Dendrobium Areas 2, 3A and 3B Terrestrial Ecology Monitoring Program Annual Report for 2017

FINAL REPORT

Prepared for Illawarra Coal

28 June 2018

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Biosis project no.:	24467, 24468, 24469 and 24781
File name:	24468.Dendrobium.Area.SharedControl.3A.3B.FFM.Annual.Report.2017.FIN.20180607

Citation: Biosis 2018. Dendrobium Terrestrial Ecology Monitoring Program Annual Report for 2017. Report for Illawarra Coal. Authors: Cable T, McCann S, Klein B & Stone L. Biosis Pty Ltd, Wollongong. Project nos. 24467, 24468, 24469 and 24781.

Document control

Version	Internal reviewer	Date issued
Draft version 01	Tony Cable	13/04/2018
Draft Version 02	Tony Cable	07/06/2018
Final Version 01	Tony Cable	23/07/2018

Acknowledgements

Biosis acknowledges the contribution of the following people and organisations in undertaking this study:

- Illawarra Coal: Gary Brassington, Ben Davis and Josh Carlon
- The Analytical Edge Statistical Consulting: Dr Joanne Potts

Biosis staff involved in this project were:

- Mathew Misdale and James Lidsey for assistance with fieldwork and data entry.
- Lauren Harley, Lachlan Milne and James Shepherd for spatial data analysis and preparation of maps.

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Summary

This document reports on the Dendrobium Terrestrial Ecology Monitoring Program (the program) required for Dendrobium Area 3A and Dendrobium Area 3B for the 2017 calendar year. Dendrobium Area 2 was not part of the 2017 program as the only site, Swamp 1, is subject to biennial monitoring as per recommendations provided by Biosis previously (2015). The site will be next monitored in 2018. It incorporates the previous 8 to 14 years in Dendrobium Area 3A and the previous 4 years in Dendrobium Area 3B. Monitoring includes a minimum of two years baseline surveys for pre-impact sites within Area 3. Some sites within Area 3B received only one year of baseline survey due to post-approval changes in monitoring requirements. Monitoring of control sites has been occurring for a minimum of three years at Dendrobium Area 3B and a maximum of 11 years at Area 2. Three additional monitoring sites were incorporated into the program for Area 3B; Swamp 14, Swamp 23 and LA2.

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 2017a; 2017b). Conclusions and recommendations for the 2017 program are in Section 4.

During the 2017 monitoring period, Longwall 12 was extracted within Dendrobium Area 3B, which was followed by extraction at Longwall 13 and current extraction at Longwalll 14. This followed Longwall 11 in 2015, 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 physical impacts following mining include lowering of shallow groundwater levels in uplands swamps, increase in the rate of recession of shallow groundwater levels within upland swamps following rainfall 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 3A and Area 3B.
- Littlejohn's Tree Frog *Litoria littlejohni* along selected streams providing suitable habitat in Dendrobium Area 3A and Area 3B.

The program includes monitoring and analysis of seven upland swamp sites as post-mining sites (Swamp 15B (S15B), Swamp 15A(2) (S15A(2)), Swamp 1A (S1A), Swamp 1B (S1B), Swamp 5 (S5), Swamp 11 (S11) and Swamp 13 (S13)). 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.

The results of the TSR analysis demonstrate the response to mining at individual swamps is complex with Swamp 15A(2) and Swamp 15B showing a decline and subsequent increase in TSR following mining and changes in shallow groundwater, and Swamp 1A, Swamp 1B and Swamp 5 showing no significant decline in TSR despite observed changes in shallow groundwater levels.

A significant change in species composition post-mining was found at Swamp 15B and Swamp 15A(2). As with TSR, these changes were observed immediately following undermining and have continued at Swamp 15B and Swamp 15A(2) for at least four years post-mining.

The area of upland swamps decreased relative to the 2014 baseline in 2017 (Figure 12) and across all impact and control swamps assessed, with the exception of Swamp 08 which recorded a marginal increase. The

overall extent of the smaller control swamps (S89, S91, S92 and S93) remained stable over the four year period. Between 2016 and 2017 the extent of each upland swamp, inclusive of control and impact swamps, remained relatively stable with only minor increases and decreases in extent observed across all treatments. To decrease the detection of false detection of changes in swamp extent LiDAR data was assessed based on a differential canopy height of 8 metres, as canopy height of swamp species soften exceeded the previous 5 metre threshold.

Tea Tree Thicket (MU43) vegetation communities recorded the largest decline however this was not found to be significant, but warrants closer investigation in 2018 monitoring and analysis.

There was a decrease in detection of adult Littlejohn's Tree Frog in 2017 compared to 2016 by approximately 32%, and tadpoles by 84%. However, 2016 was an excellent year for breeding due to high levels of rainfall, and frog numbers recorded in 2016 were much higher than previous years. Detection of Littlejohn's Tree Frog in 2017 was comparable to detection in 2015.

The monitoring program will continue to achieve the following four key objectives:

- Ongoing monitoring of biophysical characteristics within Dendrobium Area 2 (to be continued again in 2018) and Dendrobium Area 3A and 3B (and Area 2 in 2018).
- 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 *Flora and Fauna Environmental Management Program (Subsidence)* (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 has continued through to the current 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 Area 2 continues of one upland swamp, however this occurs once every two years. Monitoring within 3A and 3B is ongoing (refer to Section 1.1).

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) of upland swamps and a threatened frog, Littlejohn's Tree Frog *Litoria littlejohni* (Vulnerable EPBC Act and BC Act), within suitable habitats (second and third order streams) throughout the three domains.

The current report includes new monitoring data collected during 2017 and provides an analysis of data collected to date for the program.

1.1 Aims of this report

The aims of this monitoring report are to:

- Describe surveys undertaken in Area 3A and Area 3B during the 2017 monitoring program.
- Discuss results of statistical analysis undertaken for 2017 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.

- Provide an assessment of the results against key performance measures described in relevant management plans.
- Summarise key issues identified during the 2017 monitoring year and how they were addressed.
- Describe future ecological monitoring to be undertaken and proposed improvements to environmental management or performance.

1.2 Study area

Ecological monitoring is undertaken across three broad study areas, all of which are located within the Metropolitan Special Area and Southern Coalfield of New South Wales (Figure 1). The three areas monitored include three mining domains (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 of 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. 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 are used to identify the sections of these transects that have been impacted.

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

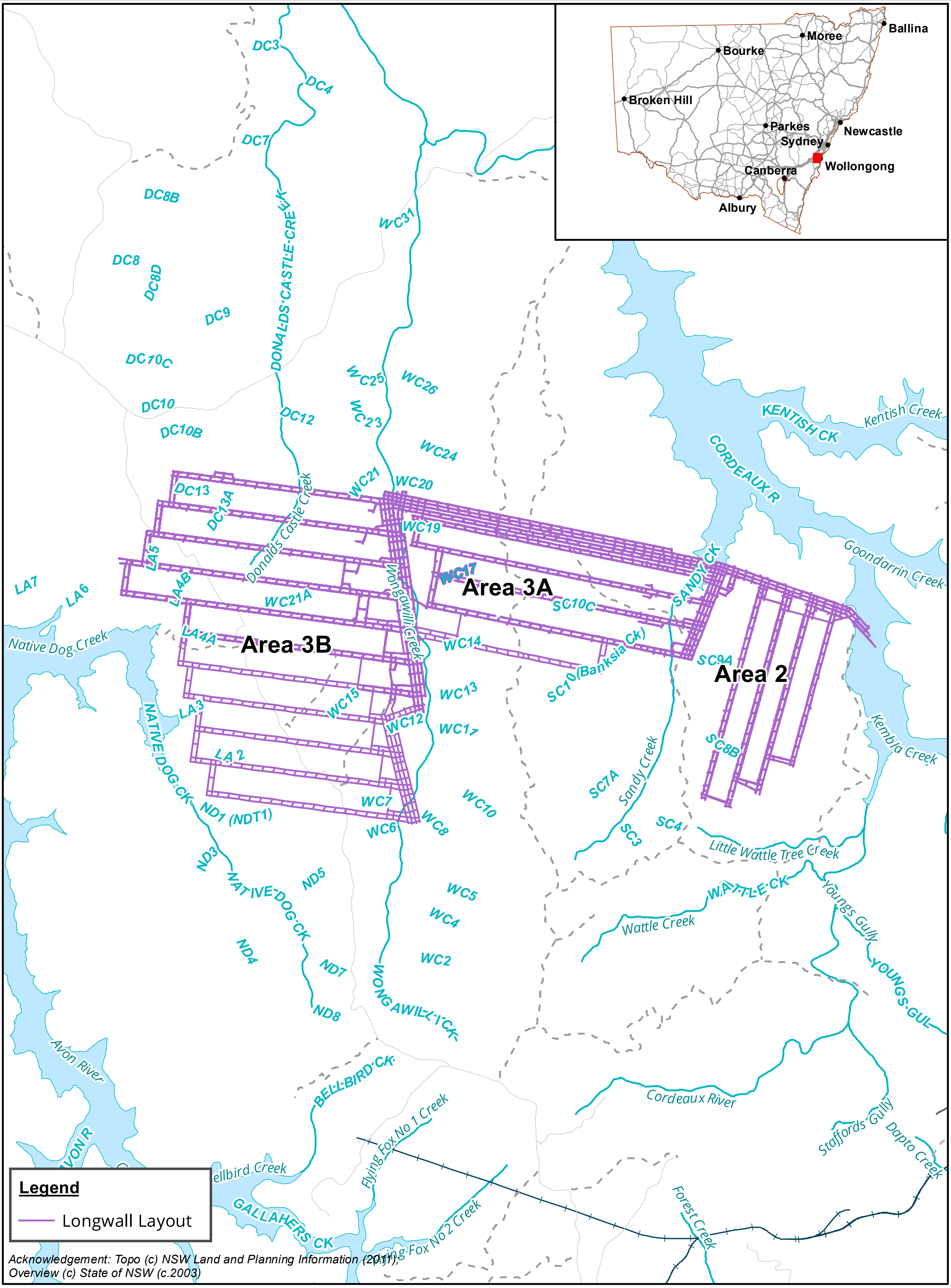

Figure 1: Location of the study area in a regional context

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Biosis Pty Ltd
Ballarat, Brisbane, Canberra, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

Matter: 20489/20490/20491/22692/24468
Date: 11 April 2018,
Checked by: LS, Drawn by: JMS, Last edited by: jshepherd
Location:P:\24400s\24468\Mapping\24468_AR_F1_Locality

0 1 2
Kilometers
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Scale 1:55,000 @ A4, GDA 1994 MGA Zone 56

1.2.1 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.

Natural features monitored as a part of this program include two upland swamps; Swamp 1 and Swamp 6. Given that no impacts to Swamp 6 were observed following three years of post-mining impact monitoring, this site 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, Swamp 1, that has been directly mined beneath continues to be monitored biennially (every second year) as a part of this program. This site was monitored in 2016, therefore was not included in the program for 2017.

1.2.2 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, Swamp 15A(2) and Swamp 15B and five threatened frog monitoring transects across four creeks (Figure 2). Swamp 15A(2) is located at the eastern end of the proposed Longwall 19 of Dendrobium Area 3A. The downstream end of Swamp 15A(2) has had mining within the RMZ, and as such the whole of swamp 15A(2) is considered to be potentially subject to the associated impacts.

Monitoring of Littlejohn's Tree Frog transects is undertaken at five locations in four creeks located within Dendrobium Area 3A during winter; 6CDL, SC10 (two sections), SC10C and WC17 (Figure 2). As a result of impacts to SC10C and WC17 observed for consecutive years in 2015 and 2016, monitoring of streams within Dendrobium Area 3A continued in 2017.

1.2.3 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 2017. Monitoring in Dendrobium Area 3B is conducted using a staged approach whereby monitoring sites are added to the program at least two years prior to longwall mining within the RMZ of a site to enable collection of adequate baseline data.

Natural features currently monitored as a part of this program in 2017 includes seven upland swamps (Swamp 1A, Swamp 1B, Swamp 5, Swamp 11, Swamp 13, Swamp 14 and Swamp 23). Two sites, Swamp 14 and Swamp 23 were added to the program in 2017 to commence pre-mining baseline monitoring. In March 2017, the RMZ of Swamp 11 was mined beneath by Longwall 13. In 2017, the RMZ of Swamp 13 was mined beneath by Longwall 13 and is expected to be mined beneath by Longwall 14 during 2018 (Figure 3). Swamp 11 and Swamp 13 have therefore been included in the impact assessment of the 2017 program.

During 2017 a total of six creeks were monitored for threatened species as part of the Dendrobium Area 3B program; continued monitoring at DC(1), DC13, LA4A, WC15, WC21 as well as the addition of LA2 to the program to commence two years of pre-mine baseline monitoring (Figure 3).

1.2.4 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 three upland swamps, Swamp 15A(1), Swamp 22 and Swamp 33 (Figure 4).

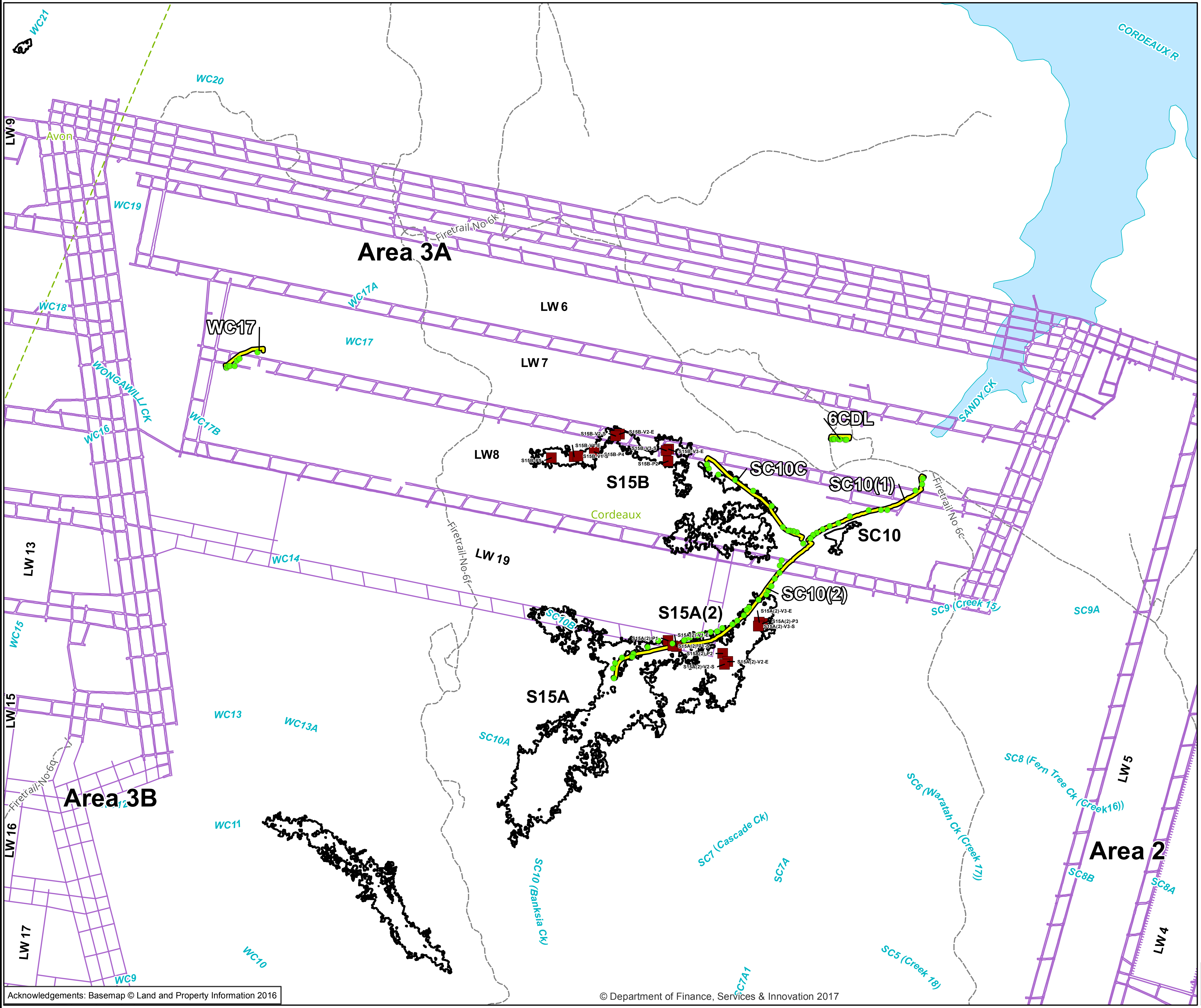
There are three additional control swamps monitored specifically for the Dendrobium Area 3B program (Swamp 88 (previously named Gallahers Creek Swamp), Swamp 87 (previously named FT15E Swamp) and Swamp 86 (previously named FT6X Swamp). These sites were established to ensure an even mix of impact and control sites in the BACI experimental design.

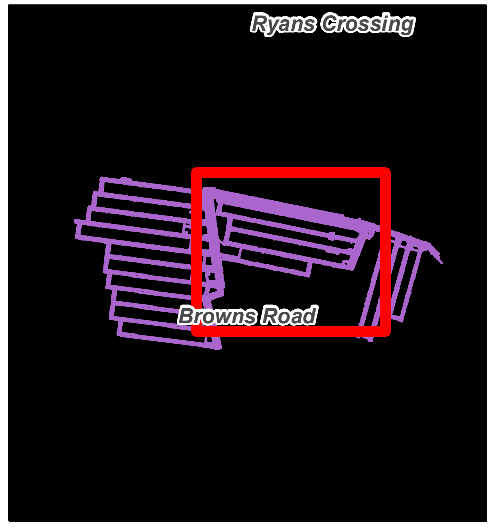
Ten control sites are surveyed as part of the Littlejohn's Tree Frog monitoring program including SC7 (two transects), SC7A, SC8, WC10, WC11, SC6, DC8, NDC, ND1 and ND2 (Figure 5).

1.3 Survey sites and monitoring periods

Sites originally proposed by Illawarra Coal for the monitoring program have been included to collect at least two years pre-mining data. Additional monitoring sites were established closer to the mining period to comply with the requirements of approval conditions and in some cases do not provide two years of pre-mining data.

A summary of all impact sites and corresponding control sites has been provided in Figure 2.





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)

Figure 2: Location of 2017 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

N

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Matter: 20489/20490/20491/22692
Date: 13 April 2018,
Checked by: CVF, Drawn by: LH, Last edited by: lharley
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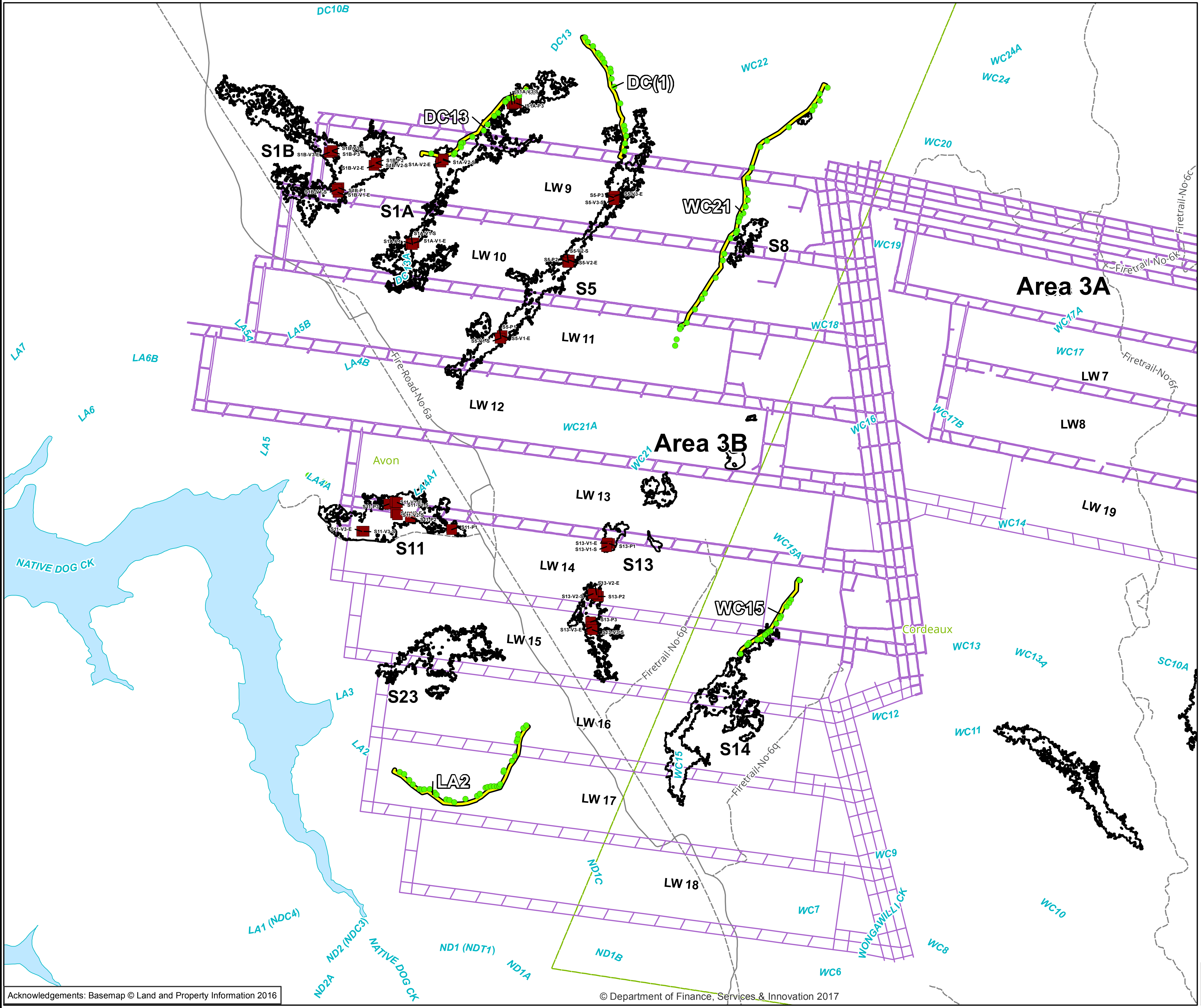

Legend

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)

Figure 3: Location of 2017 monitoring impact sites surveyed in Dendrobium Area 3B

0 200 400 600 800

Metres

Scale: 1:16,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 20489/20490/20491/22692/24468
Date: 13 April 2018,
Checked by: LS, Drawn by: JMS, Last edited by: lharley
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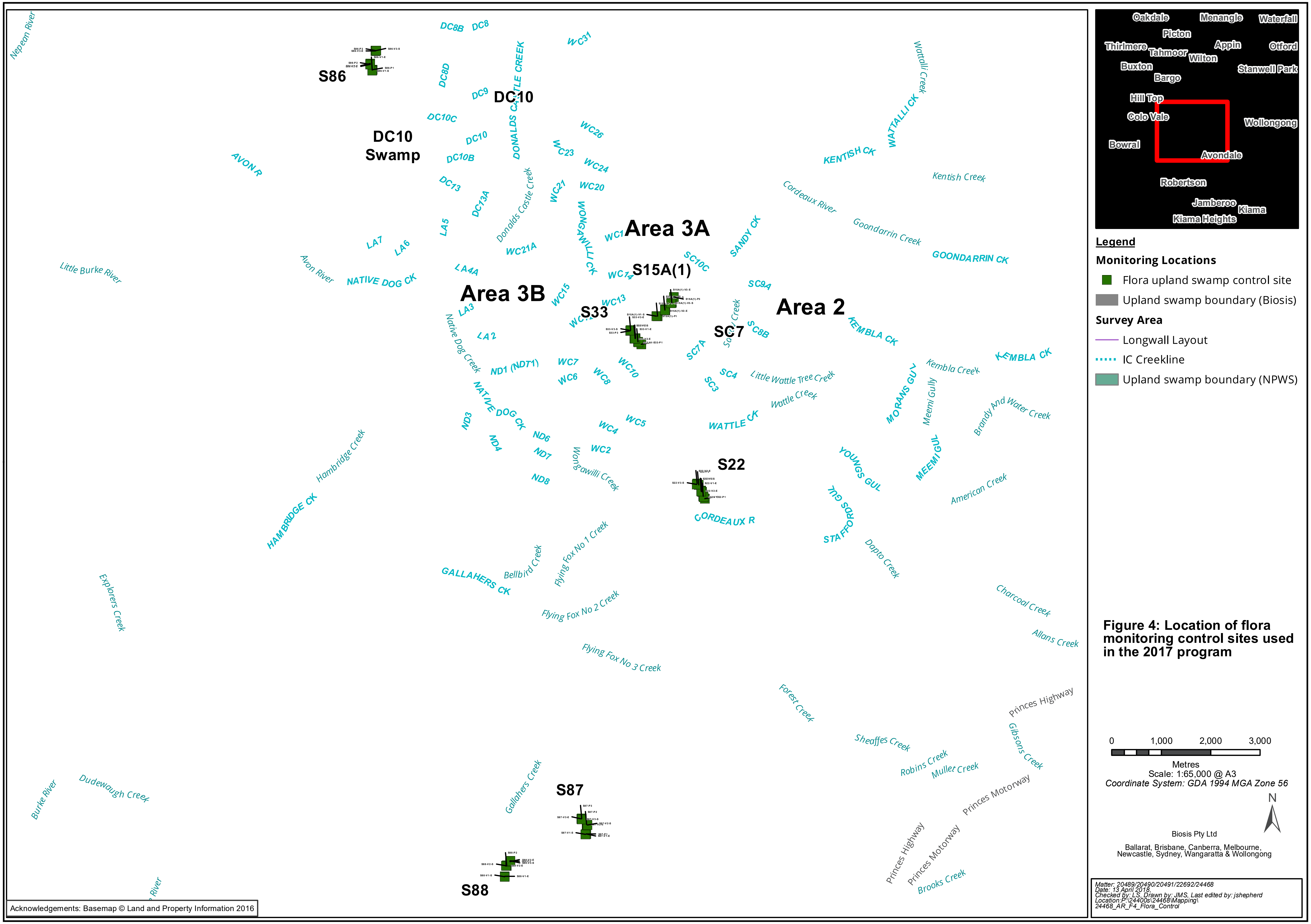
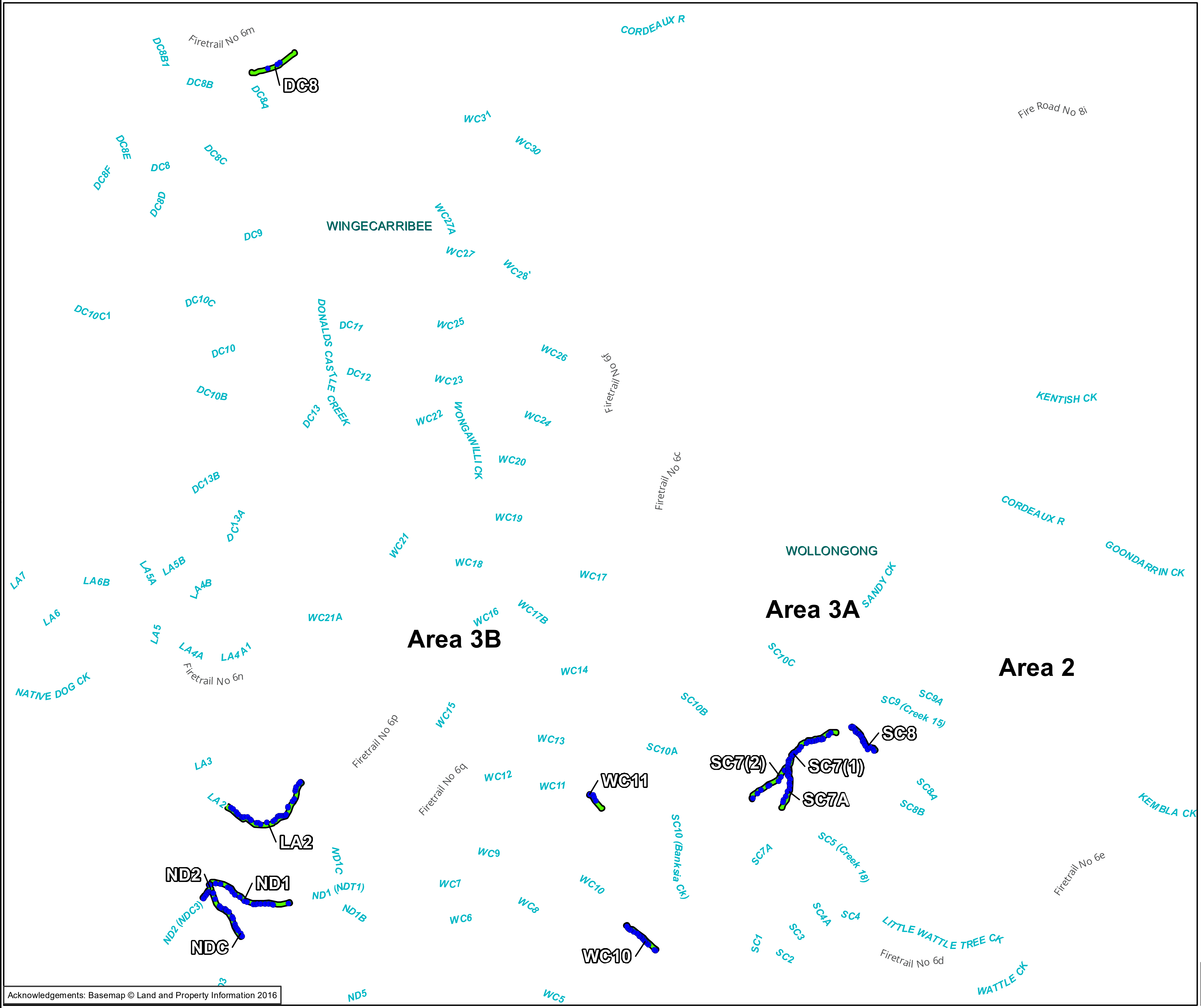
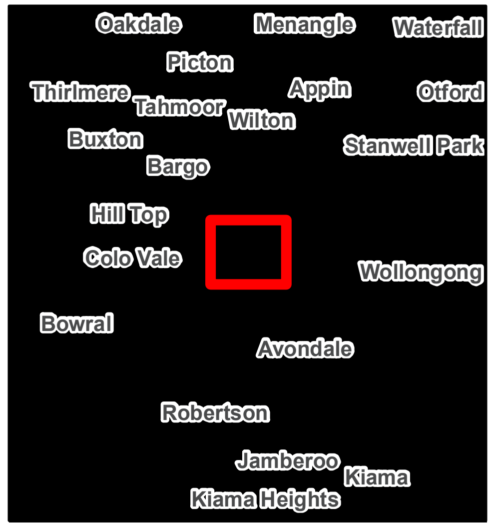


Figure 4: Location of flora monitoring control sites used in the 2017 program





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 5: Location of threatened frog monitoring control transects used in the 2017 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: 20489/20490/20491/22692/24468
Date: 13 April 2018,
Checked by: LS, Drawn by: JMS, Last edited by: jshepherd
Location:P:\24400s\24468\Mapping
24468_AR_F5_TFM_Control

Table 1 Summary of monitoring sites

Area	Impact site	Monitoring commenced	Mining progress		Control sites
Vegetation monitoring					
Dendrobium Area 3A	S15B (Swamp 15B)	2003	Within mining RMZ: • 18/09/2010	Mined beneath: • 25/08/2012	S15A(1) (Swamp 15A(1)) S11 (Swamp 11)
	S15A (2) (Swamp 15A(2))	2009	Within mining RMZ: • 20/10/2012	Mined beneath: • All points beyond goaf	S15A(1) (Swamp 15A(1)) S33 (Swamp 33) S22 (Swamp 22)
Dendrobium Area 3B	S1A (Swamp 1A)	2012	Within mining RMZ: • 23/02/2013	Mined beneath: • 11/04/2013	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
	S1B (Swamp 1B)	2005-2009, then 2012-present	Within mining RMZ: • 08/02/2013	Mined beneath: • 13/02/2013	S86 (Swamp 86) S87 (Swamp 87) S15A(1) (Swamp 15A(1)) S22 (Swamp 22) S33 (Swamp 33)
	S5 (Swamp 5)	2012	Within mining RMZ: • 18/05/2013	Mined beneath: • 25/07/2013	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
	S11	2003	Within mining RMZ: • 21/05/2016	Mined beneath: • beyond goaf • Predicted Longwall 14	S15A(1) (Swamp 15A(1)) S22 (Swamp 22) S33 (Swamp 33)

Area	Impact site	Monitoring commenced	Mining progress		Control sites
	S13 (Swamp 13)	2013 (spring only)	Within mining RMZ: • 10/07/2017	Mined beneath: • Predicted Longwall 14 • Predicted Longwall 15	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
	S14	2017	Within mining RMZ: • Predicted Longwall 17 • Predicted Longwall 16 • Predicted Longwall 15	Mined beneath: • Predicted Longwall 17 • Predicted Longwall 16 • Predicted Longwall 15	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))
	S23	2017	Within mining RMZ: • Predicted Longwall 15	Mined beneath: • Predicted Longwall 15	S86 (Swamp 86) S87 (Swamp 87) S88 (Swamp 88) S15A(1) (Swamp 15A(1))

Area	Impact site	Monitoring commenced	Mining progress		Control sites
Threatened frog breeding habitat monitoring					
Dendrobium Area 3A	SC10(1)	2006	Within mining RMZ: • End November 2011	Mined beneath: • All pools beyond goaf	SC6 (Waratah Creek) SC7(1) SC7A
	SC10(2)	2006	Within mining RMZ: • End November 2011	Mined beneath: • Predicted Longwall 19	NDC (Native Dog Creek) SC6 (Waratah Creek) SC7(1) SC7A
	SC10C	2006	Within mining RMZ: • End October 2010	Mined beneath: • End October 2012	SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7A
	6CDL	2009	Within mining RMZ: • 5 Dec 2010	Mined beneath: • All pools beyond goaf	ND2 SC6 (Waratah Creek) SC7(2) (Cascade Creek) SC8 (Fern Tree Creek)
	WC17	2011	Within mining RMZ: • March 2010	Mined beneath: • 26 Apr 2011	NDC (Native Dog Creek) ND1 SC6 (Waratah Creek) SC8 (Fern Tree Creek) WC10 (Easement Creek) WC11

Area	Impact site	Monitoring commenced	Mining progress		Control sites
Dendrobium Area 3B	DC (1) (Donald's Castle Creek)	2013	Within mining RMZ: • 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: • 21 February 2013	Mined beneath: • End March 2013	SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7(2) (Cascade Creek) SC7A SC8 (Fern Tree Creek)
	LA4A (Downstream of DA3B)	2007	Within mining RMZ: • 31 March 2016	Mined beneath: • All pools beyond goaf	ND1 SC6 (Waratah Creek) SC7(2) (Cascade Creek) SC8 (Fern Tree Creek)
	WC15	2011	Within mining RMZ: • Longwall 14	Mined beneath: • Predicted Longwall 14 • Predicted Longwall 15	DC8 NDC (Native Dog Creek) SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7A SC8 (Fern Tree Creek)

Area	Impact site	Monitoring commenced	Mining progress		Control sites
	WC21	2013	Within mining RMZ: • 27 October 2013	Mined beneath: • 21 December 2013	DC8 SC6 (Waratah Creek) SC7(1) (Cascade Creek) SC7(2) (Cascade Creek) SC7A SC8 (Fern Tree Creek) WC10 (Easement Creek) WC11
	LA2	2017	Within mining RMZ:	Mined beneath:	

2 Methods

The baseline survey methodology, results of the statistical analysis and revised survey methodologies are detailed in previous Biosis annual monitoring reports (Biosis 2005, 2007a, 2007b, 2010, 2013a, 2013b, 2014, 2015a, 2016 and 2017). 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 with consideration of state and federal survey guidelines, particularly as they apply to Littlejohn's Tree Frog. This is described further in Section 2.1.2.

Table 2 Summary of survey methodology

Survey type	Area	Timing
Upland swamp vegetation monitoring	Dendrobium Area 3A Dendrobium Area 3B	Vegetation survey once in autumn and once in spring each year.
Upland swamp vegetation extent LiDAR analysis	Dendrobium Area 3A Dendrobium Area 3B	Annual LiDAR data collection and analysis.
Littlejohn's Tree Frog breeding habitat monitoring	Dendrobium Area 3A Dendrobium Area 3B	Once in winter each year.
Photo-point monitoring	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

The following sections describe the field and data collection methodology completed to assess the following components of the Dendrobium Area 3B Swamp Monitoring TARP:

- *Terrestrial flora – ecosystem functionality*
- *Terrestrial flora – composition and distribution of species*

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 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 Littlejohn's Tree Frog monitoring

Littlejohn's Tree Frog is listed as Vulnerable under the NSW Biodiversity Conservation Act 2016 (BC 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 3A and Dendrobium Area 3B.

Targeted surveys for Littlejohn's Tree Frog are undertaken annually from mid-winter to early spring, when the species is breeding (and thus calling), and is therefore most detectable. The aims of the targeted surveys are to monitor known locations of this threatened frog species within Dendrobium impact areas, in order to detect any changes in abundance and breeding of individuals or condition of habitat following mining, and to monitor associated non-impacted (control) sites within the Dendrobium area in order to compare impact site data against natural fluctuations in local Littlejohn's Tree Frog populations. Survey sites are detailed in Table 1.

Transects have been established in breeding habitat (along a stream) within each site to create repeatable survey effort, and enable 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 allow comparison of frog abundance pre- and post-mining. Transects are surveyed at night to determine the presence of adult frogs, tadpoles and egg masses. Transects are surveyed by walking slowly down the stream line, and counting all amphibians seen or heard on either side of the line. Any tadpoles or egg masses located during the survey are also recorded. The location of any individuals detected during the targeted nocturnal surveys or any other significant incidental sightings are recorded using a GPS. Sites are surveyed once each year, or are repeated if climatic conditions result in a lack of detection of the target species. Opportunistic sightings, including threatened species such as the Giant Burrowing Frog are also documented when surveying for Littlejohn's Tree Frog.

2.1.3 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. At a minimum, photo-point monitoring tables in Appendix 2 show spring and autumn photos from a pre-mining monitoring year, a central monitoring year, the year prior to the current reporting year and the current reporting year.

All photos from all seasons and years are reviewed as part of our analysis to directly compare habitat condition. An interpretation of the photo-point monitoring is provided in Section 3.1.

2.2 Literature review

Illawarra Coal monitors a variety of features located above 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 3.4.1. 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 assessment.

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 paired to impact sites based on similarity, as assessed in the field on the basis of presence of similar upland swamp vegetation sub-communities and other relevant variables.

Sites are 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 entered into a database and validated prior to analysis. Control sites chosen for impact sites were selected on similarity of ecological features and habitat characteristics in the field.

The Analytical Edge Statistical Consulting Pty Ltd was commissioned by Biosis to undertake statistical analyses of vegetation collected at upland swamps (TAE 2018a; TAE 2018b). 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

Mining-induced 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 by impacts than others. In affected areas, these impacts may manifest as the following:

- Change in floristic Total Species Richness (TSR): the number of individual species, calculated by the total number of unique species detected at each monitoring transect 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 of different individual plant species that make up a vegetation community.

These indicators are described in further detail (Section 2.3.3).

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 detection rates, measured as the number of adults, tadpoles and egg masses detected along the monitoring reach. To standardise the varying lengths of survey reaches, the total number of each life stage is divided by the number of 100 metre sections within the survey reach. This equates to a Catch-per-unit-of-effort (CPUE) and is presented as *n*/100 m.

Changes in upland swamp TSR and floristic composition and Littlejohn’s Tree Frog detection rates may be due to mining impacts or unrelated landscape effects; for example local climatic variation, 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.

In BACI studies, the aim is to assess whether any trend in the response variable (e.g. swamp extent, total species richness, species composition or abundance) at sites that have been directly impacted (e.g., mining) differs after impact to that measured before and also differs to any global trend (i.e. trends observed at control sites that did not experience an impact). Potential outcomes in this survey design are numerous with trends potentially occurring suddenly as a pulse event, or as is more likely, gradually over time.

2.3.3 Data analysis procedure

Biosis commissioned The Analytical Edge Statistical Consulting to undertake a review of the statistical analysis and data collection methodology following the completion of the 2017 program to assist in providing a robust, statistically valid and quantitative assessment against the relevant TARPs.

The following methodology was designed and applied to the Dendrobium dataset by The Analytical Edge Statistical Consulting (2018a; 2018b) in consultation with Biosis ecologists.

Vegetation data analysis

TSR was calculated for swamp sites as the sum of individual taxa detected at each transect for each survey. Exploratory data analysis included plotting TSR for all sites grouped by mining status; 'control or pre-mining', 'post-mining (within RMZ)' or 'post-mining (mined beneath)' for each survey year. Such groupings 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 for each swamp were also plotted individually.

Differences in TSR between sites and years was first explored using box plots, which allow visual comparison of the variation and distribution of TSR about the mean and median TSR values.

To test whether trends detected visually represent statistically relevant changes in TSR and species composition, *t*-tests were applied to Level 1, 2 and 3 triggers for all impact sites; whereby two-, three-, and four-consecutive year periods, respectively, after impact were compared to TSR at paired control swamps and to the TSR before impacts. *t*-tests analysed the influence of year and mining status (pre, post or mined beneath) on TSR. Incorporating the year factor allows for identification of long-term trends in time across all sites. Mining status is a key factor of the analysis and indicates whether observed trends differ at sites were mining does and does not occur.

All modelling and the creation of graphs was completed in the statistical software program R by The Analytical Edge Statistical Consulting (2018a; 2018b).

Flora data were also 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 (which otherwise violates 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). 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. Level 1, 2 and 3 triggers were investigated by fitting the multivariate model and sub-setting data accordingly, whereby 2-, 3-, and 4- consecutive year periods were analysed post-impact, for the Level 1, 2 and 3 TARPs, respectively.

In a standard BACI study, where monitoring is conducted across many years prior to, and after the impact event, at both the impact and paired control sites, the aim would be to determine if there is any significant interaction between site (control:impact) and time (before:after) which would suggest the trend before the impact event (i.e. mining) at the impact site is different to after the impact event.

To address the specific requirements of the Dendrobium TARPs, Biosis completed multiple testing at the 2-year-, 3-year and 4-year means to test the Level 1, Level 2, and Level 3 triggers, respectively. It should be noted however that conducting multiple testing such as this can lead to erroneous interpretation of results. For example at the 95% confidence interval (or p-value=0.05), through statistical chance alone, 5% of tests may be erroneously concluded as significant, and this chance is elevated when multiple tests are conducted. This is known as a Type I error. Methods exist for correcting multiple testing (e.g., Holm–Bonferroni, Holm 1979) but this will decrease statistical power to detect a difference, if one exists. To minimise potential for Type 1 error, the outputs of the statistical analysis have been interpreted in conjunction with results of the Illawarra Coal Environmental Field Team's landscape and piezometer monitoring as well as qualitative observations of upland swamp vegetation made during surveys conducted in 2017.

LiDAR data analysis

Monitoring of upland swamps included the use of Light Detection and Ranging (LiDAR) data to detect changes in the total swamp size of upland swamps and extent of groundwater dependent upland swamp sub-communities within each swamp.

An analysis model was created in ArcGIS model builder using the 2017 LiDAR data as provided by Illawarra Coal. The model is run to determine the total swamp size of upland swamps across the Dendrobium 2, 3A and 3B areas using LiDAR data obtained in 2017. The model undertakes the following processes:

- Creation of a 0.5 m cell size raster Digital Elevation Model (DEM) from the classified ground returns in the .LAS files.
- Creation of 0.5 m cell size raster Digital Surface Model (DSM) representing the absolute height of all surface features, created from the maximum value of all returns in the LAS files using a Natural Neighbour void fill method for any cells not covered by LiDAR returns.
- Creation of 0.5 m cell size raster Canopy Height Model (CHM) by subtracting the DEM values from the DSM values.
- Refinement of the CHM using the majority filter and boundary clean spatial analyst tools in ArcGIS.
- Classifying the CHM into categories above and below 8 metres in height (relative to the DEM)
- Converting the raster into polygons based on the categories above.
- Discarding features in the greater than 8 metre category.
- Discarding any features less than 500 square metres in size.

The process incorporates changes following a review of the LiDAR swamp monitoring methodology in 2016. The review examined instances where the change in total swamp extent from baseline (2012) to current year (2014/2015) 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:

- 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.
- 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. 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 review, the LiDAR modelling processes was repeated with a canopy height threshold adjusted from 5 metres to 8 metres and 'positive' changes omitted from analyses of change in swamp extent. These updates to the process have been incorporated into the current analysis for 2017.

The defined baseline data set (2012) was identified as not providing an appropriate baseline to compare future changes in the extent of upland swamps within the study area. LiDAR data was captured at rate of one return per square metre in 2012, however in future years it was collected at a rate of four returns per square metre. Data analysis has been undertaken utilising the 2014 data set as a reference point (baseline) for change within all swamps in the 2017 analysis to remove erroneous results.

Littlejohn's Tree Frog data analysis

All Littlejohn's Tree Frog adult, tadpole and egg mass numbers were standardised to represent abundance per 100 metre length of stream. This data was then used to create line-plots of the abundance of each life stage at each impact site, alongside associated control sites. Visual analysis of graphed data was undertaken to identify trends in adult, tadpole and egg mass abundance within streams, over time and between treatment groups.

2.4 Limitations

As is common to ecological monitoring programs, the availability of suitable and logistically practical impact and control sites makes it difficult to achieve a balanced BACI design. Suitable monitoring locations immediately above longwalls or with potential to be impacted by mining are by definition limited in their geographic extent. Nearby, ecologically similar sites free from historic and/or future mining influences which can be used as control sites are also limited.

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 and have only been employed where all individual species within a complex are considered likely to respond to mining and non-mining induced change in similar ways.

Despite 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 (i.e. no Littlejohn's Tree Frog present, and a false absence record (i.e. Littlejohn's Tree Frog present but not detected). Additionally like many fauna surveys, the dataset is not normally distributed and is skewed by a high number of zero counts. These factors, along with the absence of replication within sites, means that the Littlejohn's Tree Frog data cannot be statistically analysed, limiting the information that can be acquired from the data collected. Trends instead are analysed visually, and therefore subtle patterns may not be apparent.

In summary, as is often the case with ecological monitoring, the BACI experimental design, on which the program is based, is limited by the spatial availability of appropriate monitoring sites. Any long-term monitoring program must strike a balance between what is optimal to allow statistical analyses and meaningful data interpretation and what is practical to implement on the ground given the resources available and ecosystems and species involved. Biosis is committed to an adaptive monitoring approach whereby sites included in the program, data collection methods and statistical analysis techniques are regularly reviewed and the efficacy of the program continuously improved.

As of March 2017 extraction was undertaken adjacent to two monitored swamps (Swamp S11 and S13) and a monitoring transect located within Swamp 11. Biosis recommended that Swamp 11 be analysed as an impact swamp in 2017. However in 2017, while data was collected and Swamp 11 had been removed as a pre-mining site and changed to a post-mining site, statistical analysis in change in TSR and species composition compared to control sites was not undertaken.

3 Results

Results, unless otherwise stated, are described in the following sections for the autumn, winter and spring 2017 sampling periods.

3.1 Photo-point monitoring

Photo-point monitoring has been conducted at 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 Swamp 11).

Monitoring for visual changes between impact sites and control sites provides a gross, qualitative comparison of vegetation structure and colouration on a year to year basis. Changes in vegetation coloration may be indicative of vegetation stress (e.g. change in vigour of a species or suite of species due to change in soil moisture or nutrient content) or of change in the composition or relative abundance of species within strata (e.g. an increase in vigorous, green groundwater dependent groundcover species). Fluctuations in both vegetation colour and vegetative structure are expected in response to natural climatic variability, stochastic events (e.g. fire) and potential mining-induced changes.

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, One impact site (S1B), one pre-mining site (S13) and four control sites (S15A(1), S86, S87 and S88) displayed minimal change.

Photo-point monitoring points that show structural changes in vegetation were typically those within the sub-community Upland Swamps: Banksia Thicket. The most common structural changes were increased height and density of shrub species within the vegetation community, likely due to the natural growth of vegetation over time. This type of successional species progression occurs naturally within upland swamp vegetation communities and has been attributed to environmental factors, such as long inter-fire intervals and periods of drought which favour establishment and growth of Heath Banksia and Needlebush (Keith 2006). Both impact and control sites showed evidence of natural progressive vegetation structural change, including S15A(2) and S33. Control site, S22 showed evidence of yellowing of foliage in the shrub layer, particularly at points S22-F2 and S22-F3 during Spring 2017. This may be a result of an unseasonably dry Winter in 2017.

Photo monitoring at impact sites S11, S15B, S1A and S5 also showed visual evidence of vegetation structural change. Yellowing of Needlebush observed at S11-F3 and S11-F3, and a reduction in cover of Pouched Coral Fern at S11-F5 were observed. Changes in vegetation identified at photo points were reinforced by additional observations made by Biosis field staff during surveys. Visible changes observed at S15B, S1A and S5 are detailed below.

Swamp 15B

Vegetation dieback areas within Swamp 15B were observed to have increased in length and width. The die back has extended in 2017 to the east of S15B – P2 (292905 E; 6192692 N) and west to join the eastern patch south of S15B - V3 joining with the patch that extends from east of S15B – V2 (292 760.62 E; 6192 762.34 N). The majority of dieback continues to occur within Tea Tree Thicket resulting in the loss of cyperoid sedges such as, *Chorizandra* sp. and *Baumea* sp., with large decreases in Razor Sedge *Lepidosperma limicola,* Wire Rush *Empodisma minus, Lepidosperma neesii* and Pouched Coral Fern *Gleichenia dicarpa* (Plate 1). Species such as Red-fruited Saw-sedge *Gahnia sieberi, Leptospermum* sp. and Heath Banksia *Banksia ericifolia* have not been similarly affected.

This dieback patch now includes a lobe which extends north to 292835 E; 6192722 N. This area of impact is within Cyperoid Heath (MU44c) sub-community. Buttongrass *Gymnoschoenus sphaerocephalus* was recorded as browning and having very reduced crown size, in addition to reductions in the cover of sedge and fern species detailed above (Plate 2).

The loss of *Chorizandra* sp. and *Baumea* sp., indicates a loss of seasonally pooled water, with other sedges most likely to be affected by the loss of vadose zone water close to the ground surface following being mined beneath in 2012. These areas were marked using flagging tape by Biosis to show change in extent since spring 2016.

A separate area of Swamp 15B, west of S15B-V2 (located at 292642 E; 6192775 N) recorded a reduction to approximately 30% vegetated cover in autumn 2014 in areas transitioning between Tea-tree Thicket and Banksia Thicket. This area has again recorded dieback up to 50% of total vegetated cover for *Chorizandra* sp. and *Baumea* sp., Razor Sedge *Lepidosperma limicola,* Wire Rush *Empodisma minus, Lepidosperma neesii* and Pouched Coral Fern *Gleichenia dicarpa* (Plate 3).

The western extent of S15B continues to have seedling recruitment and growth of *Eucalyptus* sp. in areas mapped in spring 2016 from S15B –V1 to S15B – P5. The established trees observed within the southern edges of the swamp continue to show vigorous growth through height increase and development of small tree canopy.

Biosis recommends that the Illawarra Coal Environmental Field Team continue to observe the extent of the area of vegetation dieback within Swamp 15B at six monthly intervals using differential GPS (i.e. sub 1 meter accuracy) to allow changes in the extent of affected vegetation to be tracked over time. We recommend this mapping be completed at the time of seasonal swamp vegetation monitoring and with the assistance of a suitably experienced botanist.

Plate 1. Dieback of restioid heath within an area of Swamp 15B – V3 west from photopoint P2

Plate 2. Dieback of new cyperoid heath within the area of west of Swamp 15B – V3.

Plate 3. Vegetation dieback (approximately 100 m²) within Swamp 15B recorded between Swamp 15B – V3 and Swamp 15B – V2.

Swamp 1A

Since the initial observation in Spring 2015, Needlebush within Swamp 1A has continued to show yellowed foliage and stunted growth. The yellowing remains concentrated between 288904 E; 6193991 N and 288849 E; 6193909 N (Plate 4) with yellowed plants recorded more often from this area to the south-west towards monitoring point S1A – V1. The area surrounding S1A – V1 has increased in area of yellowed Needlebush (Plate 5, Plate 6 and Plate 7) with unaffected plants being limited to the inferred drainage line along the north-west edge of the swamp. Biosis recommends that the Illawarra Coal Environmental Field Team monitor the area of yellowing at 6 monthly intervals to track trends in vegetation condition and extent.

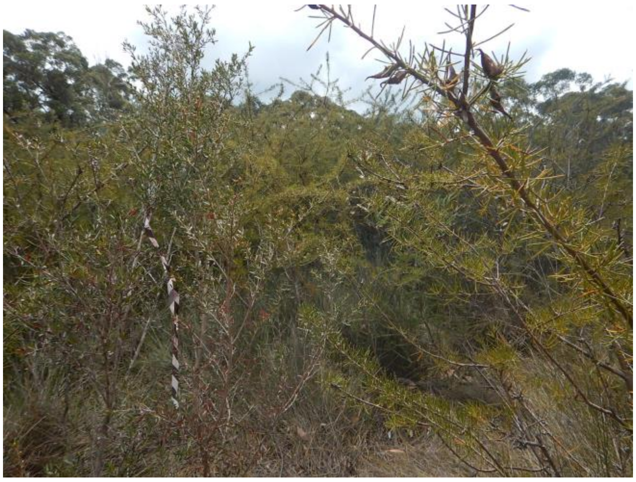

Plate 4. Area of Needlebush within Swamp 1A showing reduced signs of vegetation stress by yellowing.

Plate 5. Needlebush yellowing at monitoring point Swamp 1A – V1 showing vegetation stress by yellowing (looking north).

Plate 6. Needlebush yellowing at monitoring point Swamp 1A – V1 showing vegetation stress by yellowing (looking west).

Plate 7. Needlebush yellowing at monitoring point Swamp 1A – V1 showing vegetation stress by yellowing (looking south).

One area that may represent a change in vegetation condition has been observed to the north-east of S1A-V1 (289462.9 E 6194298.82 N) in areas of Cyperoid Heath (Plate 8 and Plate 9). The area north of S1A-V3 has been gradually reducing in Buttongrass foliage cover, with the complete dieback shown in Plate 9 only having occurred during six months since Autumn 2017. The photo-points for S1A-P3 are also showing reductions in vegetation cover for Buttongrass, Wire Sedge, Pouched Coral Fern and *Sprengelia incarnata.*

Biosis recommends that the Illawarra Coal Environmental Field Team monitor this area at 6 monthly intervals to track trends in vegetation condition and extent.

Plate 8. Cyperoid heath dieback looking north-east from S1A-V3 transect start.

Plate 9. Cyperoid heath dieback looking north and lcoated approximately south S1A-P3.

Swamp 5

Observations at S5-P3 indicate that swamp groundcover has greatly reduced when comparing control to post impact photo point images shown in Plates 10 – 17. The images show reductions in Pouched Coral Fern and Wire Rush have occurred since being mined beneath.

Plate 10. Swamp 5 – P3 (East - Spring 2013) prior to mining.

Plate 11. Swamp 5 – P3 (East - Spring 2017) showing reduction of Pouched Coral Fern and Wire Rush.

Plate 12. Swamp 5 – P3 (North - Spring 2013) prior to mining.

Plate 13. Swamp 5 – P3 (North- Spring 2017) showing reduction of Pouched Coral Fern and Wire Rush.

Plate 14. Swamp 5 – P3 (South - Spring 2013) prior to mining.

Plate 15. Swamp 5 – P3 (South- Spring 2017) showing reduction of Pouched Coral Fern and Wire Rush.

Plate 16. Swamp 5 – P3 (West - Spring 2013) prior to mining.

Plate 17. Swamp 5 – P3 (West - Spring 2017) showing reduction of Pouched Coral Fern and Wire Rush.

Monitoring points at Swamp 14 and Swamp 23 were introduced to the program in 2017, therefore interpretation of trends in site condition over time will commence in 2018. The significance of these observed changes is further investigated in Sections 3.2.1 and 3.2.2.

3.2 Vegetation

An electronic copy of vegetation monitoring data collected as part of the 2017 monitoring program has been provided to Illawarra Coal.

3.2.1 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) (**Figure 6**). It appears that there is high variability in TSR, regardless of year or mining status. TSR may have less variability in post-mining areas compared to pre-mined areas, but areas that are mined beneath appear to be more variable. Whether this is an artefact of the sampling (i.e. some swamps have only been sampled a few times), or real (e.g. the invasion of non-swamp species) cannot be determined from this analysis alone and as such analysis of species composition (Section 3.2.2) has been undertaken to compliment TSR analysis.

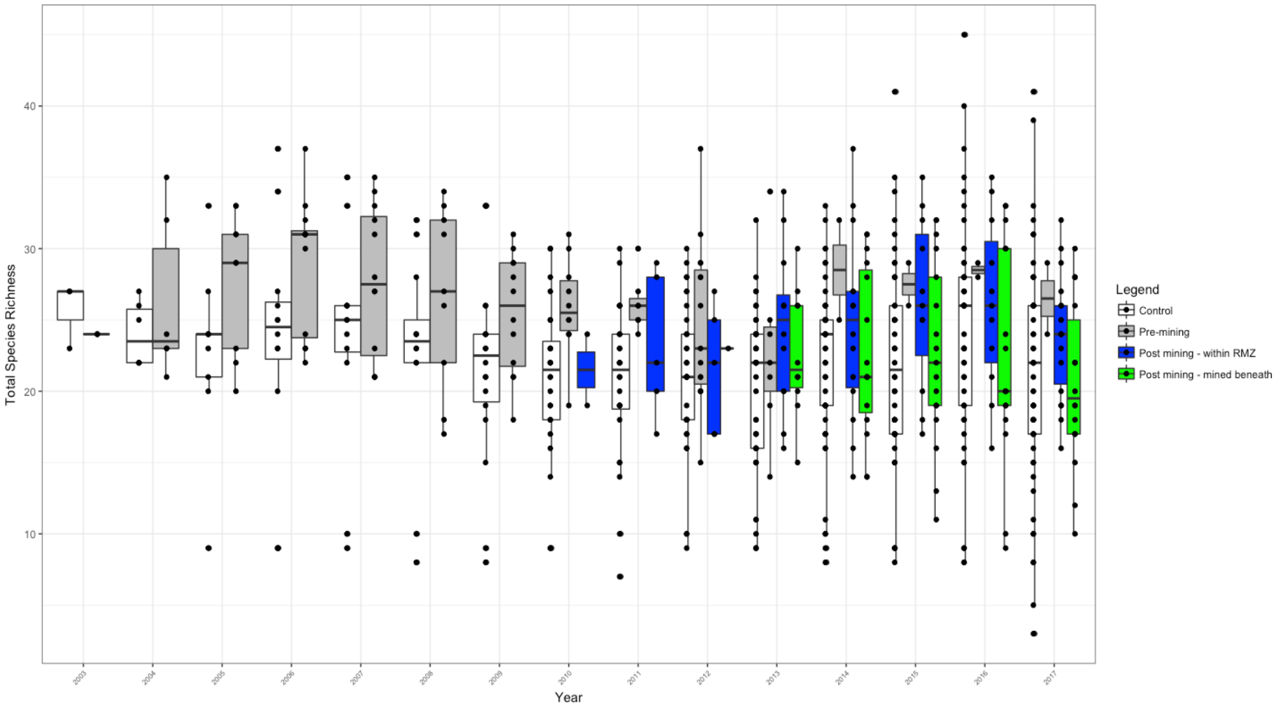

Figure 6 Boxplot of total TSR each year at all surveyed swamps located in Dendrobium Area 3A and Dendrobium Area 3B and associated control sites.

To further investigate trends in TSR, analyses were completed on a site-by-site basis in comparison to paired control sites.

Analysis of Swamp 15B (Dendrobium Area 3A)

Monitoring of Swamp 15B commenced in 2003 and was mined beneath in August 2012. The boxplot of TSR data for Swamp 15B contrasted against its paired control swamps indicates that prior to impact, TSR was more variable at control sites and typically yielded a lower TSR. This variability makes the detection of any small changes in TSR difficult.

Post-impact, TSR variability at the control sites appears to remain similar to that measured prior to impact (i.e. TSR variability remained large) while at impact sites, TSR appeared to be slightly lower (**Figure 7**).

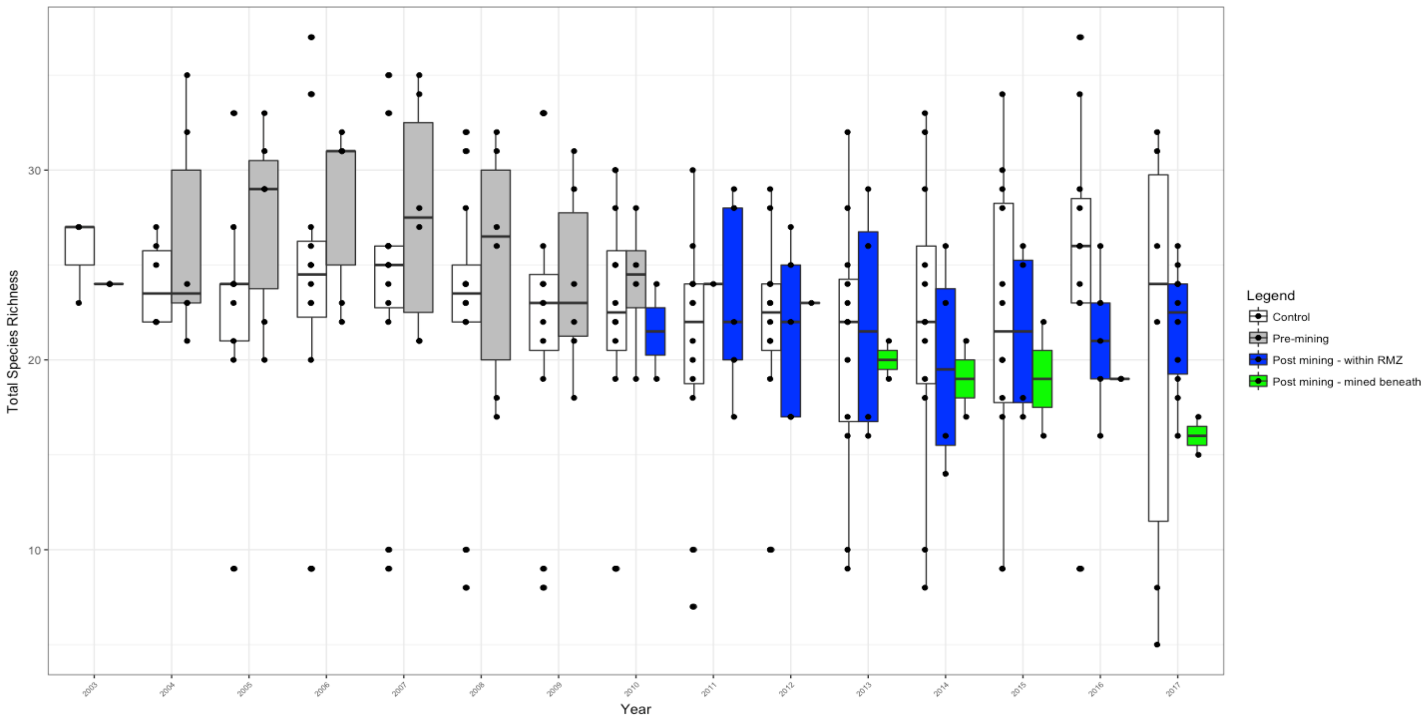

Figure 7 Boxplot of the TSR for each transect, at impact S15B, contrasted against two paired control swamps (S15A(1) and S11).

Figure 7 outlines the change in TSR for Swamp 15B since mining within the RMZ in 2010. A general decline in TSR was observed between 2010 and 2015 with TSR falling to as low as six species (approx.) below the baseline TSR during the 2014 and 2015 monitoring seasons. Comparison of the data for the 2017 monitoring period showed a small increase in TSR at S15B relative to 2016 TSR; however the median TSR at S15B in 2017 appears to be considerably lower than the median TSR observed at control sites.

The decline in TSR in the two years immediately following mining in 2010 was not significant at α=0.05 level; however a continued decline in TSR from 2012 through to 2015 resulted in a statistically significant reduction in TSR at the α=0.1 level during a period of stability at control swamps (Biosis 2017). It is important to note that p values below the α =0.1 level are used to indicate that the level of change is approaching a higher degree of confidence regarding the statistical significance of the results.

The steadily decreasing p-value since commencement of monitoring at S15B, particularly since being mined beneath in 2012, indicates a reduction in TSR becoming increasingly significant over time (**Table 3**).

Table 3 Results for t-tests of four-consecutive yearly difference in TSR between Swamp 15B and paired control swamps (S15A(1) and S11).

Change in TSR tested	Years tested	Difference in TSR	p-value
Four consecutive years of impact	2010, 2011, 2012, 2013	-3.70	0.14
	2011, 2012, 2013, 2014	-4.20	0.11
	2012, 2013, 2014, 2015	-4.83	0.09
	2013, 2014, 2015, 2016	-5.18	0.09
	2014, 2015, 2016, 2017	-5.33	0.08

Table notes: Those values identified in red indicate a significant change detected at the α=0.05 level. Those in blue indicate at significant changed detected at α=0.1 level which provides for a conservative approach to detecting potential impacts. In consultation with Illawarra Coal, Biosis have identified changes significant at the α=0.1 level as an indicator of a pre-cursor to a potential future significant impact detected at the α=0.05 level. This will guide the early implementation of management actions to mitigate impacts. *As no Dendrobium Area 3A TARP for swamps are applicable, the assessment has applied the Dendrobium Area 3B TARP levels for assessment.

Analysis of Swamp 15A(2) (Dendrobium Area 3A)

Monitoring at S15A(2) commenced in 2009 and mining within the RMZ commenced in 2013; however no monitoring sites were mined beneath. Post-impact, variability at the control sites appears to remain similar to that measured prior to impact (i.e., was still large); and at impact sites variability in TSR appears to be slightly lower following impacts, particularly for 2017 results (**Figure 8**).

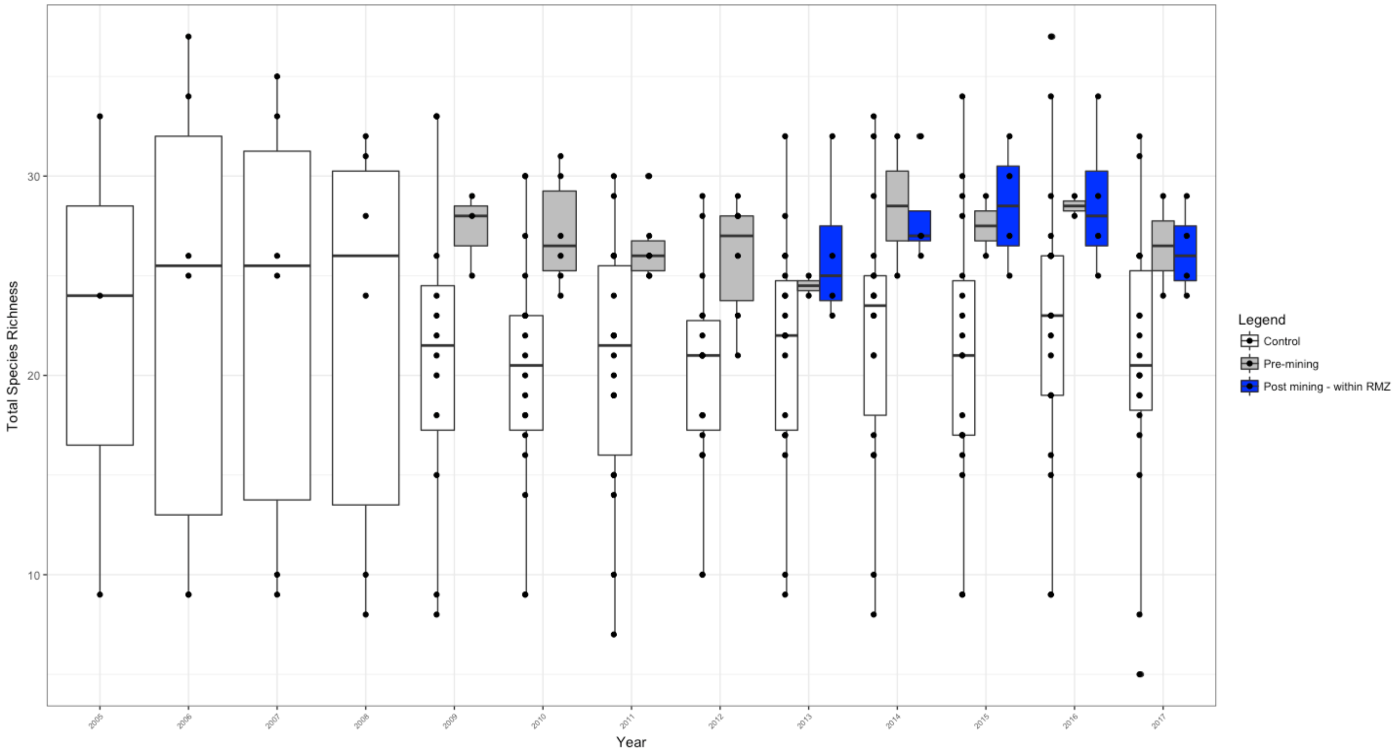

Figure 8 Boxplot of the TSR for each transect at impact Swamp S15A(2), contrasted against two paired control swamps (S15A(1), S22 and S33).

No significant difference was detected in TSR at Swamp 15A(2) between the control and impact sites, regardless of time. This is indicated by all p-values being greater than 0.05 (**Table 4**).

Table 4 Results for t-tests to test any four-consecutive yearly difference in TSR at Swamp 15A(2) when compared to paired control swamps (S15A(1), S22 and S33).

Change in TSR tested	Years tested	Difference in TSR	p-value
Four consecutive years of impact	2012, 2013, 2014, 2015	0.66	0.9
	2013, 2014, 2015, 2016	0.95	0.7
	2014, 2015, 2016, 2017	0.95	0.7

*As no Dendrobium Area 3A TARP for swamps are applicable, the assessment has applied the Dendrobium Area 3B TARP levels for assessment.

Analysis of Swamp 1A (Dendrobium Area 3B)

Monitoring of S1A commenced in 2012, with mining within the RMZ for all three sites having commenced in 2013 and were mined beneath in 2013 and 2014. The boxplot of TSR data for S1A contrasted against its paired control swamps suggest that TSR at control sites is similar to the TSR at Post mining (mined beneath). Post-impact, there is no overlap between transects that have been mined beneath and transects that have experienced mining within the RMZ. It is also clear that those transects that have been mined beneath have lower median TSR than those that were not mined beneath. One year only of pre-impact monitoring was completed (**Figure 9**).

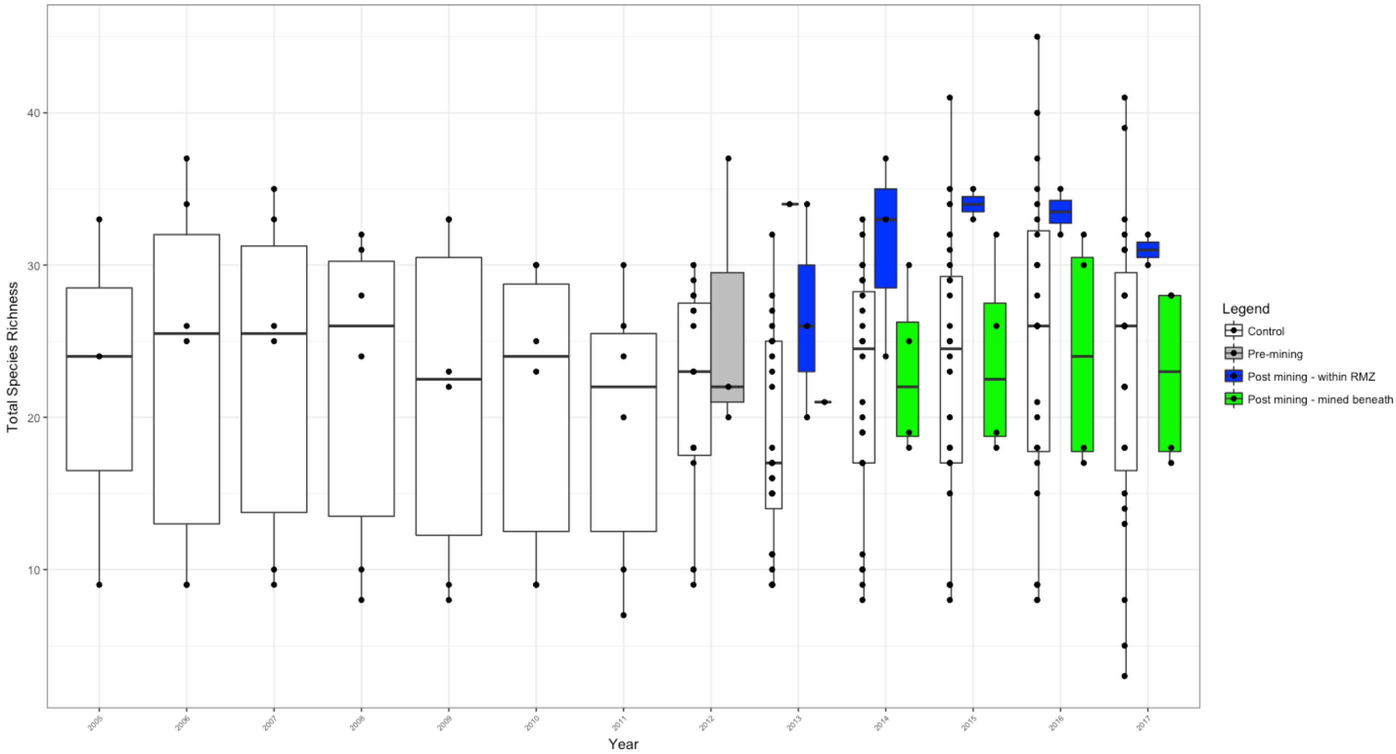

Figure 9 Boxplot of the TSR for each transect at impact Swamp 1A, contrasted against three paired control swamps (S15A(1), S86, S87, and S88).

None of the changes in TSR across monitoring years were found to be significantly different to TSR at paired control sites (p-values > 0.05, **Table 5**).

Table 5 Results for t-tests to test for four-consecutive yearly difference in TSR at Swamp 1A when compared to paired control swamps (S15A(1), S86, S87, and S88).

Change in TSR tested	Years tested	Difference in TSR	p-value
Four consecutive years of impact	2013, 2014, 2015, 2016	-3.59	0.16
	2014, 2015, 2016, 2017	-3.52	0.16

Analysis of Swamp 1B (Dendrobium Area 3B)

Monitoring at S1B commenced in 2005, mining within the RMZ and beneath all three S1B sites occurred in 2013. The boxplot of TSR data for S1B compared with its paired control swamps, indicate that increases and decreases of median TSR are mirrored at control and impact sites. Post-mining, there was no obvious visual difference in TSR at sites that were mined beneath, compared to TSR before the impact occurred (**Figure 10**).

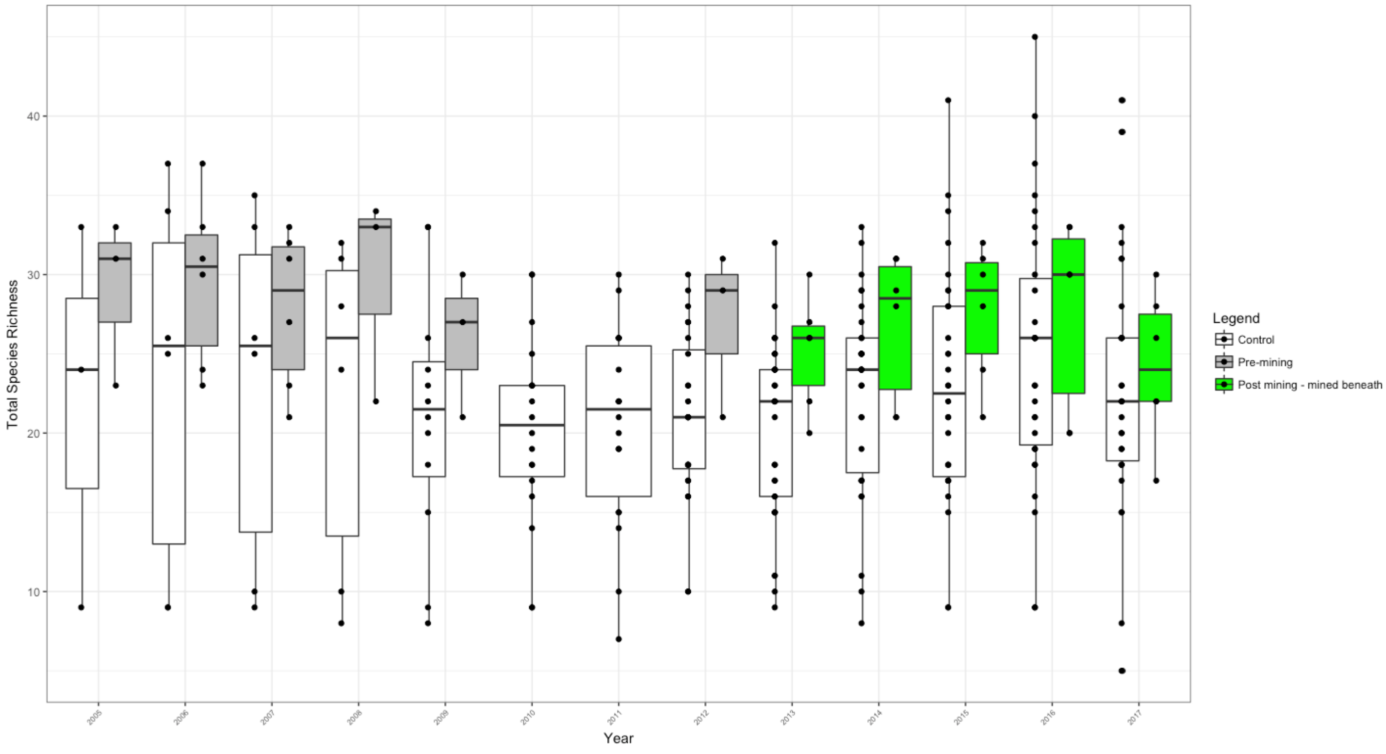

Figure 10 Boxplot of the TSR for each transect, at impact Swamp 1B, contrasted against five paired control swamps (S15A(1), S86, S87, S22 and S33).

No significant difference was detected in TSR between the control and impact sites, regardless of time (p-values > 0.05 (**Table 6**).

Table 6 Results for t-tests to test four-consecutive yearly difference in TSR at Swamp 1B when compared to paired control swamps (S15A(1), S86, S87, S22 and S33).

Change in TSR tested	Years tested	Difference in TSR	p-value
Four consecutive years of impact	2013, 2014, 2015, 2016	-1.36	0.26
	2014, 2015, 2016, 2017	-1.61	0.23

Analysis of Swamp 5 (Dendrobium Area 3B)

Monitoring at S5 commenced in 2012 and mining within the RMZ commenced in 2013. Mining beneath S5 commenced in 2013 and continued through to 2015. Two years only of pre-impact monitoring was completed for S5. The boxplot of TSR data for S5 demonstrates that the TSR at the post mining sites, while the median is typically lower, is within the range observed at control sites. The degree of variability makes the detection of any small changes in TSR difficult. Post-impact, it appears that sites that were mined beneath have a lower TSR than sites prior to impact (Figure 11).

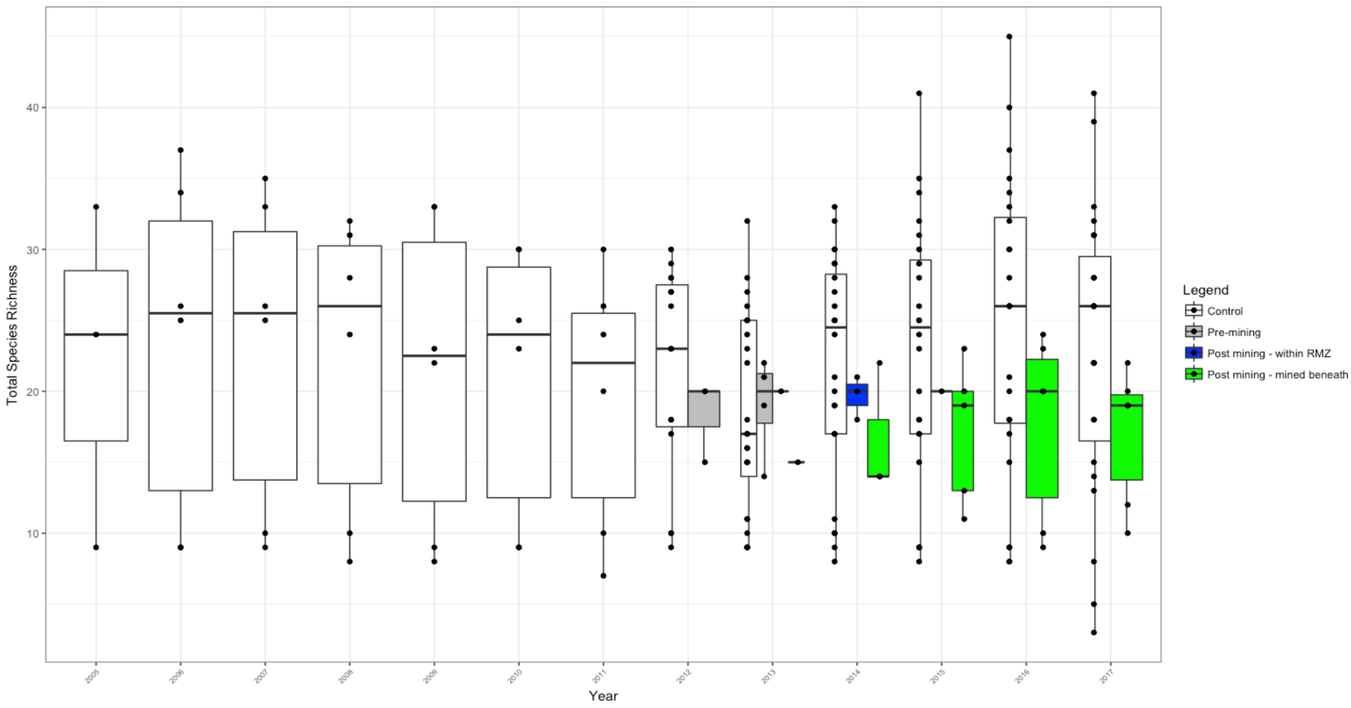

Figure 11 Boxplot of the TSR for each transect, at impact Swamp 5, contrasted against two paired control swamps (S15A(1), S86, S87 and S88).

No significant difference was detected in TSR between the control and impact sites, regardless of time (p-values > 0.05 (Table 7).

Table 7 Results for t-tests to test any four-consecutive yearly difference in TSR at Swamp 5 when compared to paired control swamps (S15A(1), S86, S87 and S88).

Change in TSR tested	Years tested	Difference in TSR	p-value
Four consecutive years of impact	2013, 2014, 2015, 2016	-0.92	0.43
	2014, 2015, 2016, 2017	-1.04	0.41

3.2.2 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. Statistically significant yearly, and occasionally seasonal, trends in species composition were detected at most sites, regardless of mining area (Dendrobium Area 3A or 3B) or treatment (control or impact sites) when applying a conservative 0.1 alpha significance threshold.

In addition to the yearly and seasonal trends across all sites, a significant change in species composition pre-mining to post-mining was found at two of the six sites; Swamp 15B and Swamp 15A(2). At the remaining sites there is no statistical significance in floristic composition when compared to before and after mining and between control and impact sites.

Analysis of Swamp 15B (Dendrobium Area 3A)

A total of 132 unique species have been detected at Swamp 15B, of which 8% have only been detected on one occasion. A background yearly-trend in species composition was found to be statistically significant at the α=0.05 level across all years. This is not surprising, as it is reasonable to expect natural species turnover to occur at the swamp. However, a statistically significant change in species composition at the α=0.05 level was detected two, three and four consecutive years following mining, commencing in 2012 (Table 8). This indicates a long term shift in the flora species comprising the Swamp 15B community.

Table 8 Results of four consecutive yearly comparisons of species composition at Swamp 15B assessing TARP Level 3

Change in species composition tested	Years tested	Statistically significant change in species composition before and after mining (p-value)
Four consecutive years of impact	2010-2013	0.019
	2011-2014	0.018
	2012-2015	0.02
	2013-2016	0.01
	2014-2017	0.01

Table notes: Those values identified in red indicate a significant change detected at the α=0.05 level. Those in blue indicate at significant changed detected at α=0.10 level which provides for a conservative approach to detecting potential impacts and has been treated with caution and further ecological interpretation for the purposes of this assessment. *As no Dendrobium Area 3A TARP for swamps are applicable, the assessment has applied the Dendrobium Area 3B TARP trigger levels.

Some species were consistently found to be less common following impact (e.g. *Goodenia dimorpha, G. stelligera, G. bellidifolia* species complex), whereas other species were consistently found to be more common after impact (e.g. *Lepidosperma neesii/Ptilothrix deusta* species complex).

The top species driving the change in species composition during the period in which a significant change was detected are as follows:

- Increase in *Lepidosperma neesii/Ptilothrix deusta* species complex following mining within the RMZ.
- Decrease in *Goodenia dimorpha, G. stelligera, G. bellidifolia* species complex following mining within the RMZ.
- Increase in *Tetrarrhena turfosa* since 2015.
- Increase in *Baumea rubiginosa* since 2016.
- Increase in *Xyris operculata* since 2015.
- Continual increase in *Tetraria capillaris* since 2012.

Of the species driving change, one (*Goodenia dimorpha stelligera bellidifolia* complex) is characteristic of shallow, free draining heath and mallee- heath within the Woronora plateau (NPWS 2003) and swamps (Harden 1992), with the remaining species (*Tetraria capillaris, Baumea rubiginosa, Lepidosperma neesii/Ptilothrix deusta*) typically preferring moist sandy soils. This indicates that that the species composition is becoming dominated by species that prefer drier soils (while still common upland swamp species) as opposed to species preferring water-logged substrate.

Analysis of Swamp 15A(2) (Dendrobium Area 3A)

A total of 131 unique species have been detected at Swamp 15A(2), of which 6% have only been detected on one occasion. A background yearly-trend in species composition was found to be statistically significant at the α=0.05 level across all years. A statistically significant change in species composition at the α=0.05 level was detected two, three and four consecutive years following mining in commencing in 2013 (Table 9).

Table 9 Results of four consecutive yearly comparisons of species composition at Swamp 15A(2) assessing TARP Level 3

Change in species composition tested	Years tested	Statistically significant change in species composition before and after mining (p-value)
Four consecutive years of impact	2013-2016	0.001
	2014-2017	0.001

Table notes: Those values identified in red indicate a significant change detected at the α=0.05 level. *As no Dendrobium Area 3A TARP for swamps are applicable, the assessment has applied the Dendrobium Area 3B TARP trigger levels.

Some species were consistently found to be more common prior to impact (e.g. *Selaginella uliginosa* and *Sprengelia incarnata*), whereas other species were consistently found to be more common after impact (e.g. *Banksia ericifolia* subsp. *ericifolia* and *Cassytha glabella, C. pubescens* species complex).

The most influential species driving the change in species composition during the period in which a significant change was detected (since 2013) are as follows:

- Decrease in *Selaginella uliginosa.*
- Decrease in *Sprengelia incarnata.*
- Increase in *Banksia ericifolia* subsp. *ericifolia*.
- Decrease in *Xanthorrhoea* species complex.
- Increase in *Cassytha glabella / C. pubescens* species complex.

The above results support the photo point monitoring observations at this swamp; indicating a natural transition into Banksia Thicket. The increased density of vegetation, particularly heathy shrubs such as *Banksia* sp., within the swamp are likely shading out species in the lower strata. This indicates a notable shift in the floristic composition of Swamp 15A(2).

Analysis of Swamp 1B (Dendrobium Area 3B)

A total of 146 unique species have been detected at Swamp 1B, of which 13% have only been detected on one occasion. A background yearly-trend in species composition was found to be statistically significant at α=0.05 level across all years.

A significant short-term change in species composition at α=0.05 level was found between 2016 and 2017 (Table 10). However, this is unlikely to indicate significant changes as a result of underground mining as these changes have not occurred long-term. The recent significant change is likely a result of short-term climatic influences such as a prolonged dry period. Biosis recommends that S1B is continued to be monitored.

Table 10 Results of two, three and four consecutive yearly comparisons of species composition at Swamp 1B

Change in species composition tested	Years tested	Statistically significant change in species composition before and after mining (p-value)
Four consecutive years of impact	2013-2016	0.079
	2014-2017	0.006

Analysis of the compositional data indicated that some species were consistently found to be more common at Swamp 1B prior to impact (e.g., *Amperea xiphoclada* and *Sprengelia incarnata*), whereas other species were consistently found to be more common after impact (e.g., *Chorizandra sphaerocephala* and *Chorizandra cymbaria*).

Analysis of Swamp 1A (Dendrobium Area 3B)

A total of 146 unique species have been detected at Swamp 1A, of which 6.2% have only been detected on one occasion. A significant interaction between years and pre-post mining was detected in species composition at both impact and control sites following mining however no statistically significant change in species composition at Swamp 1A relative to control swamps or pre-mining composition was detected (Table 11).

Table 11 Results of four consecutive yearly comparisons of species composition at Swamp 1A assessing TARP Level 3

Change in species composition tested	Years tested	Statistically significant change in species composition before and after mining (p-value)
Four consecutive years of impact	2013-2016	0.618
	2014-2017	0.666

Analysis of Swamp 5 (Dendrobium Area 3B)

A total of 146 unique species have been detected at Swamp 5, of which 4.8% have only been detected on one occasion. No background yearly trends in species composition were found to be statistically significant, nor was a significant interaction between years and pre-post mining detected in species composition at both impact and control sites following mining. Moreover, no statistically significant change in species composition was detected (Table 12) indicating that species composition has remained stable following mining beneath S5. This indicates that while a change in the overall condition of vegetation had been identified (Section 3.1) during photo-point monitoring, no statistical difference has been observed for TSR (Section 3.2.1) and species composition (Table 12).

Table 12 Results of four consecutive yearly comparisons of species composition at Swamp 5 assessing TARP Level 3

Change in species composition tested	Years tested	Statistically significant change in species composition before and after mining (p-value)
Four consecutive years of impact	2013-2016	0.464
	2014-2017	0.589

3.3 LiDAR mapping of upland swamp extent

Swamp area was assessed based on a differential canopy height of 8 metres to determine swamp margins with the 2014 data set used as the baseline, in accordance with 2016 recommendations.

The area of upland swamps decreased relative to the 2014 baseline in 2017 (Figure 12) and across all impact and control swamps assessed, with the exception of Swamp 08 which recorded a marginal increase. The overall extent of the smaller control swamps (S89, S91, S92 and S93) remained stable over the four year period. Between 2016 and 2017 the extent of each upland swamp, inclusive of control and impact swamps, remained relatively stable with only minor increases and decreases in extent observed across all treatments.

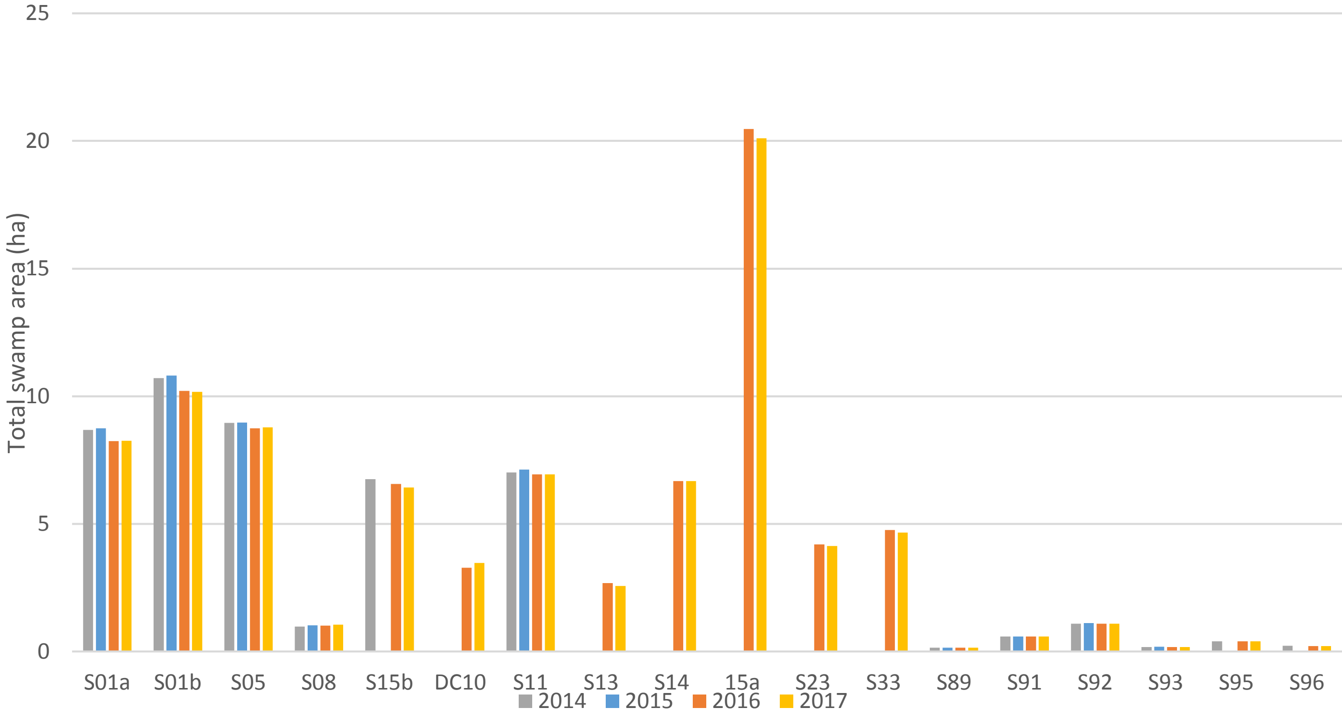

Figure 12 Total upland swamp area from 2014 to 2017

The greatest reduction in total swamp extent at impacted swamps in 2017 was observed at S01b where total swamp extent has declined by 6.5% relative to baseline, and at S01a where total swamp extent declined by 6% (Figure 13). Upland swamp S8 has recorded an increase in swamp extent of 4.3% relative to the baseline, with the largest increase, 2.8% occurring between 2016 and 2017.

Swamp extent change from the baseline for 2017 is generally expressed by a decline, with the exception of four swamps (S8, S89, S91 and S95). Declines recorded at impacted and control swamps between 2014-15 and 2016-17 is not significant (p=0.605 and p=0.144 respectively). However, the decrease in impact swamp extent, when compared to control swamps was statistically significantly different between 2015-2016 (p=0.04). While substantial change has been observed, when comparing the change in extent of impacted and control swamps across all years is not statistically significantly different (p=0.3). A noticeable change between 2015-16 was observed at control swamps, when comparing the extent across all years the lack of significance in the changes to swamp extent indicates that changes likely reflect natural variations, or if impacts are occurring they are short term.

The changes observed in "impacted" upland swamp extent between 2016 to 2017 are comparable to those observed at the control swamps.

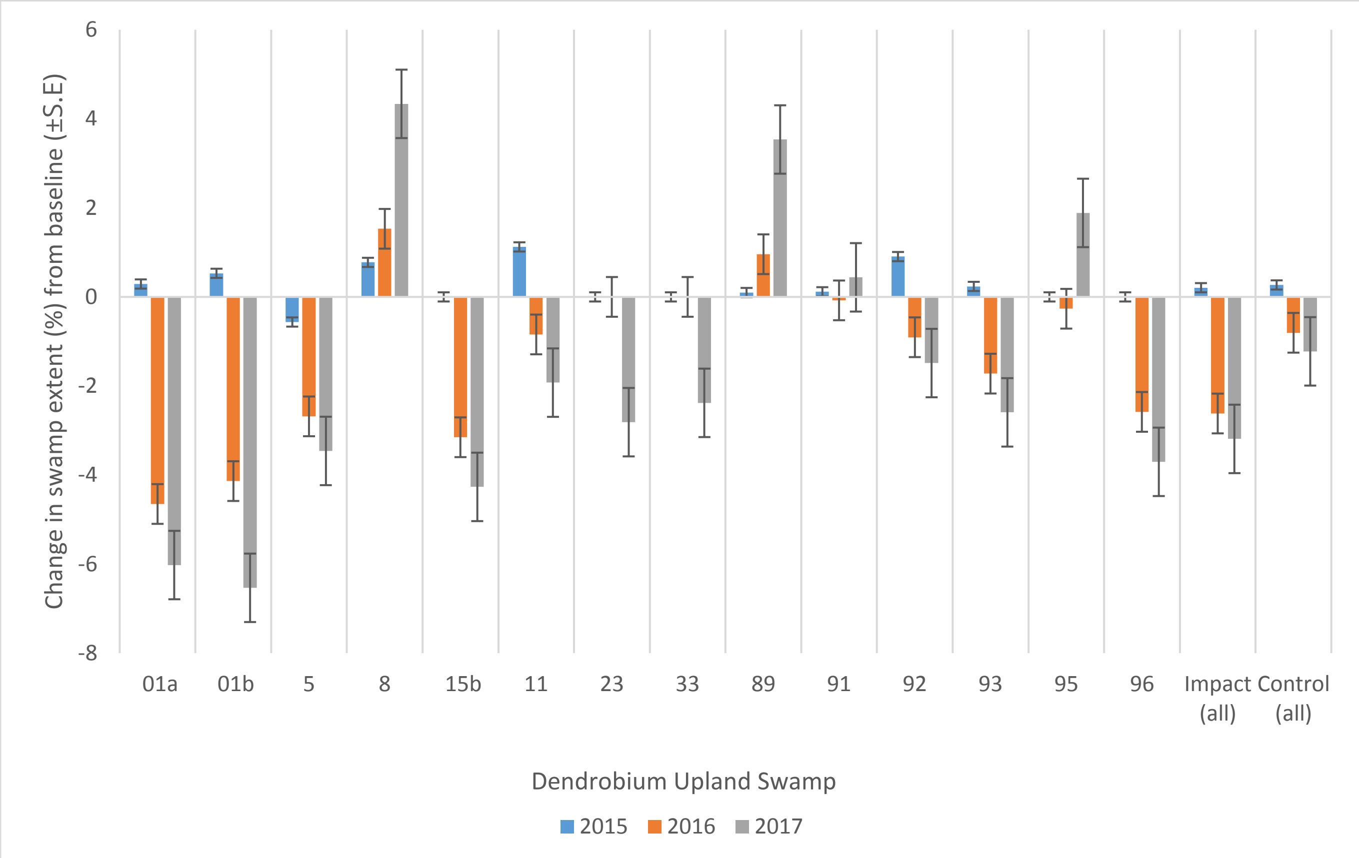

Figure 13 Percentage change in upland swamp extent from baseline

Changes in the extent of upland swamps is considered to be primarily driven by the proportion of more sensitive or robust vegetation communities, therefore analysis of the changes in extent of vegetation communities has been undertaken. Upland swamps within the study area are primarily comprised of five vegetation communities:

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

Table 13 Upland swamp vegetation community composition

Upland Swamp	Total area (Hectares)	MU42 (%)	MU43 (%)	MU44a (%)	MU44b (%)	MU44c (%)
S01a	78501.02	36	8	0	50	6
S01b	100341.94	0	1	0	78	20
S05	84097.76	40	20	6	28	6
S08	9342.00	100	0	0	0	0

Upland Swamp	Total area (Hectares)	MU42 (%)	MU43 (%)	MU44a (%)	MU44b (%)	MU44c (%)
S11	68076.95	64	4	11	13	9
S15b	61755.82	70	20	0	0	10
S89	1424.12	97	3	0	0	0
S90	544.00	100	0	0	0	0
S91	5758.58	94	6	0	0	0
S92	10436.00	100	0	0	0	0
S93	1674.00	100	0	0	0	0
S95	3693.00	100	0	0	0	0
S96	2069.00	100	0	0	0	0
Mean composition		77	5	1	13	4

Banksia thicket forms 77% of all upland swamp vegetation within the study area, with Restioid Heath forming the second most prevalent vegetation community at 13% (Table 13). The change in extent of each vegetation community, from the 2014 baseline, is presented in Figure 14.

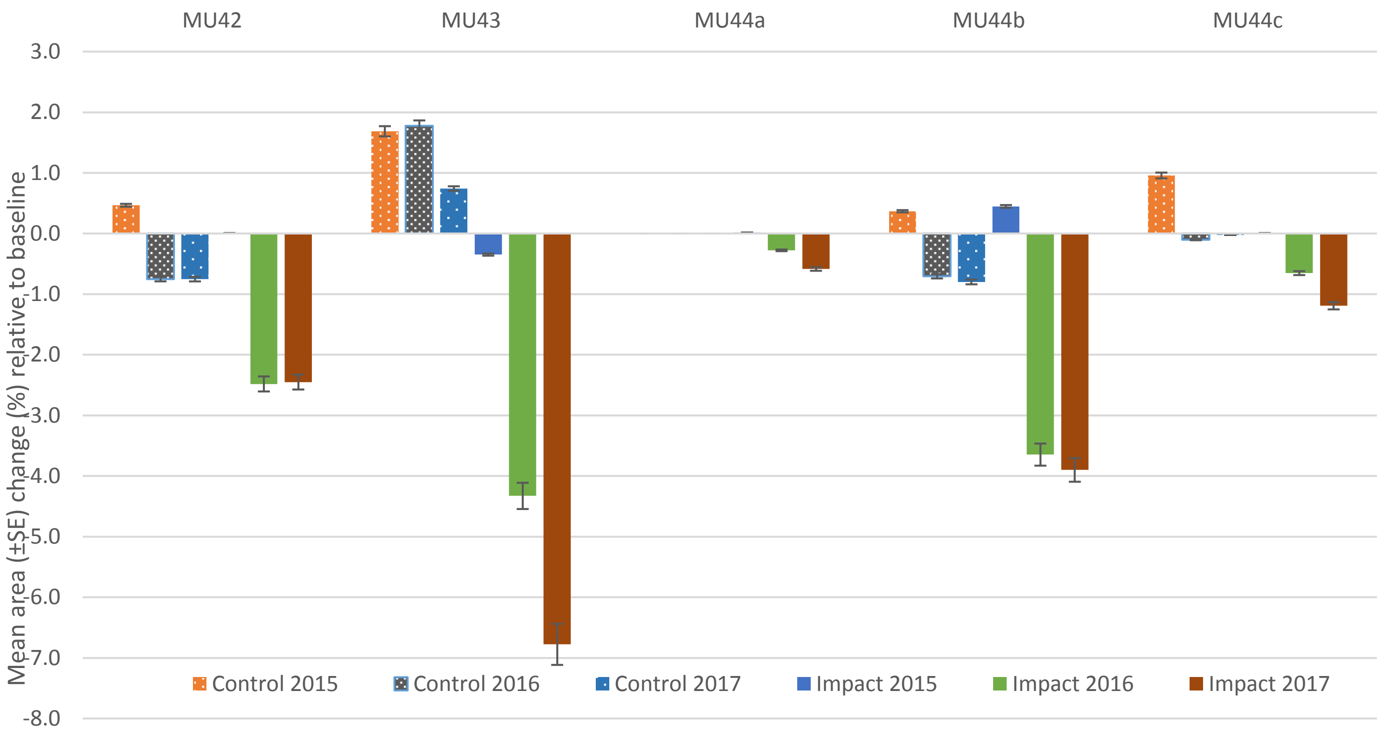

Figure 14 Change in extent of vegetation communities across all years at control and impact swamps

The change in extent of vegetation communities within upland swamp from the baseline is most notable at impact sites, with declines identified for all vegetation communities. The declines were most noticeable within the Tea-tree Thicket community, indicating that this community is the most sensitive community, however

Tea-tree Thicket only comprises 5% of all upland swamp vegetation in the study area, its overall extent is small and is disproportionately influenced by change at transitional zones between communities. Therefore the significance of the observed changes is analysed.

The change in the extent of vegetation communities forming upland swamps in the study area is not significant at the 95% confidence threshold, with *p* values for each vegetation community below:

- MU42 – $p = 0.387$
- MU43 $p = 0.057$
- MU44a $p = 0$ (no controls)
- MU44b $p = 0.13$
- MU44c $p = 0.981$

The decline of Tea-tree thicket from its baseline extent is not statistically significant, however data analysis indicates that groundtruthing of Tea-tree Thicket extent be assessed for encroachment of non-swamp vegetation in 2018, at S05 and S15b.

The most notable decline in the extent, of upland swamps and in vegetation communities forming the upland swamps, was between 2015 to 2016 with minimal change between 2016 to 2017. The significant decrease in individual swamp extent observed in 2016 was not observed in 2017. The decrease observed in the extent of upland swamp vegetation sub-communities in 2016 was not observed in 2017, however Tea-tree Thicket (MU43) should be closely reviewed and ground-truthed in 2018.

No significant change in the extent of individual upland swamps across both the control and impact treatments was observed in 2017. Both “impact” and control swamps recorded a decrease in extent, which reflects a change that is observed on a regional scale and is not attributable to localised mining impacts.

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 nine post-mining impact sites (SC10(1), SC10(2), 6CDL, WC17, WC21, DC1 and DC13) monitored as part of the threatened frog surveys in winter 2016. At two of the post-mining impact sites (SC10C and LA4A) no Littlejohn’s Tree Frogs were detected in any lifecycle stage. The species was detected at WC15, the only remaining pre-impact site, as well as nine of the ten control sites (SC8, WC10, WC11, SC7(2), SC7(1), SC7A, DC8, NDC and ND1). Littlejohn’s Tree Frog was not detected at control site ND2.

When compared to data collected in 2016, there was a decrease in detection of adult Littlejohn’s Tree Frog in 2017 by approximately 32%, and tadpoles by 84%. However, 2016 was an excellent year for breeding due to high levels of rainfall, and frog numbers recorded in 2016 were much higher than previous years. Detection of Littlejohn’s Tree Frog in 2017 was approximately equal to detection in 2015. Over the long-term, the abundance of all life stages detected has varied substantially year to year, at both impact and control sites. There is no visually discernible trend in either year or mining status (Pre/Post mining) in both mining areas (Dendrobium Areas 3A and 3B).

Plate 1 Littlejohn's Tree Frog encountered during the monitoring program.

Of the post-mining sites that have experienced subsidence related impacts, only SC10C shows a declining trend in detection – suggesting a decline in abundance - of all Littlejohn's Tree Frog life stages, triggering Level 1 of the *Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)* (Illawarra Coal 2012c). However, recruitment at this site before mining occurred was also extremely low, and numbers have remained low throughout the course of monitoring. Hence, the absence of Littlejohn's Tree Frogs at SC10C in 2017 is not considered indicative of a decline.

In 2016 a declining trend in Littlejohn's Tree Frogs was recorded at post-mining site W17, with no tadpoles or egg masses recorded from 2014 – 2016. However, in 2017 120 tadpoles were recorded at the site. This indicates a return to pre-mining recruitment conditions.

Subsidence related impacts including fracturing of bedrock, lowering of water levels and build-up of iron flocculant have been recorded at sites SC10C, SC10(1), WC17, WC21, DC1 and DC13, with each of these sites triggering either Level 1 (SC10(1), DC1) or Level 3 (SC10C, WC17, WC21 and DC13) of the *Dendrobium Area 3 Watercourse TARP* (Illawarra Coal 2015a). This is discussed further in Sections 4.1.3 and 4.2.2.

A summary of the results from the 2017 winter survey are provided in Table 14 and the records have been mapped in Figure 15.

Table 14 Summary of the results from the winter 2017 threatened frog monitoring

Mining status	Site	Survey date	Total no. recorded			No. breeding pools
			Adult	Egg mass	Tadpoles	
Pre-mining sites	WC15	08/08/2017	9	38	46	14
	LA2	22/08/2017	3	70	73	
Total			**12**	**108**	**119**	**14**
Post-mining sites (Mined beneath)	DC13	06/08/2017	5	8	27	6
	SC10C	30/08/2017	0	0	0	3
	WC17	31/07/2017	3	0	120	2
	WC21	24/08/2017	4	25	112	3
Total			**12**	**33**	**259**	**14**
Post-mining sites (Within RMZ)	6CDL	23/08/2017	0	4	120	5
	DC(1)	25/07/2017	2	0	4	3
	SC10(1)	30/08/2017	15	7	4	6
	SC10(2)	7/08/2017	23	104	89	26
	LA4A	06/08/2017	0	0	0	0
Total			**40**	**115**	**217**	**40**
Control sites	DC8	29/08/2017	8	50	7	3
	ND1	01/08/2017	17	0	105	14
	ND2	24/07/2017	0	0	0	1
	NDC	24/07/2017	4	0	29	4
	SC7(1)	31/07/2017	19	8	35	4
	SC7(2)	27/07/2017	19	0	144	15
	SC7A	27/07/2017	19	25	162	11
	SC8	02/08/2017	1	0	74	3
	WC10	31/07/2017	9	10	63	12
	WC11	23/08/2017	0	38	210	4
Total			**96**	**131**	**829**	**77**

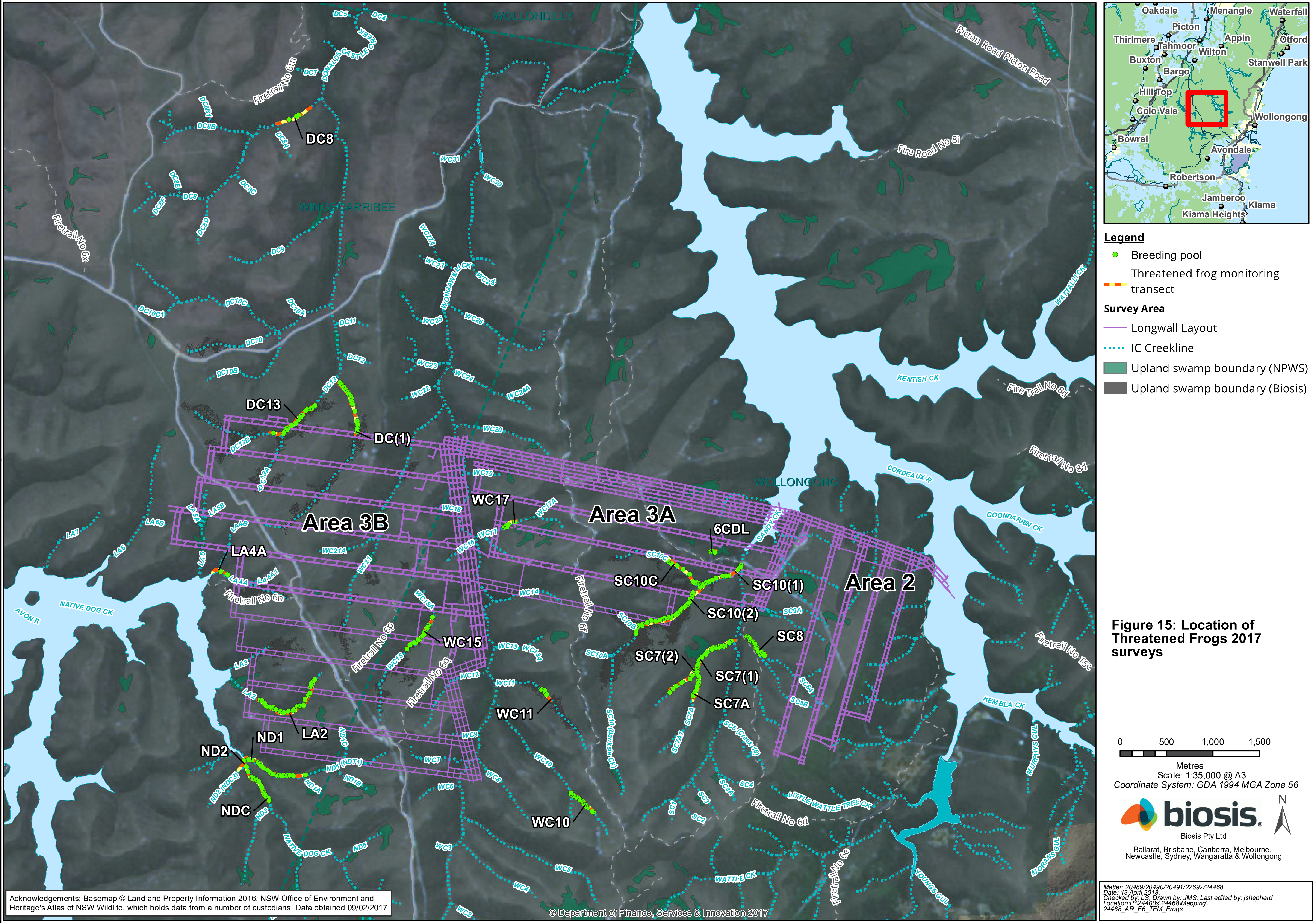

Figure 15: Location of Threatened Frogs 2017 surveys

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Ballarat, Brisbane, Canberra, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

Acknowledgements: Basemap © Land and Property Information 2016, NSW Office of Environment and Heritage's Atlas of NSW Wildlife, which holds data from a number of custodians. Data obtained 09/02/2017

Matter: 20489/20490/20491/22692/24468
Date: 13 April 2018,
Checked by: LS, Drawn by: JMS, Last edited by: jshepherd
Location:P:\24400s\24468\Mapping\24468_AR_F6_TFM_Frogs

3.4.1 Dendrobium Area 3A

Sandy Creek and tributaries

Sandy Creek and its tributaries form part of a large and significant sub-population of Littlejohn's Tree Frog. This sub-population includes the creek as well as a number of tributaries including SC10C, SC10(1), SC10(2), 6CDL, SC7(1), SC7(2), 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 and seasonal cues.

SC10C

No Littlejohn's Tree Frogs were detected in any lifecycle stage at SC10C in 2017, and tadpoles have not been recorded at the site for the past 3 years (Figure 16). The abundance of Littlejohn's Tree Frog along SC10C was also lower than that recorded at control sites. However, this is reflective of pre-mining conditions, and is not currently of significance. Littlejohn's Tree Frog tadpoles and egg masses have been detected at SC10C in very low numbers over the past 12 years of monitoring, and small fluctuations do not appear to be associated with timing of mining. However a decline in the abundance of adult frogs was observed following subsidence impacts detected at SC10C following extraction of Longwall 7 and Longwall 8 during 2011 and 2012 (2 years after the initial mining within the RMZ), and numbers have not recovered (Figure 16). This triggers Level 1 of the revised *Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)* (Illawarra Coal 2012c), and is discussed further in 4.2.2. This assessment is consistent with that made in the annual monitoring report for 2016 (Biosis 2017).

The decline in abundance of adult frogs at SC10C appears to be correlated with reductions in the pool water levels along the transect following the extraction of Longwall 7 and Longwall 8, as observed since 2012 (Biosis 2013a). In 2017 very high levels of iron flocculant was observed throughout the site, consistent with previous observations, and pools remained dry upstream of pool 4. Follow up monitoring of identified breeding habitat pools conducted in summer 2016/2017 confirmed that most pools were unable to retain water long enough after the winter breeding season for tadpoles to complete metamorphosis. Thus, there has been a significant reduction in breeding habitat for Littlejohn's Tree Frogs for more than 3 years, triggering Level 3 of the *Dendrobium Area A Watercourse TARP* (Illawarra Coal 2015a).

SC10(1)

There has been no significant decline in Littlejohn's Tree Frogs at SC10(1) since mining began in 2011 (Figure 17). Although tadpole and egg mass numbers were low in 2017, this is consistent with pre-mining records, and does not appear associated with mining impacts. The *Terrestrial Flora and Fauna TARP* has not been triggered.

During the 2017 winter survey, iron flocculant was observed covering all stream surfaces within the SC10(1) transect. This represents a reduction in breeding habitat for Littlejohn's Tree Frogs, and triggers Level 1 of the *Dendrobium Area 3A Watercourse TARP.* This is the first year the *Watercourse TARP* has been triggered for this site.

SC10(2)

There has also been no significant decline in Littlejohn's Tree Frogs at SC10(2) since mining began in 2011 (Figure 18). Numbers of tadpoles, eggs and adults observed per 100 metres of transect have consistently fallen within the abundance range recorded at control sites within the area. Over the past 3 years an increase in egg mass numbers has been observed at SC10(2) compared to pre-mining records, and this may be associated with displacement of breeding adults out of impacted areas such as SC10C, and into nearby streams. The *Terrestrial Flora and Fauna TARP* has not been triggered.

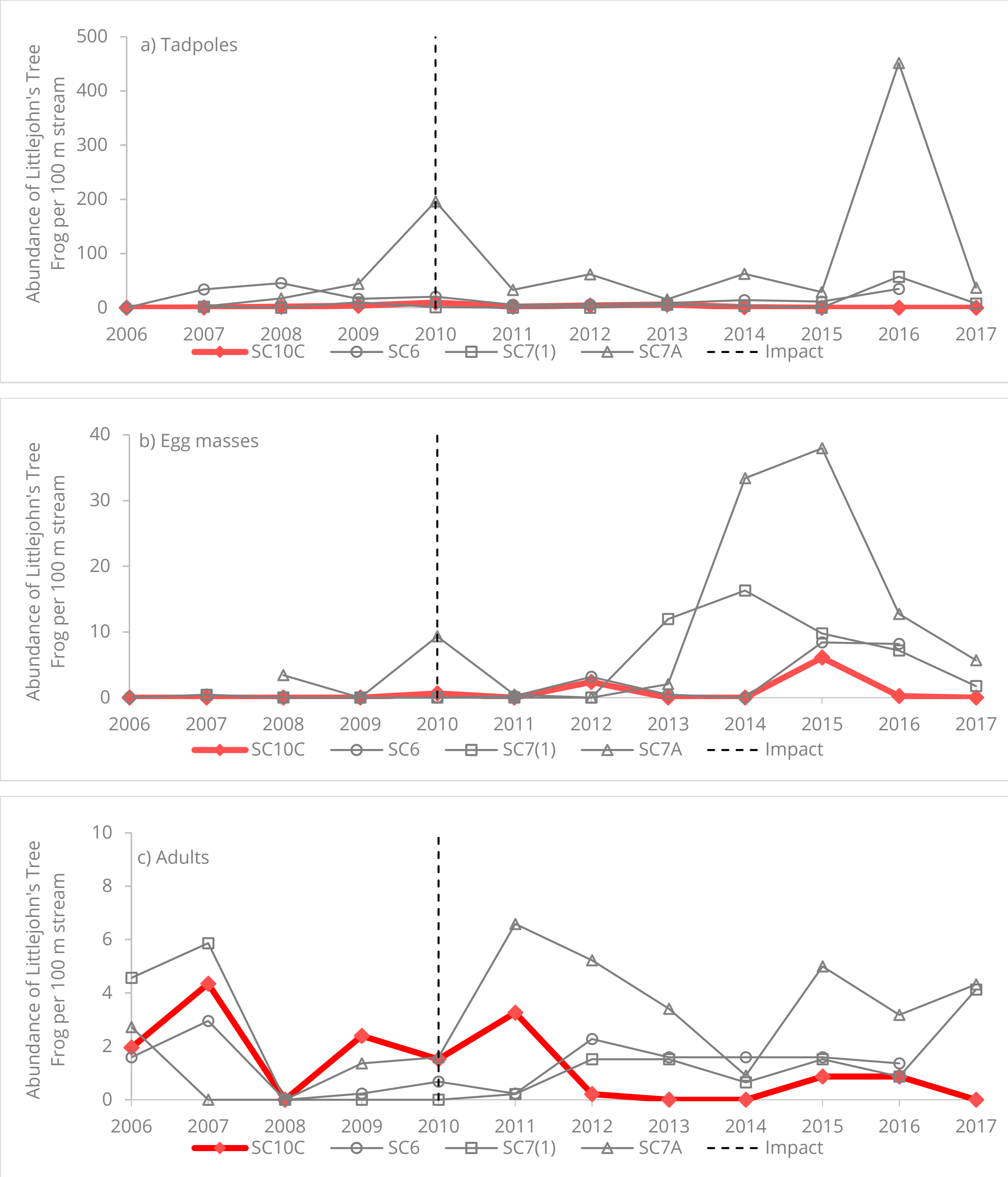

Figure 16 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site SC10C (red line) and associated control sites SC6, SC7(1) and SC7A (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

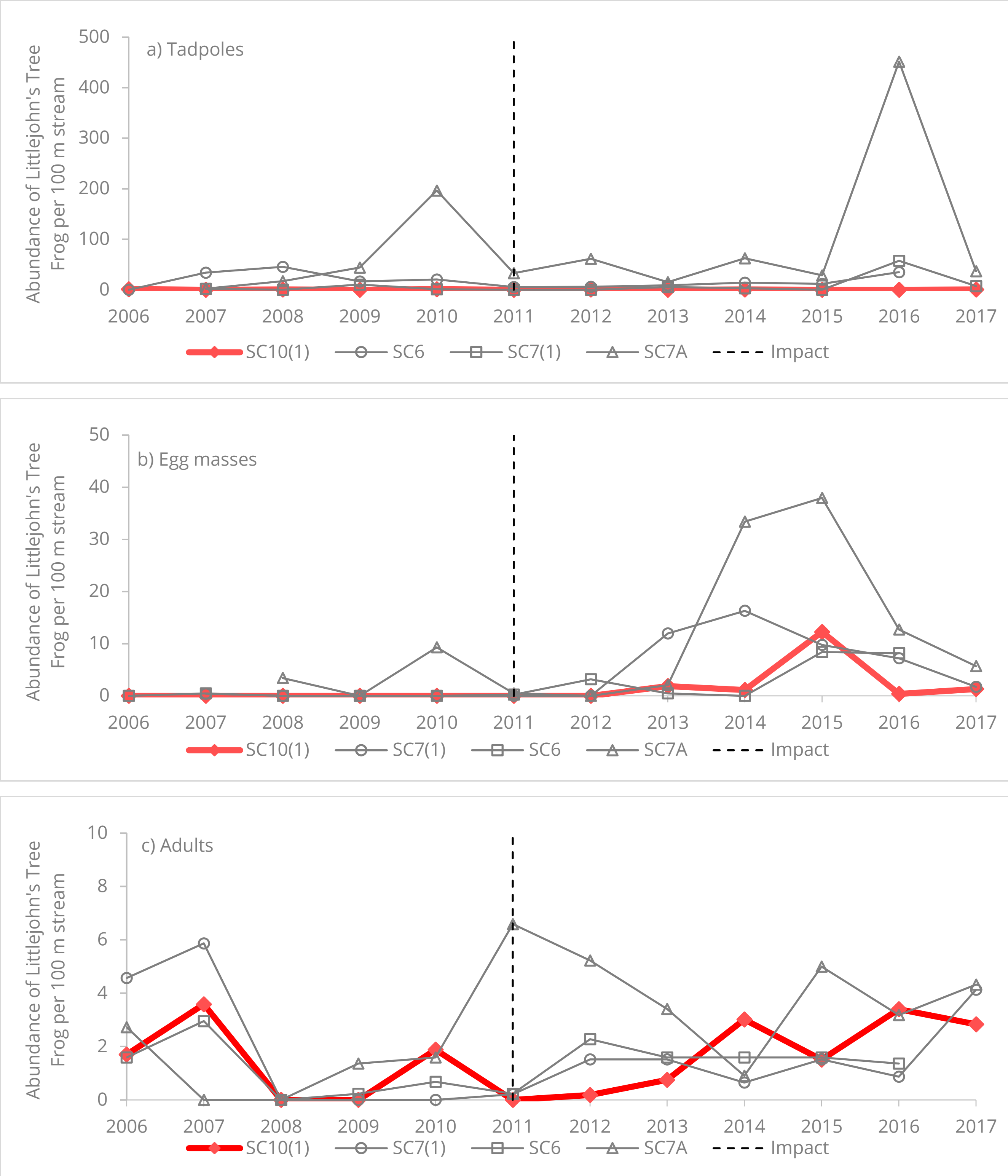

Figure 17 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site SC10(1) (red line) and associated control sites SC7(1), SC6 and SC7A (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

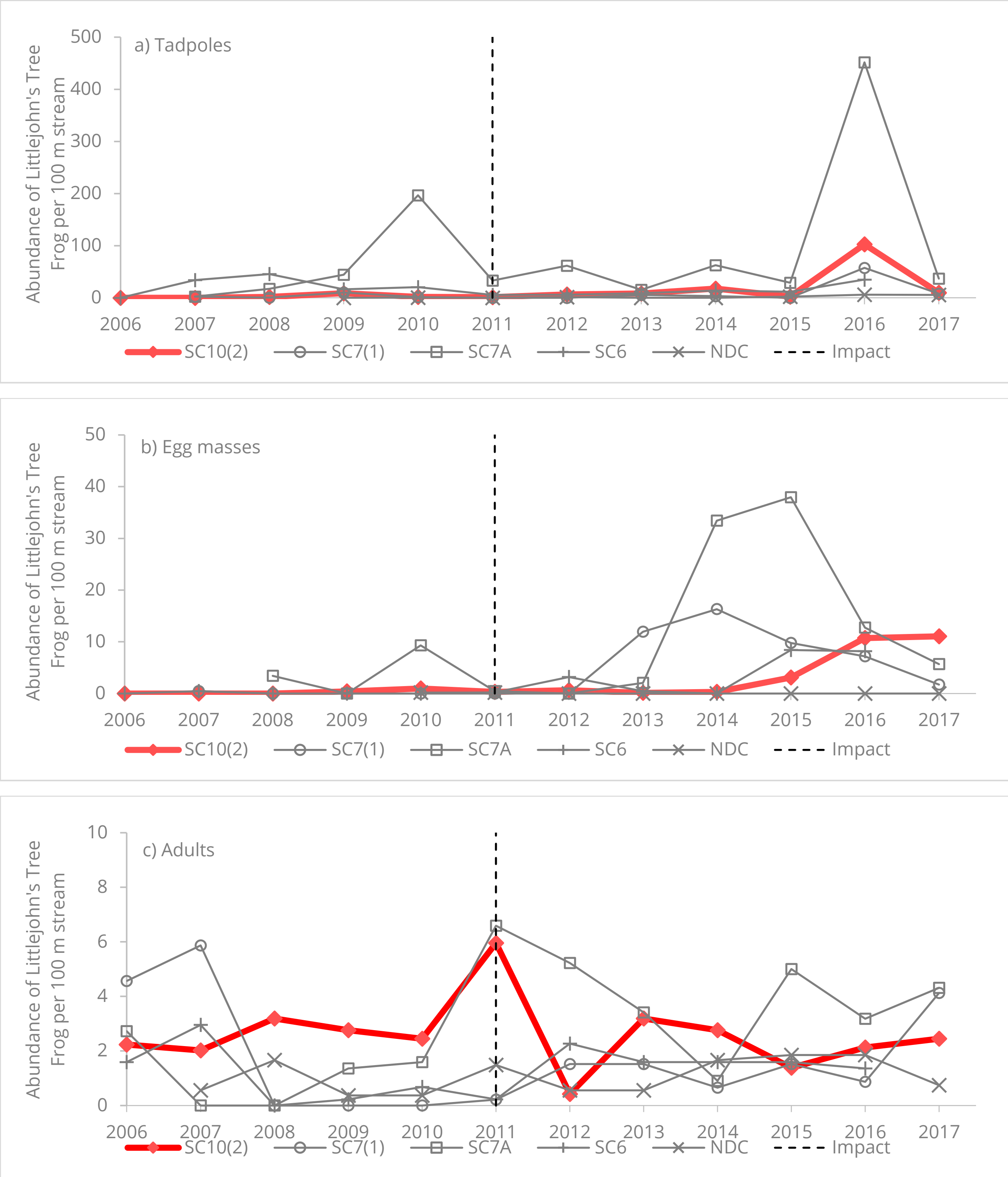

Figure 18 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site SC10(2) (red line) and associated control sites SC7(1), SC7A, SC6 and NDC (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

In 2017, minor flocking was observed in pools within the SC10(2) transect, however it is unclear whether this is associated with mining activities. Although the *Dendrobium Area 3 Watercourse TARP* has not been triggered, it is recommended that the site is monitored to determine any further change in pool conditions.

6CDL

Although highly variable over time, detection of Littlejohn's Tree Frogs at 6CDL has not shown a significant increase or decrease since mining began in 2010 (Figure 19). There were no adults observed at 6CDL during the 2017 survey, however this is consistent with pre-mining records, and cannot be attributed to mining impacts. Tadpole and egg mass records have remained consistently within or above the abundance range recorded at control sites within the area. The *Dendrobium Area 3A Landscape TARP - Terrestrial Flora and Fauna* has not been triggered.

No subsidence impacts were observed at 6CDL during the 2017 winter survey, and the *Dendrobium Area 3 Watercourse TARP* has not been triggered.

Wongawilli Creek tributaries

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. 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.

WC17

During 2016, Littlejohn's Tree Frog was detected within the WC17 transect for the first time since 2013, arresting a trending decline since 2011 following undermining. In 2017, detection of Littlejohn's Tree Frog further increased, with abundance records consistent with pre-mining numbers (Figure 20). In particular, 120 tadpoles were observed during the 2017 transect, indicating suitable recruitment conditions within the site, and the presence of breeding adult pairs. WC17 no longer triggers the *Dendrobium Area 3A Landscape TARP - Terrestrial Flora and Fauna*.

3.4.2 Dendrobium Area 3B

The remaining Wongawilli Creek tributaries monitored for Littlejohn's Tree Frog (WC21 and WC15) occur within Dendrobium Area 3B.

WC21

The detection of Littlejohn's Tree Frog at WC21 has been consistently low since surveys began in 2013 (Figure 21). Adult, egg mass and tadpole abundance increased at WC21 in 2016, with this trend consistent across most monitoring sites, and most likely associated with particularly high rainfall prior to surveys. In 2017 detection was comparable to pre-2016 records.

Impacts to WC21 were previously recorded by the Illawarra Coal Environmental Field Team between Pool 10 and the end of the transect to Pool 31, following the extraction of Longwall 9, Longwall 10, Longwall 11 and Longwall 12. This triggered Level 2 of the *Dendrobium Area 3B Watercourse TARP* in 2016 (Biosis 2017). These impacts were observed again during the 2017 survey, and include fracturing of bedrock, cracking, uplift and flow diversion. Disruption to water flow along the monitoring transect has been detected, and thus, available

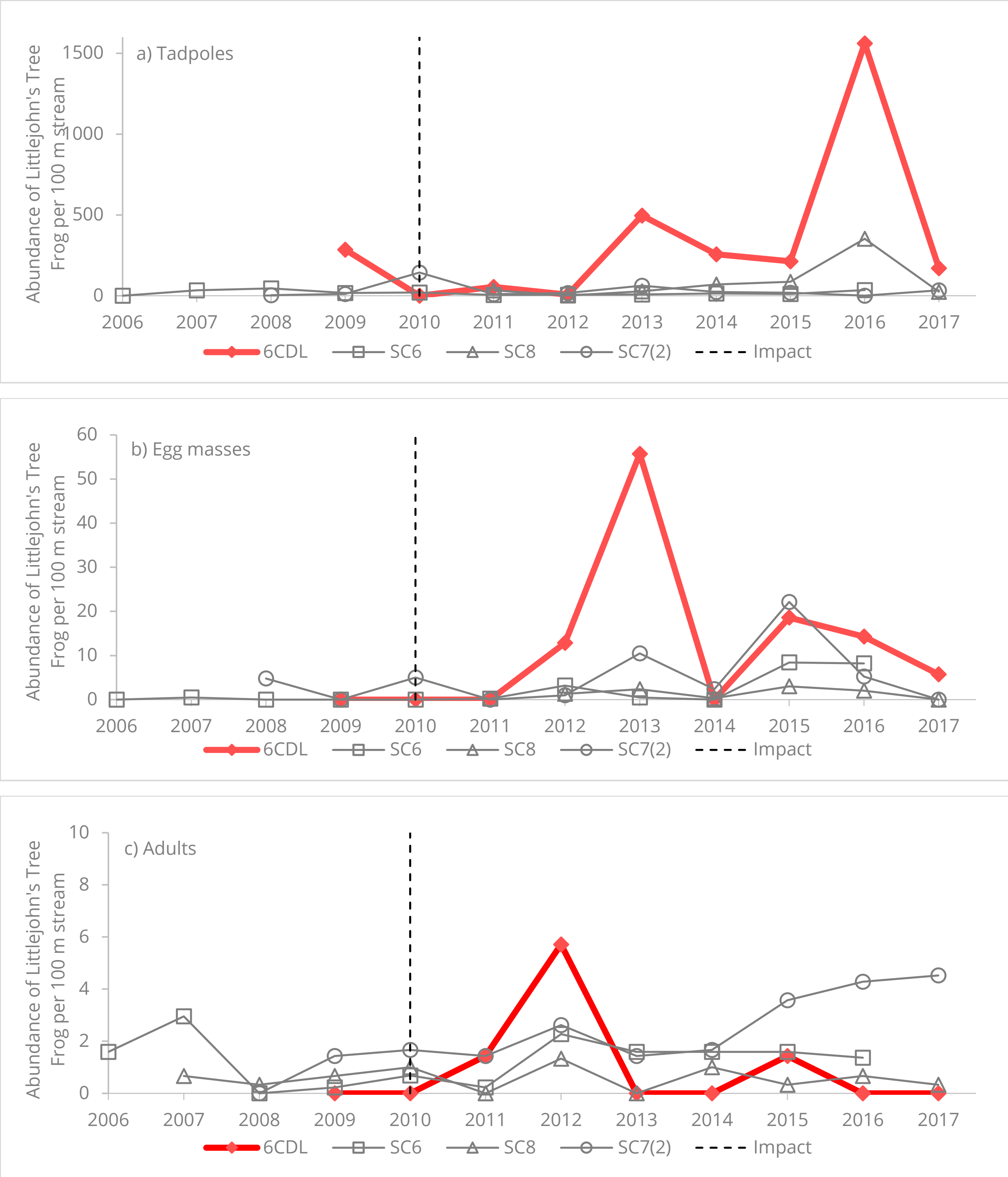

Figure 19 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site 6CDL (red line) and associated control sites SC6, SC8 and SC7(2) (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

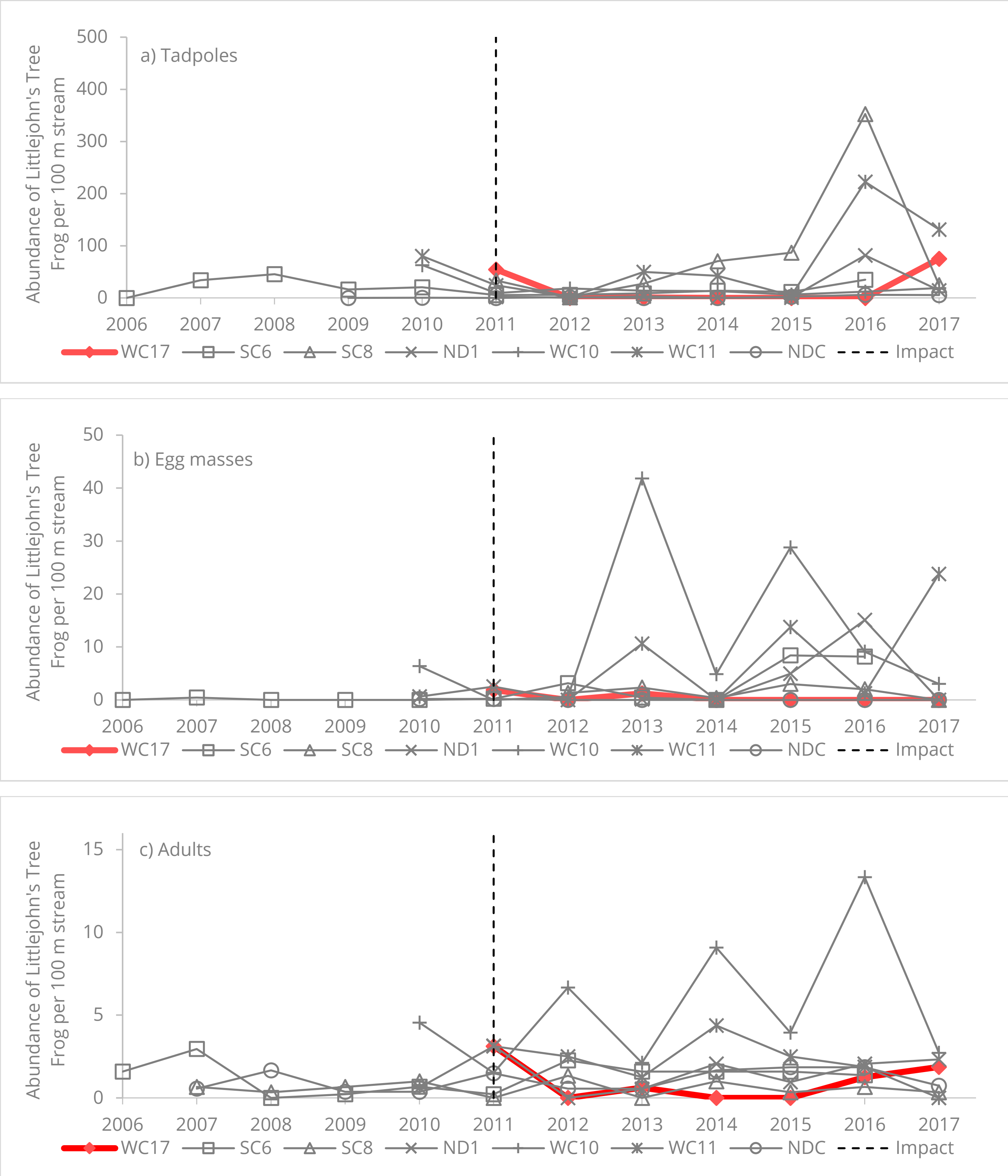

Figure 20 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site WC17 (red line) and associated control sites SC6, SC8, ND1, WC10, WC11 and NDC (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

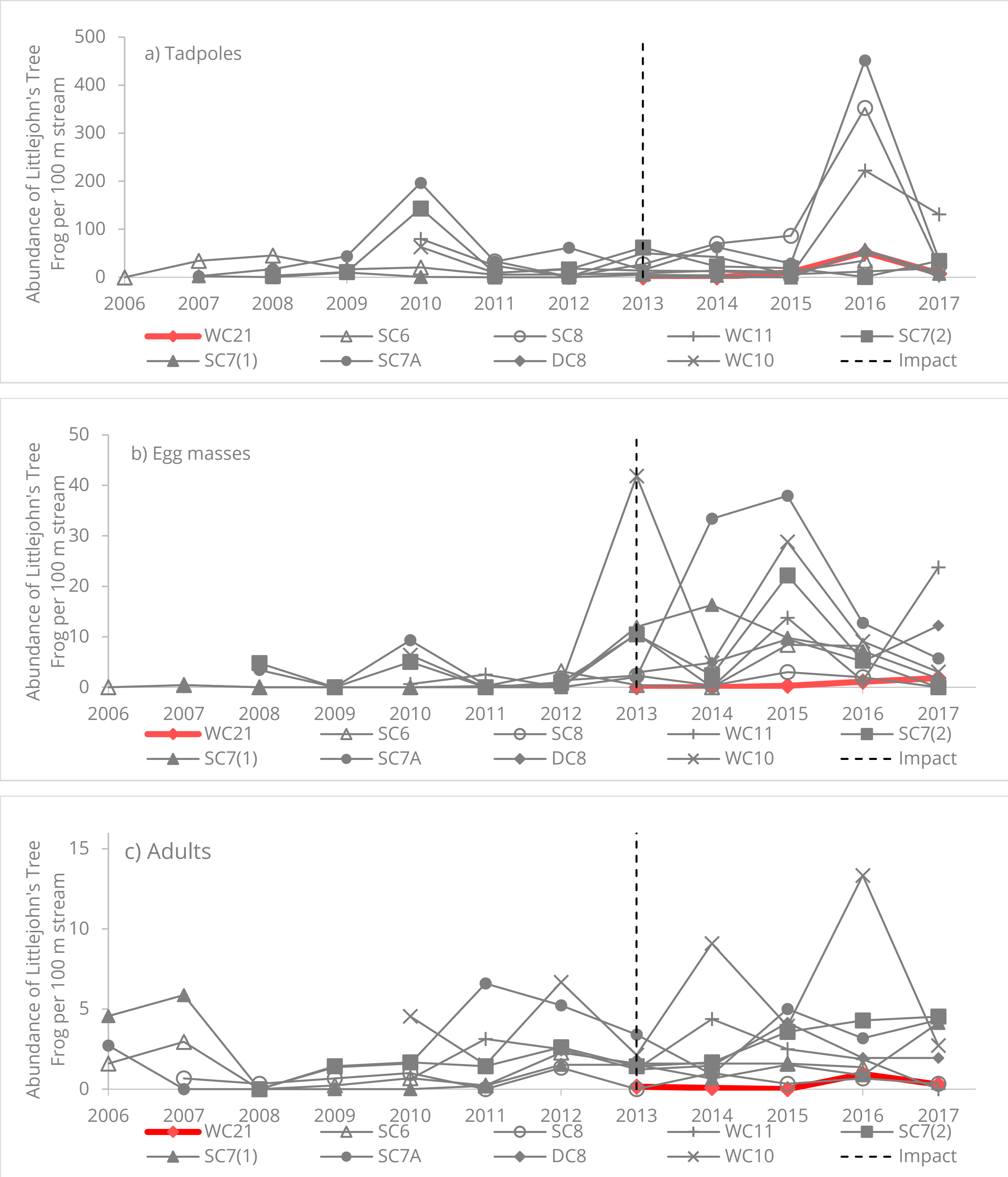

Figure 21 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site WC21 (red line) and associated control sites SC6, SC8, WC11, SC7(2), SC7(1), SC7A, DC8 and WC10 (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

habitat for the species along this transect has been substantially reduced. Follow up surveys undertaken by Biosis in summer 2016/2017 confirmed that many of the identified breeding pools had dried up before any tadpoles or eggs would have had a change to metamorphose following breeding in winter 2016. The aforementioned reduction in habitat at WC21 has now been recorded for four monitoring periods (3 years), thus triggering Level 3 of the *Dendrobium Area 3B Watercourse TARP.* This is discussed further in Section 4.2.2.

WC15

Monitoring began at WC15 in 2011, and the site currently remains a pre-impact site. Detection of tadpoles at WC15 has remained consistently low since 2011, however egg mass observations have been increasing since 2013, up to and including 2017 (Figure 22). This may be indicative of displacement of breeding adults out of impacted areas within Dendrobium Area 3B, and into nearby streams.

Donald's Castle Creek

A smaller, disjunct sub-population of Littlejohn's Tree Frog occurs along Donald's Castle Creek (DC1) and its tributaries (DC13). 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 (DC1) and at DC8 (used as a control site) in winter 2013.

DC1

DC1 has been monitored for Littlejohn’s Tree Frogs since 2013, the year of Longwall 9 extraction. Since then, detection of the species has remained consistently low, with relative abundance falling either within or below the range observed at nearby control sites (Figure 23).

Following the extraction of Longwall 9, changes in pool water levels at DC1 were recorded by the Illawarra Coal Environmental Field Team, and continued for 3.5 years (Biosis 2017). Longwall 9 is located within the RMZ of the upper reaches of DC1 and changes to the hydrology of pools along this transect is a result of impacts that occurred upstream and within Swamp 5. A loss of flow and a reduction in pool water from the DC1 Littlejohn's Tree Frog transect was observed between Pool 31 and Pool 35 during the 2016 winter surveys. In order to confirm whether water remained present in pools long enough for Littlejohn’s Tree Frog tadpoles and eggs to develop and metamorphose, follow up surveys were undertaken in summer 2016/2017 by Biosis. These surveys confirmed that pool water had dried up before recorded tadpoles and eggs had a chance to metamorphose, resulting in zero survival, and indicating a loss of Littlejohn’s Tree Frog breeding habitat within DC1 (Biosis 2017). Level 1 of the *Dendrobium Area 3B Watercourse TARP* has been triggered as a result, this is discussed further in Section 4.2.2.

DC13

Detection of Littlejohn’s Tree Frog at DC13 has remained consistently low since monitoring began, with relative abundance falling either within or below the range observed at nearby control sites (Figure 24). Adult, egg mass and tadpole abundance increased at DC13 in 2016, with this trend consistent across most monitoring sites, and most likely associated with particularly high rainfall prior to surveys. In 2017 detection of Littlejohn’s Tree Frog was comparable to pre-2016 records (Figure 24).

The upper reaches of DC13 were mined beneath by Longwall 9 in 2013. Subsidence impacts following mining have since resulted in the loss of water in pools located above this longwall. In 2016, subsidence impacts extended along approximately 30% of the monitoring transect. Pools located within this stretch (Pools 18A through to the transect end) provided known habitat for Littlejohn’s Tree Frog during the baseline monitoring period. Pools along approximately 40% of the total length of the transects had experienced a reduction in water in 2016. The remaining pools, located in the lower reaches, contained water in 2016 and provided habitat for the majority of Littlejohn’s Tree Frog adults, tadpoles and egg mass detected. At the time, of the 2016 survey, tadpoles and egg mass were detected in Pool 9 through to 17, again, downstream of Longwall 9.

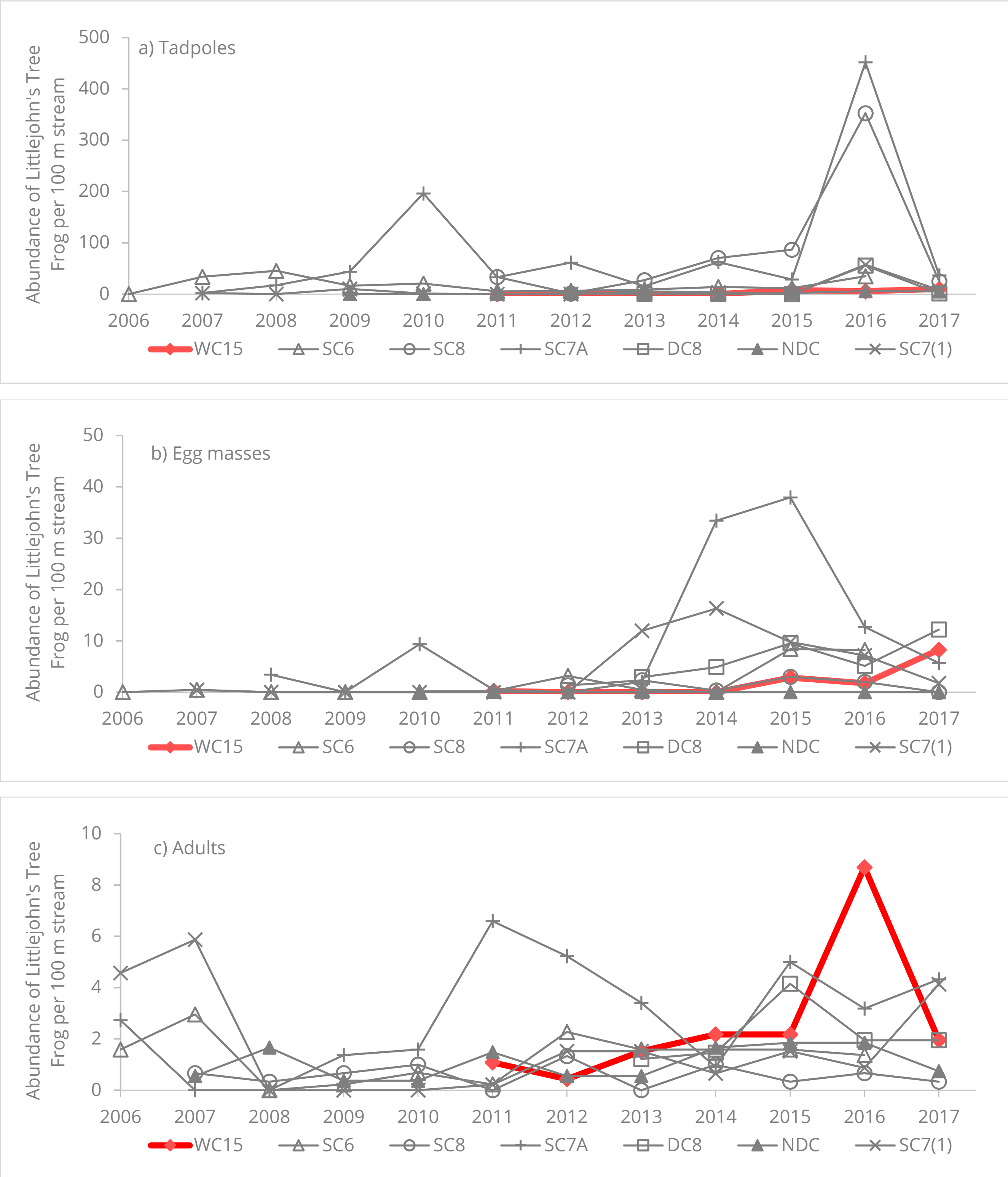

Figure 22 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site WC15 (red line) and associated control sites SC6, SC8, SC7A, DC8 and NDC (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

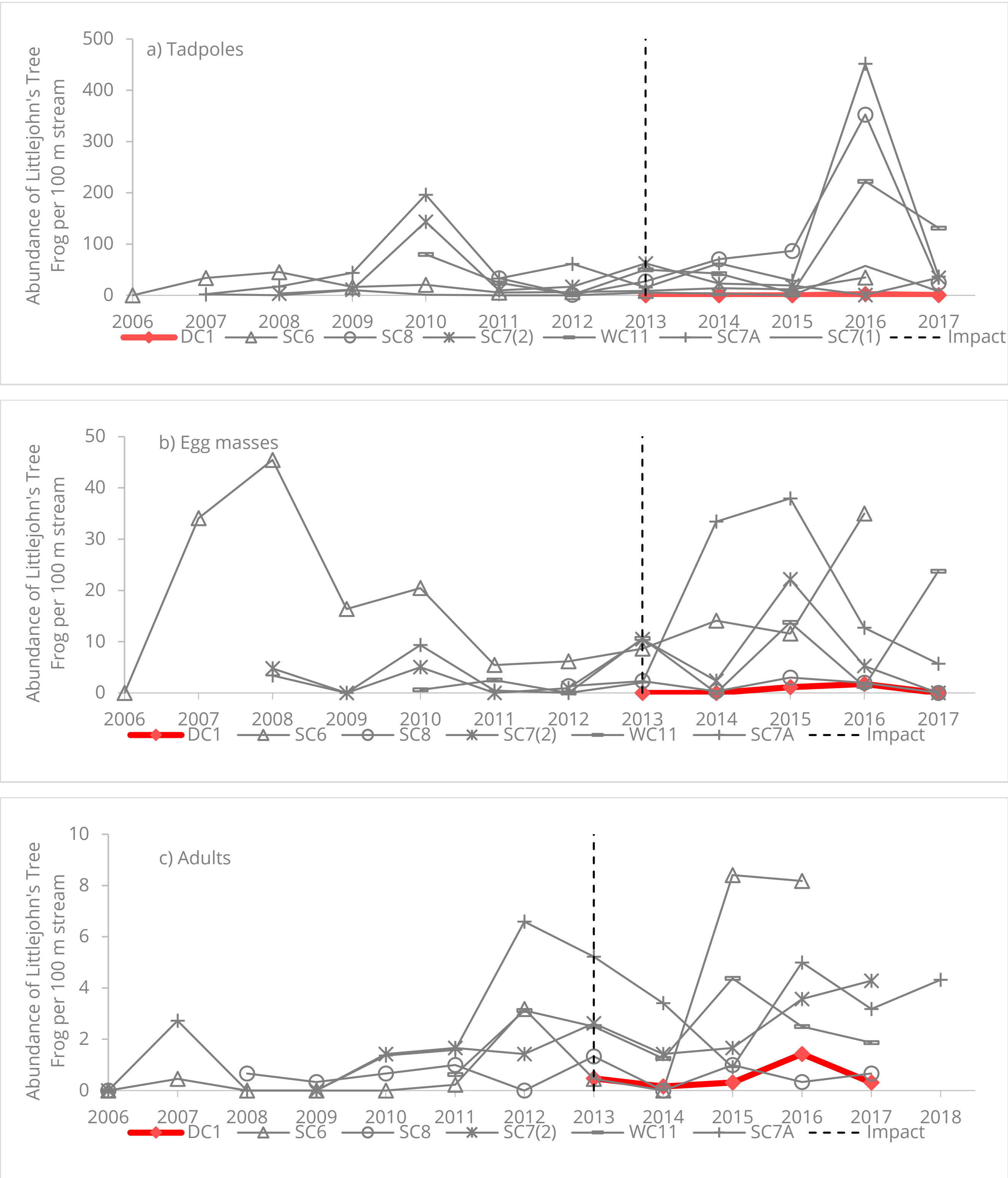

Figure 23 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site DC1 (red line) and associated control sites SC6, SC8, SC7(2), WC11 and SC7A (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

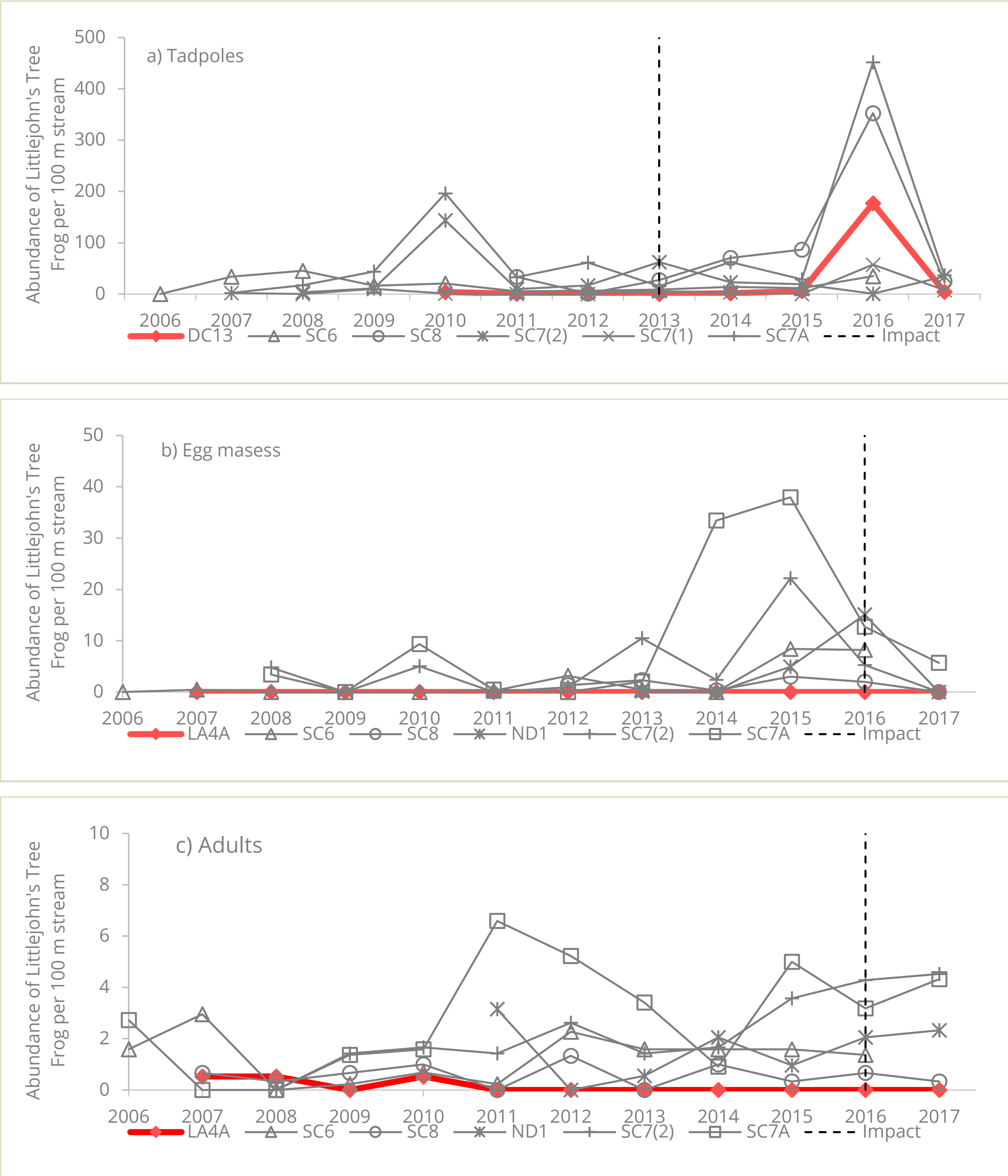

Figure 24 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site DC13 (red line) and associated control sites SC6, SC8, SC7(2), and SC7A (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

Follow up monitoring in summer 2016/2017 however, confirmed that many of the identified breeding pools had experienced a significant reduction in water, and at the time of monitoring, were no longer appropriate habitat for Littlejohn's Tree Frogs to survive to metamorphosis. Level 3 of the *Dendrobium Area 3B Watercourse TARP* has been triggered. This is discussed further in Section 4.2.2.

LA4A

Historically, adult, tadpole and egg mass abundance at LA4A has been extremely low, with values below the majority of control sites. In 2017, no Littlejohn's Tree Frogs were detected at LA4A, in any lifecycle stage (Figure 25). This does not appear to be related to mining impacts.

No observed impacts have been detected at the one breeding pool, LA4A-P1 along this stream. Some fracturing and flow diversion has been detected at the lower end of the transect where it becomes LA4, however this has not resulted in a reduction of breeding habitat for the species. The *Dendrobium Area 3B Watercourse TARP* has not been triggered.

LA2

Site LA2 was monitored for the first time during the 2017 winter survey. Seventy-three tadpoles, 70 egg masses and 3 adults were recorded at the site. The site will continue to be monitored.

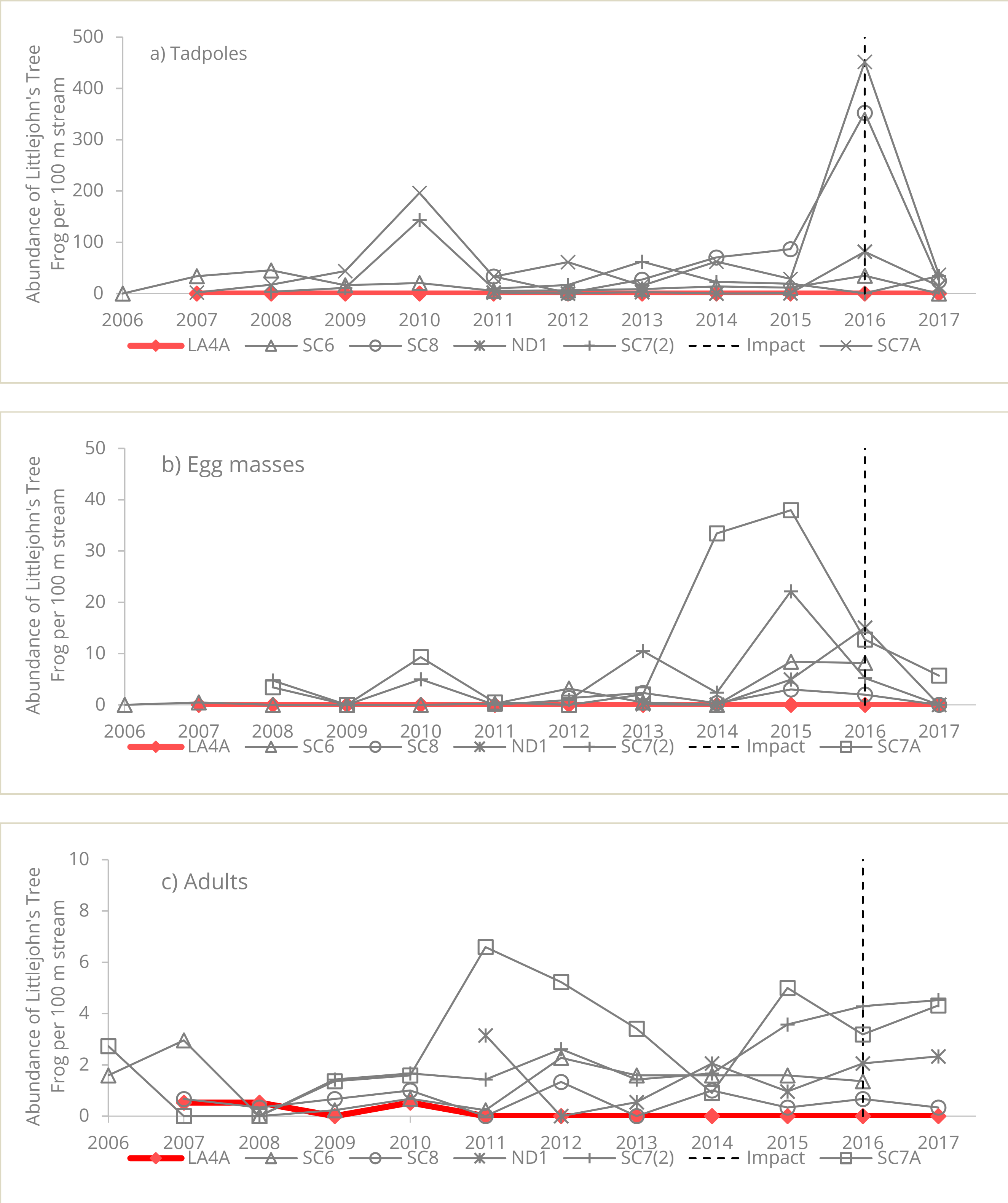

Figure 25 The number of Littlejohn's Tree Frog *Litoria littlejohni* a) tadpoles, b) egg masses and c) adults recorded at impact site LA4A (red line) and associated control sites SC6, SC8, ND1, SC7(2) and SC7A (grey lines) per 100 metres of survey transect. The dashed line represents the first year mining commenced within the RMZ. The survey was undertaken in winter 2017.

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 2017 (Table 16). No Giant Burrowing Frog *Heleioporus australiacus* (Vulnerable, EPBC Act and BC Act) adults or tadpoles were recorded incidentally during the Littlejohn's Tree Frog monitoring program, unlike previous years (Biosis 2017a). One Greater Glider *Petauroides volans* (Vulnerable, EPBC Act) was detected at WC21 during monitoring on 24 August 2017.

Table 15 Littlejohn's Tree Frog adults incidentally heard or seen in Dendrobium impact and control sites during winter 2017

Survey Date	Closest monitoring site	Lifecycle stage	Number of Littlejohn's Tree frog heard or seen
27/07/2017	SC7(2)	Adult	7
31/07/2017	WC17	Adult	6
01/08/2017	ND1	Adult	1
02/08/2017	SC8	Tadpole	8
07/08/2017	SC10(2)	Adult	2
22/08/2017	LA2	Adult	3
22/08/2017	DC8	Adult	2
23/08/2017	WC11	Tadpole	56
23/08/2017	WC11	Adult	1

3.6 Data review

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

Incidental observations recorded by Biosis staff when surveying for the annual flora monitoring locations have also been summarised herein. While this does not form part of Biosis' annual monitoring program, the information is supplied to track potential changes within the endangered ecological community (EEC), *Coastal Upland Swamp in the Sydney Basin Bioregion* (upland swamps).

During the period of the 2017 ecological monitoring program, a total of 29 surface impacts (such as cracking, fracturing of surface rock, flow diversion etc.) were identified by the Illawarra Coal Environmental Field Team in relation to the extraction of Longwall 13 (Illawarra Coal 2017). Eight of these impacts were observed along watercourses LA4 (1)and WC21 (7), with the remaining observed on fire road access tracks, sandstone outcropping or seismic lines. To date a total of 91 surface impacts have been recorded across Dendrobium Area 3B following the extraction of Longwall 9 through to 12.

Surface water, groundwater and landscape impacts to Dendrobium Areas 3A and 3B remained unchanged throughout the 2017 monitoring season with groundwater and pool water levels generally below baseline levels.

3.6.1 Dendrobium Area 3A

A total of 30 subsidence related impacts have been identified by the Illawarra Coal Environmental Field Team since extraction of Longwall 8 on 29 December 2012. These include 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. S15B has 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 new impacts associated with Area 3A have been identified and surface impact monitoring has ceased. However, piezometric monitoring has continued at swamps identified as being potentially subject, or subject, to impacts associated with longwall mining. These data are reviewed below for Swamps 15A and 15B.

Swamp 15A and Swamp 15B

No mining to date has occurred directly beneath Swamp 15A. Mining of Longwall 8 has occurred within the RMZ for the swamp in October 2012. Analysis of the long-term piezometric data at Swamp 15A is difficult as the measurement method changes from monthly dipping to installed peizometer shortly after mining within the RMZ (Figure 26). Piezometer 15a_18 is located within Swamp 15A, with vegetation at the closest transect point classified as Banksia Thicket.

Figure 26 Swamp 15A Piezometer 15a_18 data (supplied by Illawarra Coal). Mining within the RMZ occurred in October 2012 (dashed vertical line).

Swamp 15B was directly mined beneath in 2012 by Longwall 8 and mining of Longwall 7, within the RMZ, was completed January 2012. Nine piezometers are located in S15B with all results (provided by Illawarra Coal) indicating a change in the capacity of Swamp 15B to retain ground water. The results of two of the piezometers are presented in Graphs 2 and 3, with these considered representative of the nine data sets. The monitoring points and Piezometers are located in Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath). Tea-tree Thicket and Cyperoid Heath upland swamp sub-communities.

As per reporting on 2016 ecological monitoring (Biosis 2017) a review of shallow groundwater trends following the mining of Longwall 8 in 2012 indicate that piezometer 15B_26 recorded rates of water recession higher than baseline levels. In addition, the site recorded values of zero for shallow groundwater following impact (Illawarra Coal Environmental Field Team data, 15 January 2016). Subsidence related loss of shallow groundwater level supporting Swamp 15B vegetation communities has been recorded since impacts were first recorded.

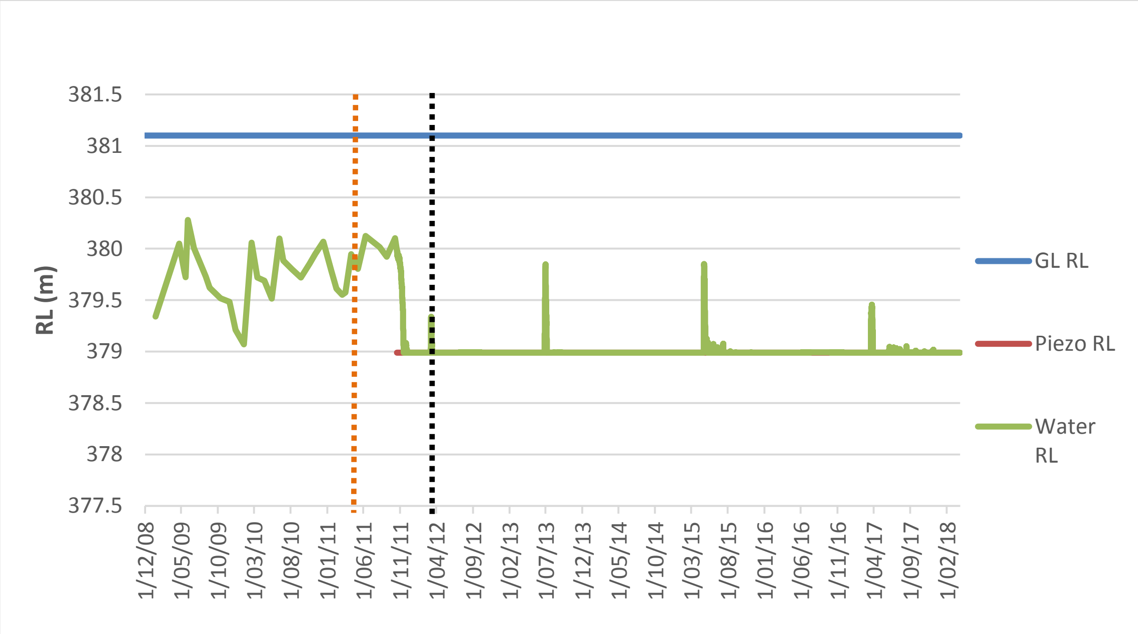

Figure 27 Swamp 15B Piezometer 15b_25 data (supplied by Illawarra Coal), with mining within RMZ (dashed orange vertical line) and mined beneath (dashed black vertical line)

Figure 28 Swamp 15B Piezometer 15b_26 (supplied by Illawarra Coal), with mining within RMZ (dashed orange vertical line) and mined beneath (dashed black vertical line)

WC17

During 2016, no mining occurred under or in proximity to WC17. As such, the Illawarra Coal Environmental Field Team have ceased monitoring of this transect.

One pool, P26 (S12) (Illawarra Coal WC17_Pool 11), has previously been identified as important Littlejohn's Tree Frog breeding habitat (Biosis 2012, Biosis 2017b). 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 increases in water levels which rapidly drop to below the previously recorded baseline levels (Figure 29). Low water levels are consistent with a Level 2 trigger identified within 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.*

During 2017, Biosis observed most pools along the transect contained water however the substrate and aquatic vegetation was covered in a thick layer of iron flocculent, including Pool 26. The pool depth measurements undertaken by Illawarra Coal indicate that Pool 26 was again dry by January 2018 (Graph 5). This indicates that the tadpoles identified during threatened frog monitoring may not have had adequate time to develop through to adulthood prior to water levels dropping.

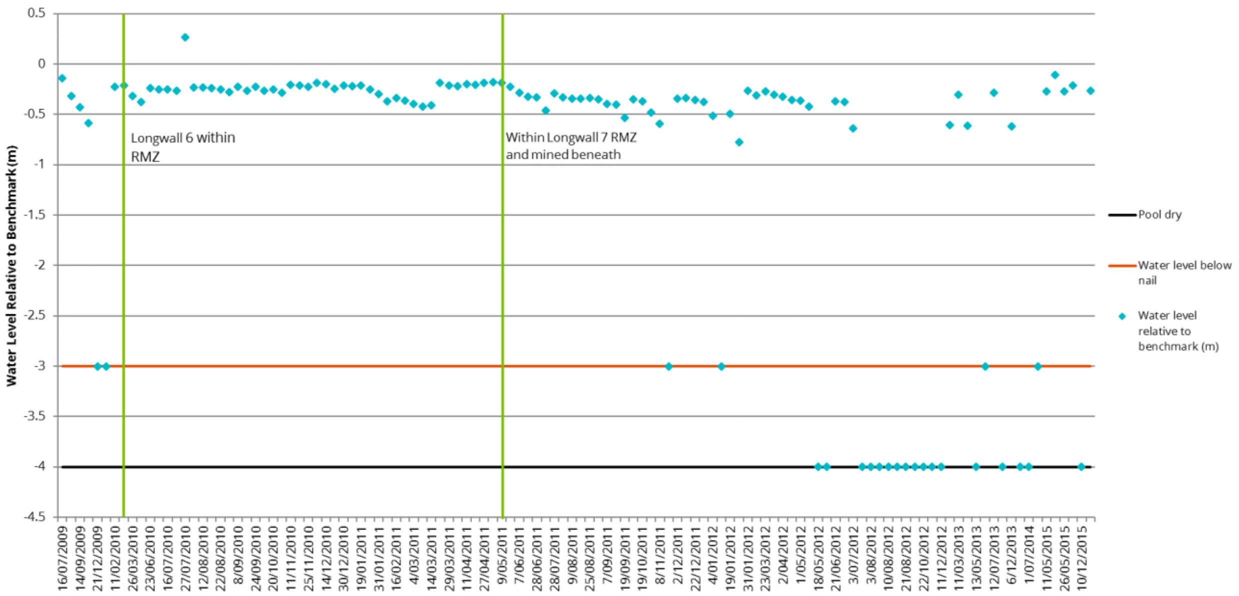

Figure 29 Water level record for WC17-Pool 26(S12) between 2009 and 2015 (data provided by Illawarra Coal)

3.6.2 Dendrobium Area 3B

To date, four longwalls have been mined within Dendrobium Area 3B being Longwalls 9, 10, 11 and 12. Longwall 13 was most recently mined and new impacts detected by the Illawarra Environmental Field Team in 2017 are associated with this longwall. WC21 is the only waterway identified during impact monitoring, and as no significant impact was identified in regards to Upland Swamp TSR or species composition only WC21 is described further.

WC21

The WC21 monitoring transect extends approximately 1.3 kilometres across Dendrobium Area 3B. The transect was mined beneath by Longwall 9 in 2013, Longwall 10 in 2014 and Longwall 11 in 2015. Longwall 12 passed beneath the upper reaches of the stream in 2016. Watercourse impacts following the extraction of these longwalls has resulted in 13 observable impacts above Longwall 9, 12 above Longwall 10, and 2 above Longwall 11. While no surface impacts were detected along WC21 in 2016 as a result of Longwall 12, several impacts were detected along a tributary running in to the stream, WC21A.

A detailed account of impacts recorded along this stream has been provided in End of Panel reports for Longwalls 9-11 (Illawarra Coal 2014; 2016). A review of the available End of Panel reports and pool data identifies the following impacts to WC21 to date:

- Iron flocculent covering substrate and aquatic vegetation between the confluence of WC21 and Wongawilli Creek up to Pool 10.
- Reduced water flow between Pool 10 and Pool 15. Reductions in pool water level within this portion of the creek were also noted.
- Fracturing of several rockbars, pool base uplift, localised surface flow diversion, reductions in surface flows and loss of pool water from Pools 16 through to Pool 30.

Following initial subsidence related impacts in late 2013, the cumulative effects of fracturing from Longwall 9, 10 and 11 include three pools (Pool 4, Pool 10 and Pool 16) where Littlejohn's Tree Frog had been recorded (Biosis 2013b). During winter 2015, Biosis identified additional locations along this stream as known breeding locations, including Pool 17 and potholes in the bedrock between Pool 14 and Pool 15.

No additional impacts were identified in 2016 as Longwall 12 passed over 300 metres upstream of the monitoring transect.

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 fast 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.

LA4A

Longwall 12 fell within the RMZ of LA4A for the first time in early 2016. The Illawarra Coal Environmental Field Team identified two surface impacts in the lower reaches of the monitoring transect where LA4A becomes LA4. The first was an area of rock fracturing and uplift of the rockbed and the second being decreased dissolved oxygen at monitoring site LA4_S1. The change in dissolved oxygen has resulted in a Level 2 Water quality trigger under the *Dendrobium Area 3B Watercourse TARP* (dated 12 October 2015).

No impacts have been detected at the single pool identified as Littlejohn's Tree Frog habitat (Pool 1).

Figure 30 Water level records for three pools along WC21 known to provide habitat for Littlejohn's Tree Frog, Pool 10 (top left), Pool 16 (top right) and Pool 17 (bottom left). Pool 30 (bottom right) demonstrates the loss of water extending to the upstream extent of the monitoring transect.

3.7 Incidental threatened species observations

A number of Littlejohn's Tree Frog were recorded outside of the monitoring transects in Dendrobium areas during winter 2016 (Table 16). In addition, Giant Burrowing Frog (Vulnerable, EPBC Act and TSC Act) adults and tadpoles were incidentally recorded at several sites during the Littlejohn's Tree Frog monitoring program. A Yellow-bellied Glider *Petaurus australis* (Vulnerable, TSC Act) was also detected at WC17 during monitoring on 12 July 2017.

Table 16 Littlejohn's Tree Frog adults incidentally heard in Dendrobium impact and control sites during winter 2016

Survey Date	Location in relation to monitoring transects	Number of Littlejohn's Tree frog heard or seen
20/6/2016	Upstream of DC(1)	1
6/7/2016	Upstream of SC7(2)	1
12/7/2016	Downstream of WC17	1
19/7/2016	Near car point of WC15 (coordinates: 289463/6191568)	1
19/7/2016	Roadside dam along Fire Road 6A (coordinates: 290484/6187983)	1
1/8/2016	Downstream of DC13	2
1/8/2016	Upstream of LA4A	1
17/8/2016	Upstream of 6CDL	1
18/8/2016	Upstream of DC8	1
30/8/2016	Downstream of WC21	1

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 2016 numerous tadpoles were again recorded at SC6 and WC11 (Table 17). 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 17). During the 2016 threatened frog monitoring, tadpoles were again recorded at the control site WC11.

While no tadpoles were recorded at any of the current impact sites during 2016, two adult Giant Burrowing Frog were detected at DC(1) during the survey undertaken on 20 June 2016. One individual was located within the monitoring transect, while the second was heard calling from upstream of the transect. This site has experienced upstream impacts however still contains some pools downstream suitable for breeding Giant Burrowing Frog and successful tadpole metamorphosis.

Table 17 Giant Burrowing Frog historical tadpole records throughout the Dendrobium impact and control sites from the commencement of monitoring

Site treatment	Site	Monitoring year								
		2008	2009	2010	2011	2012	2013	2014	2015	2016
Impact	SC10(1)				1					
	SC10(2)									
	SC10C	10				11				
	WC17									
	6CDL				4					
	DC(1)									
	DC13			70						
	WC15									
	WC21									
	LA4A									
Control	SC7(1)				1					
	SC7(2)				7					1
	SC7A									
	SC6	23	251	84	3	11	0	52	90	6
	SC8									
	ND1									
	ND2									
	NDC		48							
	WC10									
	WC11				4	3			108	166
	DC8						1			

4 Conclusion and recommendations

At the completion of the 2017 ecological monitoring program, 12 years of data has been collected for Dendrobium Area 2; 8 to 14 years of data has been collected for Dendrobium Area 3A; and 5 years of data collected for the majority of Dendrobium Area 3B (aside from Swamp 11 where monitoring has been undertaken for 14 years).

To align with the requirements of the NSW Government *Annual Review Guideline* (NSW Government 2015) the following sections provides a summary analysis of the terrestrial ecology monitoring program for the 2016 period, including:

- Section 4.1 - A summary and conclusion of trends in the data as detailed in Section 3.
- Section 4.2 - A comparison of the data to predictions made in the Environmental Impact Statement.
- Section 4.3 - Identification of any management implications and proposed improvements to environmental management or performance.

Area 3B TARP triggers levels and the relevant corrective actions are discussed herein for Area 3B monitoring sites. For monitoring sites in Area 3A, where the TARP trigger levels are not applicable and do not relate to corrective actions, TARPs have been used to frame the discussion of trends.

4.1 Discussion of ecological trends

4.1.1 Upland swamp total species richness

An overall decline in TSR has been observed at all sites and is likely indicative of landscape scale factors, such as changes in climatic conditions, natural succession of swamp vegetation and/or changes on upland swamp vegetation following bushfire. The most recent recorded fire within Dendrobium Area 3A and 3B 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.

Piezometric data indicates changes in shallow groundwater levels at Swamp 15B following extraction of longwalls in Dendrobium Areas 3A and 3B. Therefore, it is possible that statistically significant declines in TSR at this swamp is attributed to alterations in retention of shallow groundwater, with hydrographs representing rainfall driven fluctuations. At Swamp 15A(2), the decline in TSR post-mining was not statistically different to TSR pre-mining and at control swamps immediately after mining but by 2013 became statistically different, with the level of significance observed continuing to increase. This trend towards an increasingly significant difference between TSR compared with TSR before mining and at control swamps has occurred, despite no change being recorded in groundwater levels.

The results of the TSR analysis demonstrate the response to mining at individual swamps is complex with Swamp 15A(2) and Swamp 15B showing a decline and subsequent increase in TSR following mining, and Swamp 1A, Swamp 1B and Swamp 5 showing no significant decline in TSR despite observed changes in shallow groundwater availability.

4.1.2 Upland swamp species composition

Statistically significant yearly and, occasionally, seasonal trends in species composition were detected at most sites, regardless of mining area or treatment. Such global trends are indicative of natural turnover of species within upland swamps in response to seasonal and annual variability in climate, competition, disturbance and edaphic factors including nutrient availability.

When accounting for yearly effects, a statistically significant change in species composition post-mining was found at Swamp 15B and Swamp 15A(2). As with TSR, these changes were observed immediately following mining and have continued at Swamp 15B and Swamp 15A(2) for at least four years post-mining.

At Swamp 15A(2), the increase in Heath Banksia over time described by statistical analysis corresponds to field observations of increased height and density of this species within S15A(2). The observed increased height and cover of Heath Banksia has increased shading in some parts of the swamp previously open. The *Cassytha glabella / C. pubescens* species complex is widespread and proliferates by attaching to the canopy of the mid strata. An increase in this species within upland swamp vegetation is not likely to result in a structural change of the vegetation community, but represents a shift in the composition of the vegetation community.

Observed reduction in woodland species recorded at Swamp 15B is likely linked to vegetation changes following fire and subsequent increased shading by shrub species such as Heath Banksia and Needlebush. As such, the observed decrease in the *Goodenia dimorpha G. stelligera G. bellidifolia* complex, at Swamp 15B is likely indicative of changes in structure (increased shading) and likely a cumulative change in shallow groundwater (drying trend) based on its preference for shallow, free draining moist soils. While a statistically significant change has been observed, it is likely to be overstated in the data analysis.

4.1.3 Littlejohn's Tree Frog

There was a decrease in detection of adult Littlejohn's Tree Frog in 2017 compared to 2016 by approximately 32%, and tadpoles by 84%. However, 2016 was an excellent year for breeding due to high levels of rainfall, and frog numbers recorded in 2016 were much higher than previous years. Detection of Littlejohn's Tree Frog in 2017 was comparable to detection in 2015.

Since commencement of threatened frog monitoring in Areas 3A and 3B, the abundance of all life stages detected has varied substantially year to year, at both impact and control sites. This is most likely due to movement of individuals amongst sites, as well as differences in environmental conditions (e.g. time since rain, volume of rain, temperature) at the time of survey. Environmental conditions such as rainfall can influence both detectability of individuals (adults may not be active if conditions are not suitable), as well as the timing of breeding events relative to survey. Conducting amphibian surveys at one time-point during the breeding season only provides a snapshot of frog abundance at that particular time, contributing to variation seen across years. However, there is no visually discernible trend in either year or mining status (Pre/Post mining) in both mining areas (Dendrobium Areas 3A and 3B).

Subsidence related impacts at Area 3A, including fracturing of bedrock, lowering of water levels and build-up of iron flocculant have been recorded at sites SC10C and SC10(1), with each of these sites triggering either Level 1 (SC10(1), DC1) or Level 3 (SC10C) of the *Dendrobium Area 3A Watercourse TARP* (Illawarra Coal 2015a). The triggering of the Dendrobium Area 3B Watercourse level 1 TARP (Illawarra Coal 2015b) was identified at DC1 and level 3 at WC17, WC21 and DC13.

Further monitoring of breeding pools conducted in summer 2016/2017 confirmed that, at several of these sites, identified breeding pools contained sufficient water to support the laying of egg clutches in winter. However, these pools did not retain water long enough into summer for individuals to successfully reach metamorphosis. This represents a reduction in the available Littlejohn's Tree Frog breeding habitat within both Dendrobium Area 3A and Area 3B. It is recommended that the monitoring of both tadpoles and pool levels continues in summer 2018/2019. Site SC10(1) has triggered the *Dendrobium Area 3A Watercourse TARP* (Illawarra Coal 2015a) due to build-up of iron flocculant covering all stream surfaces during the winter survey. It is recommended that this waterway be added to the sites being monitored throughout summer to further investigate fluctuations in water levels and survival of Littlejohn's Tree Frog clutches.

Of the post-mining sites that have experienced subsidence related impacts, only SC10C shows a declining trend in detection of all Littlejohn's Tree Frog life stages, triggering Level 1 of the *Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)* (Illawarra Coal 2012c). However, recruitment at this site before mining occurred was also extremely low, and numbers have remained low throughout the course of monitoring. Hence, the absence of Littlejohn's Tree Frogs at SC10C in 2017 is not currently of significance.

In 2016 a declining trend in Littlejohn's Tree Frogs was recorded at post-mining site W17, with no tadpoles or egg masses recorded from 2014 – 2016. However, in 2017 120 tadpoles were recorded at the site. This indicates a return to pre-mining recruitment conditions. Detection of Littlejohn's Tree Frog at all other monitoring sites have either remained stable, or were extremely low before mining occurred, making it difficult to draw conclusions about trends in abundance.

Recommendations are made by Biosis in relation to the TARPS triggered in Section 4.2.2.

4.2 Assessment against performance measures

4.2.1 Upland swamp vegetation monitoring

Area 3B TARP triggers levels and the relevant corrective actions are discussed herein for Area 3B monitoring sites. These TARPs apply to Areas 3B only and were established under the current approvals. Area 3A TARP trigger levels and relevant corrective actions are also discussed in the context of results observed at Area 3A swamps; Swamp 15A(2) and Swamp 15B.

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 in the Subsidence Management Plans for each area (Illawarra Coal 2012a; 2012b). Specifically, localised water diversion and lowering of shallow groundwater levels within Swamp 1A, Swamp 1B and Swamp 5 was predicted (Illawarra Coal 2012a; 2012b).

The following *Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)* (Illawarra Coal 2012c) sets out the trigger levels for terrestrial flora:

- Level 1 - Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period; or no significant statistical difference between Before After Control Impact sites.
- Level 2 - Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period; or statistically significant difference of species richness and species diversity between Before After Control Impact sites as a result of mining.
- Level 3 - Vegetation impacted by mining that is not responding to CMAs.

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 2016 is discernible when considering pooled TSR data from control swamps. While this variation occurs, trends of stability are evident at all control sites paired with impact swamp located within Dendrobium Area 3A and 3B (as demonstrated in Section 3.2.1 and Section 3.2.2).

Yearly changes in species composition were detected at most sites, regardless of area or treatment. This variation is likely a function of natural turnover of species in response to climatic variability, stochastic events and successional changes (particularly post-fire). When accounting for yearly effects, a statistically significant change in species composition in post-mining data to pre-mining data was also found at Swamp 15B

(Dendrobium 3A) and Swamp 15A(2) (Dendrobium 3A). No statistically significant declines in species composition were detected for Dendrobium Area 3B swamps.

During this period of stability, no statistically significant declines in TSR were detected for Dendrobium Area 3B swamps (S1A, S1B, S5) however a statistically significant decline was detected at two impact swamps Swamp 15A(2) and Swamp 15B (Dendrobium 3A).

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

- 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.

A summary of the assessment of the results of the 2017 analysis against the Dendrobium 3A and 3B TARPs is presented below in Table 18.

Table 18 Summary of the assessment of impact swamps in Dendrobium Area 2, 3A and 3B against the TARPs

Swamp	Predicted impact	Results and TARP justification	TARP	Recommendations
Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)				
S15B	Level 1, 2 or 3 TARP.	A statistically significant difference in TSR between BACI sites (Figure 7 and Table 8). No CMAs have been initiated, therefore a Level 3 trigger cannot be assessed.	Level 2 triggered.	Continue monitoring S15B in spring and autumn each year. Consult with technical specialists to identify need and type of CMA required and implement any agreed CMA.
S15A(2)	Level 1, 2 or 3 TARP.	No significant decline in TSR was detected at S15A(2)) at the p=0.05 level. However, data analysis indicates that change in TSR is becoming increasingly significant (Section 3.2.1). A statistically significant change in species composition was detected at S15A(2) during the 4 year post-mining period (p-value = 0.003)	Level 2 triggered.	Continue monitoring S15A(2) in spring and autumn each year and investigate reasons for the TARP trigger. Consult with technical specialists to identify need and type of CMA required

		indicating a Level 2 TARP has been triggered (Table 9). No CMAs have been initiated, therefore a Level 3 trigger cannot be assessed.		and implement any agreed CMA.
Dendrobium Area 3B Swamp Monitoring – Terrestrial Flora: Composition and Distribution of Species (dated 12 October 2015)				
S1A	Level 1, 2 or 3 TARP.	TSR within S1A showed no statistically significant decline when compared with control sites. Additionally, no statistically significant decline in species composition was found post-mining at S1A.	No TARP levels triggered.	Due to the detection of decreased groundwater and incidental observations of Needlebush yellowing, continued monitoring of S1A is recommended.
S1B	Level 1, 2 or 3 TARP.	TSR within S1B showed no statistically significant decline when compared with control sites. Additionally, no statistically significant decline in species composition was found post-mining at S1B.	No TARP levels triggered.	Due to the detection of decreased groundwater, continued monitoring of S1B is recommended.
S5	Level 1, 2 or 3 TARP.	TSR within S5 showed no statistically significant decline when compared with control sites. Additionally, no statistically significant decline in species composition was found post-mining at S5.	No TARP levels triggered.	Due to the detection of decreased groundwater and soil moisture along with the yellowing of Needlebush, continued monitoring of S5 is recommended.

Upland Swamp Extent

The analysis of LiDAR data, collected by AAM Hatch used to assess the extent of upland swamps and their composite vegetation communities, has identified that while all upland swamps within the study area have decreased from the baseline minimal change was identified between 2016 and 2017.

The results of the 2017 LiDAR data analysis has identified that there are continual declines in the extent of vegetation communities that comprise upland swamps. The two vegetation communities identified as being reduced in extent are MU43 (Tee-tree Thicket) and MU44c (Sedgeland). Only declines in MU43 have been determined to be of statistical significance. Declines in the extent of MU44c, while triggering a Level 1 TARP, require further investigation to determine why this community is increasing in extent at some swamps and decreasing at others.

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' (taken to be represented by the maintenance of groundwater dependent vegetation sub-communities that comprise upland swamps):

- **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.

Table 19 Summary of the assessment of impact swamps in Dendrobium Areas 2, 3A and 3B against the 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 in 2018 using the expanded ALS capture footprint.
S1A	Level 1, 2 or 3 TARP.	One year of decline in total swamp extent greater than the mean (±SE) decline of the control group. Trending decline in the extent of sub-community MU43 for two consecutive monitoring periods greater than the mean (±SE) decline of MU43 in the control group.	Swamp Size: No TARP triggered. Ecosystem Function: Level 1 TARP triggered.	Continue monitoring in 2018 using the expanded ALS capture footprint. Investigate practical remediation measures, or offset if remediation deemed to be ineffective after 5 years.
S1B	Level 1, 2 or 3 TARP.	One year of decline in total swamp extent greater than the mean (±SE) decline of the control group. Trending decline in the extent of sub-community MU44c for two consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Swamp Size: No TARP triggered. Ecosystem Function: Level 1 TARP triggered	Continue monitoring in 2018 using the expanded ALS capture footprint. Groundtruth and assess MU44c at S1B compared with S15B (control) to determine drivers of change, to determine adequacy of practical remediation measures.
S05	Level 1, 2 or 3 TARP.	One year of decline in total swamp extent not greater than the mean (±SE) decline of the control group. Trending decline in the extent of sub-community MU43 for three consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Swamp Size: No TARP triggered. Ecosystem Function: Level 2 TARP triggered.	Continue monitoring in 2018 using the expanded ALS capture footprint. Ground-truth decline in MU43 to determine requirement of practical remediation measures..
S08	Level 1, 2 or 3 TARP.	One year of decline in total swamp extent not greater than the mean (±SE) decline of the control group.	Swamp Size: No TARP triggered. Ecosystem Function:	Continue monitoring in 2018 and investigate increases in extent.

Swamp	Predicted impact	Results and TARP justification	TARP	Recommendations
		No trending decline in the extent of any sub-communities over the monitoring period.	No TARP triggered.	

4.2.2 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 has resulted in impacts to breeding habitat for Littlejohn's Tree Frog, seen in the decreasing number of individuals detected within the site over time. The revised *Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)* (Illawarra Coal 2012c) sets out the trigger levels for terrestrial fauna:

- Level 1 - No significant statistical difference between Before After Control Impact sites.
- Level 2 - Statistically significant difference of species richness and species diversity between Before After Control Impact sites as a result of mining.
- Level 3 - Vegetation impacted by mining that is not responding to CMAs.

The above TARPS (dated 12 November 2012) relating to ecology are limited in the way they can be assessed due to the variability in the detection of Littlejohn's Tree Frog and limitations in analysis of the data due to lack of sufficient replication. As the focus of these TARPs is on vegetation, they also fail to stipulate specific actions to be undertaken following the detection of impacts to Littlejohn's Tree Frog habitat during monitoring.

It is understood however that Pool Water Level / Flow and Appearance triggers identified in the Dendrobium Area 3A Watercourse Impact Monitoring Management and Contingency Plan have been triggered at both SC10C (Level 3) and SC10(1) (Level 1), and Corrective Management Actions (CMAs) should be considered by Illawarra Coal.

Table 20 assesses impact sites in Dendrobium Area 3A against the TARPs using the definitions outlined above.

Table 20 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 Landscape Monitoring TARP (dated 12 November 2012)				
SC10C	Significant impacts to local populations of Littlejohn's Tree Frog.	Due to the level of variation in the dataset and lack of replication of monitoring events each year, a statistical analysis of the data could not be completed. However a decline in the abundance of adult frogs was observed following subsidence impacts detected at SC10C	**Level 1 TARP triggered.**	Continue monitoring to investigate whether CMAs for related watercourse TARPs may address some impacts to threatened frog habitats.

Stream	Predicted impact	Results and TARP justification	TARP	Recommendations
		following extraction of Longwall 7 and Longwall 8 during 2011 and 2012 (2 years after the initial mining within the RMZ), and numbers have not recovered (Figure 16). The following Level 1 triggers relating to terrestrial fauna have been observed: • No significant statistical difference between Before After Control Impact sites. The following triggers relating to watercourse monitoring have been observed: • Stream appearance at SC10C.		
SC10(1)	Significant impacts to local populations of Littlejohn's Tree Frog.	There has been no significant decline in Littlejohn's Tree Frogs at SC10(1) since mining began in 2011 (Figure 17). Although tadpole and egg mass numbers were low in 2017, this is consistent with pre-mining records, and does not appear associated with mining impacts. The following trigger relating to watercourse monitoring has been observed: • Iron flocculant covering all stream surfaces This represents a reduction in breeding habitat for Littlejohn's Tree Frogs.	**No TARP levels triggered.**	Continue monitoring as normal.
SC10(2)	Significant impacts to local populations of Littlejohn's Tree Frog.	There has been no significant decline in Littlejohn's Tree Frogs at SC10(1) since mining began in 2011 (Figure 18).	**No TARP levels triggered.**	Continue monitoring as normal.
WC17	Significant impacts to local populations of Littlejohn's Tree Frog.	Due to the level of variation in the dataset and lack of replication of monitoring events each year, a statistical analysis of the data could not be completed. However, in 2017, detection of Littlejohn's Tree Frog continued to increase from previous years, with abundance records consistent with pre-mining numbers (Figure 20). In particular, 120 tadpoles were observed during the 2017 transect, indicating appropriate recruitment conditions within the site, and the presence of breeding adult pairs.	**Level 1 TARP no longer triggered.**	Continue monitoring as normal.

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; or
  - 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; or
  - 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; and
  - The absence of the species (all life stages) from a site where successful breeding occurred pre-mining.

Table 21 assesses impact sites in Dendrobium Area 3B against the TARPs using the definitions outlined above.

Table 21 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)				
DC(1)	Significant impacts to local populations of Littlejohn's Tree Frog.	Following the 2016 survey at DC(1), breeding pools (Pools 32 and 33) had a reduced water level below the benchmark nail. In order to confirm whether water remained present in pools long enough for Littlejohn's Tree Frog tadpoles and eggs to develop and metamorphose, follow up surveys were undertaken in summer 2016/2017 by Biosis. These surveys confirmed that pool water had dried up before recorded tadpoles and eggs had a chance to metamorphose, resulting in zero	**Level 1 TARP triggered.**	Continue monitoring as a part of the terrestrial monitoring program. Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers. Due to the reduction in water levels, additional

Stream	Predicted impact	Results and TARP justification	TARP	Recommendations
		survival, and indicating a loss of Littlejohn's Tree Frog breeding habitat within DC1 (Biosis 2017).		tadpole surveys should be conducted in summer 2018/2019 and additional pool water level monitoring should be conducted by Illawarra Coal.
DC13	Significant impacts to local populations of Littlejohn's Tree Frog.	Subsidence impacts following mining have since resulted in the loss of water in pools located above longwall 9. In 2016, subsidence impacts extended along approximately 30% of the monitoring transect. Pools located within this stretch (Pools 18A through to the transect end) provided known habitat for Littlejohn's Tree Frog during the baseline monitoring period. Pools along approximately 40% of the total length of the transects had experienced a reduction in water in 2016. Follow up monitoring in summer 2016/2017 confirmed that many of the identified breeding pools that had water in winter 2016 had experienced a significant reduction in water by summer, and were considered no longer appropriate habitat for Littlejohn's Tree Frogs to survive to metamorphosis.	**Level 3 TARP triggered.**	Continue monitoring as a part of the terrestrial monitoring program. Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers. Additional tadpole surveys should be conducted by Biosis in summer 2018/2019 and additional pool water level monitoring should be conducted by Illawarra Coal. Illawarra Coal are to develop site CMA (subject to stakeholder feedback).
WC21	Significant impacts to local populations of Littlejohn's Tree Frog.	A reduction in habitat for five monitoring periods (four years) has been recorded at WC21 following the extraction of Longwall 9, Longwall 10, Longwall 11 and Longwall 12. Approximately 57% of the potential breeding habitat along this stream is experiencing a reduction in water levels (between Pool 11 and Pool 30) including three confirmed breeding pools (observations by Biosis during monitoring in 2015).	**Level 3 TARP triggered.**	Continue monitoring as a part of the terrestrial monitoring program. Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers. Additional tadpole surveys should be conducted by Biosis in summer 2018/2019 and additional pool water level monitoring should be

Stream	Predicted impact	Results and TARP justification	TARP	Recommendations
				conducted by Illawarra Coal. Illawarra Coal are to develop site CMA (subject to stakeholder feedback).
LA4A	Significant impacts to local populations of Littlejohn's Tree Frog.	No observed impacts have been detected at the one breeding pool, LA4A-P1 along this stream. Some fracturing and flow diversion has been detected at the lower end of the transect where it becomes LA4, however this has not resulted in a reduction of breeding habitat for the species.	**No TARP Level triggered.**	Continue monitoring as a part of the terrestrial monitoring program.

In response to the impacts to DC(1), DC13 and WC21, water level monitoring and tadpole surveys were undertaken during summer 2016/2017 to determine if metamorphosis was occurring along streams where reductions in habitat were detected (Biosis 2017b). Continuing tadpole development at DC13, WC21 and DC(1) varied based on the availability of sustained water levels within potholes and pools throughout the key development stages following the 2016 winter breeding season. Due to a limited number of breeding pools that contain water long enough to allow for full development to metamorphosis and adults, the risk of losing a generation of a local population of Littlejohn's Tree Frogs at these sites has increased as a result of mining impacts. Continued monitoring and corrective management actions are recommended in Biosis (2017b).

4.3 Site specific recommendations

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

Swamp 15(A)2 and Swamp 15B have been monitored over a significant period of time and have shown recent increases in TSR, following an initial decrease post mining, with species composition also observed to be changing over time. Further monitoring of these trends is recommended to collect additional long term data to continue to build scientific knowledge on the impacts of longwall mining on upland swamps.

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 sites as part of the 2017 monitoring program.
- Review monitoring frequency.
- Report in the End of Panel Report.
- Summarise all actions and monitoring in Annual Environmental Monitoring Report (AEMR).
- Notify relevant technical specialists and seek advice on any CMA required.
- Implement agreed CMAs as approved.

4.3.2 Dendrobium Area 3B upland swamps

While TARP trigger levels were met at sites located within Dendrobium Area 3B, all three swamp sites currently monitored as impact sites have experienced decreased groundwater levels and soil moisture at monitoring locations. Both Swamp 1A and Swamp 5 have also experienced the yellowing of Needlebush. The continued monitoring of all three sites is therefore recommended in the event that there is a lag in the detection of change to TSR, species composition or extent resulting from mining.

It is also recommended that further investigation of the increase in extent of Swamp S8 be undertaken as part of the 2018 ground truthing of LiDAR data.

4.3.3 SC10C and WC17 Littlejohn's Tree Frog monitoring

The triggering of a revised Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012) (Illawarra Coal 2012c) Level 1 TARP for SC10C requires the following actions:

- Continue monitoring program.
  - Biosis will continue monitoring SC10C as part of the monitoring program.
- Report impacts to key stakeholders.
- Summarise impacts and Report in the End of Panel Report and AEMR.

Pool Water Level / Flow and Appearance triggers in the Dendrobium Area 3 Watercourse TARP have also been triggered at SC10C and WC17, and CMAs should be considered by Illawarra Coal. Increased water levels were detected at WC17 during the Littlejohn's Tree Frog monitoring event in 2016 and 2017, however it is unknown whether these water levels persisted throughout the species' metamorphosis period in summer. Continued monitoring of this transect in 2018 will further inform whether there has been a level of natural recovery of threatened frog breeding pools within this stream.

4.3.4 SC10(1) Littlejohn's Tree Frog monitoring

Pool Water Level / Flow and Appearance triggers (Level 1) in the Dendrobium Area 3 Watercourse TARP have been triggered at SC10(1) in 2017 due to the build-up of iron flocculant on all stream surfaces. This requires the following actions:

- Continue monitoring program.
  - Biosis will continue monitoring SC10(1) as part of the monitoring program.
- Submit an Impact Report to OEH, DP&E, DPI, WaterNSW and other relevant resource managers.
- Report in the End of Panel Report.
  - Illawarra Coal to incorporate results in End of Panel report.
- Summarise actions and monitoring in AEMR.
  - Illawarra Coal to incorporate results in the AEMR.

4.3.5 DC(1) Littlejohn's Tree Frog monitoring

The triggering of a Dendrobium Area 3B Watercourse – Terrestrial Fauna: Threatened Frog Species Level 1 TARP for DC(1) requires the following actions:

- Continue monitoring program.
  - Biosis will continue monitoring DC(1) as part of the 2018 monitoring program.
- Submit an Impact Report to OEH, DP&E, DPI, WaterNSW and other relevant resource managers.

  - To be completed as part of the End of Panel report.
- Report in the End of Panel Report.
  - Illawarra Coal to incorporate results End of Panel report.
- Summarise actions and monitoring in AEMR.
  - Illawarra Coal to incorporate results in the AEMR.

4.3.6 LA4A Littlejohn's Tree Frog monitoring

No Dendrobium Area 3B Watercourse – Terrestrial Fauna: Threatened Frog Species TARPs were triggered for LA4A. It is recommended that the sites continue to be monitoring as part of the terrestrial monitoring program to increase the size of the data set.

4.3.7 WC21 and DC13 Littlejohn's Tree Frog monitoring

The triggering of a Dendrobium Area 3B Watercourse – Terrestrial Fauna: Threatened Frog Species Level 3 TARP for WC21 and DC13 requires the following actions:

- Continue monitoring program.
  - Biosis will continue monitoring WC21 and DC13 as part of the 2018 monitoring program.
- Submit an Impact Report to OEH, DP&E, DPI, WaterNSW and other relevant resource managers.
  - To be completed as part of the End of Panel report.
- Report in the End of Panel Report.
  - Illawarra Coal to incorporate results in the End of Panel report.
- Summarise actions and monitoring in AEMR.
  - Illawarra Coal to incorporate results in the AEMR.
- Review monitoring frequency.
  - Additional tadpole monitoring should be completed during summer 2018/2019 to determine tadpole success and metamorphosis.
- Notify relevant technical specialists and seek advice on any CMA required.
  - Illawarra Coal to seek advice from relevant technical specialists as to the most appropriate CMAs.
- Implement agreed CMAs as approved (subject to stakeholder feedback).
- Attend a site visit with OEH, DP&E, DPI, WaterNSW and other resource manager/s (if requested).
- Review relevant TARP and Management Plan in consultation with key stakeholders.
- Develop site CMA (subject to stakeholder feedback). This may include:
  - Grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DP&E, DPI, WaterNSW and other stakeholders.
  - Advice regarding the most appropriate breeding pools to invest in CMAs should be considered.
- Completion of works following approvals and at a time agreed between Illawarra Coal, DP&E, DPI and WaterNSW (i.e. after mining induced movements and impacts are complete), including monitoring and reporting on success.

4.4 Conclusion

Following the 2017 terrestrial monitoring it was found that an ecological response had been detected at several impact sites within Dendrobium Areas 3A and 3B where impacts to ecological values have been observed. The impacts remain within prediction levels identified within relevant Environmental Impact Statements for Dendrobium Areas 3A and 3B. Management responses are required in these areas to better understand the impacts and, where appropriate, minimise and ameliorate impacts.

Biosis is committed to the continual review of the terrestrial programs for Dendrobium Areas 2 (in 2018), 3A and 3B and actively look 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 the trigger levels in the TARPs as the framework for the assessment. Data collected in 2018 will provide further insight into trends detected in 2017.

Baseline monitoring for Swamp 23 and Swamp 14 commenced in autumn 2017, along with baseline monitoring for the proposed Littlejohn's Tree Frog transect, LA2, in winter 2017.

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Appendix 1 Photo-point monitoring

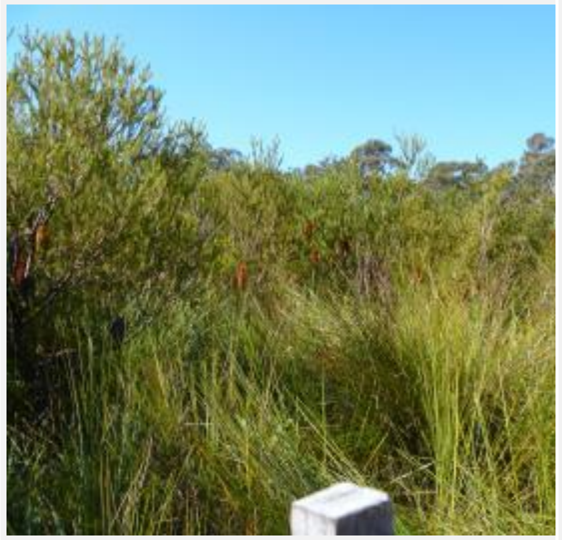
Table 22 Dendrobium Area 3A impact swamp sites 2017 photo point monitoring

S15A(2) – F1 Upstream Autumn 2011	S15A(2) – F1 Upstream Autumn 2014	S15A(2) – F1 Upstream Autumn 2015	S15A(2) – F1 Upstream Autumn 2016	S15A(2) – F1 Upstream Autumn 2017
				
S15A(2) – F1 Upstream Spring 2011	**S15A(2) – F1 Upstream Spring 2014**	**S15A(2) – F1 Upstream Spring 2015**	**S15A(2) – F1 Upstream Spring 2016**	**S15A(2) – F1 Upstream Spring 2017**
				

S15A(2) – F1 Downstream Autumn 2011	S15A(2) – F1 Downstream Autumn 2014	S15A(2) – F1 Downstream Autumn 2015	S15A(2) – F1 Downstream Autumn 2016	S15A(2) – F1 Downstream Autumn 2016
				

S15A(2) – F1 Downstream Spring 2011	S15A(2) – F1 Downstream Spring 2014	S15A(2) – F1 Downstream Spring 2015	S15A(2) – F1 Downstream Spring 2016	S15A(2) – F1 Downstream Spring 2017
			No image available. Data error.	

S15A(2) – F2 North Autumn 2011	S15A(2) – F2 North Autumn 2014	S15A(2) – F2 North Autumn 2015	S15A(2) – F2 North Autumn 2016	S15A(2) – F2 North Autumn 2017
				
S15A(2) – F2 North Spring 2011	**S15A(2) – F2 North Spring 2014**	**S15A(2) – F2 North Spring 2015**	**S15A(2) – F2 North Spring 2016**	**S15A(2) – F2 North Spring 2017**
Photo not available				

S15A(2) – F2 East Autumn 2011	S15A(2) – F2 East Autumn 2014	S15A(2) – F2 East Autumn 2015	S15A(2) – F2 East Autumn 2016	S15A(2) – F2 East Autumn 2017
				
S15A(2) – F2 East Spring 2011	**S15A(2) – F2 East Spring 2014**	**S15A(2) – F2 East Spring 2015**	**S15A(2) – F2 East Spring 2016**	**S15A(2) – F2 East Spring 2017**
				

S15A(2) – F2 South Autumn 2011	S15A(2) – F2 South Autumn 2014	S15A(2) – F2 South Autumn 2015	S15A(2) – F2 South Autumn 2016	S15A(2) – F2 South Autumn 2017
				
S15A(2) – F2 South Spring 2011	**S15A(2) – F2 South Spring 2014**	**S15A(2) – F2 South Spring 2015**	**S15A(2) – F2 South Spring 2016**	**S15A(2) – F2 South Spring 2017**
				

S15A(2) – F2 West Autumn 2011	S15A(2) – F2 West Autumn 2014	S15A(2) – F2 West Autumn 2015	S15A(2) – F2 West Autumn 2016	S15A(2) – F2 West Autumn 2017
				
S15A(2) – F2 West Spring 2011	**S15A(2) – F2 West Spring 2014**	**S15A(2) – F2 West Spring 2015**	**S15A(2) – F2 West Spring 2016**	**S15A(2) – F2 West Spring 2017**
				

S15A(2) – F3 North Autumn 2011

S15A(2) – F3 North Autumn 2014

S15A(2) – F3 North Autumn 2015

S15A(2) – F3 North Autumn 2016

S15A(2) – F3 North Autumn 2017

S15A(2) – F3 North Spring 2011

S15A(2) – F3 North Spring 2014

S15A(2) – F3 North Spring 2015

S15A(2) – F3 North Spring 2016

S15A(2) – F3 North Spring 2017

S15A(2) – F3 East Autumn 2011	S15A(2) – F3 East Autumn 2014	S15A(2) – F3 East Autumn 2015	S15A(2) – F3 East Autumn 2016	S15A(2) – F3 East Autumn 2017
				
S15A(2) – F3 East Spring 2011	**S15A(2) – F3 East Spring 2014**	**S15A(2) – F3 East Spring 2015**	**S15A(2) – F3 East Spring 2016**	**S15A(2) – F3 East Spring 2017**
				

S15A(2) – F3 South Autumn 2011	S15A(2) – F3 South Autumn 2014	S15A(2) – F3 South Autumn 2015	S15A(2) – F3 South Autumn 2016	S15A(2) – F3 South Autumn 2017
				
S15A(2) – F3 South Spring 2011	**S15A(2) – F3 South Spring 2014**	**S15A(2) – F3 South Spring 2015**	**S15A(2) – F3 South Spring 2016**	**S15A(2) – F3 South Spring 2017**
				

S15A(2) – F3 West Autumn 2011	S15A(2) – F3 West Autumn 2014	S15A(2) – F3 West Autumn 2015	S15A(2) – F3 West Autumn 2016	S15A(2) – F3 West Autumn 2017
				
S15A(2) – F3 West Spring 2011	**S15A(2) – F3 West Spring 2014**	**S15A(2) – F3 West Spring 2015**	**S15A(2) – F3 West Spring 2016**	**S15A(2) – F3 West Spring 2017**
				

S15B – F2 Upstream Autumn 2010

S15B – F2 Upstream Autumn 2014

S15B – F2 Upstream Autumn 2015

S15B – F2 Upstream Autumn 2016

S15B – F2 Upstream Autumn 2017

S15B – F2 Upstream Spring 2010

S15B – F2 Upstream Spring 2014

S15B – F2 Upstream Spring 2015

S15B – F2 Upstream Spring 2016

S15B – F2 Upstream Spring 2017

S15B – F2 Downstream Autumn 2010

S15B – F2 Downstream Autumn 2014

S15B – F2 Downstream Autumn 2015

S15B – F2 Downstream Autumn 2016

S15B – F2 Downstream Autumn 2016

S15B – F2 Downstream Spring 2010

S15B – F2 Downstream Spring 2014

S15B – F2 Downstream Spring 2015

S15B – F2 Downstream Spring 2016

S15B – F2 Downstream Spring 2017

S15B – F4 North Autumn 2010	S15B – F4 North Autumn 2014	S15B – F4 North Autumn 2015	S15B – F4 North Autumn 2016	S15B – F4 North Autumn 2017
				
S15B – F4 North Spring 2010	**S15B – F4 North Spring 2014**	**S15B – F4 North Spring 2015**	**S15B – F4 North Spring 2016**	**S15B – F4 North Spring 2017**
				

S15B – F4 East Autumn 2010	S15B – F4 East Autumn 2014	S15B – F4 East Autumn 2015	S15B – F4 East Autumn 2016	S15B – F4 East Autumn 2017
				
S15B – F4 East Spring 2010	**S15B – F4 East Spring 2014**	**S15B – F4 East Spring 2015**	**S15B – F4 East Spring 2016**	**S15B – F4 East Spring 2017**
Photo not available				

S15B – F4 South Autumn 2010	**S15B – F4 South Autumn 2014**	**S15B – F4 South Autumn 2015**	**S15B – F4 South Autumn 2016**	**S15B – F4 South Autumn 2017**
				
S15B – F4 South Spring 2010	**S15B – F4 South Spring 2014**	**S15B – F4 South Spring 2015**	**S15B – F4 South Spring 2016**	**S15B – F4 South Spring 2017**
				

S15B – F4 West Autumn 2010	S15B – F4 West Autumn 2014	S15B – F4 West Autumn 2015	S15B – F4 West Autumn 2016	S15B – F4 West Autumn 2017
				
S15B – F4 West Spring 2010	**S15B – F4 West Spring 2014**	**S15B – F4 West Spring 2015**	**S15B – F4 West Spring 2016**	**S15B – F4 West Spring 2017**
				

S15B – F5 North Autumn 2010	S15B – F5 North Autumn 2014	S15B – F5 North Autumn 2015	S15B – F5 North Autumn 2016	S15B – F5 North Autumn 2017
				

S15B – F5 North Spring 2010	S15B – F5 North Spring 2014	S15B – F5 North Spring 2015	S15B – F5 North Spring 2016	S15B – F5 North Spring 2017
				

S15B – F5 East Autumn 2010	S15B – F5 East Autumn 2014	S15B – F5 East Autumn 2015	S15B – F5 East Autumn 2016	S15B – F5 East Autumn 2017
				
S15B – F5 East Spring 2010	**S15B – F5 East Spring 2014**	**S15B – F5 East Spring 2015**	**S15B – F5 East Spring 2016**	**S15B – F5 East Spring 2017**
				

S15B – F5 South Autumn 2010	S15B – F5 South Autumn 2014	S15B – F5 South Autumn 2015	S15B – F5 South Autumn 2016	S15B – F5 South Autumn 2017
				
S15B – F5 South Spring 2010	**S15B – F5 South Spring 2014**	**S15B – F5 South Spring 2015**	**S15B – F5 South Spring 2016**	**S15B – F5 South Spring 2017**
				

S15B – F5 West Autumn 2010	S15B – F5 West Autumn 2014	S15B – F5 West Autumn 2015	S15B – F5 West Autumn 2016	S15B – F5 West Autumn 2017
				
S15B – F5 West Spring 2010	**S15B – F5 West Spring 2014**	**S15B – F5 West Spring 2015**	**S15B – F5 West Spring 2016**	**S15B – F5 West Spring 2017**
				

Table 23 Dendrobium Area 3A control swamp sites 2017 photo point monitoring

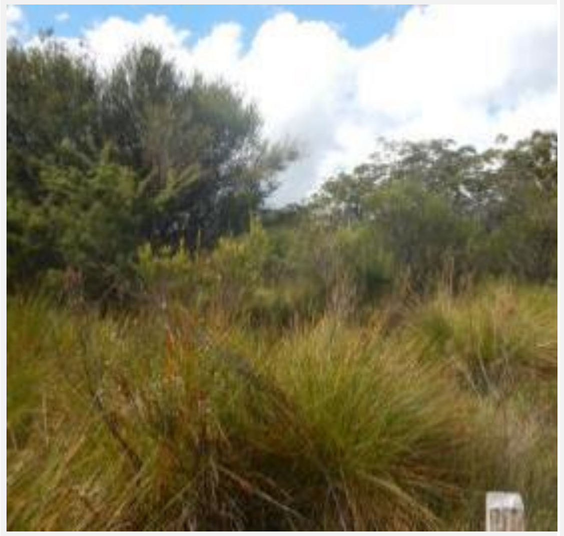
S15A(1) F1 North Autumn 2010	S15A(1) – F1 North Autumn 2014	S15A(1) – F1 North Autumn 2015	S15A(1) – F1 North Autumn 2016	S15A(1) – F1 North Autumn 2017
				
S15A(1) – F1 North Spring 2010	**S15A(1) – F1 North Spring 2014**	**S15A(1) – F1 North Spring 2015**	**S15A(1) – F1 North Spring 2016**	**S15A(1) – F1 North Spring 2017**
				

S15A(1) – F1 East Autumn 2010	S15A(1) – F1 East Autumn 2014	S15A(1) – F1 East Autumn 2015	S15A(1) – F1 East Autumn 2016	S15A(1) – F1 East Autumn 2017
				
S15A(1) – F1 East Spring 2010	**S15A(1) – F1 East Spring 2014**	**S15A(1) – F1 East Spring 2015**	**S15A(1) – F1 East Spring 2016**	**S15A(1) – F1 East Spring 2017**
				

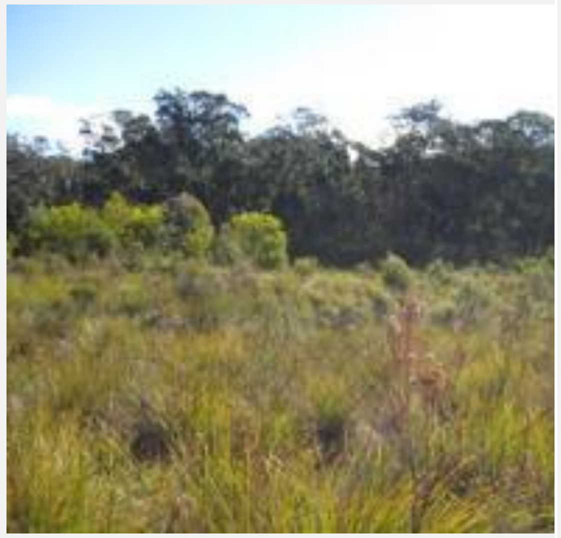
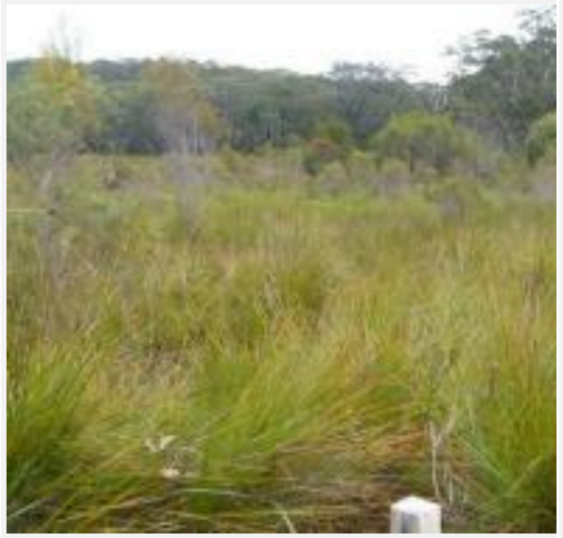
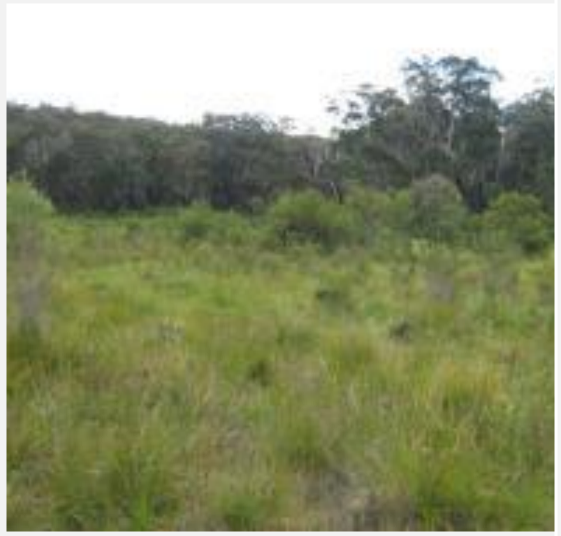
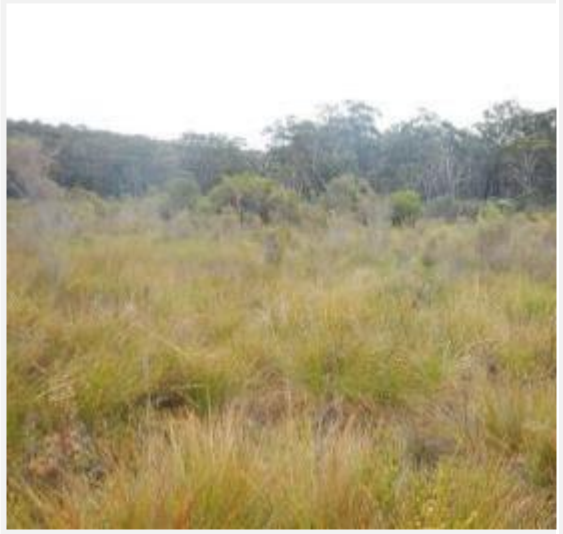
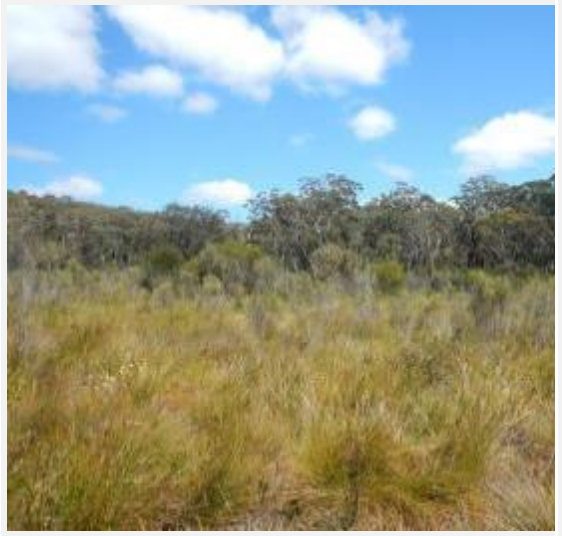
S15A(1) – F1 South Autumn 2010	**S15A(1) – F1 South Autumn 2014**	**S15A(1) – F1 South Autumn 2015**	**S15A(1) – F1 South Autumn 2016**	**S15A(1) – F1 South Autumn 2017**
				
S15A(1) – F1 South Spring 2010	**S15A(1) – F1 South Spring 2014**	**S15A(1) – F1 South Spring 2015**	**S15A(1) – F1 South Spring 2016**	**S15A(1) – F1 South Spring 2017**
				

S15A(1) – F1 West Autumn 2010	S15A(1) – F1 West Autumn 2014	S15A(1) – F1 West Autumn 2015	S15A(1) – F1 West Autumn 2016	S15A(1) – F1 West Autumn 2017
				
S15A(1) – F1 West Spring 2010	**S15A(1) – F1 West Spring 2014**	**S15A(1) – F1 West Spring 2015**	**S15A(1) – F1 West Spring 2016**	**S15A(1) – F1 West Spring 2017**
				

S15A(1) – F2 North Autumn 2010	S15A(1) – F2 North Autumn 2014	S15A(1) – F2 North Autumn 2015	S15A(1) – F2 North Autumn 2016	S15A(1) – F2 North Autumn 2017
				
S15A(1) – F2 North Spring 2010	**S15A(1) – F2 North Spring 2014**	**S15A(1) – F2 North Spring 2015**	**S15A(1) – F2 North Spring 2016**	**S15A(1) – F2 North Spring 2017**
				

S15A(1) – F2 East Autumn 2010	S15A(1) – F2 East Autumn 2014	S15A(1) – F2 East Autumn 2015	S15A(1) – F2 East Autumn 2016	S15A(1) – F2 East Autumn 2017
				
S15A(1) – F2 East Spring 2010	**S15A(1) – F2 East Spring 2014**	**S15A(1) – F2 East Spring 2015**	**S15A(1) – F2 East Spring 2016**	**S15A(1) – F2 East Spring 2017**
				

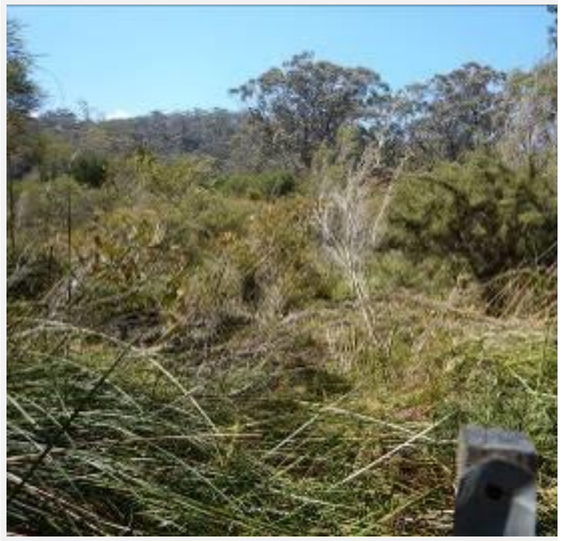
S15A(1) – F2 South Autumn 2010	S15A(1) – F2 South Autumn 2014	S15A(1) – F2 South Autumn 2015	S15A(1) – F2 South Autumn 2016	S15A(1) – F2 South Autumn 2017
				
S15A(1) – F2 South Spring 2010	**S15A(1) – F2 South Spring 2014**	**S15A(1) – F2 South Spring 2015**	**S15A(1) – F2 South Spring 2016**	**S15A(1) – F2 South Spring 2017**
				

S15A(1) – F2 West Autumn 2010	S15A(1) – F2 West Autumn 2014	S15A(1) – F2 West Autumn 2015	S15A(1) – F2 West Autumn 2016	S15A(1) – F2 West Autumn 2017
				
S15A(1) – F2 West Spring 2010	**S15A(1) – F2 West Spring 2014**	**S15A(1) – F2 West Spring 2015**	**S15A(1) – F2 West Spring 2016**	**S15A(1) – F2 West Spring 2017**
				

S15A(1) – F3 Upstream Autumn 2010	S15A(1) – F3 Upstream Autumn 2014	S15A(1) – F3 Upstream Autumn 2015	S15A(1) – F3 Upstream Autumn 2016	S15A(1) – F3 Upstream Autumn 2017
				
S15A(1) – F3 Upstream Spring 2010	**S15A(1) – F3 Upstream Spring 2014**	**S15A(1) – F3 Upstream Spring 2015**	**S15A(1) – F3 Upstream Spring 2016**	**S15A(1) – F3 Upstream Spring 2017**
				

S15A(1) – F3 Downstream Autumn 2010	S15A(1) – F3 Downstream Autumn 2014	S15A(1) – F3 Downstream Autumn 2015	S15A(1) – F3 Downstream Autumn 2016	S15A(1) – F3 Downstream Autumn 2017
				
S15A(1) – F3 Downstream Spring 2010	**S15A(1) – F3 Downstream Spring 2014**	**S15A(1) – F3 Downstream Spring 2015**	**S15A(1) – F3 Downstream Spring 2016**	**S15A(1) – F3 Downstream Spring 2017**
				

S22 – F1 North Autumn 2011	S22 – F1 North Autumn 2014	S22 – F1 North Autumn 2015	S22 – F1 North Autumn 2016	S22 – F1 North Autumn 2017
				
S22 – F1 North Spring 2011	**S22 – F1 North Spring 2014**	**S22 – F1 North Spring 2015**	**S22 – F1 North Spring 2016**	**S22 – F1 North Spring 2017**
				

S22 – F1 East Autumn 2011	S22 – F1 East Autumn 2014	S22 – F1 East Autumn 2015	S22 – F1 East Autumn 2016	S22 – F1 East Autumn 2017
				
S22 – F1 East Spring 2011	**S22 – F1 East Spring 2014**	**S22 – F1 East Spring 2014**	**S22 – F1 East Spring 2016**	**S22 – F1 East Spring 2017**
				

S22 – F1 South Autumn 2011	S22 – F1 South Autumn 2014	S22 – F1 South Autumn 2015	S22 – F1 South Autumn 2016	S22 – F1 South Autumn 2017
				
S22 – F1 South Spring 2011	**S22 – F1 South Spring 2014**	**S22 – F1 South Spring 2015**	**S22 – F1 South Spring 2016**	**S22 – F1 South Spring 2017**
				

S22 – F1 West Autumn 2011	S22 – F1 West Autumn 2014	S22 – F1 West Autumn 2015	S22 – F1 West Autumn 2016	S22 – F1 West Autumn 2017
				
S22 – F1 West Spring 2011	**S22 – F1 West Spring 2014**	**S22 – F1 West Spring 2015**	**S22 – F1 West Spring 2016**	**S22 – F1 West Spring 2017**
				

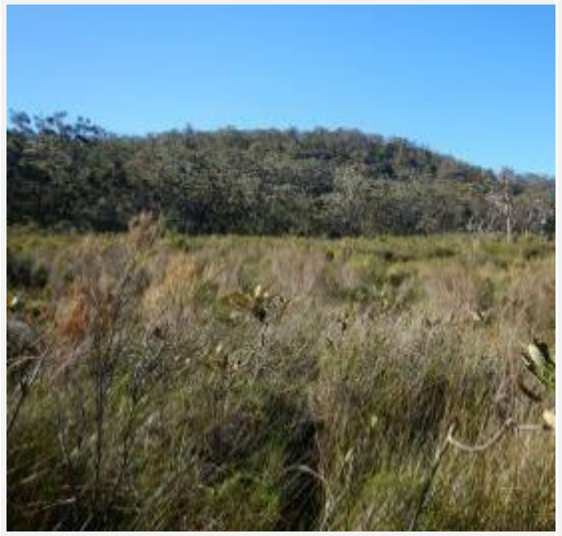
S22 – F2 North Autumn 2011	S22 – F2 North Autumn 2014	S22 – F2 North Autumn 2015	S22 – F2 North Autumn 2016	S22 – F2 North Autumn 2017
				
S22 – F2 North Spring 2011	**S22 – F2 North Spring 2014**	**S22 – F2 North Spring 2015**	**S22 – F2 North Spring 2016**	**S22 – F2 North Spring 2017**
				

S22 – F2 East Autumn 2011

S22 – F2 East Autumn 2014

S22 – F2 East Autumn 2015

S22 – F2 East Autumn 2016



S22 – F2 East Autumn 2017

S22 – F2 East Spring 2011

S22 – F2 East Spring 2014

S22 – F2 East Spring 2015

S22 – F2 East Spring 2016

S22 – F2 East Spring 2017

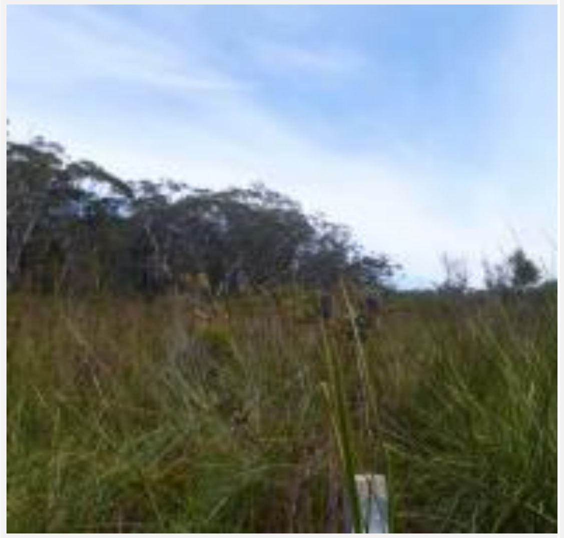
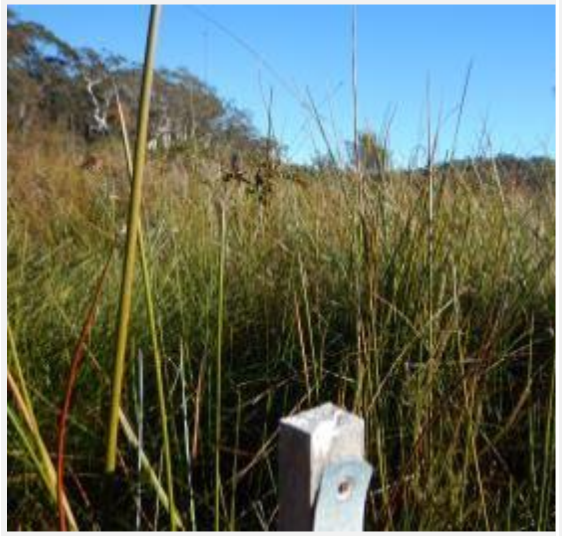
S22 – F2 South Autumn 2011	S22 – F2 South Autumn 2014	S22 – F2 South Autumn 2015	S22 – F2 South Autumn 2016	S22 – F2 South Autumn 2017
				
S22 – F2 South Spring 2011	**S22 – F2 South Spring 2014**	**S22 – F2 South Spring 2015**	**S22 – F2 South Spring 2016**	**S22 – F2 South Spring 2017**
				

S22 – F2 West Autumn 2011	S22 – F2 West Autumn 2014	S22 – F2 West Autumn 2015	S22 – F2 West Autumn 2016	S22 – F2 West Autumn 2017
				
S22 – F2 West Spring 2011	**S22 – F2 West Spring 2014**	**S22 – F2 West Spring 2015**	**S22 – F2 West Spring 2016**	**S22 – F2 West Spring 2017**
				

S22 – F3 North Autumn 2011	S22 – F3 North Autumn 2014	S22 – F3 North Autumn 2015	S22 – F3 North Autumn 2016	S22 – F3 North Autumn 2017
				
S22 – F3 North Spring 2011	**S22 – F3 North Spring 2014**	**S22 – F3 North Spring 2015**	**S22 – F3 North Spring 2016**	**S22 – F3 North Spring 2017**
				

S22 – F3 East Autumn 2011	S22 – F3 East Autumn 2014	S22 – F3 East Autumn 2015	S22 – F3 East Autumn 2016	S22 – F3 East Autumn 2017
				
S22 – F3 East Spring 2011	**S22 – F3 East Spring 2014**	**S22 – F3 East Spring 2015**	**S22 – F3 East Spring 2016**	**S22 – F3 East Spring 2017**
				

S22 – F3 South Autumn 2011	S22 – F3 South Autumn 2014	S22 – F3 South Autumn 2015	S22 – F3 South Autumn 2016	S22 – F3 South Autumn 2017
				
S22 – F3 South Spring 2011	**S22 – F3 South Spring 2014**	**S22 – F3 South Spring 2015**	**S22 – F3 South Spring 2016**	**S22 – F3 South Spring 2017**
				

S22 – F3 West Autumn 2011	S22 – F3 West Autumn 2014	S22 – F3 West Autumn 2015	S22 – F3 West Autumn 2016	S22 – F3 West Autumn 2017
				

S22 – F3 West Spring 2011	S22 – F3 West Spring 2014	S22 – F3 West Spring 2015	S22 – F3 West Spring 2016	S22 – F3 West Spring 2017
				

S33 – F1 North Autumn 2010	S33 – F1 North Autumn 2014	S33 – F1 North Autumn 2015	S33 – F1 North Autumn 2016	S33 – F1 North Autumn 2017
				
S33 – F1 North Spring 2010	**S33 – F1 North Spring 2014**	**S33 – F1 North Spring 2015**	**S33 – F1 North Spring 2016**	**S33 – F1 North Spring 2017**
				

S33 – F1 East Autumn 2010	S33 – F1 East Autumn 2014	S33 – F1 East Autumn 2015	S33 – F1 East Autumn 2016	S33 – F1 East Autumn 2017
				
S33 – F1 East Spring 2010	**S33 – F1 East Spring 2014**	**S33 – F1 East Spring 2015**	**S33 – F1 East Spring 2016**	**S33 – F1 East Spring 2017**
				

S33 – F1 South Autumn 2010	S33 – F1 South Autumn 2014	S33 – F1 South Autumn 2015	S33 – F1 South Autumn 2016	S33 – F1 South Autumn 2017
				
S33 – F1 South Spring 2010	**S33 – F1 South Spring 2014**	**S33 – F1 South Spring 2015**	**S33 – F1 South Spring 2016**	**S33 – F1 South Spring 2017**
				

S33 – F1 West Autumn 2010	S33 – F1 West Autumn 2014	S33 – F1 West Autumn 2015	S33 – F1 West Autumn 2016	S33 – F1 West Autumn 2017
				
S33 – F1 West Spring 2010	**S33 – F1 West Spring 2014**	**S33 – F1 West Spring 2015**	**S33 – F1 West Spring 2016**	**S33 – F1 West Spring 2017**
				

S33 – F2 North Autumn 2010	S33 – F2 North Autumn 2014	S33 – F2 North Autumn 2015	S33 – F2 North Autumn 2016	S33 – F2 North Autumn 2017
				
S33 – F2 North Spring 2010	**S33 – F2 North Spring 2014**	**S33 – F2 North Spring 2015**	**S33 – F2 North Spring 2016**	**S33 – F2 North Spring 2017**
				

S33 – F2 East Autumn 2010	**S33 – F2 East Autumn 2014**	**S33 – F2 East Autumn 2015**	**S33 – F2 East Autumn 2016**	**S33 – F2 East Autumn 2017**
				
S33 – F2 East Spring 2010	**S33 – F2 East Spring 2014**	**S33 – F2 East Spring 2015**	**S33 – F2 East Spring 2016**	**S33 – F2 East Spring 2017**
				

S33 – F2 South Autumn 2010	S33 – F2 South Autumn 2014	S33 – F2 South Autumn 2015	S33 – F2 South Autumn 2016	S33 – F2 South Autumn 2017
				
S33 – F2 South Spring 2010	**S33 – F2 South Spring 2014**	**S33 – F2 South Spring 2015**	**S33 – F2 South Spring 2016**	**S33 – F2 South Spring 2017**
				

S33 – F2 West Autumn 2010	S33 – F2 West Autumn 2014	S33 – F2 West Autumn 2015	S33 – F2 West Autumn 2016	S33 – F2 West Autumn 2017
				

S33 – F2 West Spring 2010	S33 – F2 West Spring 2014	S33 – F2 West Spring 2015	S33 – F2 West Spring 2016	S33 – F2 West Spring 2017
				

S33 – F3 North Autumn 2010	S33 – F3 North Autumn 2014	S33 – F3 North Autumn 2015	S33 – F3 North Autumn 2016	S33 – F3 North Autumn 2017
				
S33 – F3 North Spring 2010	**S33 – F3 North Spring 2014**	**S33 – F3 North Spring 2015**	**S33 – F3 North Spring 2016**	**S33 – F3 North Spring 2017**
				

S33 – F3 East Autumn 2010	S33 – F3 East Autumn 2014	S33 – F3 East Autumn 2015	S33 – F3 East Autumn 2016	S33 – F3 East Autumn 2017
				

S33 – F3 East Spring 2010	S33 – F3 East Spring 2014	S33 – F3 East Spring 2015	S33 – F3 East Spring 2016	S33 – F3 East Spring 2017
				

S33 – F3 South Autumn 2010	S33 – F3 South Autumn 2014	S33 – F3 South Autumn 2015	S33 – F3 South Autumn 2016	S33 – F3 South Autumn 2017
				

S33 – F3 South Spring 2010	S33 – F3 South Spring 2014	S33 – F3 South Spring 2015	S33 – F3 South Spring 2016	S33 – F3 South Spring 2017
				

S33 – F3 West Autumn 2010	S33 – F3 West Autumn 2014	S33 – F3 West Autumn 2015	S33 – F3 West Autumn 2016	S33 – F3 West Autumn 2017
				
S33 – F3 West Spring 2010	**S33 – F3 West Spring 2014**	**S33 – F3 West Spring 2015**	**S33 – F3 West Spring 2016**	**S33 – F3 West Spring 2017**
				

S11 – F1 North Autumn 2010	S11 – F1 North Autumn 2014	S11 – F1 North Autumn 2015	S11 – F1 North Autumn 2016	S11 – F1 North Autumn 2017
				
S11 – F1 North Spring 2010	**S11 – F1 North Spring 2014**	**S11 – F1 North Spring 2015**	**S11 – F1 North Spring 2016**	**S11 – F1 North Spring 2017**
				

S11 – F1 East Autumn 2010	S11 – F1 East Autumn 2014	S11 – F1 East Autumn 2015	S11 – F1 East Autumn 2016	S11 – F1 East Autumn 2017
				
S11 – F1 East Spring 2010	**S11 – F1 East Spring 2014**	**S11 – F1 East Spring 2015**	**S11 – F1 East Spring 2016**	**S11 – F1 East Spring 2017**
				

S11 – F1 South Autumn 2010	S11 – F1 South Autumn 2014	S11 – F1 South Autumn 2015	S11 – F1 South Autumn 2016	S11 – F1 South Autumn 2017
				
S11 – F1 South Spring 2010	**S11-F1 South Spring 2014**	**S11-F1 South Spring 2015**	**S11-F1 South Spring 2016**	**S11-F1 South Spring 2017**
				

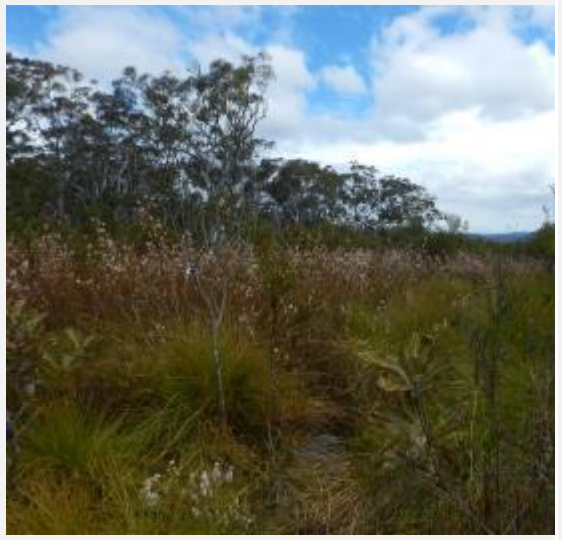
S11 – F1 West Autumn 2010	**S11 – F1 West Autumn 2014**	**S11 – F1 West Autumn 2015**	**S11 – F1 West Autumn 2016**	**S11 – F1 West Autumn 2017**
				
S11 – F1 West Spring 2010	**S11 – F1 West Spring 2014**	**S11 – F1 West Spring 2015**	**S11 – F1 West Spring 2016**	**S11 – F1 West Spring 2017**
				

S11 – F3 North Autumn 2010	S11 – F3 North Autumn 2014	S11 – F3 North Autumn 2015	S11 – F3 North Autumn 2016	S11 – F3 North Autumn 2017
				
S11 – F3 North Spring 2010	**S11 – F3 North Spring 2014**	**S11 – F3 North Spring 2015**	**S11 – F3 North Spring 2016**	**S11 – F3 North Spring 2017**
				

S11 – F3 East Autumn 2010	S11 – F3 East Autumn 2014	S11 – F3 East Autumn 2015	S11 – F3 East Autumn 2016	S11 – F3 East Autumn 2017
				
S11 – F3 East Spring 2010	**S11 – F3 East Spring 2014**	**S11 – F3 East Spring 2015**	**S11 – F3 East Spring 2016**	**S11 – F3 East Spring 2017**
				

S11 – F3 South Autumn 2010	S11 – F3 South Autumn 2014	S11 – F3 South Autumn 2015	S11 – F3 South Autumn 2016	S11 – F3 South Autumn 2017
				
S11 – F3 South Spring 2010	**S11 – F3 South Spring 2014**	**S11 – F3 South Spring 2015**	**S11 – F3 South Spring 2016**	**S11 – F3 South Spring 2017**
				

S11 – F3 West Autumn 2010	S11 – F3 West Autumn 2014	S11 – F3 West Autumn 2015	S11 – F3 West Autumn 2016	S11 – F3 West Autumn 2017
				

S11 – F3 West Spring 2010	S11 – F3 West Spring 2014	S11 – F3 West Spring 2015	S11 – F3 West Spring 2016	S11 – F3 West Spring 2017
				

S11 – F5 North Autumn 2010	S11 – F5 North Autumn 2014	S11 – F5 North Autumn 2015	S11 – F5 North Autumn 2016	S11 – F5 North Autumn 2017
				

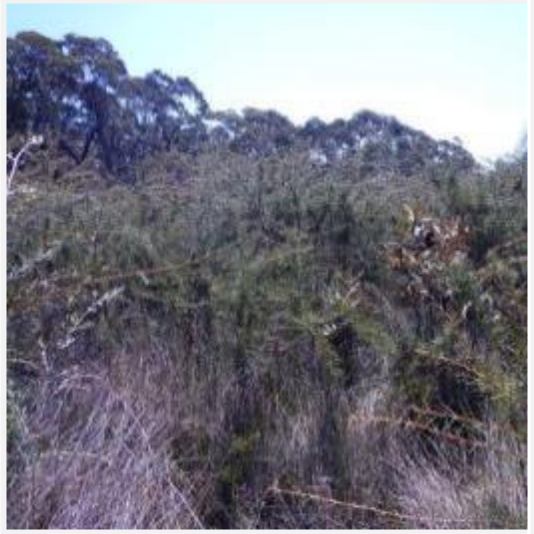
S11 – F5 North Spring 2010	S11 – F5 North Spring 2014	S11 – F5 North Spring 2015	S11 – F5 North Spring 2016	S11 – F5 North Spring 2017
				

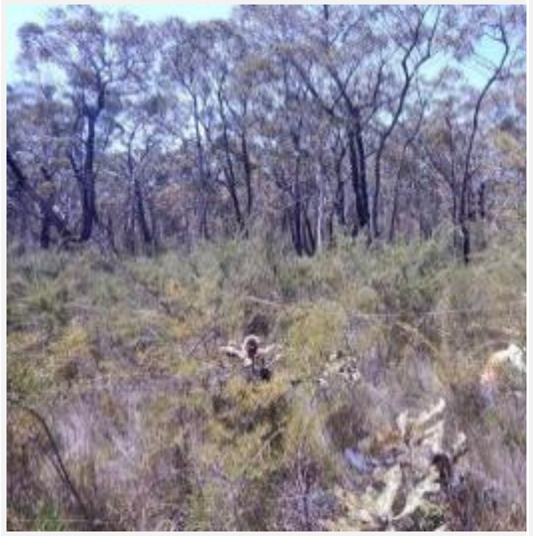
S11 – F5 East Autumn 2010	S11 – F5 East Autumn 2014	S11 – F5 East Autumn 2015	S11 – F5 East Autumn 2016	S11 – F5 East Autumn 2017
				
S11 – F5 East Spring 2010	**S11 – F5 East Spring 2014**	**S11 – F5 East Spring 2015**	**S11 – F5 East Spring 2016**	**S11 – F5 East Spring 2017**
				

S11 – F5 South Autumn 2010	S11 – F5 South Autumn 2014	S11 – F5 South Autumn 2015	S11 – F5 South Autumn 2016	S11 – F5 South Autumn 2017
				
S11 – F5 South Spring 2010	**S11 – F5 South Spring 2014**	**S11 – F5 South Spring 2015**	**S11 – F5 South Spring 2016**	**S11 – F5 South Spring 2017**
				

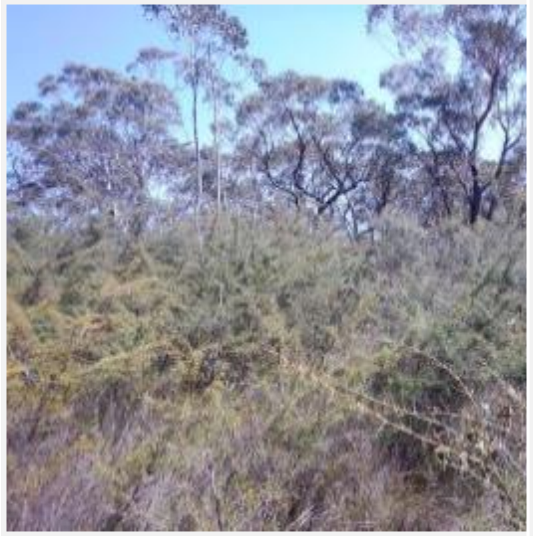
S11 – F5 West Autumn 2010	S11 – F5 West Autumn 2014	S11 – F5 West Autumn 2015	S11 – F5 West Autumn 2016	S11 – F5 West Autumn 2017
				
S11 – F5 West Spring 2010	**S11 – F5 West Spring 2014**	**S11 – F5 West Spring 2015**	**S11 – F5 West Spring 2016**	**S11 – F5 West Spring 2017**
				

Table 24 Dendrobium Area 3B impact swamp sites 2017 photo point monitoring

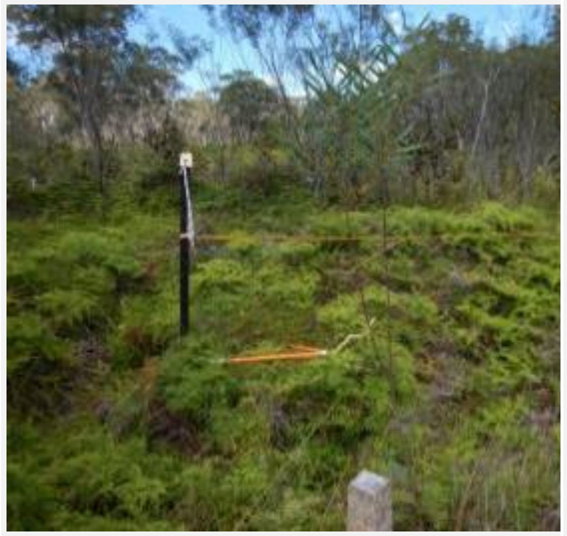
S1A – F1 North Autumn 2012	S1A – F1 North Autumn 2014	S1A – F1 North Autumn 2015	S1A – F1 North Autumn 2016	S1A – F1 North Autumn 2017
Not monitored				
S1A – F1 North Spring 2012	**S1A – F1 North Spring 2014**	**S1A – F1 North Spring 2015**	**S1A – F1 North Spring 2016**	**S1A – F1 North Spring 2017**
				

S1A – F1 East Autumn 2012	S1A – F1 East Autumn 2014	S1A – F1 East Autumn 2015	S1A – F1 East Autumn 2016	S1A – F1 East Autumn 2017
Not monitored				
S1A – F1 East Spring 2012	**S1A – F1 East Spring 2014**	**S1A – F1 East Spring 2015**	**S1A – F1 East Spring 2016**	**S1A – F1 East Spring 2017**
				

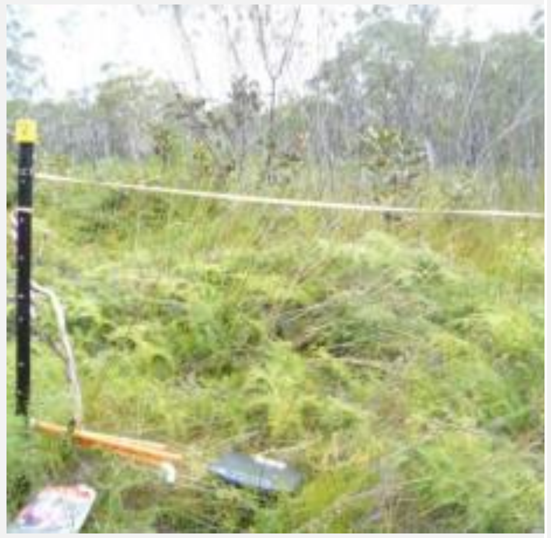
S1A – F1 South Autumn 2012	S1A – F1 South Autumn 2014	S1A – F1 South Autumn 2015	S1A – F1 South Autumn 2016	S1A – F1 South Autumn 2017
Not monitored				
S1A – F1 South Spring 2012	**S1A – F1 South Spring 2014**	**S1A – F1 South Spring 2015**	**S1A – F1 South Spring 2016**	**S1A – F1 South Spring 2017**
				

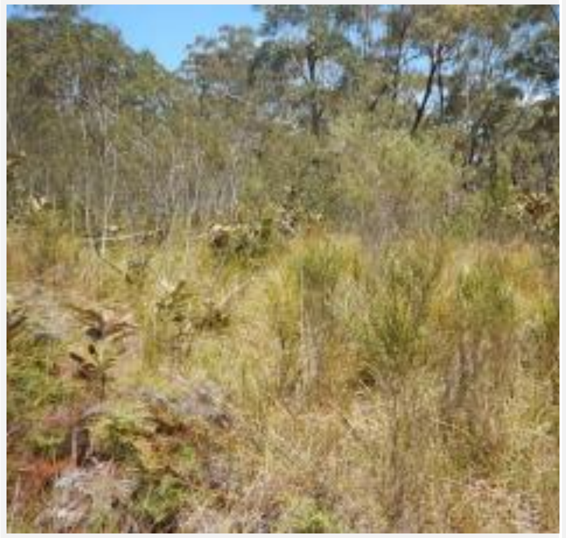
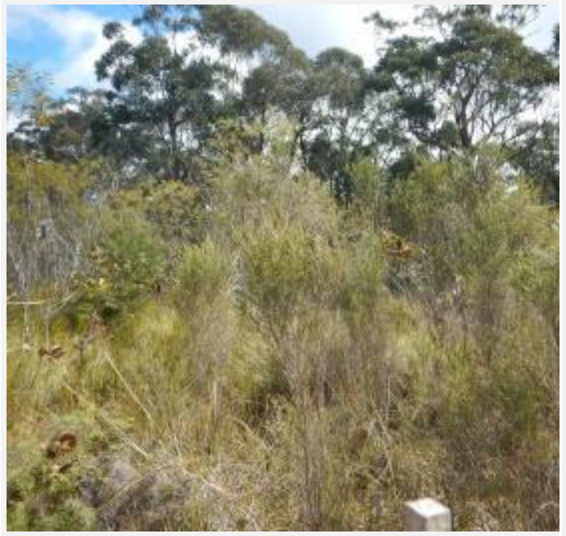
S1A – F1 West Autumn 2012	S1A – F1 West Autumn 2014	S1A – F1 West Autumn 2015	S1A – F1 West Autumn 2016	S1A – F1 West Autumn 2017
Not monitored				
S1A – F1 West Spring 2012	**S1A – F1 West Spring 2014**	**S1A – F1 West Spring 2015**	**S1A – F1 West Spring 2016**	**S1A – F1 West Spring 2017**
				

S1A – F2 North Autumn 2012	S1A – F2 North Autumn 2014	S1A – F2 North Autumn 2015	S1A – F2 North Autumn 2016	S1A – F2 North Autumn 2017
Not monitored				
S1A – F2 North Spring 2012	**S1A – F2 North Spring 2014**	**S1A – F2 North Spring 2015**	**S1A – F2 North Spring 2016**	**S1A – F2 North Spring 2017**
				

S1A – F2 East Autumn 2012	S1A – F2 East Autumn 2014	S1A – F2 East Autumn 2015	S1A – F2 East Autumn 2016	S1A – F2 East Autumn 2017
Not monitored				

S1A – F2 East Spring 2012	S1A – F2 East Spring 2014	S1A – F2 East Spring 2015	S1A – F2 East Spring 2016	S1A – F2 East Spring 2017
				

S1A – F2 South Autumn 2015	**S1A – F2 South Autumn 2014**	**S1A – F2 South Autumn 2015**	**S1A – F2 South Autumn 2016**	**S1A – F2 South Autumn 2017**
Not monitored				
S1A – F2 South Spring 2012	**S1A – F2 South Spring 2014**	**S1A – F2 South Spring 2015**	**S1A – F2 South Spring 2016**	**S1A – F2 South Spring 2017**
				

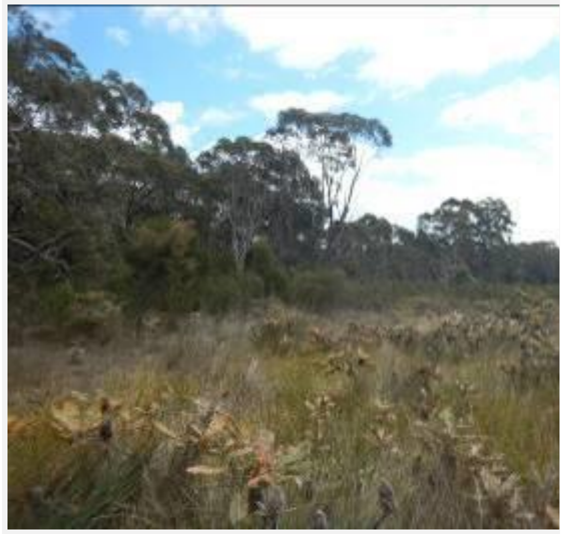
S1A – F2 West Autumn 2012	S1A – F2 West Autumn 2014	S1A – F2 West Autumn 2015	S1A – F2 West Autumn 2016	S1A – F2 West Autumn 2017
Not monitored				
S1A – F2 West Spring 2012	**S1A – F2 West Spring 2014**	**S1A – F2 West Spring 2015**	**S1A – F2 West Spring 2016**	**S1A – F2 West Spring 2017**
				

S1A – F3 North Autumn 2012	S1A – F3 North Autumn 2014	S1A – F3 North Autumn 2015	S1A – F3 North Autumn 2016	S1A – F3 North Autumn 2017
Not monitored				
S1A – F3 North Spring 2012	**S1A – F3 North Spring 2014**	**S1A – F3 North Spring 2015**	**S1A – F3 North Spring 2016**	**S1A – F3 North Spring 2017**
				

S1A – F3 East Autumn 2012	S1A – F3 East Autumn 2014	S1A – F3 East Autumn 2015	S1A – F3 East Autumn 2016	S1A – F3 East Autumn 2017
Not monitored				
S1A – F3 East Spring 2012	**S1A – F3 East Spring 2014**	**S1A – F3 East Spring 2015**	**S1A – F3 East Spring 2016**	**S1A – F3 East Spring 2017**
				

S1A – F3 South Autumn 2012	S1A – F3 South Autumn 2014	S1A – F3 South Autumn 2015	S1A – F3 South Autumn 2016	S1A – F3 South Autumn 2017
Not monitored				
S1A – F3 South Spring 2012	**S1A – F3 South Spring 2014**	**S1A – F3 South Spring 2015**	**S1A – F3 South Spring 2016**	**S1A – F3 South Spring 2017**
				

S1A – F3 West Autumn 2012	S1A – F3 West Autumn 2014	S1A – F3 West Autumn 2015	S1A – F3 West Autumn 2016	S1A – F3 West Autumn 2017
Not monitored				
S1A – F3 West Spring 2012	**S1A – F3 West Spring 2014**	**S1A – F3 West Spring 2015**	**S1A – F3 West Spring 2016**	**S1A – F3 West Spring 2017**
				

S1B – F1 North Autumn 2010	S1B – F1 North Autumn 2014	S1B – F1 North Autumn 2015	S1B – F1 North Autumn 2016	S1B – F1 North Autumn 2017
				
S1B – F1 North Spring 2009	**S1B - F1 North Spring 2014**	**S1B - F1 North Spring 2015**	**S1B - F1 North Spring 2016**	**S1B - F1 North Spring 2017**
				

S1B – F1 East Autumn 2010	S1B – F1 East Autumn 2014	S1B – F1 East Autumn 2015	S1B – F1 East Autumn 2016	S1B – F1 East Autumn 2017
				
S1B – F1 East Spring 2009	**S1B - F1 East Spring 2014**	**S1B - F1 East Spring 2015**	**S1B - F1 East Spring 2016**	**S1B - F1 East Spring 2017**
				

S1B – F1 South Autumn 2010

S1B – F1 South Autumn 2014

S1B – F1 South Autumn 2015

S1B – F1 South Autumn 2016

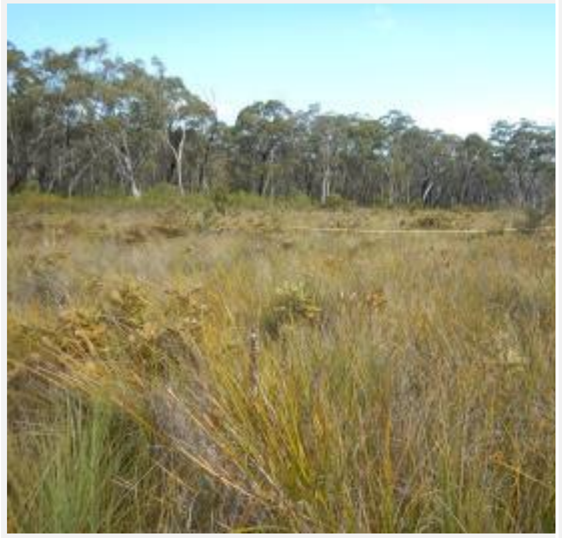
S1B – F1 South Autumn 2017

S1B – F1 South Spring 2009

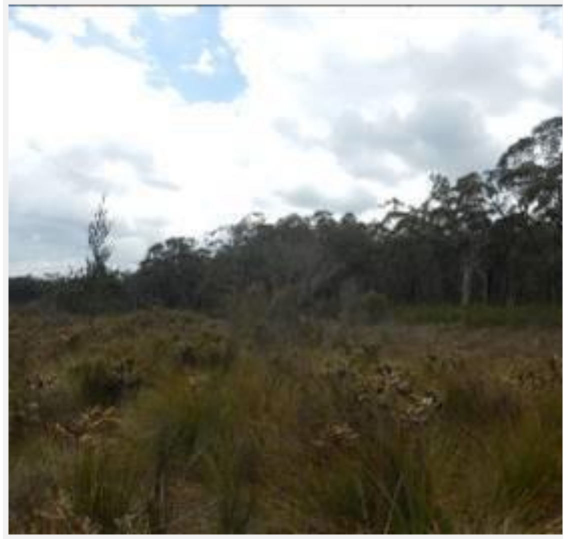
S1B - F1 South Spring 2014

S1B - F1 South Spring 2015

S1B - F1 South Spring 2016



S1B - F1 South Spring 2017



S1B – F1 West Autumn 2010	S1B – F1 West Autumn 2014	S1B – F1 West Autumn 2015	S1B – F1 West Autumn 2016	S1B – F1 West Autumn 2017
				
S1B – F1 West Spring 2009	**S1B - F1 West Spring 2014**	**S1B - F1 West Spring 2015**	**S1B - F1 West Spring 2016**	**S1B - F1 West Spring 2017**
				

S1B – F2 North Autumn 2010	S1B – F2 North Autumn 2014	S1B – F2 North Autumn 2015	S1B – F2 North Autumn 2016	S1B – F2 North Autumn 2017
				
S1B – F2 North Spring 2009	**S1B – F2 North Spring 2014**	**S1B – F2 North Spring 2015**	**S1B – F2 North Spring 2016**	**S1B – F2 North Spring 2017**
				

S1B – F2 East Autumn 2010	S1B – F2 East Autumn 2014	S1B – F2 East Autumn 2015	S1B – F2 East Autumn 2016	S1B – F2 East Autumn 2017
				
S1B – F2 East Spring 2009	**S1B – F2 East Spring 2014**	**S1B – F2 East Spring 2015**	**S1B – F2 East Spring 2016**	**S1B – F2 East Spring 2017**
				

S1B – F2 South Autumn 2010	S1B – F2 South Autumn 2014	S1B – F2 South Autumn 2015	S1B – F2 South Autumn 2016	S1B – F2 South Autumn 2017
				
S1B – F2 South Spring 2009	**S1B – F2 South Spring 2014**	**S1B – F2 South Spring 2015**	**S1B – F2 South Spring 2016**	**S1B – F2 South Spring 2017**
				

S1B – F2 West Autumn 2010	S1B – F2 West Autumn 2014	S1B – F2 West Autumn 2015	S1B – F2 West Autumn 2016	S1B – F2 West Autumn 2017
				
S1B – F2 West Spring 2009	**S1B – F2 West Spring 2014**	**S1B – F2 West Spring 2015**	**S1B – F2 West Spring 2016**	**S1B – F2 West Spring 2017**
				

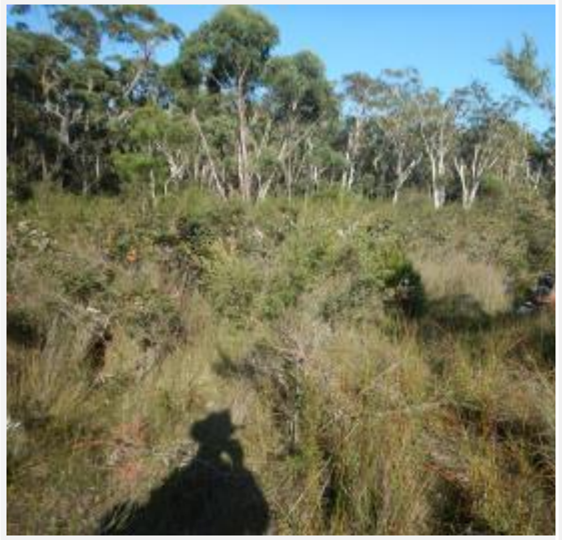
S1B – F3 North Autumn 2010	S1B - F3 North Autumn 2014	S1B - F3 North Autumn 2015	S1B - F3 North Autumn 2016	S1B - F3 North Autumn 2017
		Photo not available		

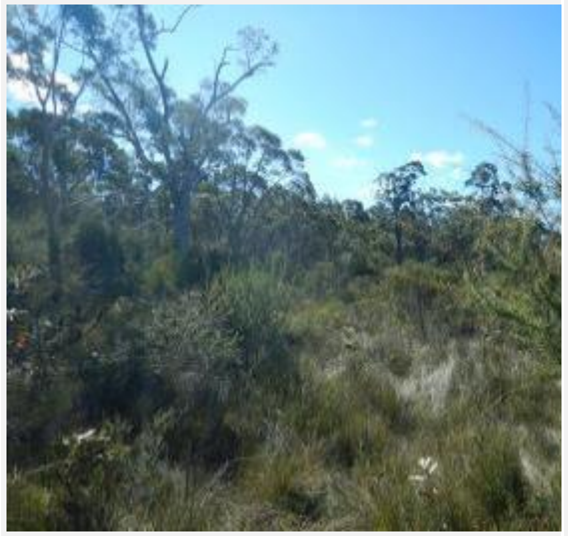
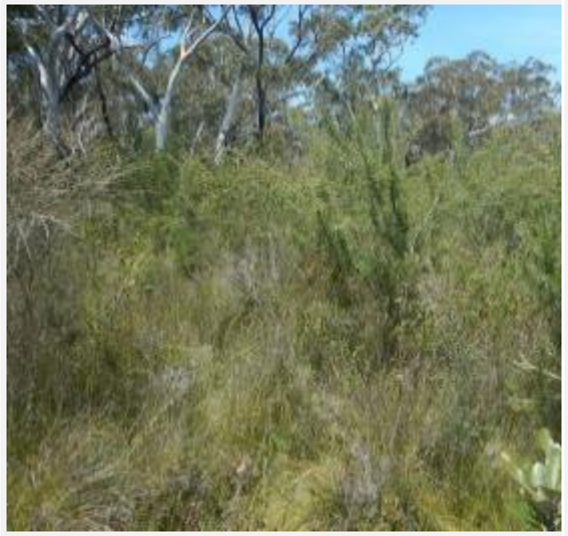
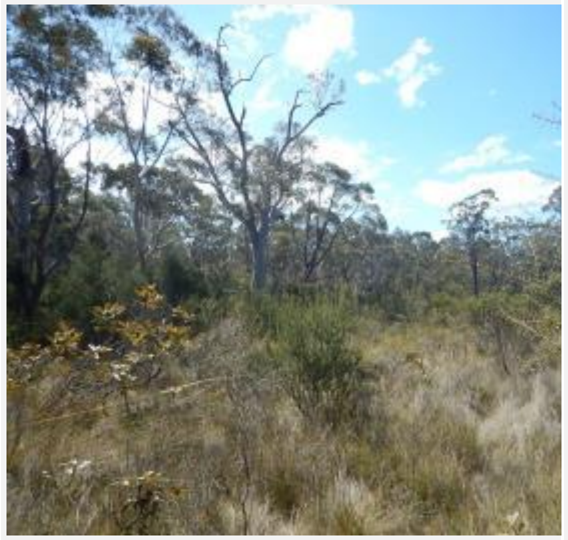
S1B – F3 North Spring 2009	S1B – F3 North Spring 2014	S1B – F3 North Spring 2015	S1B – F3 North Spring 2016	S1B – F3 North Spring 2017
				

S1B – F3 East Autumn 2010	1B – F3 East Autumn 2014	S1B – F3 East Autumn 2015	S1B – F3 East Autumn 2016	S1B – F3 East Autumn 2017
		Photo not available		
S1B – F3 East Spring 2009	**S1B – F3 East Spring 2014**	**S1B – F3 East Spring 2015**	**S1B – F3 East Spring 2016**	**S1B – F3 East Spring 2017**
				

S1B – F3 South Autumn 2010	S1B – F3 South Autumn 2014	S1B – F3 South Autumn 2015	S1B – F3 South Autumn 2016	S1B – F3 South Autumn 2017
		Photo not available		

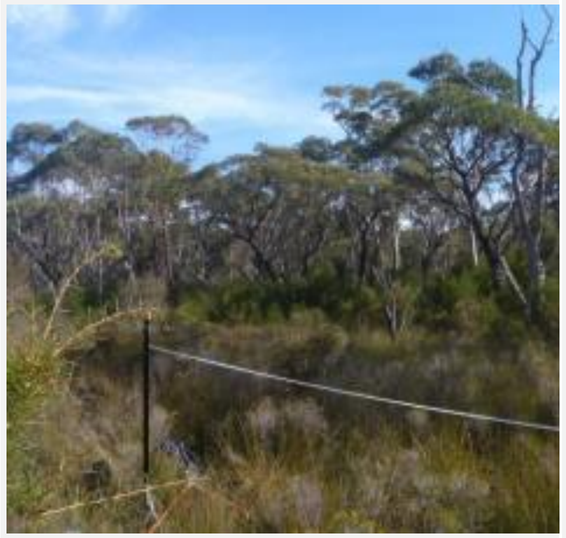
S1B – F3 South Spring 2009	S1B – F3 South Spring 2014	S1B – F3 South Spring 2015	S1B – F3 South Spring 2016	S1B – F3 South Spring 2017
				

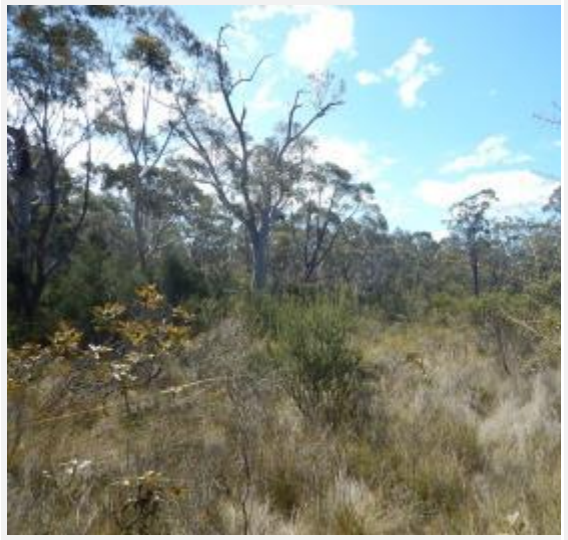
S1B – F3 West Autumn 2010	S1B – F3 West Autumn 2014	S1B – F3 West Autumn 2015	S1B – F3 West Autumn 2016	S1B – F3 West Autumn 2017
		Photo not available		
S1B – F3 West Spring 2009	**S1B – F3 West Spring 2014**	**S1B – F3 West Spring 2015**	**S1B – F3 West Spring 2016**	**S1B – F3 West Spring 2017**
				

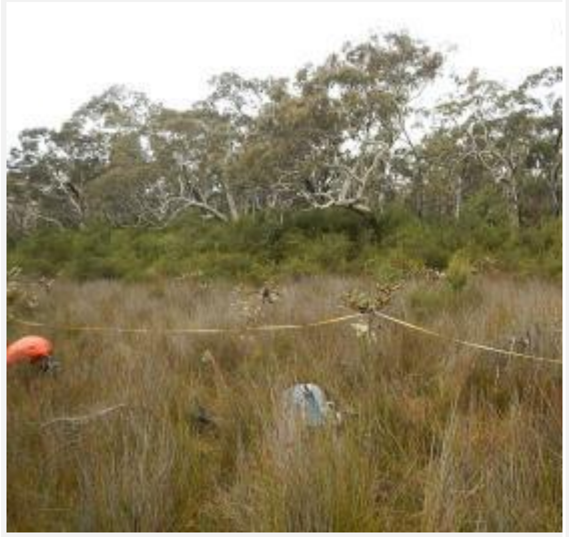
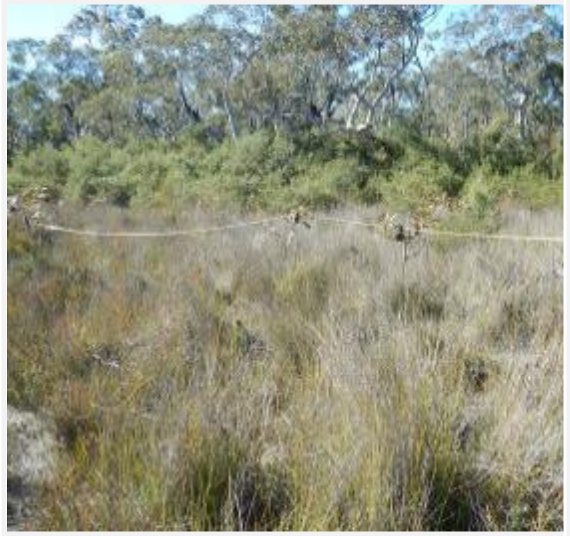
S5 – F1 North Autumn 2012	S5 – F1 North Autumn 2014	S5 – F1 North Autumn 2015	S5 – F1 North Autumn 2016	S5 – F1 North Autumn 2017
Not monitored				
S5 – F1 North Spring 2012	**S5 – F1 North Spring 2014**	**S5 – F1 North Spring 2015**	**S5 – F1 North Spring 2016**	**S5 – F1 North Spring 2017**
				

S5 – F1 East Autumn 2012	S5 – F1 East Autumn 2014	S5 – F1 East Autumn 2015	S5 – F1 East Autumn 2016	S5 – F1 East Autumn 2017
Not monitored				
S5 – F1 East Spring 2012	**S5 – F1 East Spring 2014**	**S5 – F1 East Spring 2015**	**S5 – F1 East Spring 2016**	**S5 – F1 East Spring 2017**
				

S5 – F1 South Autumn 2012	S5 – F1 South Autumn 2014	S5 – F1 South Autumn 2015	S5 – F1 South Autumn 2016	S5 – F1 South Autumn 2017
Not monitored				
S5 – F1 South Spring 2012	**S5 – F1 South Spring 2014**	**S5 – F1 South Spring 2015**	**S5 – F1 South Spring 2016**	**S5 – F1 South Spring 2017**
				

S5 – F1 West Autumn 2012	S5 – F1 West Autumn 2014	S5 – F1 West Autumn 2015	S5 – F1 West Autumn 2016	S5 – F1 West Autumn 2017
Not monitored				
S5 – F1 West Spring 2012	**S5 – F1 West Spring 2014**	**S5 – F1 West Spring 2015**	**S5 – F1 West Spring 2016**	**S5 – F1 West Spring 2017**
				

S5 – F2 North Autumn 2012	S5 – F2 North Autumn 2014	S5 – F2 North Autumn 2015	S5 – F2 North Autumn 2016	S5 – F2 North Autumn 2017
Not monitored				
S5 – F2 North Spring 2012	**S5 – F2 North Spring 2014**	**S5 – F2 North Spring 2015**	**S5 – F2 North Spring 2016**	**S5 – F2 North Spring 2017**
				

S5 – F2 East Autumn 2012	S5 – F2 East Autumn 2014	S5 – F2 East Autumn 2015	S5 – F2 East Autumn 2016	S5 – F2 East Autumn 2017
Not monitored				
S5 – F2 East Spring 2012	**S5 – F2 East Spring 2014**	**S5 – F2 East Spring 2015**	**S5 – F2 East Spring 2016**	**S5 – F2 East Spring 2017**
				

S5 – F2 South Autumn 2012	S5 – F2 South Autumn 2014	S5 – F2 South Autumn 2015	S5 – F2 South Autumn 2016	S5 – F2 South Autumn 2017
Not monitored				
S5 – F2 South Spring 2012	**S5 – F2 South Spring 2014**	**S5 – F2 South Spring 2015**	**S5 – F2 South Spring 2016**	**S5 – F2 South Spring 2017**
				

S5 – F2 West Autumn 2012	S5 – F2 West Autumn 2014	S5 – F2 West Autumn 2015	S5 – F2 West Autumn 2016	S5 – F2 West Autumn 2017
Not monitored				
S5 – F2 West Spring 2012	**S5 – F2 West Spring 2014**	**S5 – F2 West Spring 2015**	**S5 – F2 West Spring 2016**	**S5 – F2 West Spring 2017**
				

S5 – F3 North Autumn 2012	S5 – F3 North Autumn 2014	S5 – F3 North Autumn 2015	S5 – F3 North Autumn 2016	S5 – F3 North Autumn 2017
Not monitored				
S5 – F3 North Spring 2012	**S5 – F3 North Spring 2014**	**S5 – F3 North Spring 2015**	**S5 – F3 North Spring 2016**	**S5 – F3 North Spring 2017**
				

S5 – F3 East Autumn 2012	S5 – F3 East Autumn 2014	S5 – F3 East Autumn 2015	S5 – F3 East Autumn 2016	S5 – F3 East Autumn 2017
Not monitored				
S5 – F3 East Spring 2012	**S5 – F3 East Spring 2014**	**S5 – F3 East Spring 2015**	**S5 – F3 East Spring 2016**	**S5 – F3 East Spring 2017**
				

S5 – F3 South Spring 2012	S5 – F3 South Autumn 2014	S5 – F3 South Autumn 2015	S5 – F3 South Autumn 2016	S5 – F3 South Autumn 2017
Not monitored				
S5 – F3 South Spring 2012	**S5 – F3 South Spring 2014**	**S5 – F3 South Spring 2015**	**S5 – F3 South Spring 2016**	**S5 – F3 South Spring 2017**
				

S5 – F3 West Autumn 2012	S5 – F3 West Autumn 2014	S5 – F3 West Autumn 2015	S5 – F3 West Autumn 2016	S5 – F3 West Autumn 2017
				
S5 – F3 West Spring 2012	**S5 – F3 West Spring 2014**	**S5 – F3 West Spring 2015**	**S5 – F3 West Spring 2016**	**S5 – F3 West Spring 2017**
				

S13 – F1 North Autumn 2013	S13 – F1 North Autumn 2014	S13 – F1 North Autumn 2015	S13 – F1 North Autumn 2016	S13 – F1 North Autumn 2017
Not monitored				

S13 – F1 North Spring 2013	S13 – F1 North Spring 2014	S13 – F1 North Spring 2015	S13 – F1 North Spring 2016	S13 – F1 North Spring 2017
				

S13 – F1 East Autumn 2013	S13 – F1 East Autumn 2014	S13 – F1 East Autumn 2015	S13 – F1 East Autumn 2016	S13 – F1 East Autumn 2017
Not monitored				
S13 – F1 East Spring 2013	**S13 – F1 East Spring 2014**	**S13 – F1 East Spring 2015**	**S13 – F1 East Spring 2016**	**S13 – F1 East Spring 2017**
				

S13 – F1 South Autumn 2013	S13 – F1 South Autumn 2014	S13 – F1 South Autumn 2015	S13 – F1 South Autumn 2016	S13 – F1 South Autumn 2017
Not monitored				
S13 – F1 South Spring 2013	**S13 – F1 South Spring 2014**	**S13 – F1 South Spring 2015**	**S13 – F1 South Spring 2016**	**S13 – F1 South Spring 2017**
				

S13 – F1 West Autumn 2013	S13 – F1 West Autumn 2014	S13 – F1 West Autumn 2015	S13 – F1 West Autumn 2016	S13 – F1 West Autumn 2017
				
S13 – F1 West Spring 2013	**S13 – F1 West Spring 2014**	**S13 – F1 West Spring 2015**	**S13 – F1 West Spring 2016**	**S13 – F1 West Spring 2017**
				

S13 – F2 North Autumn 2013	S13 – F2 North Autumn 2014	S13 – F2 North Autumn 2015	S13 – F2 North Autumn 2016	S13 – F2 North Autumn 2017
Not monitored				
S13 – F2 North Spring 2013	**S13 – F2 North Spring 2014**	**S13 – F2 North Spring 2015**	**S13 – F2 North Spring 2016**	**S13 – F2 North Spring 2017**
				

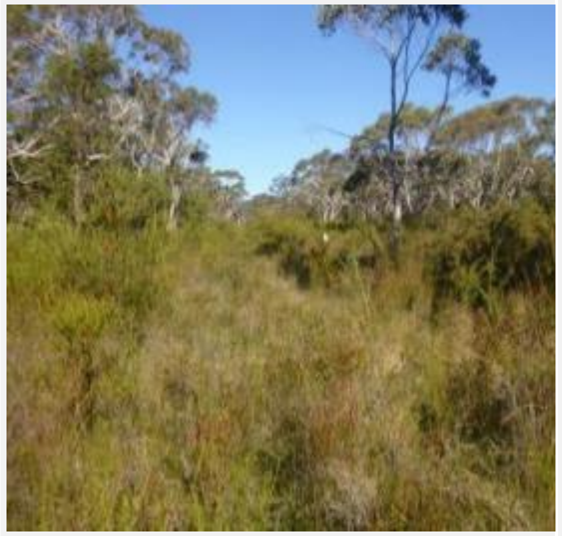
S13 – F2 East Autumn 2013	S13 – F2 East Autumn 2014	S13 – F2 East Autumn 2015	S13 – F2 East Autumn 2016	S13 – F2 East Autumn 2017
Not monitored				
S13 – F2 East Spring 2013	**S13 – F2 East Spring 2014**	**S13 – F2 East Spring 2015**	**S13 – F2 East Spring 2016**	**S13 – F2 East Spring 2017**
				

S13 – F2 South Autumn 2013	S13 – F2 South Autumn 2014	S13 – F2 South Autumn 2015	S13 – F2 South Autumn 2016	S13 – F2 South Autumn 2017
Not monitored				
S13 – F2 South Spring 2013	**S13 – F2 South Spring 2014**	**S13 – F2 South Spring 2015**	**S13 – F2 South Spring 2016**	**S13 – F2 South Spring 2017**
				

S13 – F2 West Autumn 2013	S13 – F2 West Autumn 2014	S13 – F2 West Autumn 2015	S13 – F2 West Autumn 2016	S13 – F2 West Autumn 2017
Not monitored				
S13 – F2 West Spring 2013	**S13 – F2 West Spring 2014**	**S13 – F2 West Spring 2015**	**S13 – F2 West Spring 2016**	**S13 – F2 West Spring 2017**
				

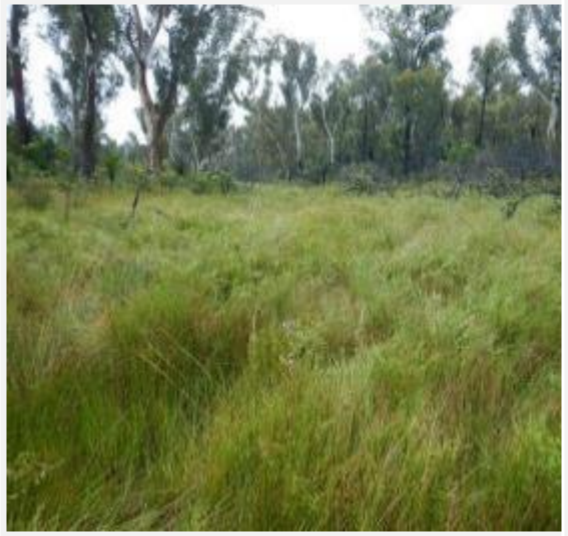
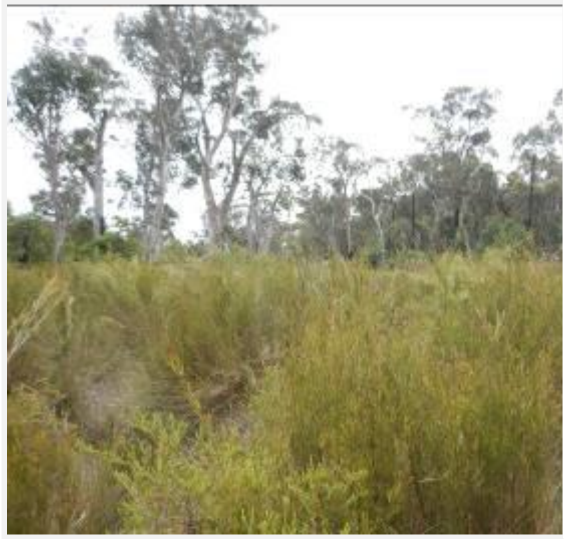
S13 – F3 North Autumn 2013	S13 – F3 North Autumn 2014	S13 – F3 North Autumn 2015	S13 – F3 North Autumn 2016	S13 – F3 North Autumn 2017
Not monitored				
S13 – F3 North Spring 2013	**S13 – F3 North Spring 2014**	**S13 – F3 North Spring 2015**	**S13 – F3 North Spring 2016**	**S13 – F3 North Spring 2017**
				

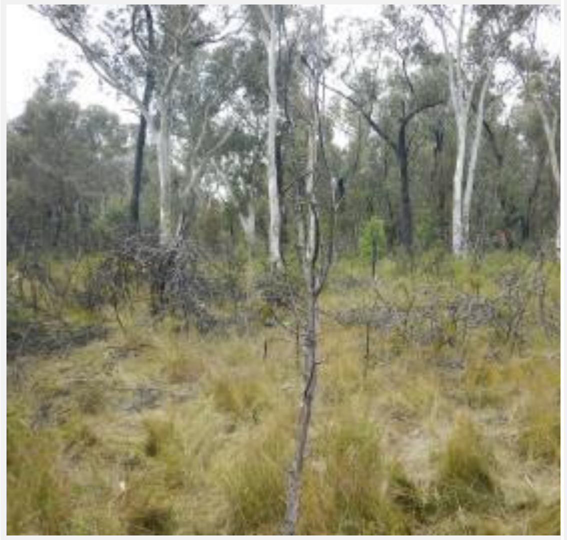
S13 – F3 East Autumn 2013	S13 – F3 East Autumn 2014	S13 – F3 East Autumn 2015	S13 – F3 East Autumn 2016	S13 – F3 East Autumn 2017
Not monitored				
S13 – F3 East Spring 2013	**S13 – F3 East Spring 2014**	**S13 – F3 East Spring 2015**	**S13 – F3 East Spring 2016**	**S13 – F3 East Spring 2017**
				

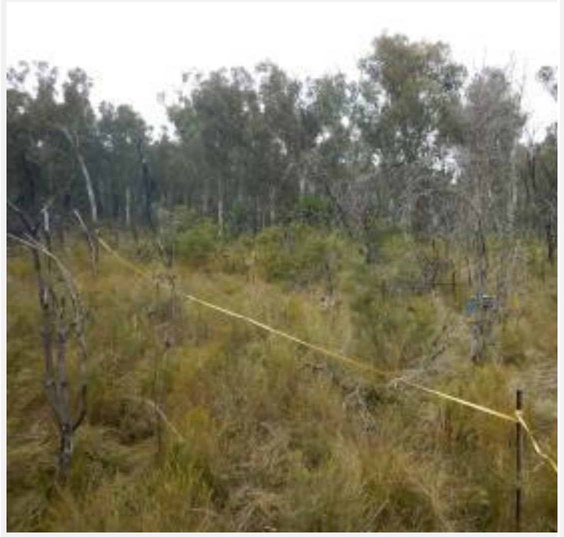
S13 – F3 South Autumn 2013	S13 – F3 South Autumn 2014	S13 – F3 South Autumn 2015	S13 – F3 South Autumn 2016	S13 – F3 South Autumn 2017
Not monitored				
S13 – F3 South Spring 2013	**S13 – F3 South Spring 2014**	**S13 – F3 South Spring 2015**	**S13 – F3 South Spring 2016**	**S13 – F3 South Spring 2017**
				

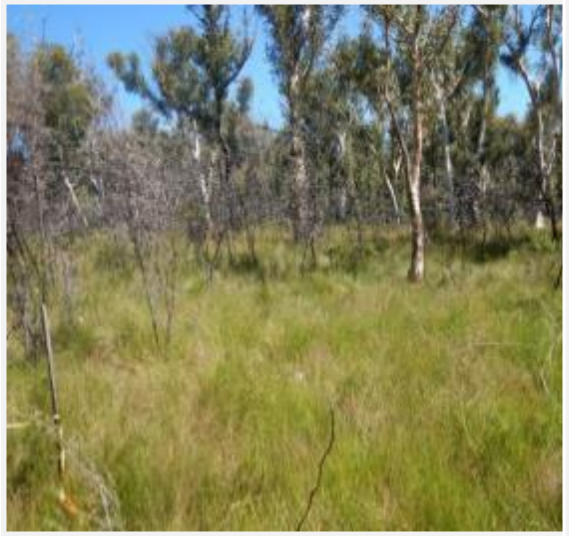
S13 – F3 West Autumn 2013	S13 – F3 West Autumn 2014	S13 – F3 West Autumn 2015	S13 – F3 West Autumn 2016	S13 – F3 West Autumn 2017
Not monitored				
S13 – F3 West Spring 2013	**S13 – F3 West Spring 2014**	**S13 – F3 West Spring 2015**	**S13 – F3 West Spring 2016**	**S13 – F3 West Spring 2017**
				

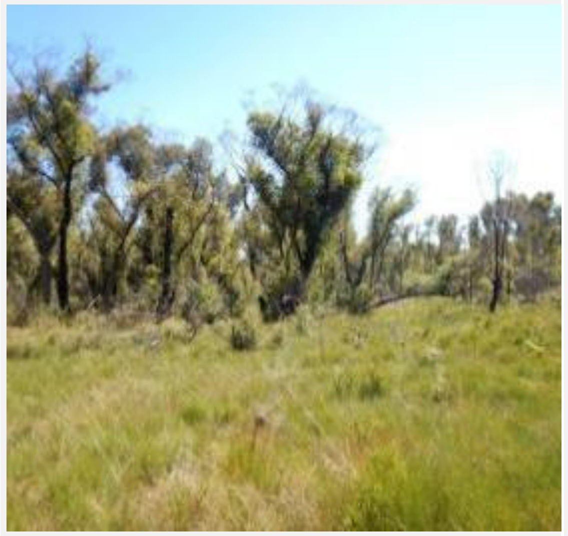
Table 25 Dendrobium Area 3B control swamp sites 2017 photo point monitoring

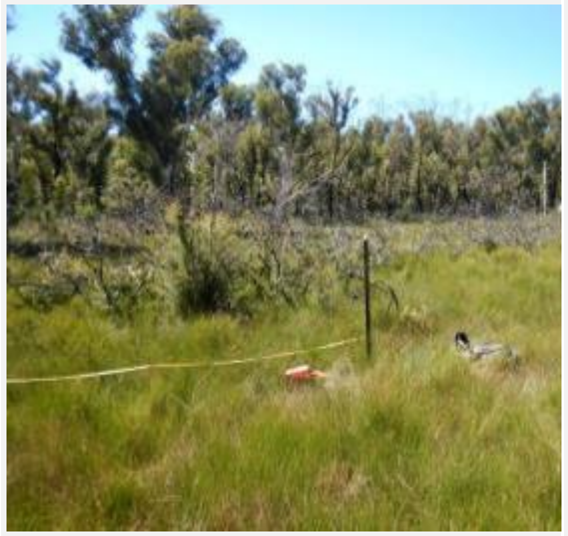
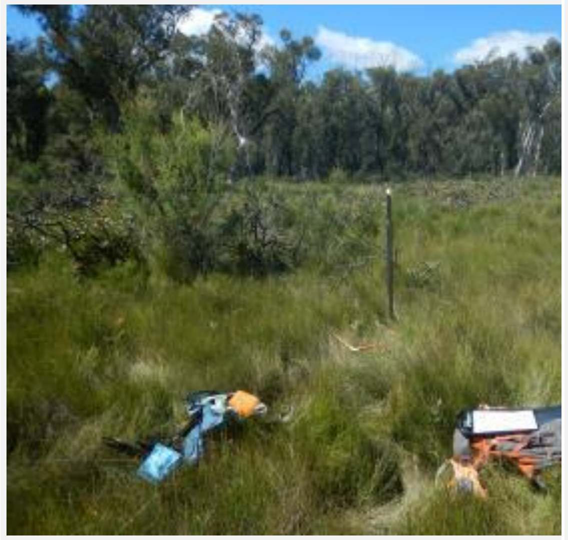
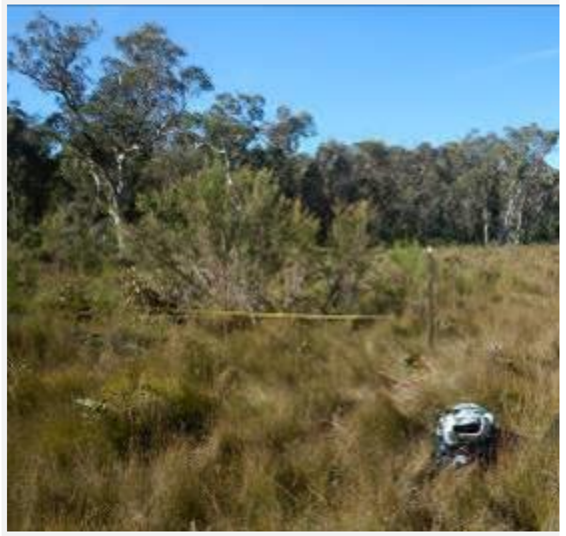
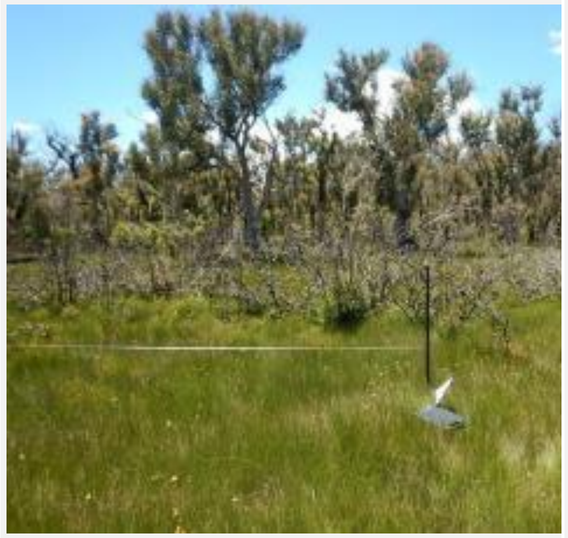
S86 – F1 North Autumn 2012	S86 – F1 North Autumn 2014	S86 – F1 North Autumn 2015	S86 – F1 North Autumn 2016	S86 – F1 North Autumn 2017
Not monitored				
S86 – F1 North Spring 2012	**S86 – F1 North Spring 2014**	**S86 – F1 North Spring 2015**	**S86 – F1 North Spring 2016**	**S86 – F1 North Spring 2017**
				

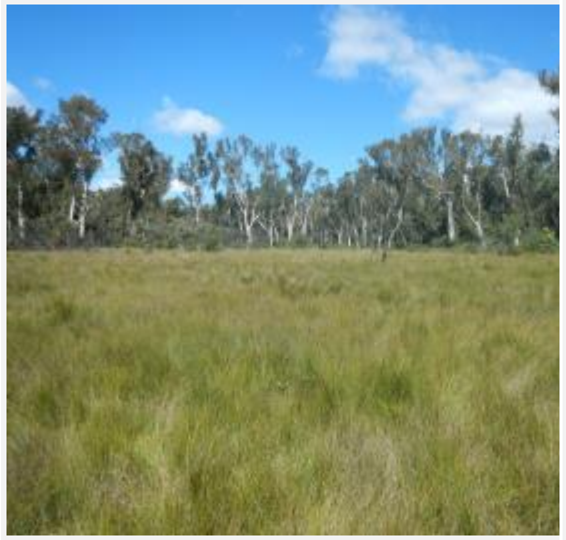
S86 – F1 East Autumn 2012	S86 – F1 East Autumn 2014	S86 – F1 East Autumn 2015	S86 – F1 East Autumn 2016	S86 – F1 East Autumn 2017
Not monitored				
S86 – F1 East Spring 2012	**S86 – F1 East Spring 2014**	**S86 – F1 East Spring 2015**	**S86 – F1 East Spring 2016**	**S86 – F1 East Spring 2017**
				

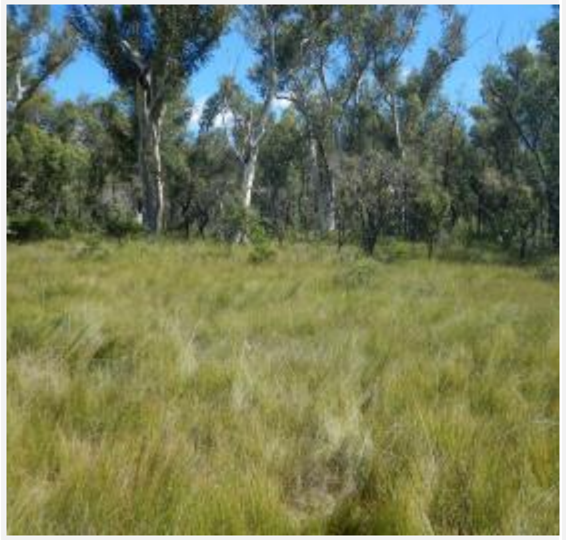
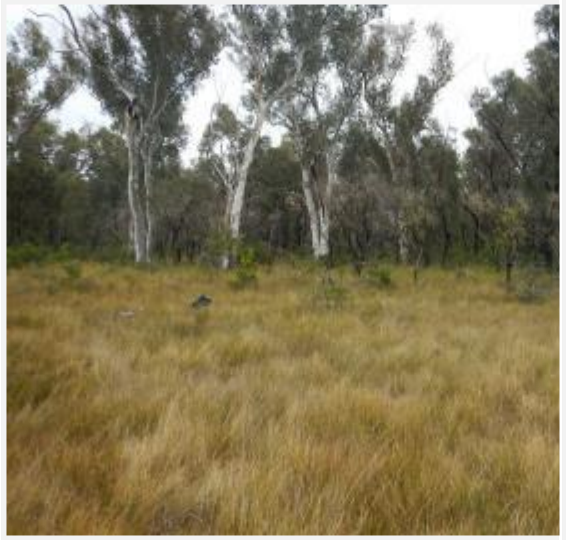
S86 – F1 South Autumn 2012	**S86 – F1 South Autumn 2014**	**S86 – F1 South Autumn 2015**	**S86 – F1 South Autumn 2016**	**S86 – F1 South Autumn 2017**
Not monitored				
S86 – F1 South Spring 2012	**S86 – F1 South Spring 2014**	**S86 – F1 South Spring 2015**	**S86 – F1 South Spring 2016**	**S86 – F1 South Spring 2017**
				

S86 – F1 West Autumn 2012	S86 – F1 West Autumn 2014	S86 – F1 West Autumn 2015	S86 – F1 West Autumn 2016	S86 – F1 West Autumn 2017
Not monitored				
S86 – F1 West Spring 2012	**S86 – F1 West Spring 2014**	**S86 – F1 West Spring 2015**	**S86 – F1 West Spring 2016**	**S86 – F1 West Spring 2017**
				

S86 – F2 North Autumn 2012	S86 – F2 North Autumn 2014	S86 – F2 North Autumn 2015	S86 – F2 North Autumn 2016	S86 – F2 North Autumn 2017
Not monitored				
S86 – F2 North Spring 2012	**S86 – F2 North Spring 2014**	**S86 – F2 North Spring 2015**	**S86 – F2 North Spring 2016**	**S86 – F2 North Spring 2017**
				

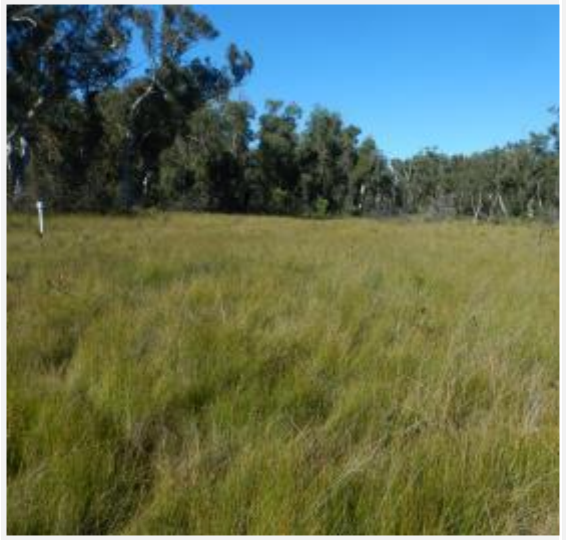
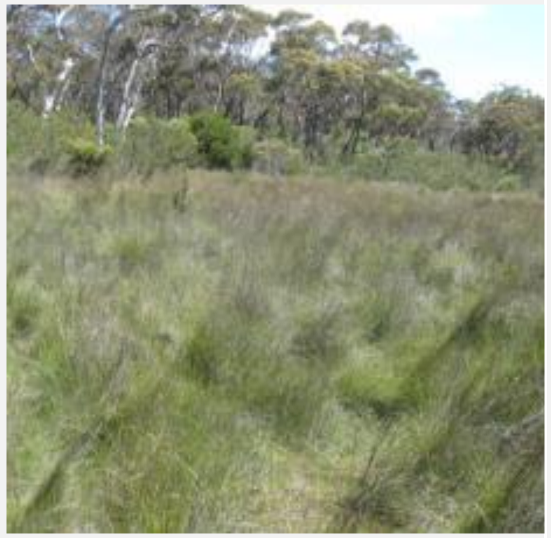
S86– F2 East Autumn 2012	S86– F2 East Autumn 2014	S86– F2 East Autumn 2015	S86– F2 East Autumn 2016	S86– F2 East Autumn 2017
Not monitored				
S86– F2 East Spring 2012	**S86– F2 East Spring 2014**	**S86– F2 East Spring 2015**	**S86– F2 East Spring 2016**	**S86– F2 East Spring 2017**
				

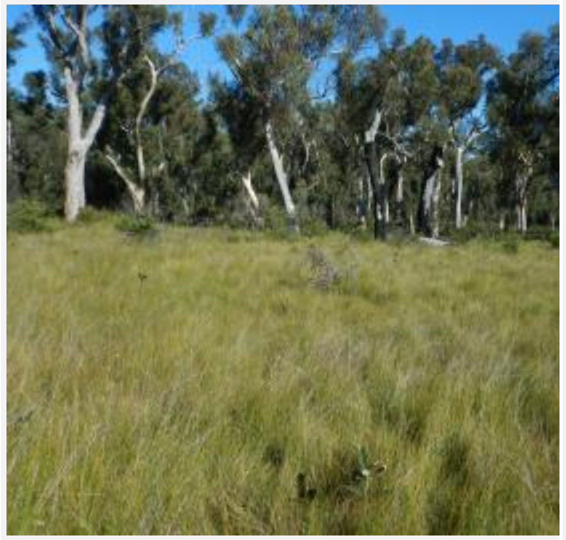
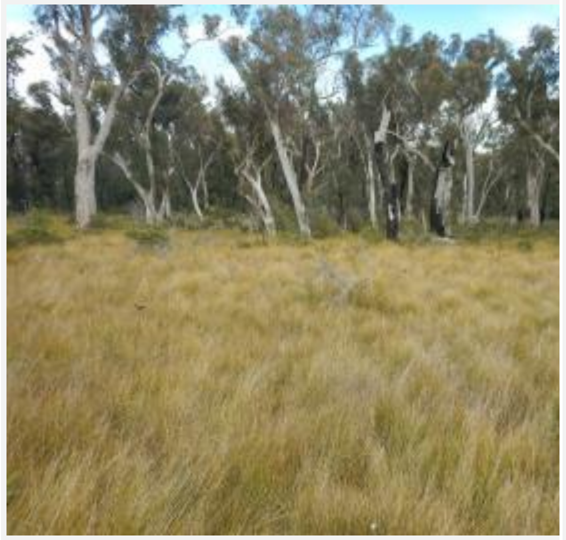
S86– F2 South Autumn 2012	S86– F2 South Autumn 2014	S86– F2 South Autumn 2015	S86– F2 South Autumn 2016	S86– F2 South Autumn 2017
Not monitored				
S86– F2 South Spring 2012	**S86– F2 South Spring 2014**	**S86– F2 South Spring 2015**	**S86– F2 South Spring 2016**	**S86– F2 South Spring 2017**
				

S86– F2 West Spring 2012	S86– F2 West Autumn 2014	S86– F2 West Autumn 2015	S86– F2 West Autumn 2016	S86– F2 West Autumn 2017
Not monitored				
S86– F2 West Spring 2012	**S86– F2 West Spring 2014**	**S86– F2 West Spring 2015**	**S86– F2 West Spring 2016**	**S86– F2 West Spring 2017**
				

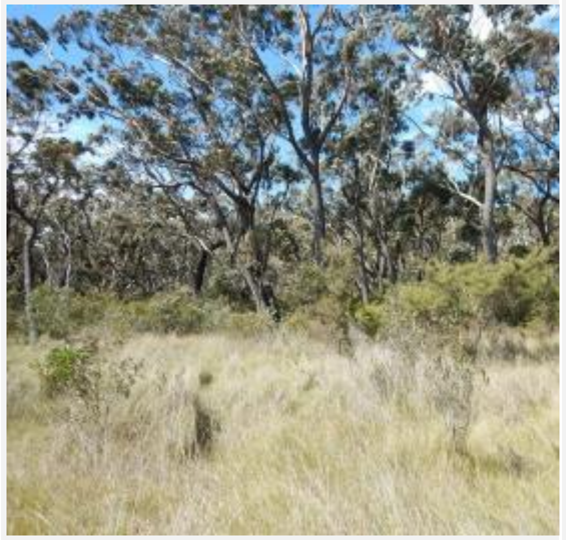
S86– F3 North Autumn 2012	S86– F3 North Autumn 2014	S86– F3 North Autumn 2015	S86– F3 North Autumn 2016	S86– F3 North Autumn 2017
Not monitored				
S86– F3 North Spring 2012	**S86– F3 North Spring 2014**	**S86– F3 North Spring 2015**	**S86– F3 North Spring 2016**	**S86– F3 North Spring 2017**
				

S86– F3 East Autumn 2012	S86– F3 East Autumn 2014	S86– F3 East Autumn 2015	S86– F3 East Autumn 2016	S86– F3 East Autumn 2017
Not monitored				
S86– F3 East Spring 2012	**S86– F3 East Spring 2014**	**S86– F3 East Spring 2015**	**S86– F3 East Spring 2016**	**S86– F3 East Spring 2017**
				

S86– F3 South Autumn 2012	S86– F3 South Autumn 2014	S86– F3 South Autumn 2015	S86– F3 South Autumn 2016	S86– F3 South Autumn 2017
Not monitored				
S86– F3 South Spring 2012	**S86– F3 South Spring 2014**	**S86– F3 South Spring 2015**	**S86– F3 South Spring 2016**	**S86– F3 South Spring 2017**
				

S86– F3 West Autumn 2012	S86– F3 West Autumn 2014	S86– F3 West Autumn 2015	S86– F3 West Autumn 2016	S86– F3 West Autumn 2017
Not monitored				
S86– F3 West Spring 2012	**S86– F3 West Spring 2014**	**S86– F3 West Spring 2015**	**S86– F3 West Spring 2016**	**S86– F3 West Spring 2017**
				

S87 – F1 North Autumn 2012	S87 – F1 North Autumn 2014	S87 – F1 North Autumn 2015	S87 – F1 North Autumn 2016	S87 – F1 North Autumn 2017
Not monitored				
S87 – F1 North Spring 2012	**S87 – F1 North Spring 2014**	**S87 – F1 North Spring 2015**	**S87 – F1 North Spring 2016**	**S87 – F1 North Spring 2017**
				

S87 – F1 East Autumn 2012	S87 – F1 East Autumn 2014	S87 – F1 East Autumn 2015	S87 – F1 East Autumn 2016	S87 – F1 East Autumn 2017
Not monitored				
S87 – F1 East Spring 2012	**S87 – F1 East Spring 2014**	**S87 – F1 East Spring 2014**	**S87 – F1 East Spring 2016**	**S87 – F1 East Spring 2017**
				

S87 – F1 South Autumn 2012	S87 – F1 South Autumn 2014	S87 – F1 South Autumn 2015	S87 – F1 South Autumn 2016	S87 – F1 South Autumn 2017
Not monitored				
S87 – F1 South Spring 2012	**S87 – F1 South Spring 2014**	**S87 – F1 South Spring 2015**	**S87 – F1 South Spring 2016**	**S87 – F1 South Spring 2017**
				

S87 – F1 West Autumn 2012	S87 – F1 West Autumn 2014	S87 – F1 West Autumn 2015	S87 – F1 West Autumn 2016	S87 – F1 West Autumn 2017
Not monitored				
S87 – F1 West Spring 2012	**S87 – F1 West Spring 2014**	**S87 – F1 West Spring 2015**	**S87 – F1 West Spring 2016**	**S87 – F1 West Spring 2017**
				

S87 – F2 North Autumn 2012	S87 – F2 North Autumn 2014	S87 – F2 North Autumn 2015	S87 – F2 North Autumn 2016	S87 – F2 North Autumn 2017
Not monitored				
S87 – F2 North Spring 2012	**S87 – F2 North Spring 2014**	**S87 – F2 North Spring 2015**	**S87 – F2 North Spring 2016**	**S87 – F2 North Spring 2017**
				

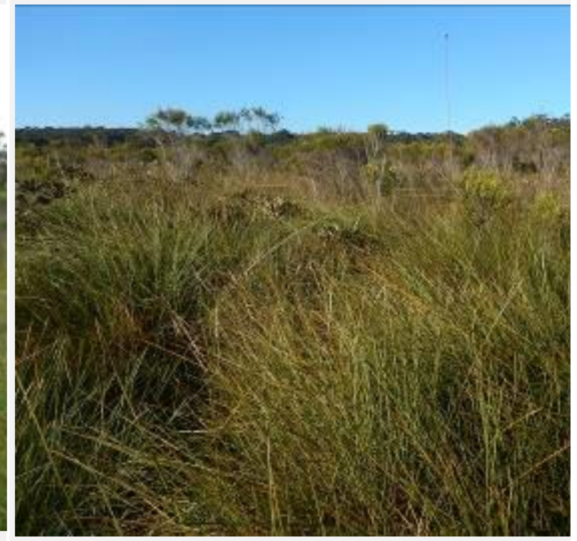
S87 – F2 East Autumn 2012	S87 – F2 East Autumn 2014	S87 – F2 East Autumn 2015	S87 – F2 East Autumn 2016	S87 – F2 East Autumn 2017
				
S87 – F2 East Spring 2012	**S87 – F2 East Spring 2014**	**S87 – F2 East Spring 2015**	**S87 – F2 East Spring 2016**	**S87 – F2 East Spring 2017**
				

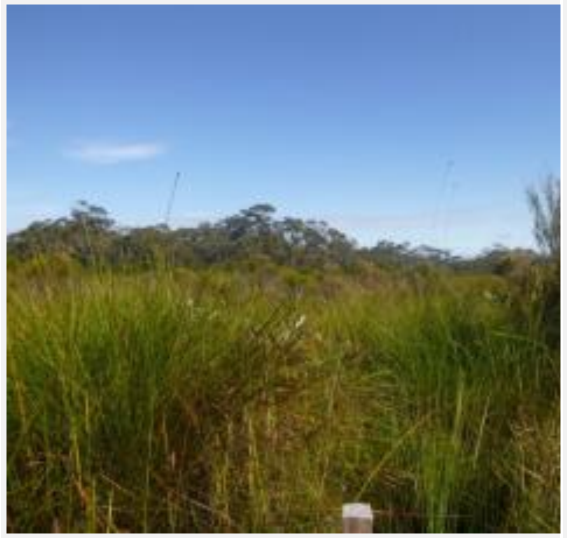
S87 – F2 South Autumn 2012	S87 – F2 South Autumn 2014	S87 – F2 South Autumn 2015	S87 – F2 South Autumn 2016	S87 – F2 South Autumn 2017
Not monitored				
S87 – F2 South Spring 2012	**S87 – F2 South Spring 2014**	**S87 – F2 South Spring 2015**	**S87 – F2 South Spring 2016**	**S87 – F2 South Spring 2017**
				

S87 – F2 West Autumn 2012	S87 – F2 West Autumn 2014	S87 – F2 West Autumn 2015	S87 – F2 West Autumn 2016	S87 – F2 West Autumn 2017
Not monitored				
S87 – F2 West Spring 2012	**S87 – F2 West Spring 2014**	**S87 – F2 West Spring 2015**	**S87 – F2 West Spring 2016**	**S87 – F2 West Spring 2017**
				

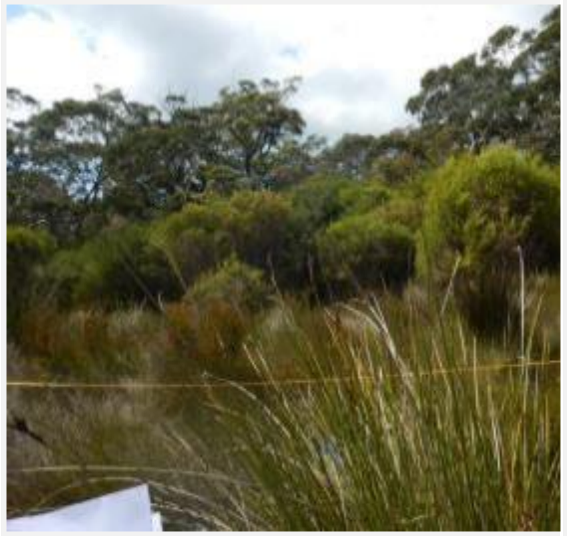
S87 – F3 North Autumn 2012	S87 – F3 North Autumn 2014	S87 – F3 North Autumn 2015	S87 – F3 North Autumn 2016	S87 – F3 North Autumn 2017
Not monitored				
S87 – F3 North Spring 2012	**S87 – F3 North Spring 2014**	**S87 – F3 North Spring 2015**	**S87 – F3 North Spring 2016**	**S87 – F3 North Spring 2017**
				

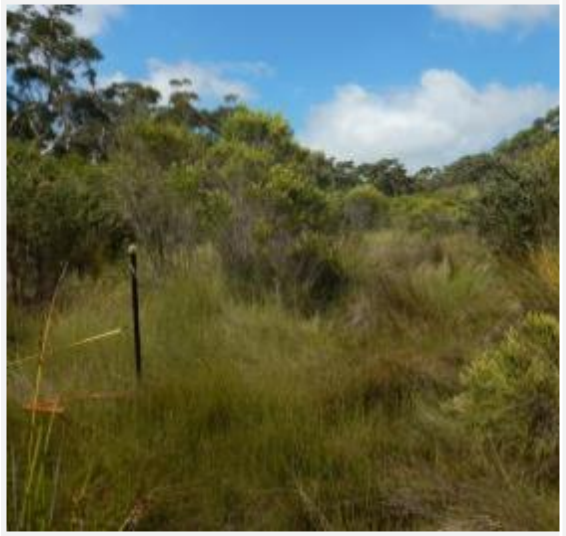
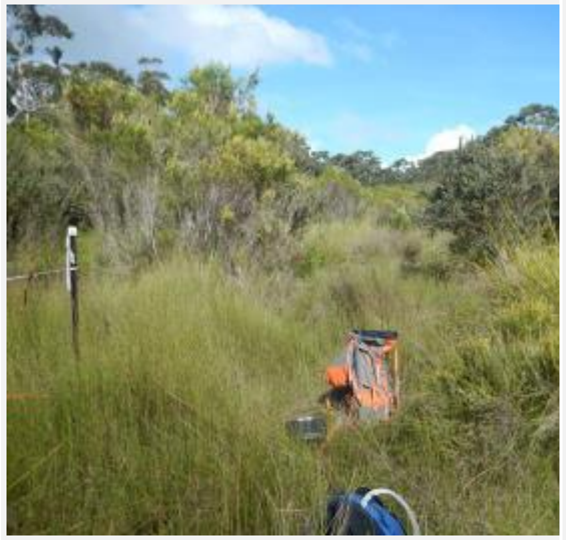
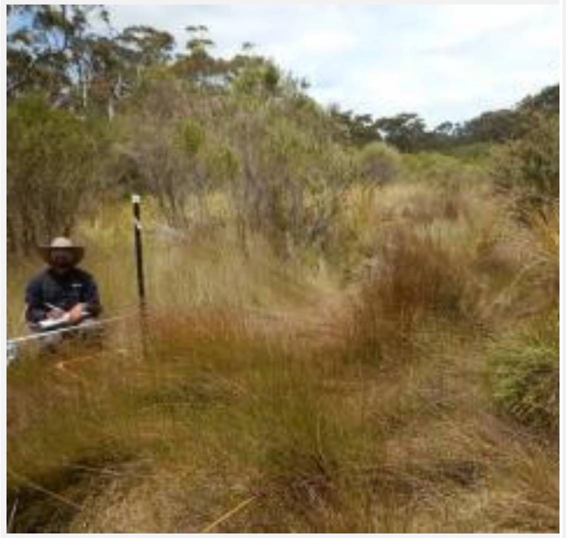
S87 – F3 East Autumn 2012	S87 – F3 East Autumn 2014	S87 – F3 East Autumn 2015	S87 – F3 East Autumn 2016	S87 – F3 East Autumn 2017
Not monitored				
S87 – F3 East Spring 2012	**S87 – F3 East Spring 2014**	**S87 – F3 East Spring 2015**	**S87 – F3 East Spring 2016**	**S87 – F3 East Spring 2017**
				

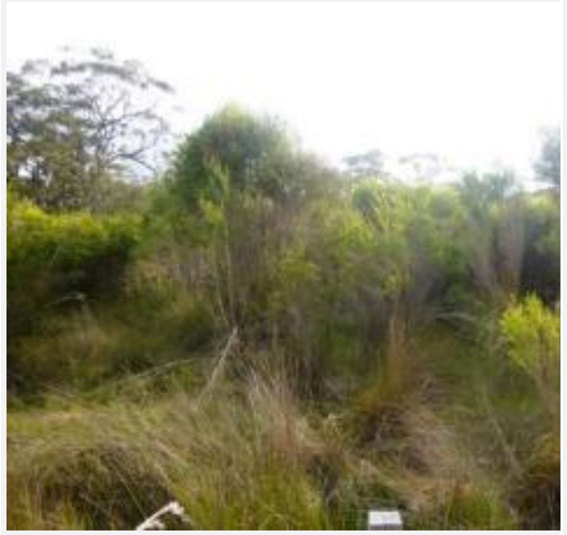
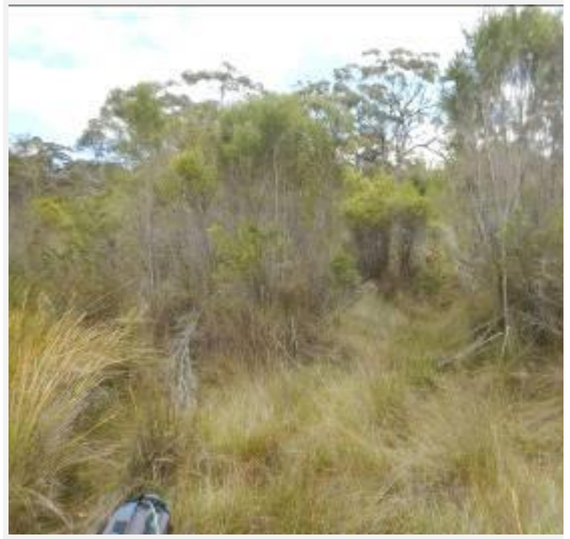
S87 – F3 South Autumn 2012	S87 – F3 South Autumn 2014	S87 – F3 South Autumn 2015	S87 – F3 South Autumn 2016	S87 – F3 South Autumn 2017
Not monitored				
S87 – F3 South Spring 2012	**S87 – F3 South Spring 2014**	**S87 – F3 South Spring 2015**	**S87 – F3 South Spring 2016**	**S87 – F3 South Spring 2017**
				

S87 – F3 West Autumn 2012	S87 – F3 West Autumn 2014	S87 – F3 West Autumn 2015	S87 – F3 West Autumn 2016	S87 – F3 West Autumn 2017
Not monitored				
S87 – F3 West Spring 2012	**S87 – F3 West Spring 2014**	**S87 – F3 West Spring 2015**	**S87 – F3 West Spring 2016**	**S87 – F3 West Spring 2017**
				

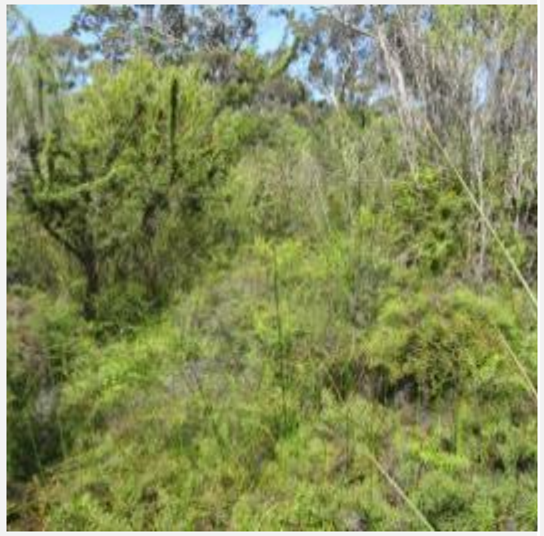
S88 – F1 North Autumn 2012	S88 – F1 North Autumn 2014	S88 – F1 North Autumn 2015	S88 – F1 North Autumn 2016	S88 – F1 North Autumn 2017
Not monitored				
S88 – F1 North Spring 2012	**S88 – F1 North Spring 2014**	**S88 – F1 North Spring 2015**	**S88 – F1 North Spring 2016**	**S88 – F1 North Spring 2017**
				

S88 – F1 East Autumn 2012	S88 – F1 East Autumn 2014	S88 – F1 East Autumn 2015	S88 – F1 East Autumn 2016	S88 – F1 East Autumn 2017
Not monitored				
S88 – F1 East Spring 2012	**S88 – F1 East Spring 2014**	**S88 – F1 East Spring 2015**	**S88 – F1 East Spring 2016**	**S88 – F1 East Spring 2017**
				

S88 – F1 South Autumn 2012	S88 – F1 South Autumn 2014	S88 – F1 South Autumn 2015	S88 – F1 South Autumn 2016	S88 – F1 South Autumn 2017
Not monitored				
S88 – F1 South Spring 2012	**S88 – F1 South Spring 2014**	**S88 – F1 South Spring 2015**	**S88 – F1 South Spring 2016**	**S88 – F1 South Spring 2017**
				

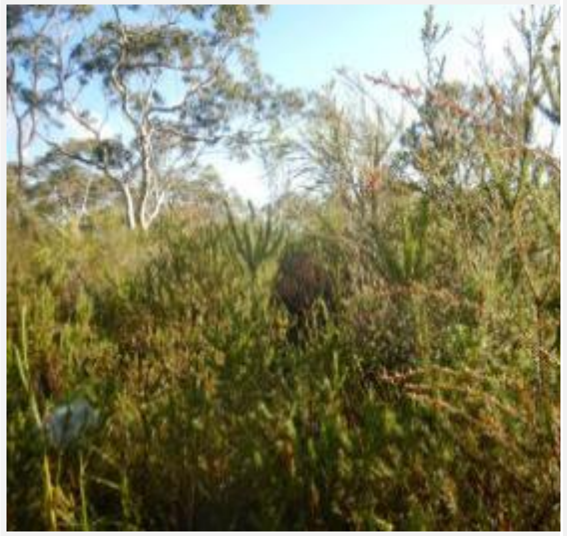
S88 – F1 West Autumn 2012	S88 – F1 West Autumn 2014	S88 – F1 West Autumn 2015	S88 – F1 West Autumn 2016	S88 – F1 West Autumn 2017
				
S88 – F1 West Spring 2012	**S88 – F1 West Spring 2014**	**S88 – F1 West Spring 2015**	**S88 – F1 West Spring 2016**	**S88 – F1 West Spring 2017**
				

S88 – F2 North Autumn 2012	S88 – F2 North Autumn 2014	S88 – F2 North Autumn 2015	S88 – F2 North Autumn 2016	S88 – F2 North Autumn 2017
Not monitored				
S88 – F2 North Spring 2012	**S88 – F2 North Spring 2014**	**S88 – F2 North Spring 2015**	**S88 – F2 North Spring 2016**	**S88 – F2 North Spring 2017**
				

S88 – F2 East Autumn 2012	S88 – F2 East Autumn 2014	S88 – F2 East Autumn 2015	S88 – F2 East Autumn 2016	S88 – F2 East Autumn 2017
				
S88 – F2 East Spring 2012	**S88 – F2 East Spring 2014**	**S88 – F2 East Spring 2015**	**S88 – F2 East Spring 2016**	**S88 – F2 East Spring 2017**
				

S88 – F2 South Autumn 2012	S88 – F2 South Autumn 2014	S88 – F2 South Autumn 2015	S88 – F2 South Autumn 2016	S88 – F2 South Autumn 2017
Not monitored				
S88 – F2 South Spring 2012	**S88 – F2 South Spring 2014**	**S88 – F2 South Spring 2015**	**S88 – F2 South Spring 2016**	**S88 – F2 South Spring 2017**
				

S88 – F2 West Autumn 2012	S88 – F2 West Autumn 2014	S88 – F2 West Autumn 2015	S88 – F2 West Autumn 2016	S88 – F2 West Autumn 2017
Not monitored				
S88 – F2 West Spring 2012	**S88 – F2 West Spring 2014**	**S88 – F2 West Spring 2015**	**S88 – F2 West Spring 2016**	**S88 – F2 West Spring 2017**
				

S88 – F3 North Autumn 2012	S88 – F3 North Autumn 2014	S88 – F3 North Autumn 2015	S88 – F3 North Autumn 2016	S88 – F3 North Autumn 2017
Not monitored				
S88 – F3 North Spring 2012	**S88 – F3 North Spring 2014**	**S88 – F3 North Spring 2015**	**S88 – F3 North Spring 2016**	**S88 – F3 North Spring 2017**
				

S88 – F3 East Autumn 2012	S88 – F3 East Autumn 2014	S88 – F3 East Autumn 2015	S88 – F3 East Autumn 2016	S88 – F3 East Autumn 2017
Not monitored				
S88 – F3 East Spring 2012	**S88 – F3 East Spring 2014**	**S88 – F3 East Spring 2015**	**S88 – F3 East Spring 2016**	**S88 – F3 East Spring 2017**
				

S88 – F3 South Autumn 2013	S88 – F3 South Autumn 2014	S88 – F3 South Autumn 2015	S88 – F3 South Autumn 2016	S88 – F3 South Autumn 2017
Not monitored				
S88 – F3 South Spring 2012	**S88 – F3 South Spring 2014**	**S88 – F3 South Spring 2015**	**S88 – F3 South Spring 2016**	**S88 – F3 South Spring 2017**
				

S88 – F3 West Autumn 2012	S88 – F3 West Autumn 2014	S88 – F3 West Autumn 2015	S88 – F3 West Autumn 2016	S88 – F3 West Autumn 2017
Not monitored				
S88 – F3 West Spring 2012	**S88 – F3 West Spring 2014**	**S88 – F3 West Spring 2015**	**S88 – F3 West Spring 2016**	**S88 – F3 West Spring 2017**
				

Table 26 Two additional pre-impact swamp sites at Dendrobium Area 3B new to the photo point monitoring in 2017

S14 – F1 North Autumn 2017	S14 – F1 East Autumn 2017	S14 – F1 South Autumn 2017	S14 – F1 West Autumn 2017
			
S14 – F1 North Spring 2017	**S14 – F1 East Spring 2017**	**S14 – F1 South Spring 2017**	**S14 – F1 West Spring 2017**
			

S14 – F2 North Autumn 2017	S14 – F2 East Autumn 2017	S14 – F2 South Autumn 2017	S14 – F2 West Autumn 2017
			
S14 – F2 North Spring 2017	**S14 – F2 East Spring 2017**	**S14 – F2 South Spring 2017**	**S14 – F2 West Spring 2017**
			

S14 – F3 North Autumn 2017	S14 – F3 East Autumn 2017	S14 – F3 South Autumn 2017	S14 – F3 West Autumn 2017
			
S14 – F3 North Spring 2017	**S14 – F3 East Spring 2017**	**S14 – F3 South Spring 2017**	**S14 – F3 West Spring 2017**
			

S23 – F1 North Autumn 2017	S23 – F1 East Autumn 2017	S23 – F1 South Autumn 2017	S23 – F1 West Autumn 2017
			
S23 – F1 North Spring 2017	**S23 – F1 East Spring 2017**	**S23 – F1 South Spring 2017**	**S23 – F1 West Spring 2017**
			

S23 – F2 North Autumn 2017	S23 – F2 East Autumn 2017	S23 – F2 South Autumn 2017	S23 – F2 West Autumn 2017
			
S23 – F2 North Spring 2017	**S23 – F2 East Spring 2017**	**S23 – F2 South Spring 2017**	**S23 – F2 West Spring 2017**
			

S23 – F3 North Autumn 2017	S23 – F3 East Autumn 2017	S23 – F3 South Autumn 2017	S23 – F3 West Autumn 2017
			
S23 – F3 North Spring 2017	**S23 – F3 East Spring 2017**	**S23 – F3 South Spring 2017**	**S23 – F3 West Spring 2017**