn 2014	S13 – F3 South Autumn 2015
Not monitored		
S13 – F3 South Spring 2013	**S13 – F3 South Spring 2014**	**S13 – F3 South Spring 2015**
		

S13 – F3 West Autumn 2013	S13 – F3 West Autumn 2014	S13 – F3 West Autumn 2015
Not monitored		
S13 – F3 West Spring 2013	**S13 – F3 West Spring 2014**	**S13 – F3 West Spring 2015**
		

Table 31 Dendrobium Area 3B control swamp sites 2015 photo point monitoring

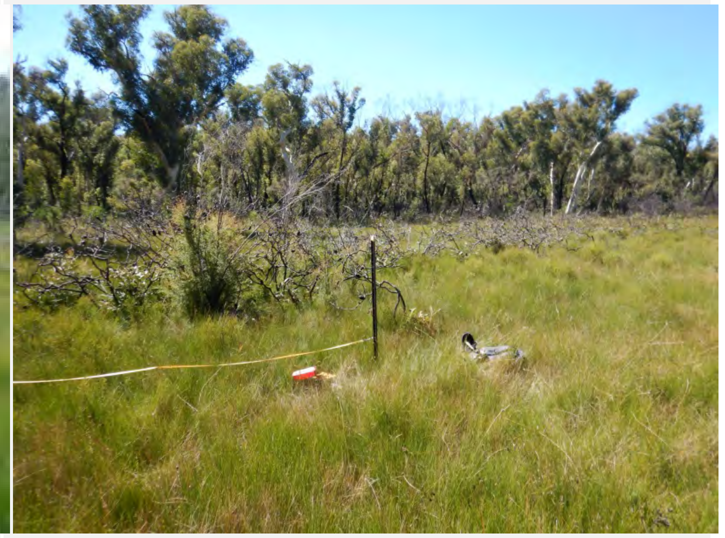
FT6XS – F1 North Autumn 2012	FT6XS – F1 North Autumn 2013	FT6XS – F1 North Autumn 2014	FT6XS – F1 North Autumn 2015
Not monitored			
FT6XS – F1 North Spring 2012	**FT6XS – F1 North Spring 2013**	**FT6XS – F1 North Spring 2014**	**FT6XS – F1 North Spring 2015**
			

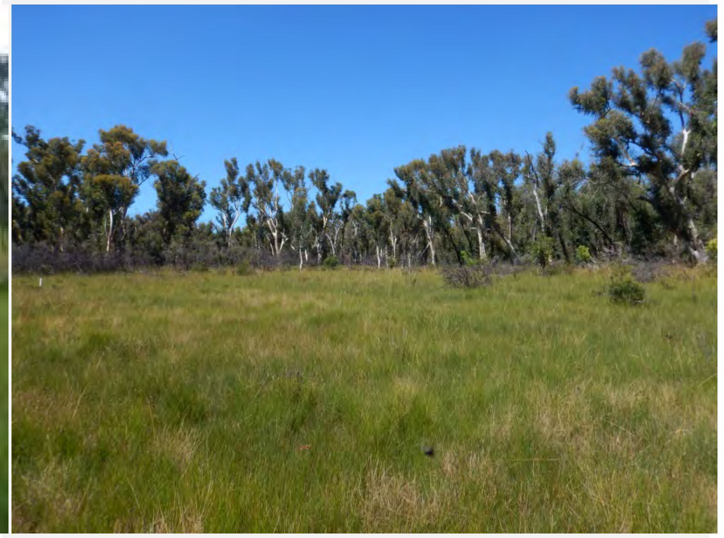
FT6XS – F1 East Autumn 2012	FT6XS – F1 East Autumn 2013	FT6XS – F1 East Autumn 2014	FT6XS – F1 East Autumn 2015
Not monitored			
FT6XS – F1 East Spring 2012	**FT6XS – F1 East Spring 2013**	**FT6XS – F1 East Spring 2014**	**FT6XS – F1 East Spring 2015**
			

FT6XS – F1 South Autumn 2012	FT6XS – F1 South Autumn 2013	FT6XS – F1 South Autumn 2014	FT6XS – F1 South Autumn 2015
Not monitored			
FT6XS – F1 South Spring 2012	**FT6XS – F1 South Spring 2013**	**FT6XS – F1 South Spring 2014**	**FT6XS – F1 South Spring 2015**
			

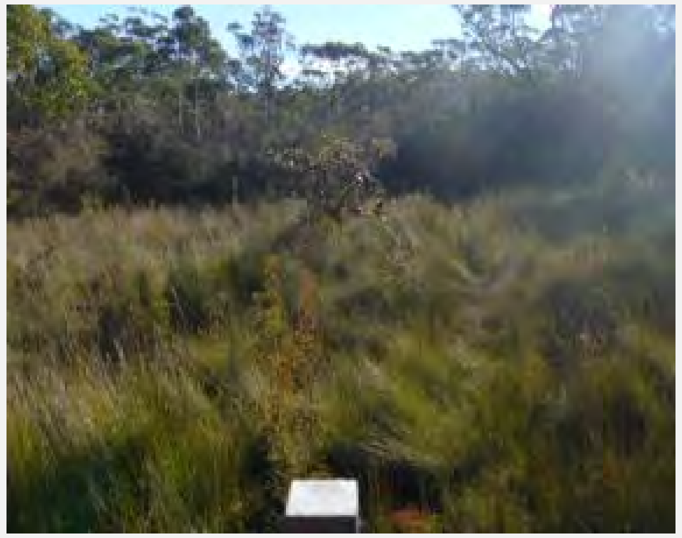
FT6XS – F1 West Autumn 2012	FT6XS – F1 West Autumn 2013	FT6XS – F1 West Autumn 2014	FT6XS – F1 West Autumn 2015
Not monitored			
FT6XS – F1 West Spring 2012	**FT6XS – F1 West Spring 2013**	**FT6XS – F1 West Spring 2014**	**FT6XS – F1 West Spring 2015**
			

FT6XS – F2 North Autumn 2012	FT6XS – F2 North Autumn 2013	FT6XS – F2 North Autumn 2014	FT6XS – F2 North Autumn 2015
Not monitored			
FT6XS – F2 North Spring 2012	**FT6XS – F2 North Spring 2013**	**FT6XS – F2 North Spring 2014**	**FT6XS – F2 North Spring 2015**
			

FT6XS – F2 East Autumn 2012	FT6XS – F2 East Autumn 2013	FT6XS – F2 East Autumn 2014	FT6XS – F2 East Autumn 2015
Not monitored			
FT6XS – F2 East Spring 2012	**FT6XS – F2 East Spring 2013**	**FT6XS – F2 East Spring 2014**	**FT6XS – F2 East Spring 2015**
			

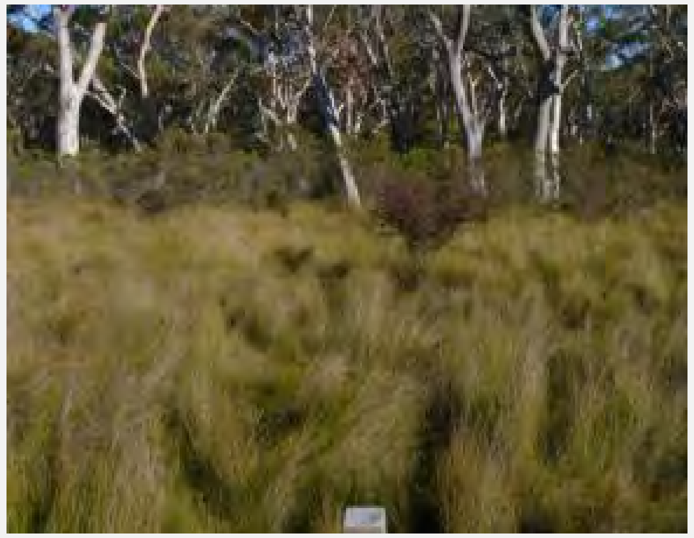
FT6XS – F2 South Autumn 2012	FT6XS – F2 South Autumn 2013	FT6XS – F2 South Autumn 2014	FT6XS – F2 South Autumn 2015
Not monitored			
FT6XS – F2 South Spring 2012	**FT6XS – F2 South Spring 2013**	**FT6XS – F2 South Spring 2014**	**FT6XS – F2 South Spring 2015**
			

FT6XS – F2 West Spring 2012	FT6XS – F2 West Autumn 2013	FT6XS – F2 West Autumn 2014	FT6XS – F2 West Autumn 2015
Not monitored			
FT6XS – F2 West Spring 2012	**FT6XS – F2 West Spring 2013**	**FT6XS – F2 West Spring 2014**	**FT6XS – F2 West Spring 2015**
			

FT6XS – F3 North Autumn 2012	FT6XS – F3 North Autumn 2013	FT6XS – F3 North Autumn 2014	FT6XS – F3 North Autumn 2015
Not monitored			
FT6XS – F3 North Spring 2012	**FT6XS – F3 North Spring 2013**	**FT6XS – F3 North Spring 2014**	**FT6XS – F3 North Spring 2015**
			

FT6XS – F3 East Autumn 2012	FT6XS – F3 East Autumn 2013	FT6XS – F3 East Autumn 2014	FT6XS – F3 East Autumn 2015
Not monitored			
FT6XS – F3 East Spring 2012	**FT6XS – F3 East Spring 2013**	**FT6XS – F3 East Spring 2014**	**FT6XS – F3 East Spring 2015**
			

FT6XS – F3 South Autumn 2012	FT6XS – F3 South Autumn 2013	FT6XS – F3 South Autumn 2014	FT6XS – F3 South Autumn 2015
Not monitored			
FT6XS – F3 South Spring 2012	**FT6XS – F3 South Spring 2013**	**FT6XS – F3 South Spring 2014**	**FT6XS – F3 South Spring 2015**
			

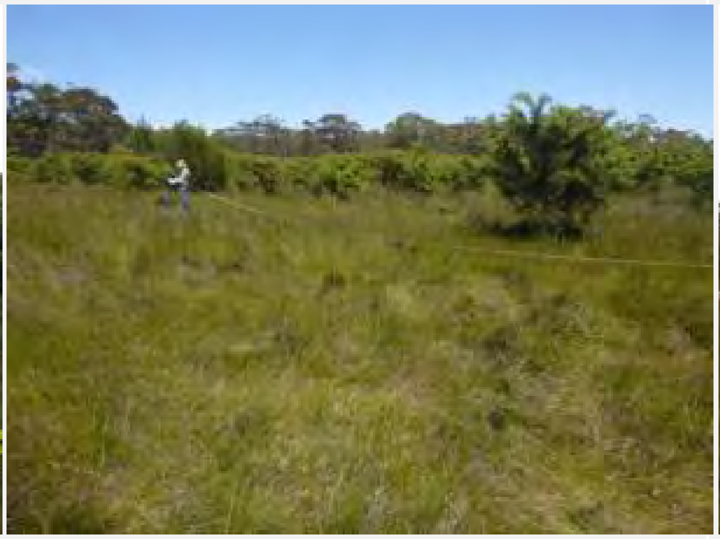
FT6XS – F3 West Autumn 2012	FT6XS – F3 West Autumn 2013	FT6XS – F3 West Autumn 2014	FT6XS – F3 West Autumn 2015
Not monitored			
FT6XS – F3 West Spring 2012	**FT6XS – F3 West Spring 2013**	**FT6XS – F3 West Spring 2014**	**FT6XS – F3 West Spring 2015**
			

FT15ES – F1 North Autumn 2012	FT15ES – F1 North Autumn 2013	FT15ES – F1 North Autumn 2014	FT15ES – F1 North Autumn 2015
Not monitored			
FT15ES – F1 North Spring 2012	**FT15ES – F1 North Spring 2013**	**FT15ES – F1 North Spring 2014**	**FT15ES – F1 North Spring 2015**
			

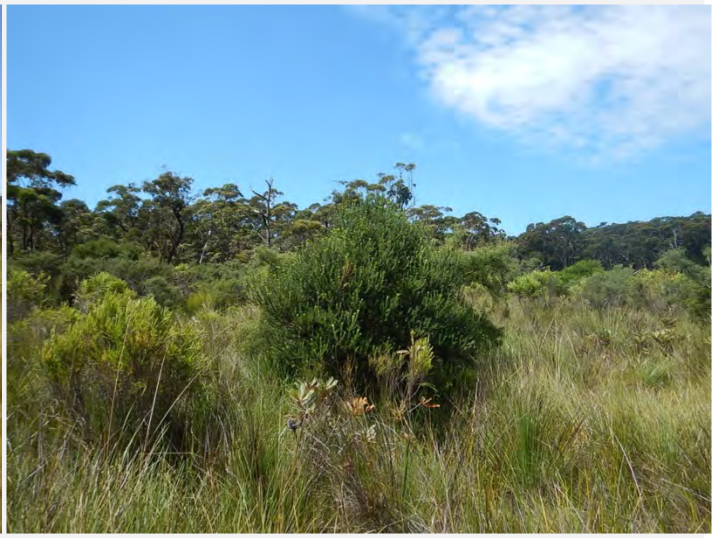
FT15ES – F1 East Autumn 2012	FT15ES – F1 East Autumn 2013	FT15ES – F1 East Autumn 2014	FT15ES – F1 East Autumn 2015
Not monitored			
FT15ES – F1 East Spring 2012	**FT15ES – F1 East Spring 2013**	**FT15ES – F1 East Spring 2014**	**FT15ES – F1 East Spring 2014**
			

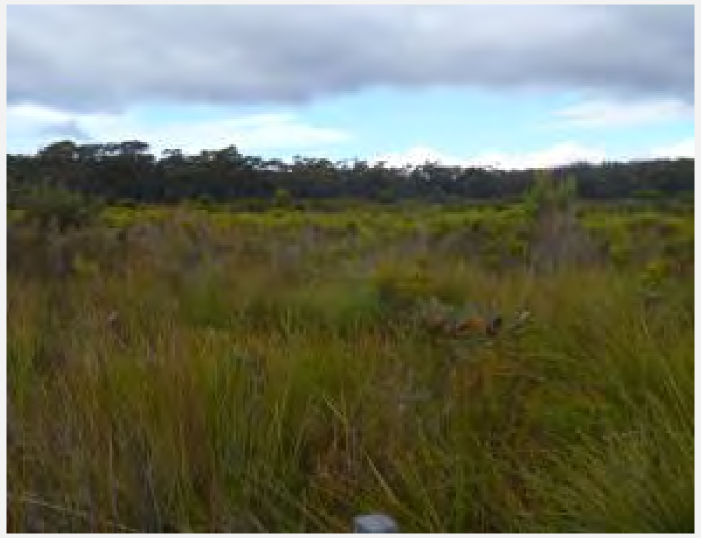
FT15ES – F1 South Autumn 2012	FT15ES – F1 South Autumn 2013	FT15ES – F1 South Autumn 2014	FT15ES – F1 South Autumn 2015
Not monitored			

FT15ES – F1 South Spring 2012	FT15ES – F1 South Spring 2013	FT15ES – F1 South Spring 2014	FT15ES – F1 South Spring 2015
			

FT15ES – F1 West Autumn 2012	FT15ES – F1 West Autumn 2013	FT15ES – F1 West Autumn 2014	FT15ES – F1 West Autumn 2015
Not monitored			
FT15ES – F1 West Spring 2012	**FT15ES – F1 West Spring 2013**	**FT15ES – F1 West Spring 2014**	**FT15ES – F1 West Spring 2015**
			

FT15ES – F2 North Autumn 2012	FT15ES – F2 North Autumn 2013	FT15ES – F2 North Autumn 2014	FT15ES – F2 North Autumn 2015
Not monitored			
FT15ES – F2 North Spring 2012	**FT15ES – F2 North Spring 2013**	**FT15ES – F2 North Spring 2014**	**FT15ES – F2 North Spring 2015**
			

FT15ES – F2 East Autumn 2012	FT15ES – F2 East Autumn 2013	FT15ES – F2 East Autumn 2014	FT15ES – F2 East Autumn 2015
			
FT15ES – F2 East Spring 2012	**FT15ES – F2 East Spring 2013**	**FT15ES – F2 East Spring 2014**	**FT15ES – F2 East Spring 2015**
			

FT15ES – F2 South Autumn 2012	FT15ES – F2 South Autumn 2013	FT15ES – F2 South Autumn 2014	FT15ES – F2 South Autumn 2015
Not monitored			
FT15ES – F2 South Spring 2012	**FT15ES – F2 South Spring 2013**	**FT15ES – F2 South Spring 2014**	**FT15ES – F2 South Spring 2015**
			

FT15ES – F2 West Autumn 2012	FT15ES – F2 West Autumn 2013	FT15ES – F2 West Autumn 2014	FT15ES – F2 West Autumn 2015
Not monitored			
FT15ES – F2 West Spring 2012	**FT15ES – F2 West Spring 2013**	**FT15ES – F2 West Spring 2014**	**FT15ES – F2 West Spring 2015**
			

FT15ES – F3 North Autumn 2012	FT15ES – F3 North Autumn 2013	FT15ES – F3 North Autumn 2014	FT15ES – F3 North Autumn 2015
Not monitored			
FT15ES – F3 North Spring 2012	**FT15ES – F3 North Spring 2013**	**FT15ES – F3 North Spring 2014**	**FT15ES – F3 North Spring 2015**
			

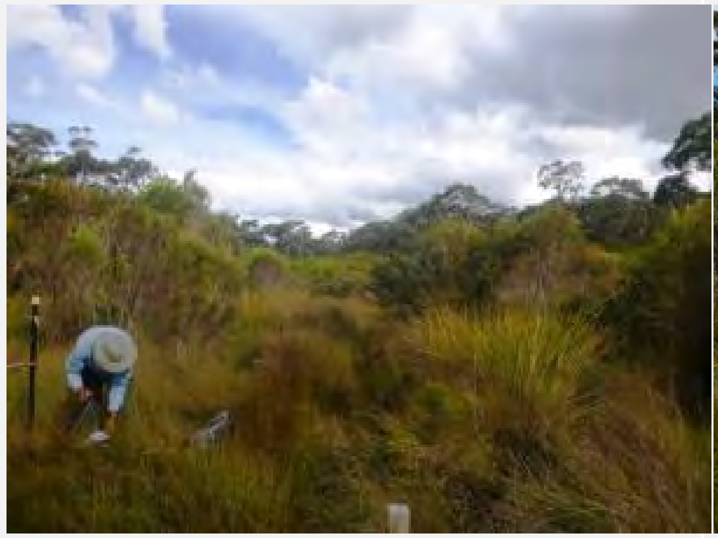
FT15ES – F3 East Autumn 2012	FT15ES – F3 East Autumn 2013	FT15ES – F3 East Autumn 2014	FT15ES – F3 East Autumn 2015
Not monitored			
FT15ES – F3 East Spring 2012	**FT15ES – F3 East Spring 2013**	**FT15ES – F3 East Spring 2014**	**FT15ES – F3 East Spring 2015**
			

FT15ES – F3 South Autumn 2012	FT15ES – F3 South Autumn 2013	FT15ES – F3 South Autumn 2014	FT15ES – F3 South Autumn 2015
Not monitored			
FT15ES – F3 South Spring 2012	**FT15ES – F3 South Spring 2013**	**FT15ES – F3 South Spring 2014**	**FT15ES – F3 South Spring 2015**
			

FT15ES – F3 West Autumn 2012	FT15ES – F3 West Autumn 2013	FT15ES – F3 West Autumn 2014	FT15ES – F3 West Autumn 2015
Not monitored			
FT15ES – F3 West Spring 2012	**FT15ES – F3 West Spring 2013**	**FT15ES – F3 West Spring 2014**	**FT15ES – F3 West Spring 2015**
			

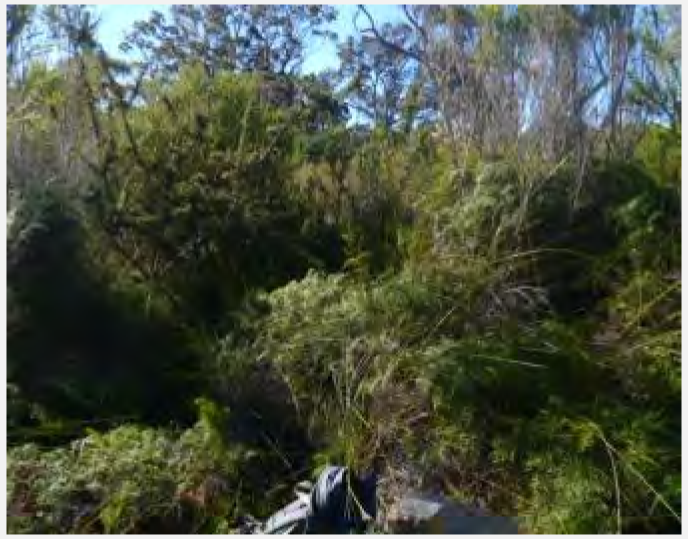
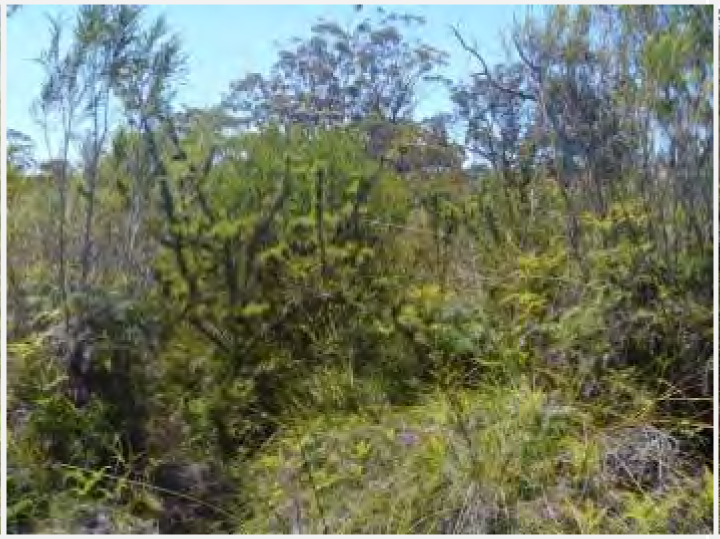
GCS – F1 North Autumn 2012	GCS – F1 North Autumn 2013	GCS – F1 North Autumn 2014	GCS – F1 North Autumn 2015
Not monitored			
GCS – F1 North Spring 2012	**GCS – F1 North Spring 2013**	**GCS – F1 North Spring 2014**	**GCS – F1 North Spring 2015**
			

GCS – F1 East Autumn 2012	GCS – F1 East Autumn 2013	GCS – F1 East Autumn 2014	GCS – F1 East Autumn 2015
Not monitored			
GCS – F1 East Spring 2012	**GCS – F1 East Spring 2013**	**GCS – F1 East Spring 2014**	**GCS – F1 East Spring 2015**
			

GCS – F1 South Autumn 2012	GCS – F1 South Autumn 2013	GCS – F1 South Autumn 2014	GCS – F1 South Autumn 2015
Not monitored			
GCS – F1 South Spring 2012	**GCS – F1 South Spring 2013**	**GCS – F1 South Spring 2014**	**GCS – F1 South Spring 2015**
			

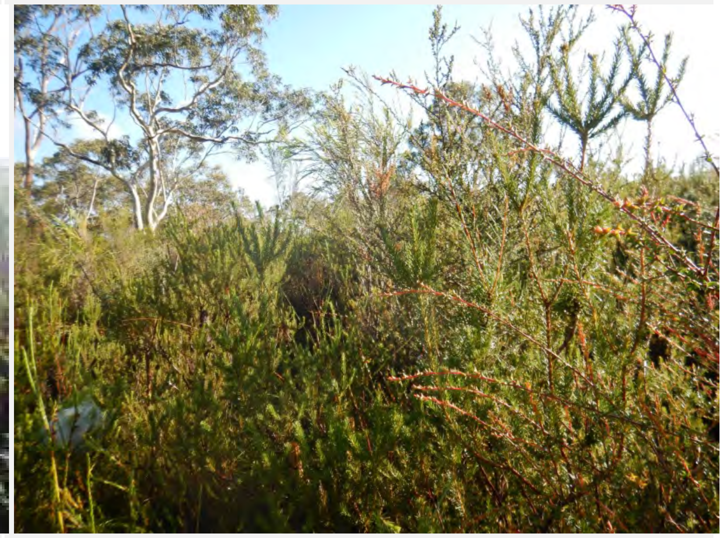
GCS – F1 West Autumn 2012	GCS – F1 West Autumn 2013	GCS – F1 West Autumn 2014	GCS – F1 West Autumn 2015
			
GCS – F1 West Spring 2012	**GCS – F1 West Spring 2013**	**GCS – F1 West Spring 2014**	**GCS – F1 West Spring 2015**
			

GCS – F2 North Autumn 2012	GCS – F2 North Autumn 2013	GCS – F2 North Autumn 2014	GCS – F2 North Autumn 2015
Not monitored			
GCS – F2 North Spring 2012	**GCS – F2 North Spring 2013**	**GCS – F2 North Spring 2014**	**GCS – F2 North Spring 2015**
			

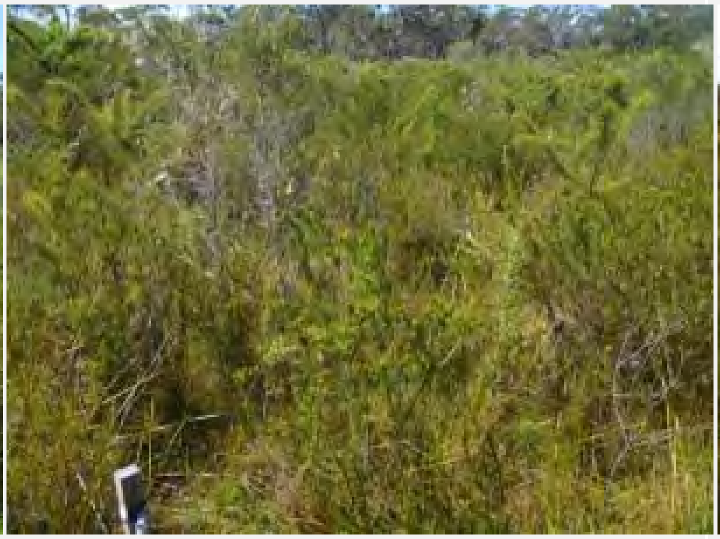
GCS – F2 East Autumn 2012	GCS – F2 East Autumn 2013	GCS – F2 East Autumn 2014	GCS – F2 East Autumn 2015
			
GCS – F2 East Spring 2012	**GCS – F2 East Spring 2013**	**GCS – F2 East Spring 2014**	**GCS – F2 East Spring 2015**
			

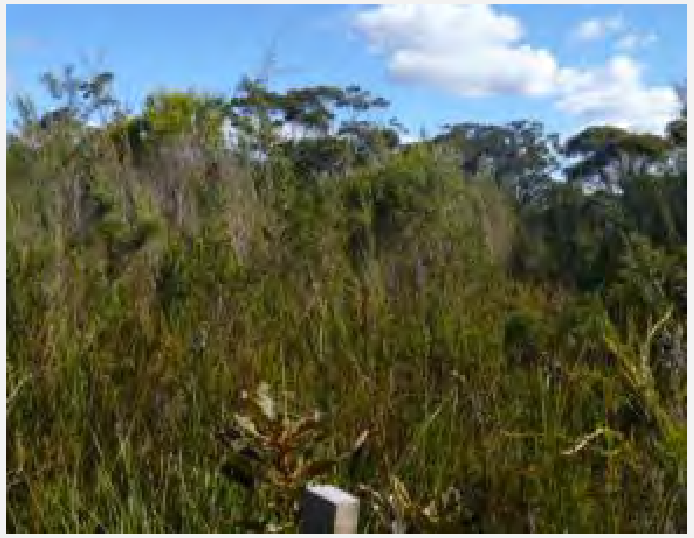
GCS – F2 South Autumn 2012	GCS – F2 South Autumn 2013	GCS – F2 South Autumn 2014	GCS – F2 South Autumn 2015
Not monitored			
GCS – F2 South Spring 2012	**GCS – F2 South Spring 2013**	**GCS – F2 South Spring 2014**	**GCS – F2 South Spring 2015**
			

GCS – F2 West Autumn 2012	GCS – F2 West Autumn 2013	GCS – F2 West Autumn 2014	GCS – F2 West Autumn 2015
Not monitored			
GCS – F2 West Spring 2012	**GCS – F2 West Spring 2013**	**GCS – F2 West Spring 2014**	**GCS – F2 West Spring 2015**
			

GCS – F3 North Autumn 2012	GCS – F3 North Autumn 2013	GCS – F3 North Autumn 2014	GCS – F3 North Autumn 2015
Not monitored			
GCS – F3 North Spring 2012	**GCS – F3 North Spring 2013**	**GCS – F3 North Spring 2014**	**GCS – F3 North Spring 2015**
			

GCS – F3 East Autumn 2012	GCS – F3 East Autumn 2013	GCS – F3 East Autumn 2014	GCS – F3 East Autumn 2015
Not monitored			
GCS – F3 East Spring 2012	**GCS – F3 East Spring 2013**	**GCS – F3 East Spring 2014**	**GCS – F3 East Spring 2015**
			

GCS – F3 South Autumn 2013	GCS – F3 South Autumn 2013	GCS – F3 South Autumn 2014	GCS – F3 South Autumn 2015
Not monitored			
GCS – F3 South Spring 2012	**GCS – F3 South Spring 2013**	**GCS – F3 South Spring 2014**	**GCS – F3 South Spring 2015**
			

GCS – F3 West Autumn 2012	GCS – F3 West Autumn 2013	GCS – F3 West Autumn 2014	GCS – F3 West Autumn 2015
Not monitored			
GCS – F3 West Spring 2012	**GCS – F3 West Spring 2013**	**GCS – F3 West Spring 2014**	**GCS – F3 West Spring 2015**