

Dendrobium Area 3A and 3B  
Littlejohn's Tree Frog tadpole surveys  
DC(1), DC13, WC21, WC17 and SC10C

Final report

Prepared for Illawarra Coal

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# 1 Introduction

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Littlejohn's Tree Frog *Litoria littlejohni* is a threatened species listed as Vulnerable under the *Threatened Species Conservation Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The species is known to occur throughout the Southern Coalfield including Dendrobium Area 3B and Dendrobium Area 3A.

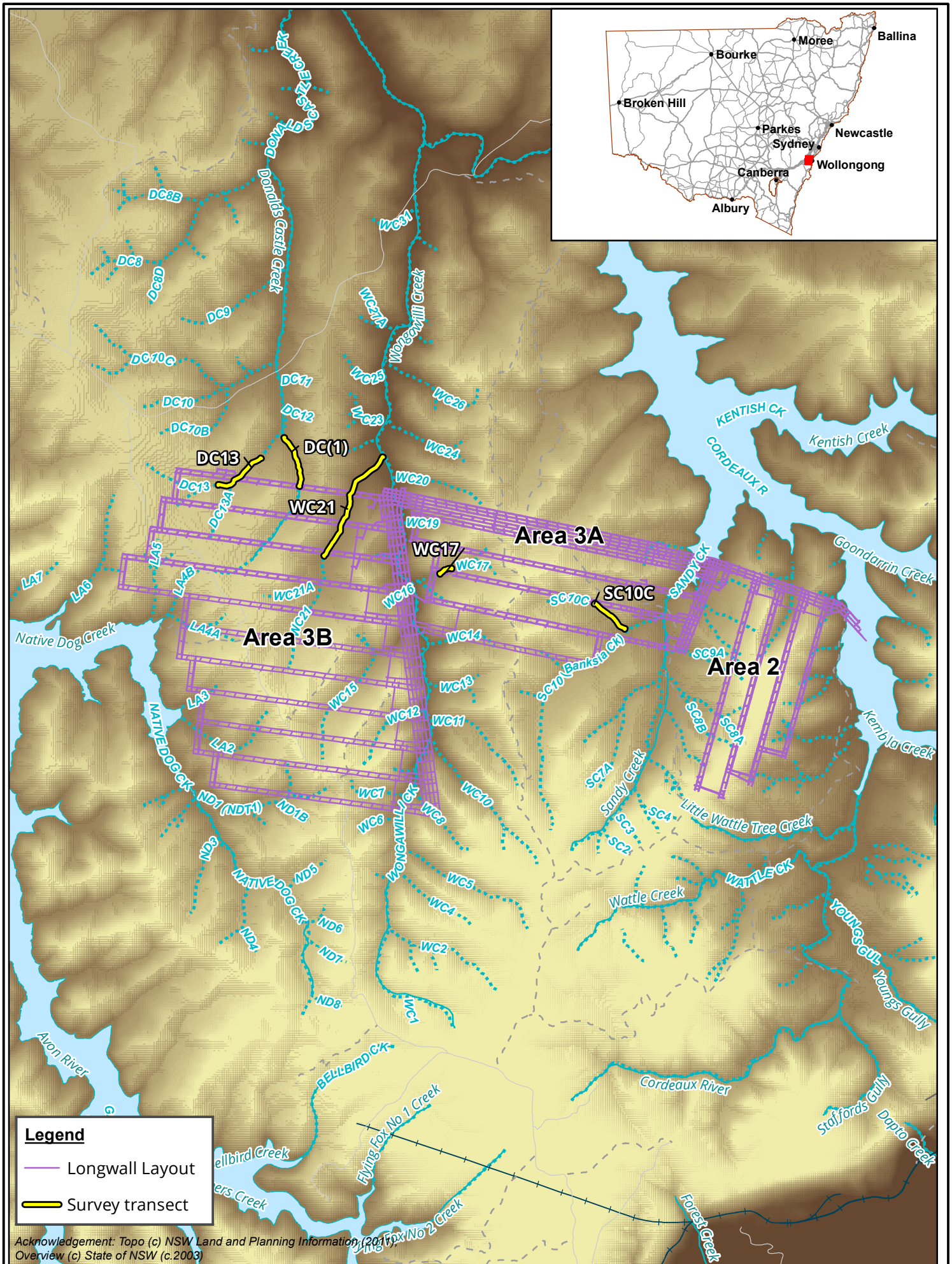
Biosis Pty Ltd (Biosis) was commissioned by South32 Illawarra Coal (Illawarra Coal) to undertake monthly monitoring of Littlejohn's Tree Frog tadpoles at three streams located within the Dendrobium Area 3B mining area, DC(1), DC13 and WC21 (Figure 1). Additional monitoring was recommended by Biosis following the annual monitoring of the species during the 2016 breeding season. Subsidence effects observed during this monitoring included fracturing of stream bedrock, diversion of surface flows and iron flocculent in known breeding pools.

To confirm whether streams located in both Dendrobium Area 3B and Dendrobium Area 3A retained sufficient water throughout the Littlejohn's Tree Frog metamorphosis period, Biosis also recommended that Illawarra Coal increase the monitoring of selected breeding pools between November 2016 and February 2017. Streams monitored included DC(1), DC13, WC21, SC10C and WC17.

## 1.1 Objective

The objective of the tadpole monitoring program at DC(1), DC13 and WC21 was to determine if tadpoles were developing through to metamorphosis and adults, indicated by an overall decline in tadpole numbers coincident with an increase in later developmental stages for tadpoles over time. This hypothesis was deemed to represent metamorphosis and successful completion of this life stage, and thus negligible impact to the species during the monitoring period.

The second objective of the study was to determine whether suitable habitat was present over the development period at SC10C, WC17, DC(1), DC13 and WC21.



**Legend**

- Longwall Layout
- Survey transect

Acknowledgement: Topo (c) NSW Land and Planning Information (2017)  
 Overview (c) State of NSW (c.2003)

Figure 1: Location of watercourses surveyed in Dendrobium Area 3A and Dendrobium Area 3B

## 1.2 Background

### 1.2.1 Dendrobium Area 3A

Following the extraction of Longwalls 6-8 in Dendrobium Area 3A between 2010 and 2012, 30 subsidence impacts were recorded including rock fracturing and flow diversion within WC17 and SC10C sub-catchments. A total of nine impacts were located along streams and have resulted in the draining and/or loss of water from Littlejohn's Tree Frog breeding pools. Both SC10C and WC17 are located above Longwall 7 and Longwall 8 in Dendrobium Area 3A.

#### Dendrobium Area 3A Trigger Action Response Plan (TARP)

The revised *Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)* (Illawarra Coal 2012) 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 difficulty to statistically analyse the data. As such, for the purposes of this report, a Level 1 is considered to be triggered in the event that a non-statistically significant decrease in adults, egg mass or tadpoles is detected at an impact site when compared to stability or an increase before impact and at control sites. As the focus of these TARPs is on vegetation however, they fail to stipulate specific actions to be undertaken following the detection of impacts to Littlejohn's Tree Frog habitat during monitoring.

#### WC17

Ecological monitoring surveys completed at WC17 during 2016 identified two adult Littlejohn's Tree Frog in Pool 21 and Pool 26, and three individuals calling outside of the transect. This was the first time the species has been recorded at this site since 2013, breaking a trending decline following undermining in 2011. One individual was located in Pool 26, which appeared to have returned to pre-impact water levels at the time of survey. The second individual was located at Pool 21, which, while the bedrock was fractured, also contained sufficiently flowing water. No egg mass or tadpoles were recorded during the winter monitoring survey despite recording calling adults.

Pool 26 has previously been identified as important Littlejohn's Tree Frog breeding habitat (Biosis 2013a). During the monitoring period, Biosis noted that all pools on the WC17 transect contained water and flow was present between Pool 21 and Pool 26, however the substrate and aquatic vegetation was covered in a thick layer of iron flocculent, including Pool 26 (Biosis 2017). This observation is consistent with data collected in 2015, but contrasts with the observations of the 2014.

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

#### SC10C

During 2016, no mining occurred below Sandy Creek or any of the Sandy Creek tributaries and no additional impacts were observed. Following impacts resulting from the extraction of Longwall 7 in 2011 and Longwall 8 in 2012, Pool 1, Pool 3, Pool 5 and Pool 8b have become particularly important for breeding Littlejohn's Tree Frog along SC10C.



Adult detection at SC10C during the 2016 monitoring period was higher than previous post-mining years of monitoring. Previous declines in the presence of Littlejohn's Tree Frog adults at SC10C have correlated with reductions in pool water levels along the transect following the transect being mined beneath by Longwall 7 in 2011. This trend was broken in 2015 with a high rainfall event coinciding with the winter monitoring surveys and facilitating a breeding event. In 2016, monitoring was conducted following a break in a dry period, with 3.5 millimetres of rain recorded at the time of survey, and 5.5 millimetres of rain the night before (Centroid Rainfall – DA3A). At the time of survey, Pool 4, Pool 5 and Pool 8B contained areas of shallow pooling water, however Pool 6, Pool 7 and Pool 8 were dry, despite the rain. As has been recorded in previous years, iron flocculent was present within the lower third of the monitoring transect, coating egg mass in Pool 1.

Despite the presence of water in several pools, adult abundance remained below pre-mining values. No tadpoles were recorded at SC10C during the 2016 monitoring period and one small egg mass was recorded in a shallow pool of water located at the top of a sandstone shelf (Pool 8B).

A specialist review of SC10C was completed in 2014 by Ecoengineers (Ecoengineers 2014) following observations consistent with the Level 3 trigger of the revised *Dendrobium Area 3A Watercourse Potential Impacts, Key Monitoring, Triggers and Response* (dated 12 November 2012). The Level 3 stream appearance trigger for SC10C is as follows:

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

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

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

The above Level 3 triggers for SC10C are considered to continue operating throughout 2016. Biosis estimated that 28% of SC10C experienced a reduction in habitat in 2016 (Biosis 2017).

## 1.2.2 Dendrobium Area 3B

### Dendrobium Area 3B TARP

All three sites located in Dendrobium Area 3B (DC13, WC21 and DC(1)), have been assessed against the *Dendrobium Area 3B Watercourse Monitoring TARP* (dated 12 October 2015) which include the following trigger levels for *terrestrial fauna - threatened frog species*, which state that:

- 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.

To assist in the assessment against the TARP, Biosis has defined a reduction in habitat as any of 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.

### DC(1)

During the 2016 monitoring period, Pools 29, 32 and 33 were identified as Littlejohn's Tree Frog breeding habitat with adults, tadpoles and egg mass recorded at all three pools (Biosis 2017).

Following the extraction of Longwall 9, a reduction in pool water levels at DC(1) were recorded by the Illawarra Coal Environmental Field Team and have continued for 3.5 years. Similarly, a loss of flow and a reduction in pool water from the DC(1) Littlejohn's Tree Frog transect was observed between Pool 31 and Pool 35 during the 2016 winter surveys by Biosis. Longwall 9 is within the RMZ of the top section of DC(1) and changes to the hydrology of pools along this transect is a result of impacts that occurred upstream.

Biosis estimated that 36% of DC(1) experienced a reduction in habitat in 2016 (Biosis 2017).

### DC13

During the 2016 monitoring period, a substantial increase in adults, tadpoles and egg mass clusters were recorded along the transect between Pool 9 and the potholes near Pool 17 (Biosis 2017). Adult counts totalled five individuals between Pool 9 and Pool 17 and a total of 66 egg mass clusters were detected across these pools as well. A total of 564 tadpoles were recorded across Pool 10 (450 individuals), Pool 11 (50 individuals) and Pool 17 (64 individuals), with another 506 tadpoles recorded across the potholes in proximity to Pool 17 (Biosis 2017). Despite the increased numbers of adults, egg mass and tadpoles in 2016, declines in water level remained evident during the survey.

The upper 300 metre section of DC13 is located above Longwall 9. Since the Biosis monitoring program began in 2010, 12 of the 17 pools along DC13 have been identified as important for breeding Littlejohn's Tree Frog. The six pools upstream and including Pool 18A were impacted through a reduction of water in April 2013 during Longwall 9 extraction (Illawarra Coal 2014) and four of these were known to provide Littlejohn's Tree Frog breeding habitat (Biosis 2013b). In 2016, pools located between Pool 18B and Pool 14 continued to contain less water than pre-mining conditions. As such, pools located above Longwall 9 have experienced periods of complete loss of water, while pools immediately downstream have experienced a reduction in pool level. Pools downstream of Pool 14 continue to retain water and provide habitat for Littlejohn's Tree Frog.

Biosis estimated that 36% of DC13 experienced a reduction in habitat in 2016 (Biosis 2017).

### WC21

Adult, egg mass and tadpole abundance substantially increased along WC21 in 2016, following consistently low numbers in previous years. A total of 14 adults, 15 egg mass clusters and 769 tadpoles were detected

along the stream (Biosis 2017). Many of these records were associated with a series of potholes located on sandstone benches unaffected by subsidence impacts (i.e. cracking and drainage flow diversion) that have affected the majority of the remainder of the transect following undermining by Longwall 9 in 2013 and subsequent longwalls.

Potholes 'a' to 'e' are located directly above Longwall 9, adjacent to Pool 11 and upstream of the large drop off associated with Pool 10. Potholes 'f' and 'g' are located approximately 100 metres upstream and Pothole 'h' is further upstream again, above Pool 18. At the time of survey, no flow was present along the main channel of this section of WC21 and pools mapped by the Illawarra Coal Environmental Field Team were dry or contained very small amounts of water (Biosis 2017). As such, these potholes provided an important resource for breeding along WC21 during the 2016 breeding season.

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 across the upper reaches of the stream in 2016. Watercourse impacts following the extraction of these longwalls has resulted in a total of 13 observed impacts above Longwall 9, 12 impacts above Longwall 10, and 2 impacts above Longwall 11 including;

- Iron flocculent covering substrate and aquatic vegetation.
- Fracturing of several rockbars, bedrock uplift, localised surface flow diversion, reductions in surface flows and loss of pool water level from Pool 10 through to Pool 30.

Following initial subsidence related impacts in late 2013, the cumulative effects of fracturing from Longwall 9, 10 and 11 include the following pools where Littlejohn's Tree Frog had been recorded:

- Pool 4
- Pool 10
- Pool 12
- Potholes on the bedrock near Pool 11, Pool 14, Pool 15 and Pool 18
- Pool 16
- Pool 17
- Pool 18
- Pool 21
- Pool 28

Of the 32 pools mapped by Illawarra Coal along WC21, 8 have been confirmed to contain breeding habitat for Littlejohn's Tree Frog. In addition, 'a' to 'e' potholes located adjacent to Pool 11, Potholes 'f' and 'g' located between Pool 14 and Pool 15 and Pothole 'h' located between Pool 18 and Pool 19 also provide breeding habitat for the species.

All of these pools and potholes are considered to be important breeding locations for the Littlejohn's Tree Frog. Biosis estimated that 57% of WC21 experienced a reduction in habitat in 2016 (Biosis 2017).

### 1.2.3 Performance against the TARP

Based on the information above in Section 1.2.1 and Section 1.2.2, Biosis made an assessment of the sites against the relevant TARPs in the annual monitoring report (Biosis 2017). It was concluded that due to the reduction in Littlejohn's Tree Frog habitat detected at DC13 and WC21 since mining, that a Level 3 and Level 2 had been triggered at each stream respectively. DC(1) also experienced a reduction in water levels in 2016,

which was evident for the first time during the winter monitoring season. As such further tadpole and pool water depth monitoring over the following development period was recommended and forms the basis of this report.

Table 1 below provides a summary of the assessment of SC10C and WC17 against *Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna (12 November 2012)*, while Table 2 provides an assessment of DC13, WC21 and DC(1) sites against the *Dendrobium Area 3B Watercourse Monitoring TARP (dated 12 October 2015)* made in the annual monitoring report (Biosis 2017).

**Table 1 Assessment of Littlejohn's Tree Frog monitoring results at SC10C and WC17 against Dendrobium Area 3A TARPs**

Stream	Predicted impact	Results and TARP justification	TARP
WC17	Significant impacts to the Littlejohn's Tree Frog.	<p>A decline in all life forms of Littlejohn's Tree Frog was detected at WC17 when compared to before mining data and control sites. 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.</p> <p>Increased water levels were detected during the Littlejohn's Tree Frog monitoring event in 2016. The current investigation aims to determine whether important breeding pools along WC17 were able to hold water for a sufficient time to allow for full development to occur.</p>	Level 1 trigger.
SC10C	Significant impacts to the Littlejohn's Tree Frog.	<p>A decline in all life forms of Littlejohn's Tree Frog was detected at SC10C when compared to before mining data and control sites. 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.</p> <p>The following Level 1 triggers (<i>Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna</i>) relating to watercourse monitoring have been observed:</p> <ul style="list-style-type: none"> <li>• Stream appearance at SC10C.</li> <li>• Aquatic ecology including pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat at SC10C.</li> </ul>	Level 1 trigger.

**Table 2 Assessment of Littlejohn's Tree Frog monitoring results at DC(1), DC13 and WC21 against Dendrobium Area 3B TARPs**

Stream	Predicted impact	Results and TARP justification	TARP
DC(1)	Significant impacts to the	Following the 2016 survey at DC(1), breeding pools (Pools 32 and 33) had a reduced water level below the	No TARP triggered.

Stream	Predicted impact	Results and TARP justification	TARP
	Littlejohn's Tree Frog.	<p>benchmark nail. This reduction in habitat was first recorded in November 2015, and continued throughout 2016. Continued monitoring during 2017 will determine whether this is a Level 1 trigger for DC(1).</p> <p>Despite the reduced area of available habitat, Littlejohn's Tree Frog was recorded in all three life stages along DC(1) during the winter survey in 2016. The survey was undertaken shortly after a rainfall event and it is not known whether this pool was able to hold water for a sufficient time to allow for full development to occur. The current investigation aims to determine whether important breeding pools along DC(1) were able to hold water for a sufficient time to allow for full development to occur.</p>	
<b>DC13</b>	Significant impacts to the Littlejohn's Tree Frog.	<p>Pools that were previously utilised by the species to breed (Pools 18A upstream through to the transect end) have been recorded to have minimal to no water from 2013 to 2016. No adults, tadpoles or eggmass have been recorded in this section during this period either. This represents a reduction in breeding habitat across five monitoring periods, or four years. Additionally, a number of pools where eggmass or tadpoles were recorded in 2016 showed signs of reduced water level or increased recession rate (Pool 16B and Pool 17).</p> <p>Due to a reduction in habitat recorded for more than two years following an active subsidence period (2013, 2014, 2015 and 2016), a Level 3 TARP has been triggered. The current investigation aims to determine whether important breeding pools along DC13 were able to hold water for a sufficient time to allow for full development to occur.</p>	Level 3 trigger.
<b>WC21</b>	Significant impacts to the Littlejohn's Tree Frog.	<p>Pools where the species has been recorded prior to being mined beneath (Pools 12 and 18) have been found to be impacted from 2014 onwards, following the active subsidence period of Longwall 9. In 2016 all habitat from Pool 11 to Pool 30 was recorded to have minimal to no water. This gradual reduction in habitat is likely the result of the transect being mined beneath by Longwall 9, Longwall 10 and Longwall 11 respectively. Although the species was recorded breeding along the transect in 2016, this breeding activity was mostly restricted to a number of potholes that retain water.</p>	Level 2 trigger.

Stream	Predicted impact	Results and TARP justification	TARP
		Due to the reduction of habitat over a two year period following an active subsidence period, a Level 2 TARP has been triggered. The current investigation aims to determine whether important breeding pools along WC21 were able to hold water for a sufficient time to allow for full development to occur.	

### 1.2.4 Response to TARP trigger

A Level 1 trigger was met at WC17 and SC10C in the 2016 monitoring program. No additional monitoring is required for a Level 1 trigger for sites located within Dendrobium Area 3A. The winter monitoring program is to continue and Illawarra Coal must report the impacts to key stakeholders and summarise in the Annual Environmental Monitoring Report (AEMR). The revised Dendrobium Area 3A TARPS (dated 12 November 2012) relating to ecology could not be assessed due to the limitations of the approved survey design. Pool Water Level / Flow and Appearance triggers identified in the Dendrobium Area 3A *Watercourse Potential Impacts, Key Monitoring, Triggers and Response* TARP have however been triggered at SC10C.

Increased water levels were detected at WC17 during the Littlejohn's Tree Frog monitoring event in 2016. Continued monitoring of this transect in 2017 will further inform whether there has been a level of natural recovery of threatened frog breeding pools within this stream.

To further inform the Level 1 trigger, Illawarra Coal increased the frequency of pool water level monitoring along SC10C and WC17 in summer 2016/2017. The results of this monitoring are detailed herein.

In response to the impacts detected along DC13, WC21 and DC(1), the following actions, in accordance with the *Dendrobium Area 3B Watercourse Monitoring TARP* have been initiated following the recommendation of the 2016 annual monitoring report (Biosis 2017).

#### Level 1

- Continue monitoring program.
  - Biosis will continue to monitor DC13, DC(1) and WC21 as part of the 2017 threatened frog monitoring program.
- Submit an Impact Report to Office of Environment and Heritage (OEH), Department of Planning and Environment (DP&E), Department of Primary Industries, Office of Water, Fisheries, WaterNSW and other relevant resource managers.
  - As detailed herein and to be completed as part of the Longwall 12 End of Panel report.
- Report in the End of Panel Report.
  - End of Panel Terrestrial Ecology Reports have been prepared for Longwalls 7-11.
  - Illawarra Coal to incorporate results in the Longwall 12 End of Panel report.
- Summarise actions and monitoring in AEMR.
  - Biosis recommends that the results detailed herein are included in the 2016 AEMR.

## Level 2

- Review monitoring frequency.
  - Biosis conducted additional tadpole monitoring during summer 2016/2017 to determine tadpole success and metamorphosis. Methods and results have been further discussed in Section 2 and Section 3 herein.
- Notify relevant technical specialists and seek advice on any CMA required.
  - As detailed in Section 4 herein.
  - Illawarra Coal to seek advice from relevant technical specialists as to the most appropriate CMAs.
- Implement agreed CMAs as approved (subject to stakeholder feedback).

## Level 3

- Site visit with OEH, DP&E, DPI, WaterNSW and other resource manager/s (if requested)
- Implement additional monitoring or increase frequency if required:
  - Biosis conducted additional tadpole monitoring during summer 2016/2017 to determine tadpole success and metamorphosis. Methods and results have been further discussed in Section 2 and Section 3 herein.
- 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, DoPE, T&I, Water NSW and other stakeholders.
- Completion of works following approvals and at a time agreed between Illawarra Coal, DP&E, DPI and WaterNSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success.

## 2 Survey methods

### 2.1 Increased monitoring of breeding pools

In response to the recommendations made in the annual report (Biosis 2017), as summarised in Section 1 herein, Illawarra Coal increased the frequency of pool water level monitoring along SC10C, WC17, DC(1), DC13 and WC21.

A summary of pools recommended by Biosis for increased monitoring frequency is provided below in Table 3 and mapped in Figure 2

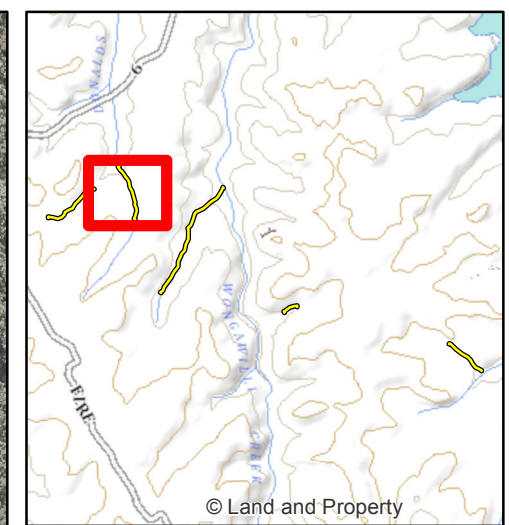
**Table 3 Summary of all pools along SC10C, WC17, DC(1), DC13 and WC21 recommended for increased water level monitoring during the Littlejohn's Tree Frog tadpole development period**

Site	Pools
<b>Dendrobium Area 3A</b>	
<b>SC10C</b>	Pool 1, Pool 2, Pool 2A, Pool 2B, Pool 3, Pool 4, Pool 5, Pool 6, Pool 7, Pool 8, Rockbar 9 and a pool on sandstone between Pool 8 and 8b.
<b>WC17</b>	Pool 20(S12), Pool 21(S12), Pool 22(S12), Pool 23(S12), Pool 24(S12), Pool 25(S12) and Pool 26(S12)
<b>Dendrobium Area 3B</b>	
<b>DC(1)</b>	Pool 19, Pool 20, Pool 21, Pool 22, Pool 23, Pool 24, Pool 25, Pool 26, Pool 27, Pool 28, Pool 29, Pool 30, Pool 31, Pool 32, Pool 32 (b), Pool 33, Pool 33 (b), Pool 34 and Pool 35.
<b>DC13</b>	Pool 1, Pool 9, Pool 10, Pool 11, Pool 12, Pool 13 (a), Pool 13 (b), Pool 14, Pool 15, Pool 16 (a), Pool 16 (b), Crevice, Pothole A between Pool 16(b) & 17, Pothole B between Pool 16(b) & 17, Pothole C between Pool 16(b) & 17, Pothole D between Pool 16(b) & 17, Pothole E between Pool 16(b) & 17, Pool 17, Pool 18 (a), Pool 18 (b), Pool 19, Pool 20 and Pool 21
<b>WC21</b>	Pool 1, Pool 2, Pool 3, Pool 4, Pool 5, Rockbar 5 between Pool 5 & 6, Pool 6, Pool 7, Pool 8, Pool 9, Pool 10, Pool 11, Pothole A between Pool 11 & 12, Pothole B between Pool 11 & 12, Pothole C between Pool 11 & 12, Pothole D between Pool 11 & 12, Pothole E between Pool 11 & 12, Pool 12, Pool 13, Pool 14, Pothole F between Pool 14 & 15, Pothole G between Pool 14 & 15, Pool 15, Pool 16, Pool 17, Pool 18, Pothole H between Pool 18 & 19, Pool 19, Pool 20, Pool 21, Pool 22, Pool 23, Pothole I between Pool 23 & 24, Pool 24, Pool 25, Pool 26, Pool 27, Pool 28, Pool 29 and Pool 30.

Data was forwarded to Biosis at the end of the monitoring period, in March 2017, to review pool water levels. The pool monitoring data was then plotted by Biosis in Microsoft Excel to determine the extent of impact to Littlejohn's Tree Frog habitat at SC10C, WC17, DC(1), DC13 and WC21.

For successful metamorphosis to occur at pools located along SC10C, WC17, DC(1), DC13 and WC21, pools must retain water for at least four months following a breeding event (Anstis 2013). Therefore if a key breeding pool was recorded as dry at any time during the four months from a breeding event (critical time for breeding and tadpole development), it was assumed that successful breeding was compromised and therefore an impact to a sub-population had occurred.





**Legend**

- Survey transect
- Pool

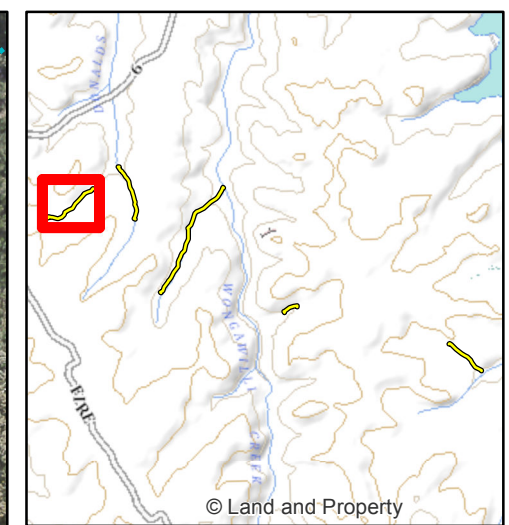
**Figure 2: Location of pools along DC(1)**

0 25 50 75 100 125  
Metres

Scale: 1:2,480 @ A3  
Coordinate System: GDA 1994 MGA Zone 56

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**Legend**

- Survey transect
- Pool

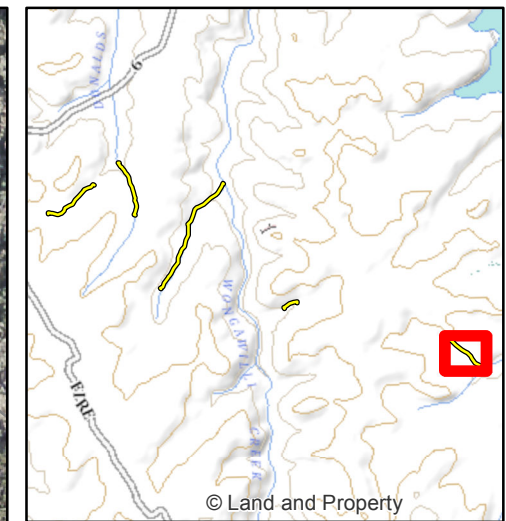
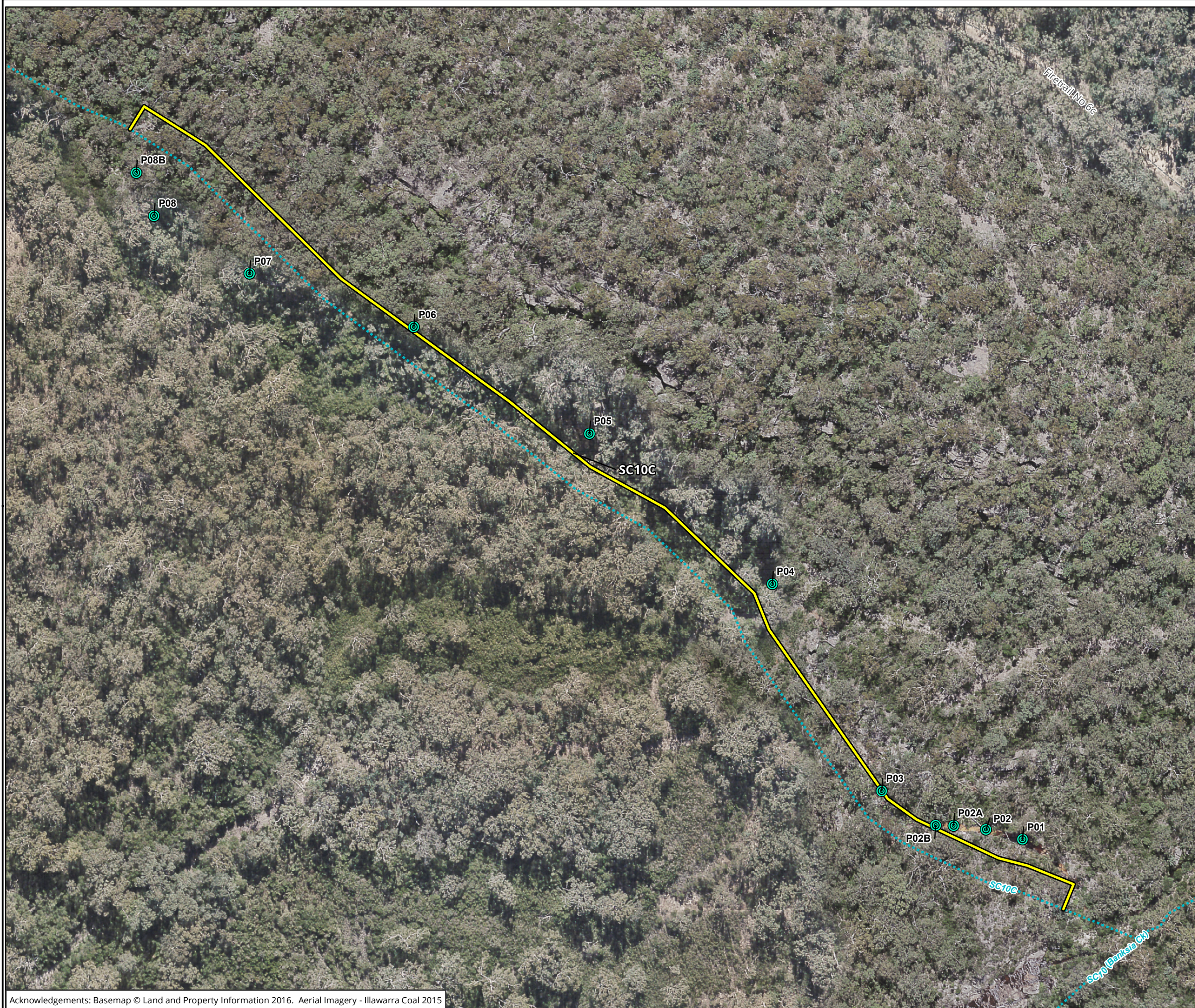
**Figure 2: Location of pools along DC13**

0 10 20 30 40 50  
 Metres  
 Scale: 1:1,820 @ A3  
 Coordinate System: GDA 1994 MGA Zone 56

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Matter: 23829  
 Date: 27 March 2017,  
 Checked by: JML, Drawn by: ANP, Last edited by: apritchard  
 Location: P:\23800s\23829\Mapping\23829\_TARP\_F2\_PoolLocations



**Legend**

- Survey transect
- ⊙ Pool

**Figure 2: Location of pools along SC10C**



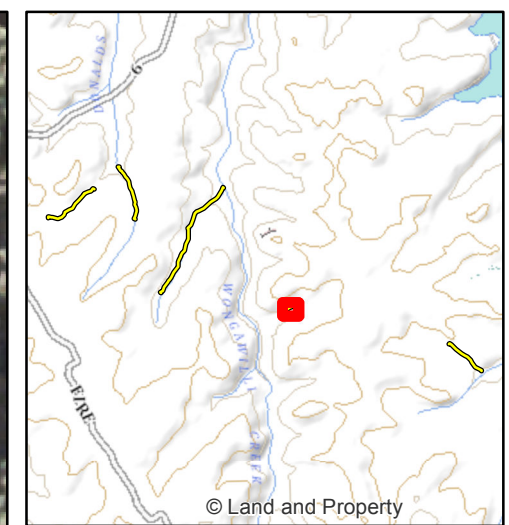
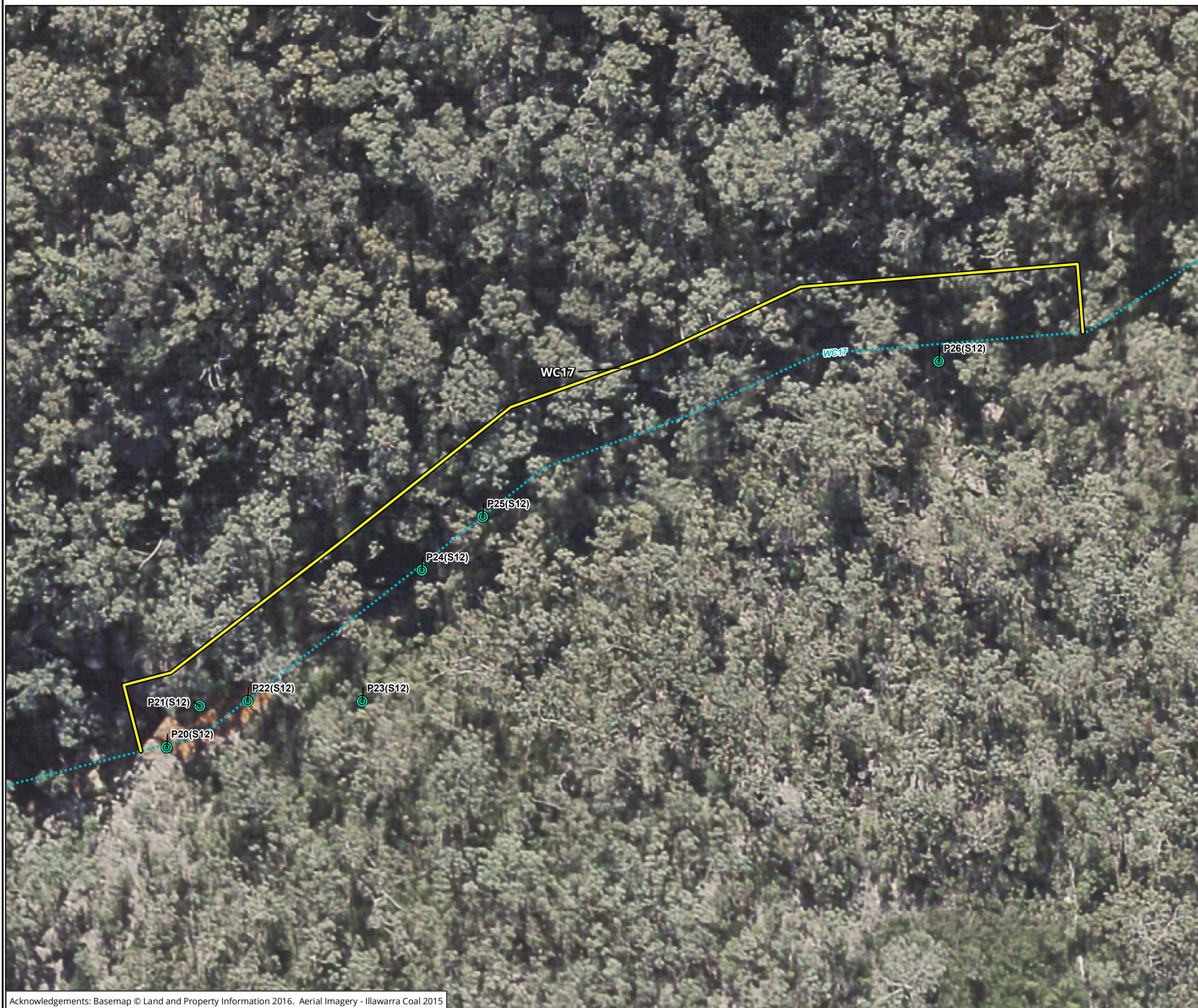
Scale: 1:1,320 @ A3  
 Coordinate System: GDA 1994 MGA Zone 56

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 Location: P:\23800s\23829\Mapping\23829\_TARP\_F2\_PoolLocations



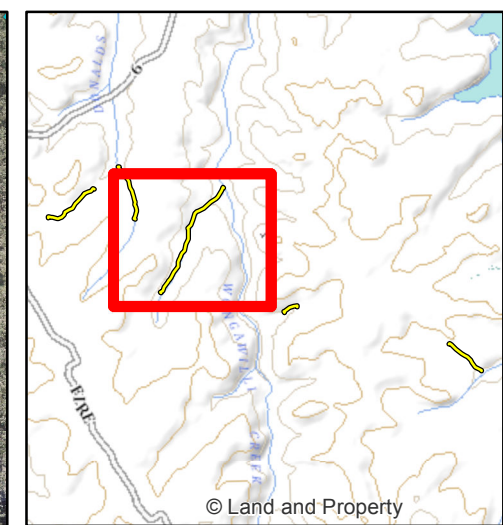
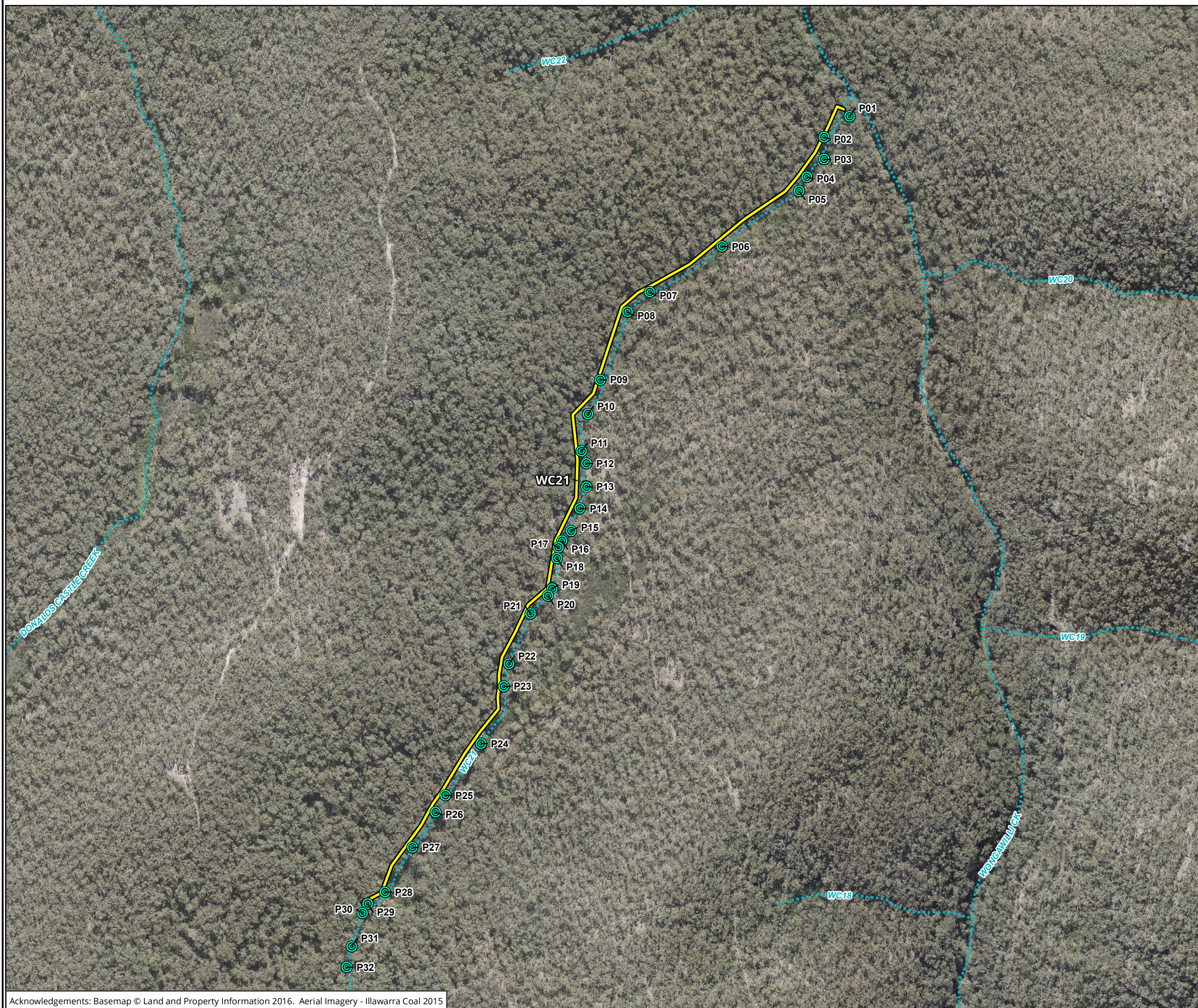
**Legend**

- Survey transect
- Pool

**Figure 2: Location of pools along WC17**

0 5 10 15 20 25  
Metres  
Scale: 1:520 @ A3  
Coordinate System: GDA 1994 MGA Zone 56

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**Legend**

- Survey transect
- Pool

**Figure 2: Location of pools along WC21**

0 50 100 150 200 250  
Metres

Scale: 1:5,010 @ A3  
Coordinate System: GDA 1994 MGA Zone 56

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Matter: 23829  
Date: 27 March 2017,  
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Location: P:\23800s\23829\Mapping\23829\_TARP\_F2\_PoolLocations

## 2.2 Monthly tadpole surveys

In addition to increased pool water level monitoring, Biosis also completed monthly tadpole surveys to confirm whether egg mass successfully hatched and whether tadpoles survived through to metamorphosis. Monitoring of egg mass and tadpoles assisted in determining the following:

- The success of hatching egg mass and survivorship of tadpoles where water persisted but only as very shallow pools or stagnant potholes.
  - Rationale: Low water levels and small potholes have the potential to facilitate an increase in tadpole predation and reduce survivorship, while the typically stagnant nature of potholes increases the chance that the water quality reduces to the point where successful metamorphosis is compromised.
- The success of egg mass hatching and survivorship of tadpoles during the first stages of development in locations where iron flock was present.
  - Rationale: It is unknown what effects iron flock may have on the early stages of development, therefore this information would allow confirmation of successful breeding in locations such as the lower pools at WC21 where many egg mass were coated in iron flock. Specifically, if water levels remained high enough to allow for successful metamorphosis, it would be beneficial to confirm the successful hatching of egg mass and survival of tadpoles until the point that their lungs were sufficiently developed to gulp air.

Surveys were undertaken by a qualified Biosis zoologist and a member of the Illawarra Coal Environmental Field Team between November 2016 and February 2017. Weather observations for each survey date are shown in Table 4.

**Table 4 Weather observations during tadpole surveys between November 2016 and February 2017 (Source Moss Vale AWS and Dendrobium weather station)**

Survey date	Temperature (°C) from Moss Vale AWS		Rain (mm) from Dendrobium weather station	
	Minimum	Maximum	On survey day	Cumulative over month prior
<b>DC(1)</b>				
28-Nov-16	13.7	29	0	30
22-Dec-16	13	20.8	0	33.5
23-Jan-17	16	32.8	0	28
<b>DC13</b>				
29-Nov-16	13.5	23.3	0	30
22-Dec-17	13	20.8	0	33.5
23-Jan-17	16	32.8	0	29
15-Feb-17	12.5	24.5	0.5	92
<b>WC21</b>				
29-Nov-16	13.5	23.3	0	30
15-Dec-16	12	13.9	1	13

Survey date	Temperature (°C) from Moss Vale AWS		Rain (mm) from Dendrobium weather station	
	Minimum	Maximum	On survey day	Cumulative over month prior
24-Jan-17	22.4	28.8	0	29
16-Feb-17	13.4	31.7	0	92

Surveys were undertaken at night and included counts of all tadpoles within pools. Counts were undertaken by a minimum of two people walking parallel to the creek and counting all tadpoles in each pool surveyed. Following these initial counts a representative sample of tadpoles was selected to identify the developmental stage (Gosner stage) to determine the overall trend in development of tadpoles in the pools.

During the first replicate, each pool was surveyed for tadpoles along the entire length of the monitoring transect. Subsequent surveys included those pools where tadpoles were recorded in the initial replicate and those downstream to ensure the survey covered any individuals that may have been flushed downstream in a high rainfall event or natural flow. Due to the location of pools and impacts, all pools along DC13 and WC21 were surveyed in all four replicates. Following an extended period of dry pools in DC(1) during the later months of 2016, the final replicate in February was not undertaken as no tadpoles or egg mass were recorded during December and January survey replicates.

During winter 2016 surveys, small potholes along DC13 and WC21 were identified as stable waterbodies in which Littlejohn's Tree Frog tadpoles can metamorphose. These potholes were monitored in addition to the existing pools by both the Illawarra Coal Environmental Field Team and Biosis.

Across the DC13 transect a total of five potholes were recorded and were labelled A, B, C, D and E respectively (Photos for D and E were unattainable) (Plate 1, Plate 2, Plate 3)



**Plate 1 DC13 Pothole A**



**Plate 2 DC13 Pothole B**



**Plate 3 DC13 Pothole C**

Along WC21, a total of ten potholes (including Rockbar 5, which was identified during the first month of additional survey) were confirmed to provide habitat for Littlejohn's Tree Frog. For reference, these potholes were labelled Rockbar 5, A, B, C, D, E, F, G, H and I respectively (Plate 4, Plate 5, Plate 6, Plate 7, Plate 8, Plate 9, Plate 10, Plate 11, Plate 12, Plate 13).





**Plate 4 WC21 Pothole Rockbar 5**



**Plate 5 WC21 Pothole A**



**Plate 6 WC21 Pothole B**



**Plate 7 WC21 Pothole C**



**Plate 8 WC21 Pothole D**



**Plate 9 WC21 Pothole E**



**Plate 10 WC21 Pothole F**



**Plate 11 WC21 Pothole G**



**Plate 12 WC21 Pothole H**



**Plate 13 WC21 Pothole I**

During all surveys across DC13 and WC21, heavy colouring resulting from natural plant tannins made it difficult to see the bottom of the pools and therefore difficult to survey during the initial and second replicate. The survey time was extended and a net was used to capture the tadpoles present to ensure the entire pothole was exhaustively searched. Once surveyed, all tadpoles were released back into respective pool or pothole.

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## 2.3 Limitations

During the additional pool data collection period between October 2016 and March 2017, catchment closures due to weather and unforeseen circumstances resulted in large gaps in the data collected by the Illawarra Coal Environmental Field Team. As a result Biosis has used a combination of Illawarra Coal Environmental Field Team data and Biosis' observational data collected during the additional monitoring periods to determine if water was present or absent from the pools mapped along each transect. The absence of water at any point during the additional surveys was assumed to be a complete loss of habitat at the time of survey.

### 3 Results and discussion

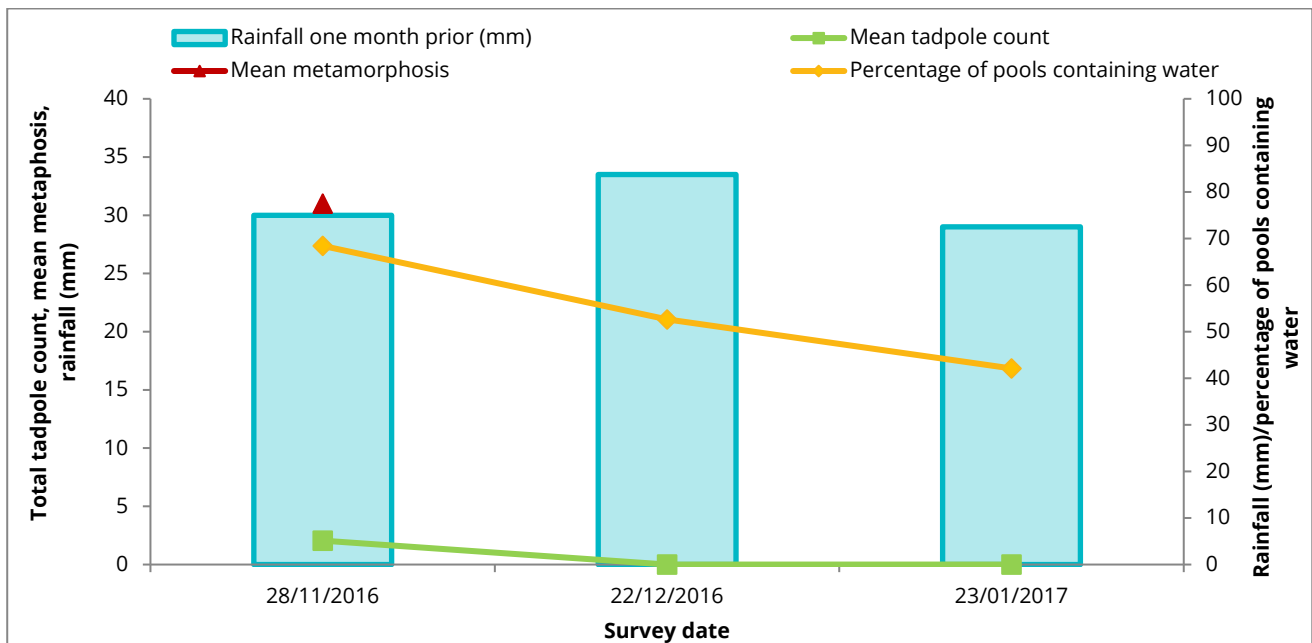
Based on the additional surveys undertaken over late 2016/early 2017 the results and discussion of their impact on pool water levels, tadpole counts and successful metamorphosis of Littlejohn’s Tree Frog are discussed below.

#### 3.1 DC(1)

##### Pool water level investigation

During the additional surveys at DC(1), a gradual decline in the percentage of pools containing water was noted (68% November 2016 to 42% January 2017) (Graph 1). The majority of pools containing water were downstream of Pool 29 and have typically not provided breeding habitat for Littlejohn’s Tree Frog in the past. The pools confirmed as providing breeding habitat for Littlejohn’s Tree Frog (upstream of Pool 29) were either subjected to complete water loss or became completely dry throughout the monitoring period.

**Graph 1 Percentage of pools containing water along DC(1) during the 2016-17 additional monitoring of Littlejohn’s Tree Frog habitat**



As shown in Graph 1, tadpoles were only recorded during the first replicate of DC(1) in November 2016. This is further discussed below.

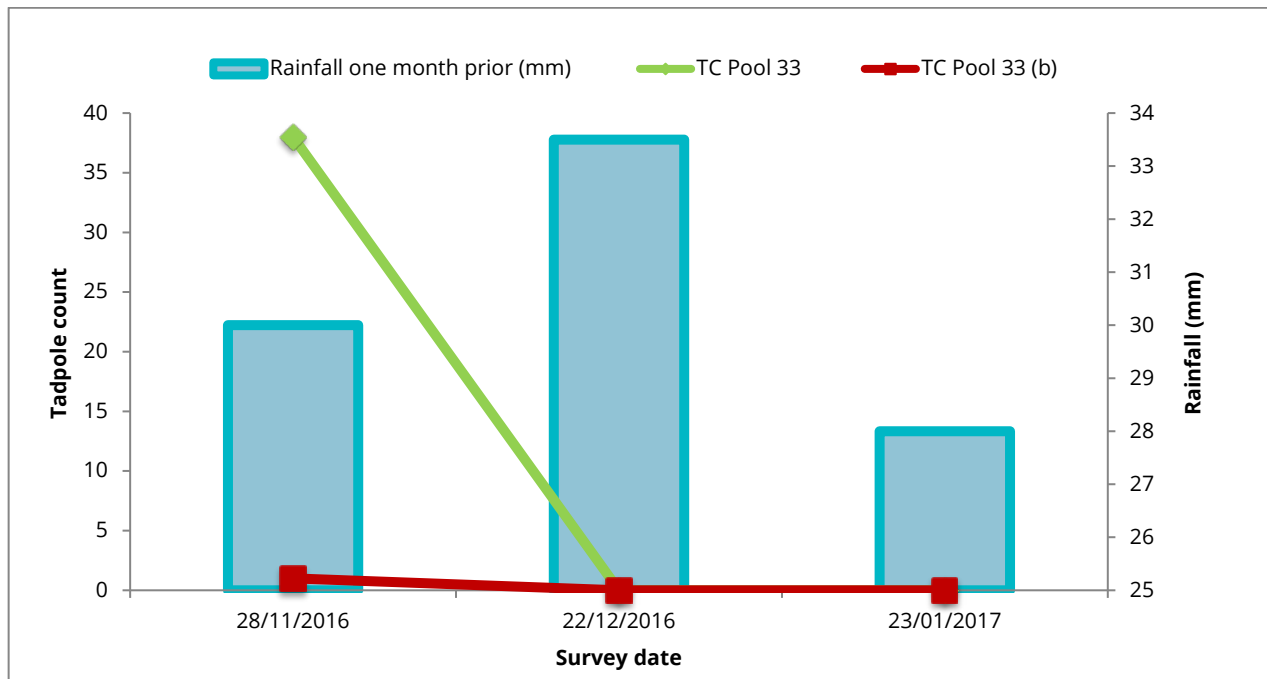
##### Tadpole count and metamorphosis

During the annual monitoring completed in winter 2016, breeding adults, tadpoles and egg mass were detected across Pool 29, 30, 32, 32 (b), 33, 33(b) and 34. In total, 15 tadpoles were recorded across the DC(1) transect. During the tadpole surveys over late 2016 to early 2017, an overall increase (60%) in the number of tadpoles was noted across pools, this is likely due to additional breeding events following the winter survey along with the hatching of those egg mass recorded during the survey period (11 in total) and developing into tadpoles.

Along the entire transect at DC(1), tadpoles were only recorded on the first replicate of monitoring in November (Graph 8). Surveys detected immature tadpoles in Pools 33 and 33(b), however these pools and the other pools where individuals were recorded in winter 2016 were subsequently dry in December 2016 and remained dry until the end of the survey period (Biosis observations).

Surveys were continued in January to see if individuals were present in pools retaining water. Despite the water remaining in the pools on the lower end of the transect, no more individuals were detected in any pools following the first survey in November 2016 (Graph 2). The final replicate was not undertaken in February as no individuals were detected in the previous two months.

**Graph 2 Littlejohn's Tree Frog tadpole count at DC(1) over the 2016-17 additional survey period**



Developmental stages of individuals in Pools 33 and 33(b) were recorded to be between 30 and 32 (Gosner Index) in the initial month of survey (Anstis 2013). These individuals had developed hindlimb buds however due to loss of water in both pools, it was concluded that the individuals that were present did not survive through the natural metamorphosis progression.

The observed decrease in tadpoles at the pools along DC(1) can be attributed to factors including:

- The loss of water in key breeding pools (Pools 32 and 33) resulted in the death of tadpoles.
- Low water levels may have reduced available resources therefore increasing competition between individuals and increasing the risk of predation.

As a result, full metamorphosis of the species into sub-adult and or adult frog form was not observed during the monitoring period.

## 3.2 DC13

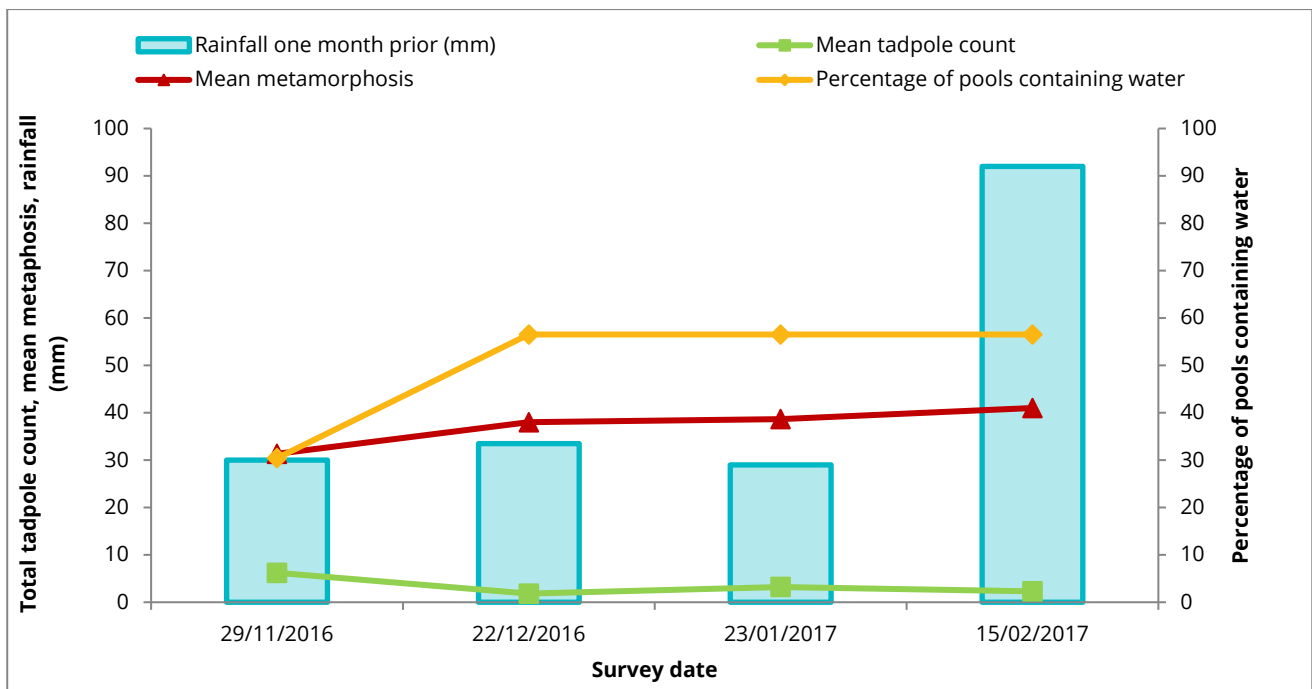
### Pool water level investigation

At DC13, the number of pools throughout the Littlejohn's Tree Frog tadpole development period ranged between 30% in the initial survey and 57% percent in all remaining surveys (Graph 3). Those pools containing

water however were mostly restricted to those that were not identified as confirmed habitat during the annual monitoring surveys in 2016. For example, Pool 10, 11 and 17, previously identified as confirmed breeding habitat for Littlejohn’s Tree Frog, were recorded to have no water at some point during the additional months of survey and therefore assumed to be a loss of habitat for the species. In association with this, the majority of pools retaining water over this additional survey period had low water levels and were considered to be a more hostile environment for tadpoles to develop.

Contrasting to this, Potholes A – E along DC13 provided consistent water levels throughout the additional monitoring period.

**Graph 3 Percentage of pools containing water along DC13 during the 2016-17 additional monitoring of Littlejohn’s Tree Frog habitat**



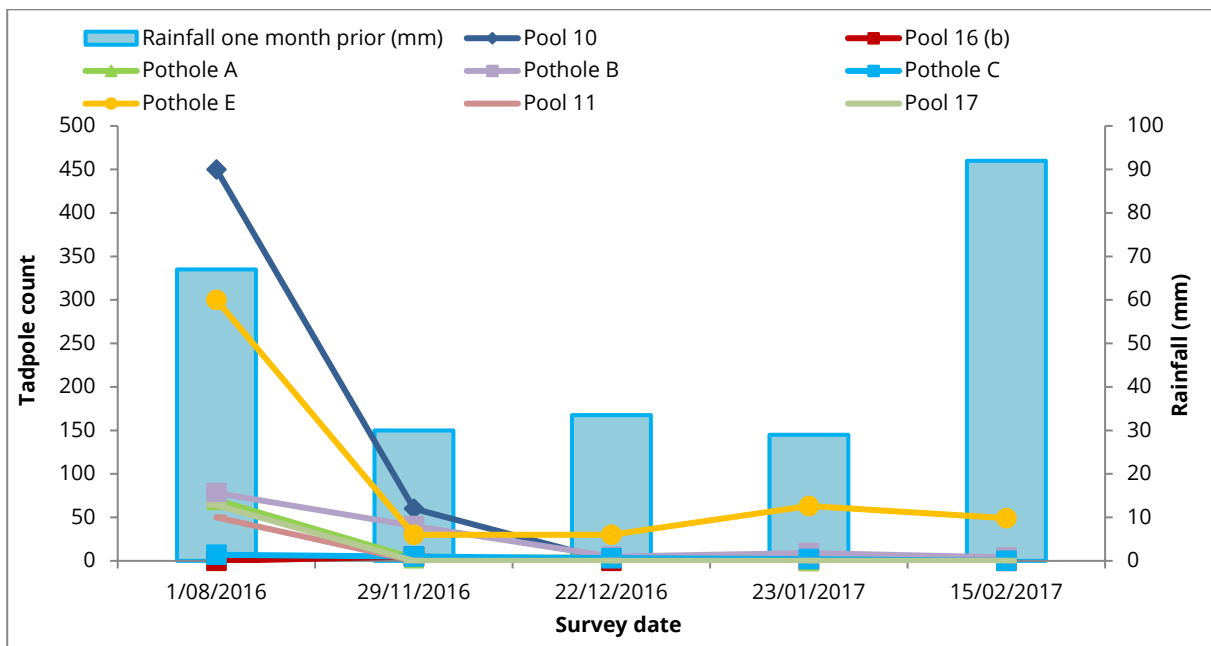
As shown in Graph 3, tadpole numbers decreased over time along DC13, while metamorphosis increased over time. This is further investigated below.

### Tadpole count and metamorphosis

During the annual winter monitoring completed at DC13 in 2016, breeding adults, tadpoles and egg mass were recorded in pools; 9, 10, 11, 12, 16(b), 17 and Potholes A – E. In total, 1,069 tadpoles were recorded across the DC13 transect. During the first replicate of the additional surveys in November 2016, an overall reduction (87%) in the number of individuals was noted across the transect (Graph 4). The observed decrease in tadpoles at the pools along DC13 can be attributed to factors including:

- Key pools that were confirmed breeding habitat during the winter monitoring period were completely dry during the tadpole surveys (Pool 11 and Pool 17).
- The reduction in habitat through lower water levels may have reduced available resources therefore increasing competition between individuals and increasing the risk of predation.

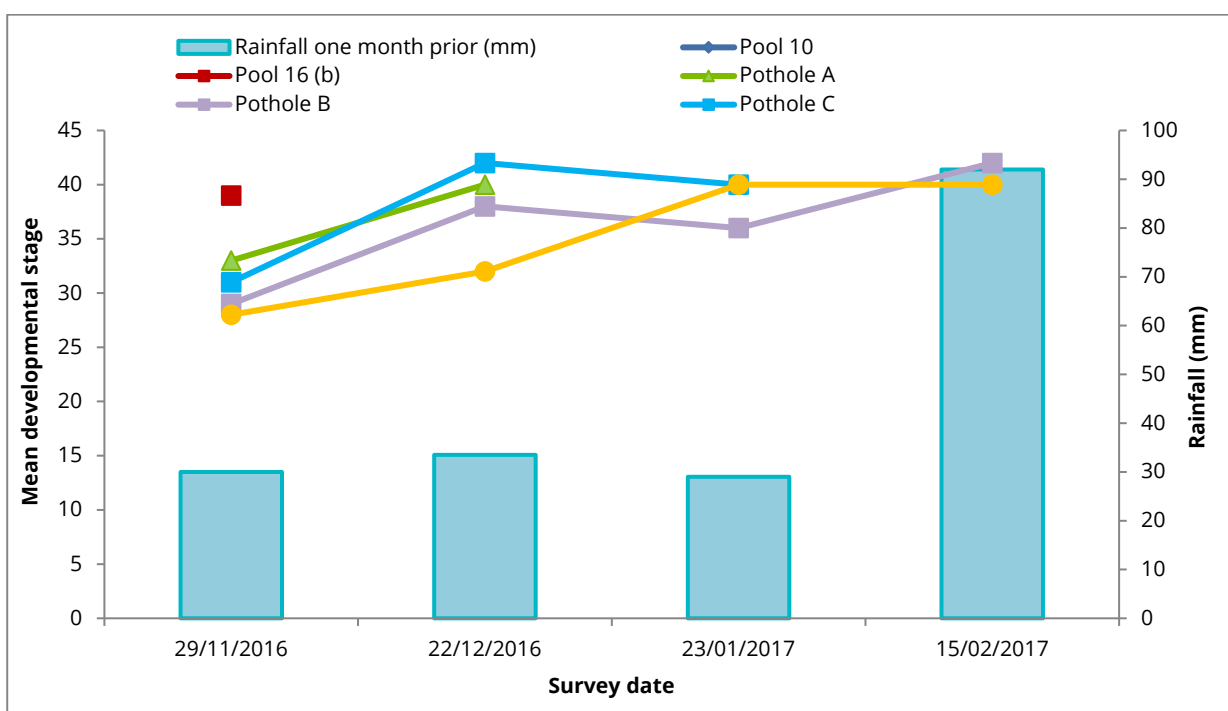
**Graph 4 Littlejohns's Tree Frog tadpole count at DC13 over the additional survey period**



Although the initial replicate of the additional surveys identified individuals at Pool 10 (60 tadpoles) and 16(b) (5 tadpoles), consecutive replicates saw a reduction in habitat through water loss and the absence of the individuals initially recorded. Contrasting to this, the potholes along DC13 provided stable habitat for individuals to continue to develop throughout the additional monitoring period.

Sustained growth and development of tadpoles (through the Gosner stages) was detected throughout these potholes (Graph 5) with a gradual decrease in the number of individuals coinciding with the continued development into the later Gosner stages.

**Graph 5 Littlejohns's Tree Frog mean metamorphosis at DC13 over the additional survey period**



Completion of full metamorphosis of the species into sub-adult and or adult frog form was not observed during the monitoring period. Once frogs metamorphose and vacate the waterbody they are likely to be difficult to detect.

### 3.3 WC21

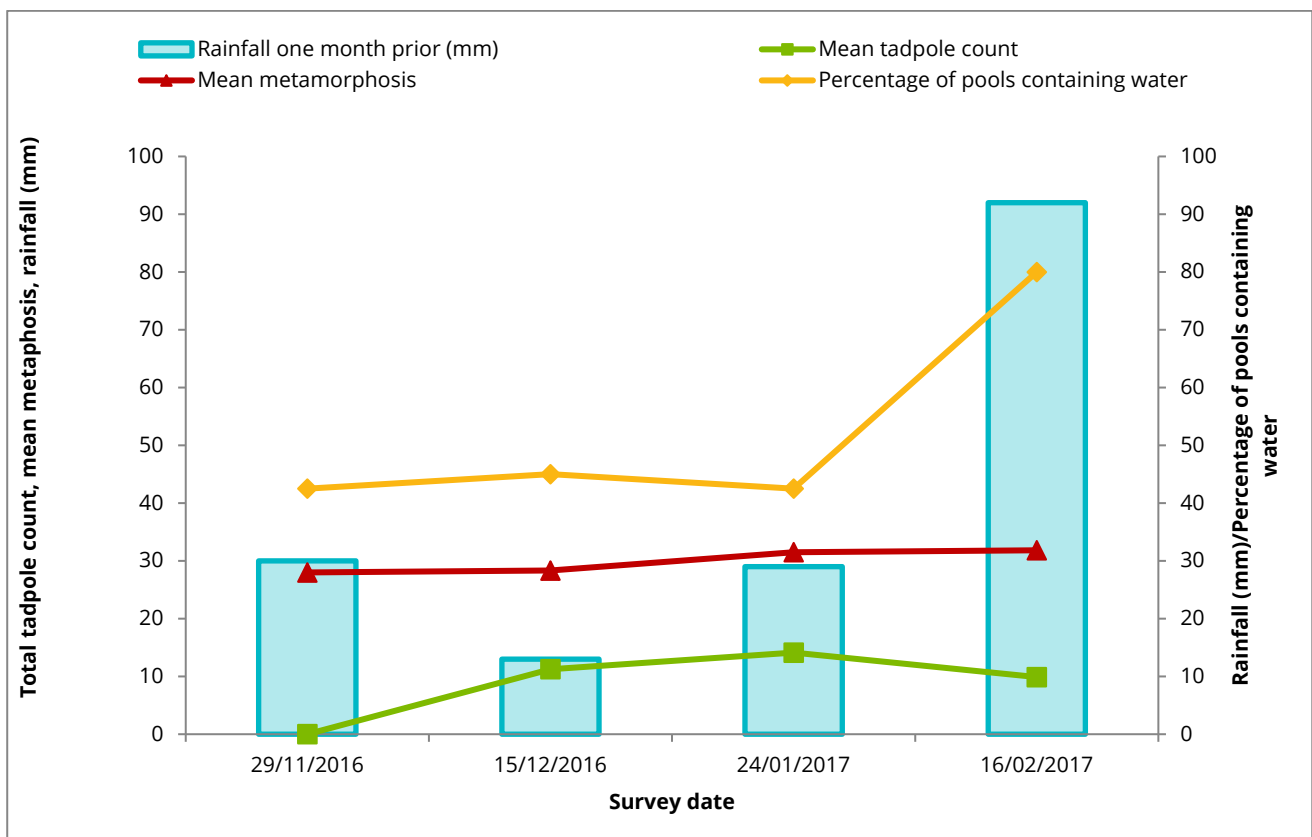
#### Pool water level investigation

Pool water level varied across the WC21 transect. Throughout the tadpole monitoring period, water was present between Pool 1 and 10, however the substrate and emergent vegetation was subjected to high levels of iron flocking.

Reduced water flow was observed between Pools 10 and 15. This reduced flow is caused by flow diversion resulting from fracturing of rockbars and uplifting of bedrock along the transect. Of the 40 pools monitored, 43-45% contained water during the first three replicates, this was followed by an increase to 80% during the final replicate. This increase coincides with a significant increase in rainfall of the month prior, with 92 mm of rain recorded from the Den Area 3B Weather Station (Graph 6).

Of the pools confirmed to be breeding habitat during the annual surveys in 2015 and 2016, Pool 17 and 21 were both recorded dry at some point during the additional monitoring period and is therefore considered a loss in habitat. The presence of potholes located between Pool 14 and Pool 15 provided a consistent source of water for tadpoles to develop within during periods of low water levels elsewhere along the transect.

**Graph 6 Percentage of pools containing water along WC21 during the 2016-17 additional monitoring of Littlejohn's Tree Frog habitat**



As shown in Graph 6, tadpole numbers showed an increasing trend initially, then decreasing over time along WC21. Metamorphosis showed a slight increase over time. This is further investigated below.



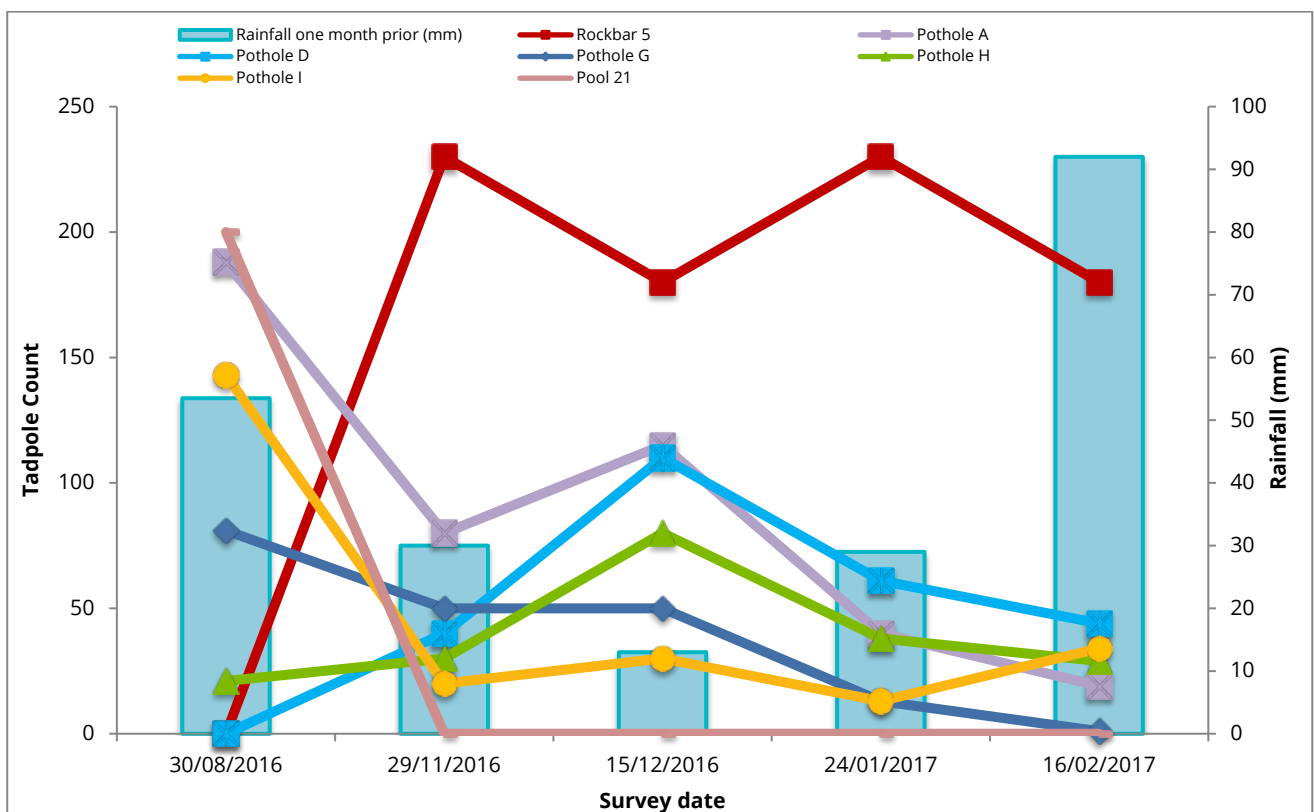
## Tadpole count and metamorphosis

During the annual monitoring completed in winter 2016, breeding adults, tadpoles and egg mass were detected across Pools; 21, 28 and Potholes A, B, C, D, E, F, G, H and I. During the tadpole monitoring in late 2016, tadpoles were only recorded within Potholes A, D, G, H and I. In addition to this a new pothole was identified between Pool 5 and 6 which contained 230 tadpoles on the first replicate of the tadpole surveys. This is not surprising as the peak breeding season extends to mid-September (authors observations) within the region and Littlejohn's Tree Frog adults would have deposited egg mass following the survey in winter 2016. This pool was labelled Rockbar 5 in accordance with the existing Illawarra Coal nomenclature.

In total, 1,304 tadpoles were recorded across the WC21 transect during the annual winter monitoring period. When compared to the initial survey in November 2016, an overall reduction (68%) in the number of individuals was recorded (Graph 7). Of the individuals recorded during the additional monitoring period along the WC21 transect, a gradual reduction in the number of individuals was apparent in all the potholes (Graph 7). Contrasting to this, Rockbar 5 remained at relatively steady tadpole count throughout the additional monitoring period and coincided with the individuals present remaining in the early Gosner stages of development.

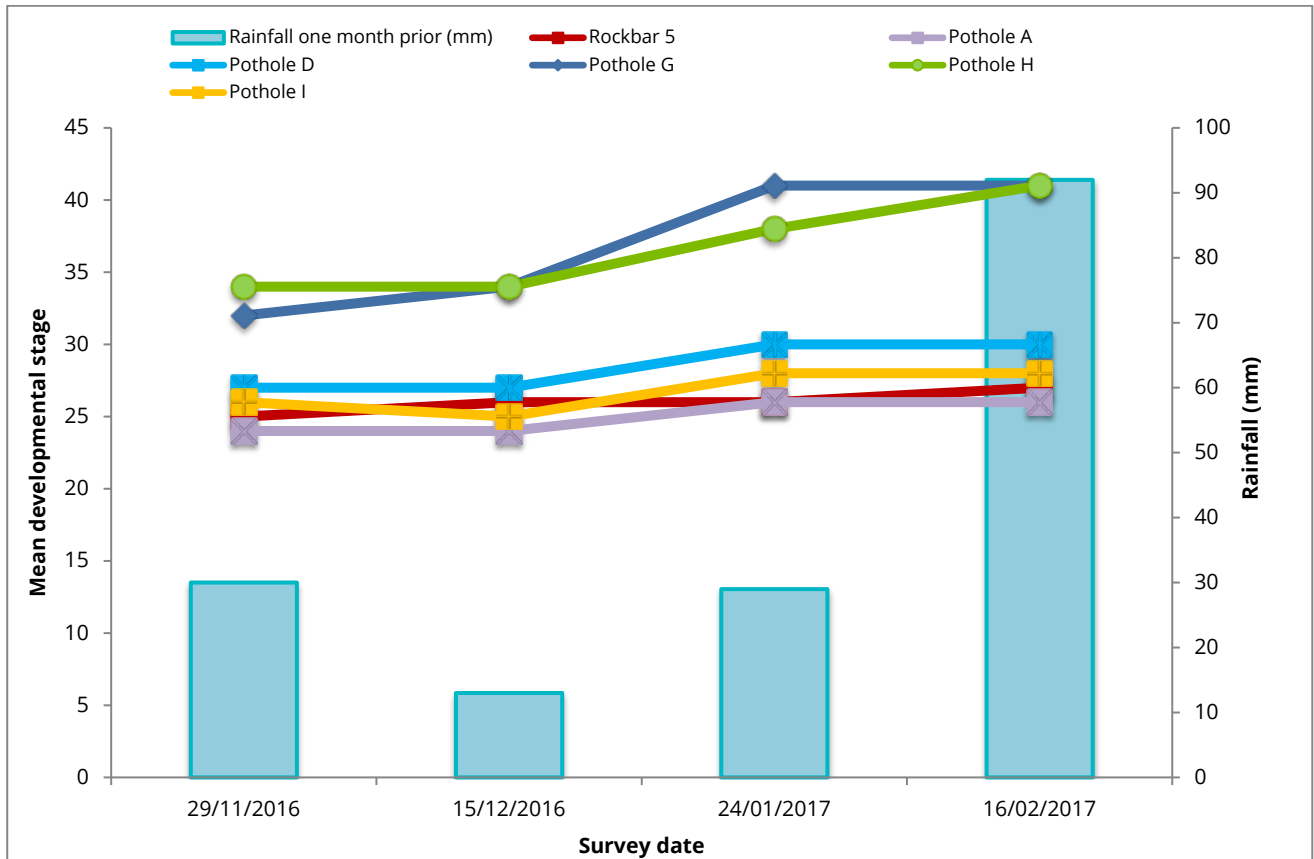
An overall increase in the number of individuals recorded during the December 2016 replicate can be seen in Graph 7 and can be attributed to changes in the survey design. As previously mentioned, heavy colouring resulting from natural plant tannins made it difficult to see the bottom of the pools. Extended survey times with the addition of a net to exhaustively search each pothole resulted in more accurate tadpole counts. In addition to this, tadpoles present had no significant difference in the stage of development they were at (i.e one group at early Gosner stages and another in the later stages). This was to confirm this increase was not the result of another breeding event.

**Graph 7 Littlejohn's Tree Frog tadpole count at WC21 over the additional survey period**



Development in tadpoles across WC21 varied between locations along the transect and individual potholes. By the end of the monitoring season (February 2017), Pothole A, Pothole D, Pothole I and Rockbar 5 continued to host individuals remaining in the early Gosner stages of 25 – 30 (Graph 8), potentially due to a dormancy in development by which individuals reserve their energy into survival rather than growth and metamorphosis (Wells 2007). Contrasting to this, Potholes G and H showed signs of the natural metamorphoses progression with gradual decreases in the number of individuals coinciding with a greater number of individuals reaching the later life stages according to the Gosner index (Graph 6).

**Graph 8 Littlejohns's Tree Frog mean metamorphosis at WC21 over the additional survey period**



Completion of full metamorphosis of the species into sub-adult and or adult frog form was not observed during the monitoring period however 42 individuals were recorded in the later Gosner stages (>40) as shown in Plate 14. Once frogs metamorphose and vacate the waterbody they are likely to be difficult to detect.

**Plate 14 Littlejohn's Tree Frog in Pothole H at WC21 in metamorphosis (Stage 43)**



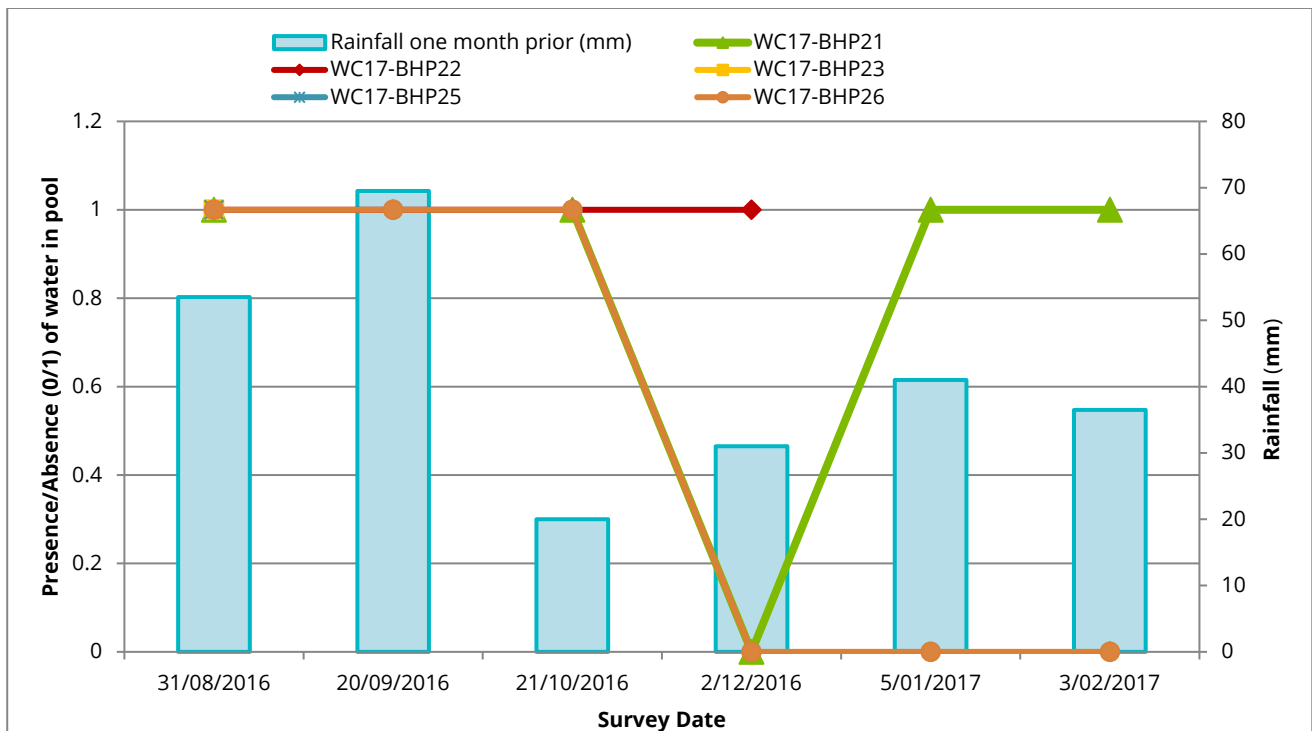
The observed decrease in tadpoles at the pools along WC21 can be attributed to the following factors:

- The successful metamorphosis of individuals in Potholes G and H.
- A reduction in habitat between Pool 11 and Pool 30 where low pool water levels may have reduced available resources therefore increasing competition between individuals and increasing the risk of predation.

### **3.4 WC17**

During the winter monitoring of WC17, an increase in water levels was noted across the transect between Pools 21 and 26. Furthermore, two adult Littlejohn's Tree Frog on the WC17 transect were located in Pool 21 and Pool 26. Due to inconsistencies within the data collected for the additional monitoring period in late 2016/early 2017, accurate measurements on water levels along WC17 cannot be made. Data was pulled back to a presence/absence of water in the pools monitored and is graphed below (Graph 9)

**Graph 9 The presence (1) or absence (0) of water at a selection of pools monitored by the Illawarra Coal Environmental Team along WC17 during the 2016-17 Littlejohn's Tree Frog tadpole development period**



Due to Pool 26 and Pool 21 having Littlejohn's Tree Frog adults recorded within them during the winter 2016 monitoring period, these pools were identified as important habitat for the Littlejohn's Tree Frog along the WC17 transect. Water was present in Pool 26 during the winter monitoring and was maintained over the following two months, this was thought to be due to relatively high rainfall over the August and September months. A loss of water was identified by the Illawarra Coal Environmental Field Team in December 2016 which continued until the end of the additional pool monitoring period. This drop in pool levels coincided with relatively dry months in October and November. If the Littlejohn's Tree Frog adults were to have had a breeding event and laid eggmass during the winter of 2016, the resulting tadpoles would not have the opportunity to successfully metamorphose in Pool 26 as there was a reduction in habitat during key months where metamorphosis takes place.

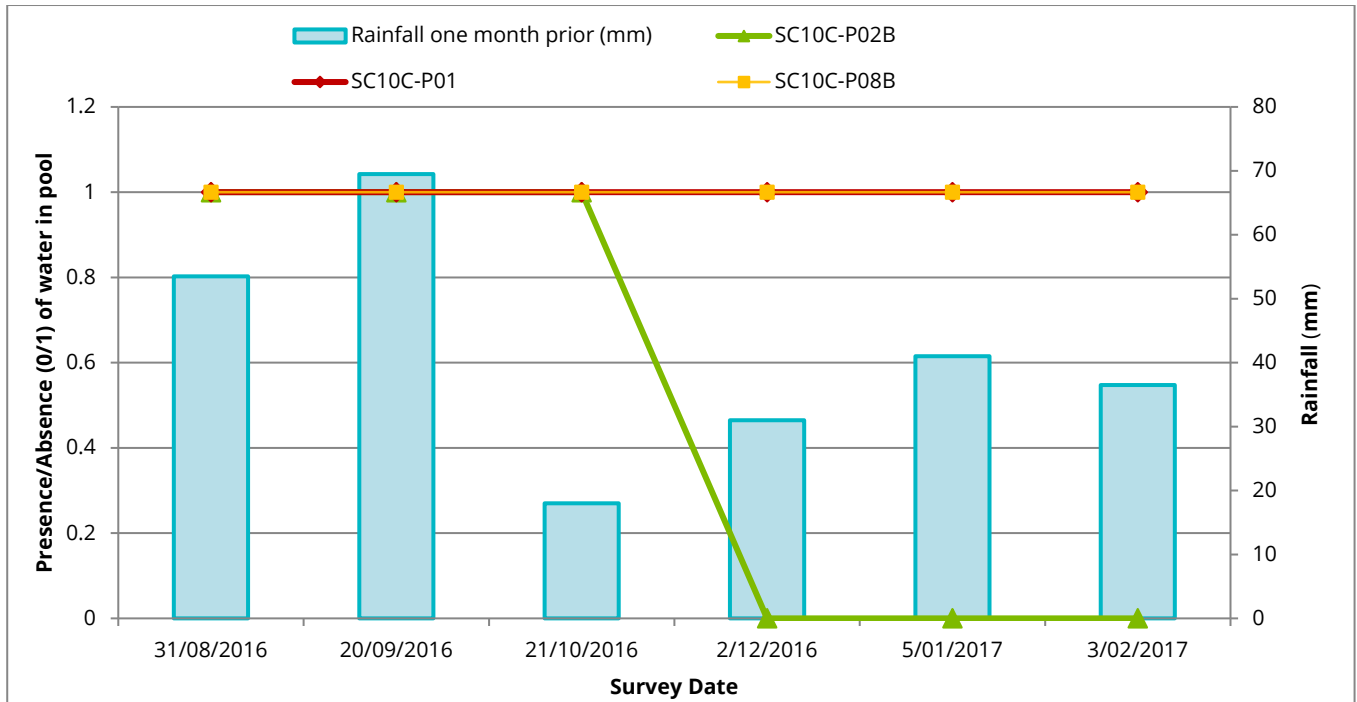
Pool 21 was also recorded to have water present during the winter monitoring period and again was noted to have water present during October 2016 before a reduction in habitat occurred during survey in December 2016. This was followed by the return of pool water levels during the final two months of additional survey in January and February 2017. If individuals were present within Pool 21 across winter to early 2017, the loss of habitat during the December monitoring replicate would not allow individuals to successfully metamorphose.

### 3.5 SC10C

During the annual monitoring of SC10C, four adults and one small eggmass (located in a shallow pool at the top of a sandstone shelf (Pool 8B)) was recorded. Pools 1, 3, 5 and 8b were previously noted as important breeding pools on the transect. During the additional water monitoring period, Pool 1 and Pool 8b consistently retained water across the months into early 2017 (Graph 10).

While Pools 1 and 8b consistently retained water, the pool water levels remained low at Pool 1 ranging between 0.2 metres and 0.4 metres. Pool 8b was significantly lower with values ranging between 0.03 metres to 0.14 metres.

**Graph 10 The presence (1) or absence (0) of water at a selection of pools monitored by the Illawarra Coal Environmental Team along SC10C during the 2016-17 Littlejohn’s Tree Frog tadpole development period**



Historically, SC10C has seen a decline in the abundance of adult frogs following subsidence impacts detected at SC10C following extraction of Longwall 7 and Longwall 8 during 2011 and 2012. Although increases in individuals during the 2015/16 annual monitoring periods are thought to be in relation to increases in rainfall.

As Pool 1 retained water levels between 0.2 metres and 0.4 metres throughout the key months for Littlejohn’s Tree Frog tadpoles to develop, if a breeding event occurred after the winter monitoring period this pool could provide suitable habitat for Littlejohn’s Tree Frog tadpoles to successfully move through the metamorphosis stages. Although due to the lack of pool water level data for the final metamorphosis months and tadpole monitoring data, it is difficult to ascertain whether completion of metamorphosis along the transect was likely.

Although Pool 8b continued to retain water over the key months for Littlejohn’s Tree Frog tadpoles to develop, the relatively low levels of water (0.03 metres to 0.14 metres) would have placed any individuals within the pool at a higher risk of predation and competition for resources. Again, due to the lack of data, it is difficult to determine whether individuals in Pool 8b would successfully complete metamorphosis.

## 4 Recommendations and conclusion

Based on the results detailed in Section 3, the following provides additional details regarding the required TARP level response detailed in Section 1.2.4.

Table 5 below provides a summary of each site, their current TARP level, results of the additional monitored and recommendations on any CMA to be undertaken at each of the sites.

**Table 5 Recommended actions following the Littlejohn's Tree Frog monitoring results at impacted sites within Dendrobium Area 3A and Dendrobium Area 3B**

Transect	Current TARP level	Summary of additional monitoring results (undertaken between November 2016 and February 2017)	Recommendations on CMA's
DC13	Level 3 according to the <i>Dendrobium Area 3B Watercourse Monitoring TARP</i>	<p>Results from the additional pool monitoring confirmed that a reduction in habitat within identified LittleJohn's Tree Frog breeding pools (Pool 10, 11 and 17) occurred, with the majority of the remaining pools retaining low levels of water and were considered to be a more hostile environment for tadpoles to develop. Potholes retained adequate water levels for individuals to continue to develop throughout the additional monitoring period.</p> <p>Although detecting the completion of metamorphosis is difficult (as individuals leave the pool), considering the trends identified in the results, successful metamorphosis of individuals in all the potholes was likely.</p>	<p><b>Level 3 response: Develop site CMA (subject to stakeholder feedback)</b></p> <p>It is recommended that grouting of rockbar and bedrock at key locations where water flow is diverting is considered to ensure water is retained in important habitat pools, including:</p> <ul style="list-style-type: none"> <li>Pool 16A – associated with DA3B_LW9_003, DA3B_LW9_004, DA3B_LW9_005, DA3B_LW9_002, DA3B_LW9_001.</li> <li>Pool 16B – associated with DA3B_LW9_003, DA3B_LW9_004, DA3B_LW9_005, DA3B_LW9_002, DA3B_LW9_001..</li> <li>Pool 17 – associated with DA3B_LW9_003, DA3B_LW9_004, DA3B_LW9_005, DA3B_LW9_002, DA3B_LW9_001..</li> <li>Pool 18A – associated with DA3B_LW9_003, DA3B_LW9_004, DA3B_LW9_005, DA3B_LW9_002, DA3B_LW9_001..</li> <li>Pool 18B – associated with DA3B_LW9_003, DA3B_LW9_004, DA3B_LW9_005, DA3B_LW9_002, DA3B_LW9_001..</li> <li>Pool 19 – associated with DA3B_LW9_003, DA3B_LW9_004, DA3B_LW9_005, DA3B_LW9_002, DA3B_LW9_001.</li> <li>The above pools have been selected based on the location of impacts (as provided by Illawarra Coal in GIS .shp format), historical records of tadpoles and egg mass along DC13 and the proximity to the potholes in which metamorphosis was recorded during the current survey.</li> </ul>

Transect	Current TARP level	Summary of additional monitoring results (undertaken between November 2016 and February 2017)	Recommendations on CMA's
WC21	Level 2 according to the <i>Dendrobium Area 3B Watercourse Monitoring TARP</i> .	<p>Results from the additional pool monitoring confirmed that a reduction in habitat within identified LittleJohn's Tree Frog breeding pools (Pool 17 and 21) occurred, with the majority of the remaining pools being subject to impacts along the transect. Potholes retained adequate water levels for individuals to continue to develop throughout the additional monitoring period.</p> <p>Although detecting the completion of metamorphosis is difficult (as individual leave the pool), considering the trends identified in the results, successful metamorphosis of individuals in potholes G and H was likely, whereas Rockbar 5 showed a relatively stable number of individuals in developmental dormancy and Potholes A, B, C, D, E, F, and I had gradual decline with the gradual increase in individuals progressing to the later stages (&gt;40) of metamorphosis.</p>	<p><b>Level 2 response: Notify relevant technical specialists and seek advice on any CMA required.</b></p> <p>Considering the extent of impact occurring along WC21 it is likely that without CMAs, a Level 3 TARP will be triggered in 2017.</p> <p>Biosis recommends the consideration of CMA's in the form of grouting of rockbar and bedrock at key locations where water flow has been diverted. Important habitat pools include;</p> <ul style="list-style-type: none"> <li>• Pool 11- associated with DA3B_LW9_018</li> <li>• Pool 12 – associated with DA3B_LW9_018</li> <li>• Pools 14 – associated with DA3B_LW9_016, DA3B_LW9_014, DA3B_LW9_015</li> <li>• Pool 15 – associated with DA3B_LW9_016, DA3B_LW9_014, DA3B_LW9_015</li> <li>• Pool 16 – associated with DA3B_LW9_016, DA3B_LW9_014, DA3B_LW9_015</li> <li>• Pool 17 – associated with DA3B_LW9_016, DA3B_LW9_014, DA3B_LW9_015</li> <li>• Pool 18 – associated with DA3B_LW9_016, DA3B_LW9_014, DA3B_LW9_015</li> <li>• Pool 19 – associated with DA3B_LW10_016, DA3B_LW9_020</li> <li>• Pool 20 – associated with DA3B_LW10_016, DA3B_LW9_020</li> <li>• Pool 21 – associated with DA3B_LW10_015</li> <li>• Pool 24 – associated with DA3B_LW10_008</li> </ul> <p>The above pools have been selected based on the location of impacts, historical records of tadpoles and egg mass along WC21 and the proximity to the potholes in which metamorphosis was recorded during the current survey.</p>

Transect	Current TARP level	Summary of additional monitoring results (undertaken between November 2016 and February 2017)	Recommendations on CMA's
<b>DC(1)</b>	No threatened frog or fauna TARP level triggered according to the <i>Dendrobium Area 3B Watercourse Monitoring TARP</i>	<p>Results from the additional pool monitoring confirmed that a reduction in habitat within identified LittleJohn's Tree Frog breeding pools (Pool 29 – 34 for DC(1)) occurred.</p> <p>Along DC(1), completion of metamorphosis was not detected as individuals recorded in the initial replicate of the additional surveys were not recorded in the consecutive months. This was the result of the loss of habitat in the pools they were detected within.</p>	<p>No CMA's required at DC(1). Monitoring in 2017 will determine whether a Level 1 has been triggered.</p> <p>Consider response in line with the CMA's required for the Level 3 trigger under the <i>Dendrobium Area 3B Watercourse Monitoring TARP</i> (dated 12 October 2015) for SC10C.</p>
<b>SC10C WC17</b>	Level 1 according to the <i>Dendrobium Area 3A Landscape Monitoring - Terrestrial Flora and Fauna TARP</i>	<p>Results from the additional pool monitoring confirmed that a reduction in habitat within identified LittleJohn's Tree Frog breeding pools (Pool 21 and 26 for WC17 and Pool 8b for SC10C) occurred. Pool 1 along SC10C had potential to remain breeding habitat for Littlejohn's Tree Frog across the monitoring period but without additional tadpole surveys this could not be confirmed.</p>	<p>No additional monitoring is required for a Level 1 trigger for sites located within Dendrobium Area 3A.</p> <p>Continue existing annual monitoring program in addition with reporting any impacts to key stakeholders with a summary of the impacts to be written in the AEMR.</p>

#### 4.1 Details of CMAs recommended

It is recommended that Illawarra Coal consider surface sealing techniques, such as grouting, at key locations of water flow diversion in accordance with the techniques summarised in the *Dendrobium Watercourse Impact Monitoring Management and Contingency Plan*. Surface grouting, which can be mixed and placed by hand onsite, should be placed at strategic locations such as rock bars above breeding pools, rather than all fractures along the watercourse with the aim to create a low permeability membrane that allows for water retention in important breeding pools (as detailed in Table 5 above). Over time, natural infill of sediment may supplement grouting.

Following installation of any CMAs, ongoing monitoring would be required in accordance with adaptive management principles to ensure the ongoing effectiveness of the action. Consultation and approvals from the relevant agencies including WaterNSW would be required.



## 4.2 Conclusion

Continuing habitat and tadpole development at DC13, WC21, DC(1), SC10C and WC17 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 currently 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 significantly increased as a result of mining impacts.

As previously identified in Table 5 and Section 4.1, Biosis recommends that CMA's are undertaken at key locations along DC13 and WC21.

It is recommended that annual threatened frog monitoring continue as a part of Illawarra Coal's ecological monitoring program. The monitoring program will determine whether adult frogs attempt to breed at DC13, WC21, DC(1), SC10C and WC17 following any CMAs. Similarly, the ongoing monitoring of pool water depth and presence by the Illawarra Coal Environmental Field Team will provide the data to determine whether flows remain diverted and whether observed impacts are likely to have a long-term impact on the local population of this species.

## 5 References

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## Appendix

### Pool data

**Table 6 SC10C pool data provided by Illawarra Coal Environmental Team on March 2017. Presence (1) and absence (0) of water present across additionally monitored pools.**

Survey date	SC10C-P01	SC10C-P02B	SC10C-P08B
31/08/2016	1	1	1
20/09/2016	1	1	1
21/10/2016	1	1	1
2/12/2016	1	0	1
5/01/2017	1	0	1
3/02/2017	1	0	1

**Table 7 WC17 pool data provided by Illawarra Coal Environmental Team on March 2017. Presence (1) and absence (0) of water present across additionally monitored pools.**

Survey date	WC17-BHP21	WC17-BHP22	WC17-BHP23	WC17-BHP24	WC17-BHP25	WC17-BHP26
31/08/2016	1	1	1	1	1	1
20/09/2016	-	1	-	-	-	1
26/10/2016	1	1	-	-	-	1
2/12/2016	0	1	-	-	-	0
5/01/2017	1	-	-	-	-	0
3/02/2017	1	0	-	-	-	0

**Table 8 DC13 tadpole count (Collected by Biosis), mean metamorphosis stage (Collected by Biosis) and presence (1)/absence(0) pool data (Collected by Illwarra Coal Environmental Team) for pools between Pool 1 - Crevice**

Tadpole Count												
Survey date	Pool 1	Pool 9	Pool 10	Pool 11	Pool 12	Pool 13 (a)	Pool 13 (b)	Pool 14	Pool 15	Pool 16 (a)	Pool 16 (b)	Crevice
1/08/2016	0	0	450	50	0	0	0	0	0	0	0	0
29/11/2016	0	0	60	0	0	0	0	0	0	0	5	0
22/12/2016	0	0	0	0	0	0	0	0	0	0	0	0
23/01/2017	0	0	0	0	0	0	0	0	0	0	0	0
15/02/2017	0	0	0	0	0	0	0	0	0	0	0	0
Mean Metamorphosis												
Survey date	Pool 1	Pool 9	Pool 10	Pool 11	Pool 12	Pool 13 (a)	Pool 13 (b)	Pool 14	Pool 15	Pool 16 (a)	Pool 16 (b)	Crevice
29/11/2016	0	0	28	0	0	0	0	0	0	0	39	0
22/12/2016	0	0	0	0	0	0	0	0	0	0	0	0
23/01/2017	0	0	0	0	0	0	0	0	0	0	0	0
15/02/2017	0	0	0	0	0	0	0	0	0	0	0	0
Pool Data (presence/absence of water)												
Survey date	Pool 1	Pool 9	Pool 10	Pool 11	Pool 12	Pool 13 (a)	Pool 13 (b)	Pool 14	Pool 15	Pool 16 (a)	Pool 16 (b)	Crevice
29/11/2016	0	0	1	0	1	0	0	0	0	0	1	0
22/12/2016	0	1	1	1	1	1	1	0	0	1	1	0
23/01/2017	0	0	0	0	0	1	1	1	0	1	1	1
15/02/2017	0	1	1	1	1	1	1	0	0	0	1	1

**Table 9 DC13 tadpole count (Collected by Biosis), mean metamorphosis stage (Collected by Biosis) and presence (1)/absence(0) pool data (Collected by Illwarra Coal Environmental Team) for pools between pothole A - pool 21**

Tadpole Count											
Survey date	Pothole A	Pothole B	Pothole C	Pothole D	Pothole E	Pool 17	Pool 18 (a)	Pool 18 (b)	Pool 19	Pool 20	Pool 21
1/08/2016	70	78	7	50	300	64	0	0	0	0	0
29/11/2016	3	40	5	0	30	0	0	0	0	0	0
22/12/2016	4	5	3	0	30	0	0	0	0	0	0
23/01/2017	0	9	2	0	63	0	0	0	0	0	0
15/02/2017	0	4	0	0	49	0	0	0	0	0	0
Mean Metamorphosis											
Survey date	Pothole A	Pothole B	Pothole C	Pothole D	Pothole E	Pool 17	Pool 18 (a)	Pool 18 (b)	Pool 19	Pool 20	Pool 21
29/11/2016	33	29	31	0	28	0	0	0	0	0	0
22/12/2016	40	38	42	0	32	0	0	0	0	0	0
23/01/2017	0	36	40	0	40	0	0	0	0	0	0
15/02/2017	0	42	0	0	40	0	0	0	0	0	0
Pool Data (presence/absence of water)											
Survey date	Pothole A	Pothole B	Pothole C	Pothole D	Pothole E	Pool 17	Pool 18 (a)	Pool 18 (b)	Pool 19	Pool 20	Pool 21
29/11/2016	1	1	1	0	1	0	0	0	0	0	0
22/12/2016	1	1	1	1	1	0	0	0	0	0	0
23/01/2017	1	1	1	1	1	1	0	1	0	0	0

15/02/2017	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
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**Table 10 DC(1) tadpole count (Collected by Biosis), mean metamorphosis stage (Collected by Biosis) and presence (1)/absence (0) pool data (Collected by Illwarra Coal Environmental Team).**

Tadpole Count																			
Survey Date	Pool 19	Pool 20	Pool 21	Pool 22	Pool 23	Pool 24	Pool 25	Pool 26	Pool 27	Pool 28	Pool 29	Pool 30	Pool 31	Pool 32	Pool 32 (b)	Pool 33	Pool 33 (b)	Pool 34	Pool 35
28/11/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	1	0	0
22/12/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23/01/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean Metamorphosis																			
Survey date	Pool 19	Pool 20	Pool 21	Pool 22	Pool 23	Pool 24	Pool 25	Pool 26	Pool 27	Pool 28	Pool 29	Pool 30	Pool 31	Pool 32	Pool 32 (b)	Pool 33	Pool 33 (b)	Pool 34	Pool 35
28/11/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	32	0	0
22/12/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23/01/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pool Data (presence/absence of water)																			
Survey date	Pool 19	Pool 20	Pool 21	Pool 22	Pool 23	Pool 24	Pool 25	Pool 26	Pool 27	Pool 28	Pool 29	Pool 30	Pool 31	Pool 32	Pool 32 (b)	Pool 33	Pool 33 (b)	Pool 34	Pool 35
28/11/2016	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	0	0
22/12/2016	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0
23/01/2017	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0

**Table 11 WC21 tadpole count (Collected by Biosis), mean metamorphosis stage (Collected by Biosis) and presence (1)/absence(0) pool data (Collected by Illwarra Coal Environmental Team) for pools between Pool 1 - Pool 12**

Tadpole Count																		
Survey Date	Pool 1	Pool 2	Pool 3	Pool 4	Pool 5	Rockbar 5	Pool 6	Pool 7	Pool 8	Pool 9	Pool 10	Pool 11	Pothole A	Pothole B	Pothole C	Pothole D	Pothole E	Pool 12
29/11/2016	0	0	0	0	0	230	0	0	0	0	0	0	80	0	0	40	0	0
15/12/2016	0	0	0	0	0	180	0	0	0	0	0	0	115	0	0	110	0	0
24/01/2017	0	0	0	0	0	230	0	0	0	0	0	0	40	0	0	61	0	0
16/02/2017	0	0	0	0	0	180	0	0	0	0	0	0	19	0	0	44	0	0
Mean Metamorphosis																		
Survey Date	Pool 1	Pool 2	Pool 3	Pool 4	Pool 5	Rockbar 5	Pool 6	Pool 7	Pool 8	Pool 9	Pool 10	Pool 11	Pothole A	Pothole B	Pothole C	Pothole D	Pothole E	Pool 12
29/11/2016	0	0	28	0	0	25	0	0	0	0	0	0	24	0	0	27	0	0
22/12/2016	0	0	0	0	0	26	0	0	0	0	0	0	24	0	0	27	0	0
23/01/2017	0	0	0	0	0	26	0	0	0	0	0	0	26	0	0	30	0	0
15/02/2017	0	0	0	0	0	27	0	0	0	0	0	0	26	0	0	30	0	0
Pool Data (presence/absence of water)																		
Survey Date	Pool 1	Pool 2	Pool 3	Pool 4	Pool 5	Rockbar 5	Pool 6	Pool 7	Pool 8	Pool 9	Pool 10	Pool 11	Pothole A	Pothole B	Pothole C	Pothole D	Pothole E	Pool 12
29/11/2016	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	0
22/12/2016	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0
23/01/2017	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	0
15/02/2017	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0

**Table 12 WC21 tadpole count (Collected by Biosis), mean metamorphosis stage (Collected by Biosis) and presence (1)/absence(0) pool data (Collected by Illwarra Coal Environmental Team) for pools between: Pool 13 - Pool 30**

Tadpole Count																						
Survey Date	Pool 13	Pool 14	Pothole F	Pothole G	Pool 15	Pool 16	Pool 17	Pool 18	Pothole H	Pool 19	Pool 20	Pool 21	Pool 22	Pool 23	Pothole I	Pool 24	Pool 25	Pool 26	Pool 27	Pool 28	Pool 29	Pool 30
29/11/2016	0	0	0	50	0	0	0	0	30	0	0	0	0	0	20	0	0	0	0	0	0	0
15/12/2016	0	0	0	50	0	0	0	0	80	0	0	0	0	0	30	0	0	0	0	0	0	0
24/01/2017	0	0	0	13	0	0	0	0	38	0	0	0	0	0	13	0	0	0	0	0	0	0
16/02/2017	0	0	0	1	0	0	0	0	29	0	0	0	0	0	34	0	0	0	0	0	0	0
Mean Metamorphosis																						
Survey Date	Pool 13	Pool 14	Pothole F	Pothole G	Pool 15	Pool 16	Pool 17	Pool 18	Pothole H	Pool 19	Pool 20	Pool 21	Pool 22	Pool 23	Pothole I	Pool 24	Pool 25	Pool 26	Pool 27	Pool 28	Pool 29	Pool 30
29/11/2016	0	0	0	32	0	0	0	0	34	0	0	0	0	0	26	0	0	0	0	0	0	0
22/12/2016	0	0	0	34	0	0	0	0	34	0	0	0	0	0	25	0	0	0	0	0	0	0
23/01/2017	0	0	0	41	0	0	0	0	38	0	0	0	0	0	28	0	0	0	0	0	0	0
15/02/2017	0	0	0	41	0	0	0	0	41	0	0	0	0	0	26	0	0	0	0	0	0	0
Pool Data (presence/absence of water)																						
Survey Date	Pool 13	Pool 14	Pothole F	Pothole G	Pool 15	Pool 16	Pool 17	Pool 18	Pothole H	Pool 19	Pool 20	Pool 21	Pool 22	Pool 23	Pothole I	Pool 24	Pool 25	Pool 26	Pool 27	Pool 28	Pool 29	Pool 30
29/11/2016	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
22/12/2016	0	0	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0
23/01/2017	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
15/02/2017	1	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0	1	1	1	1	1	1