WAMBO COAL PTY LTD
2016 ANNUAL REVIEW

1 January – 31 December 2016

Name of operation	Wambo Coal Mine
Name of operator	Wambo Coal Pty Ltd
Development consent /Project Approval #	DA305-7-2003, DA177-8-2004, EPBC 2003/1138
Name of holder of development consent	Wambo Coal Pty Ltd
Title/Mining lease #	CL365, CL374, CL397, CCL743, ML1402, ML1572, ML1594, A444, EL7211
Name of holder of mining lease	Wambo Coal Pty Ltd
Water licence #	As per **Table 3**
Name of holder of water licence	Wambo Coal Pty Ltd
MOP start date	31 March 2015
MOP end date	30 March 2020
Annual Review start date	1 January 2016
Annual Review end date	31 December 2016

I, Steven Peart, certify that this audit report is a true and accurate record of the compliance status of Wambo Coal Mine for the period 1 January 2016 to 31 December 2016 and that I am authorised to make this statement on behalf of Wambo Coal Pty Ltd

Note.

a) *The Annual Review is an 'environmental audit' for the purposes of section 122B(2) of the Environmental Planning and Assessment Act 1979. Section 122E provides that a person must not include false or misleading information (or provide information for inclusion in) an audit report produced to the Minister in connection with an environmental audit if the person knows that the information is false or misleading in a material respect. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.*

b) *The Crimes Act 1900 contains other offences relating to false and misleading information: section 192G (Intention to defraud by false or misleading statement—maximum penalty 5 years imprisonment); sections 307A, 307B and 307C (False or misleading applications/information/documents—maximum penalty 2 years imprisonment or $22,000, or both).*

Name of authorised reporting officer	Steven Peart
Title of authorised reporting officer	Manager Environment and Community
Signature of authorised reporting officer	
Date	31/3/17

Statement of Compliance

Were all conditions of the relevant approval(s) complied with?	
EPL529	No
DA305-7-2003	No
DA177-8-2004	Yes
EPBC 2003/1138	Yes
CL365	Yes
CL374	Yes
CL397	Yes
CCL743	Yes
ML1402	Yes
ML1574	Yes
ML1592	Yes
A444	No
EL7211	Yes
Water licences (As per **Table 3**)	Yes

Non-Compliances

Relevant Approval	Condition #	Condition Description (summary)	Compliance Status	Comment	Where addressed in Annual Review
EPL 529	O1.1	Carrying out Activities in Competent Manner	Subject to proceedings	Uncontrolled release from temporary sediment dam	Section 10.1
EPL 529	M2.2	Air Monitoring Requirements	Non-compliant	Failure to record 24hr averages of PM10 data due to hardware failures and local power outages	Section 10.2
EPL 529	M4.1	Weather Monitoring	Non-compliant	Software failure resulted in loss of continuous weather monitoring data	Section 10.3
EPL 529	M7.1	Monitoring – HRSTS	Non-compliant	Failure to monitor HRSTS discharge volume	Section 10.4
EPL 529	M9.1	Monitoring – HRSTS	Non-compliant	Failure to maintain discharge point communication equipment	Section 10.5
EPL 529	M8.1	Monitoring – Blasting	Non-compliant	Failure to capture all blast data	Section 10.6
DA305-7-2003	29 (Sch 4)	Monitoring – Stream Flow	Non-compliant	Failure to monitor flow in South Wambo and Stony Creeks	Section 10.7

Relevant Approval	Condition #	Condition Description (summary)	Compliance Status	Comment	Where addressed in Annual Review
A444	12.d)	Groundwater Monitoring and Modelling Plan	Non-compliant	Failure to obtain Minister's approval for the plan prior to undertaking relevant prospecting operations	Section 10.8

Compliance Status Key

Risk Level	Colour Code	Description
High	Non-compliant	Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence.
Medium	Non-compliant	Non-compliance with: • potential for serious environmental consequences, but is unlikely to occur; or • potential for moderate environmental consequences, but is likely to occur.
Low	Non-compliant	Non-compliance with: • potential for moderate environmental consequences, but is unlikely to occur; or • potential for low environmental consequences, but is likely to occur.
Administrative non-compliance	Non-compliant	Only to be applied where the non-compliance does not result in any risk of environmental harm (e.g. submitting a report to government later than required under approval conditions).

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1.0 Introduction

The Wambo Coal Mine (the Mine) is situated approximately 15 kilometres (km) west of Singleton, near the village of Warkworth, New South Wales (NSW) (**Figure 1**). The Mine is owned and operated by Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Limited.

A range of open cut and underground mine operations have been conducted at the Mine since mining operations commenced in 1969. Mining under the current Development Consent (DA 305-7-2003) commenced in 2004 and permits both open cut and underground operations and associated activities to be conducted. The approved run-of-mine (ROM) coal production rate is 14.7 million tonnes per annum and all product coal is transported from the Mine by rail.

Figure 2 shows the approved Mine layout including mining lease boundaries, current operational disturbance footprint and Remnant Woodland Enhancement Areas (RWEAs). **Figure 3** shows the approved Mine longwall layout.

This Annual Review details WCPL's environmental and community performance for the reporting period 1 January 2016 – 31 December 2016. This Annual Review has been prepared in accordance with the NSW Department of Planning and Environment (DPE) *Post-approval requirements for State significant mining developments – Annual Review Guideline – October 2015* (DPE, 2015) and WCPL's statutory approvals (**Section 2.1**).

The Annual Review is not intended to be an exhaustive description of WCPL's operations, approvals and activities rather it is a summary of WCPL's compliance status with respect to WCPL's statutory approvals.

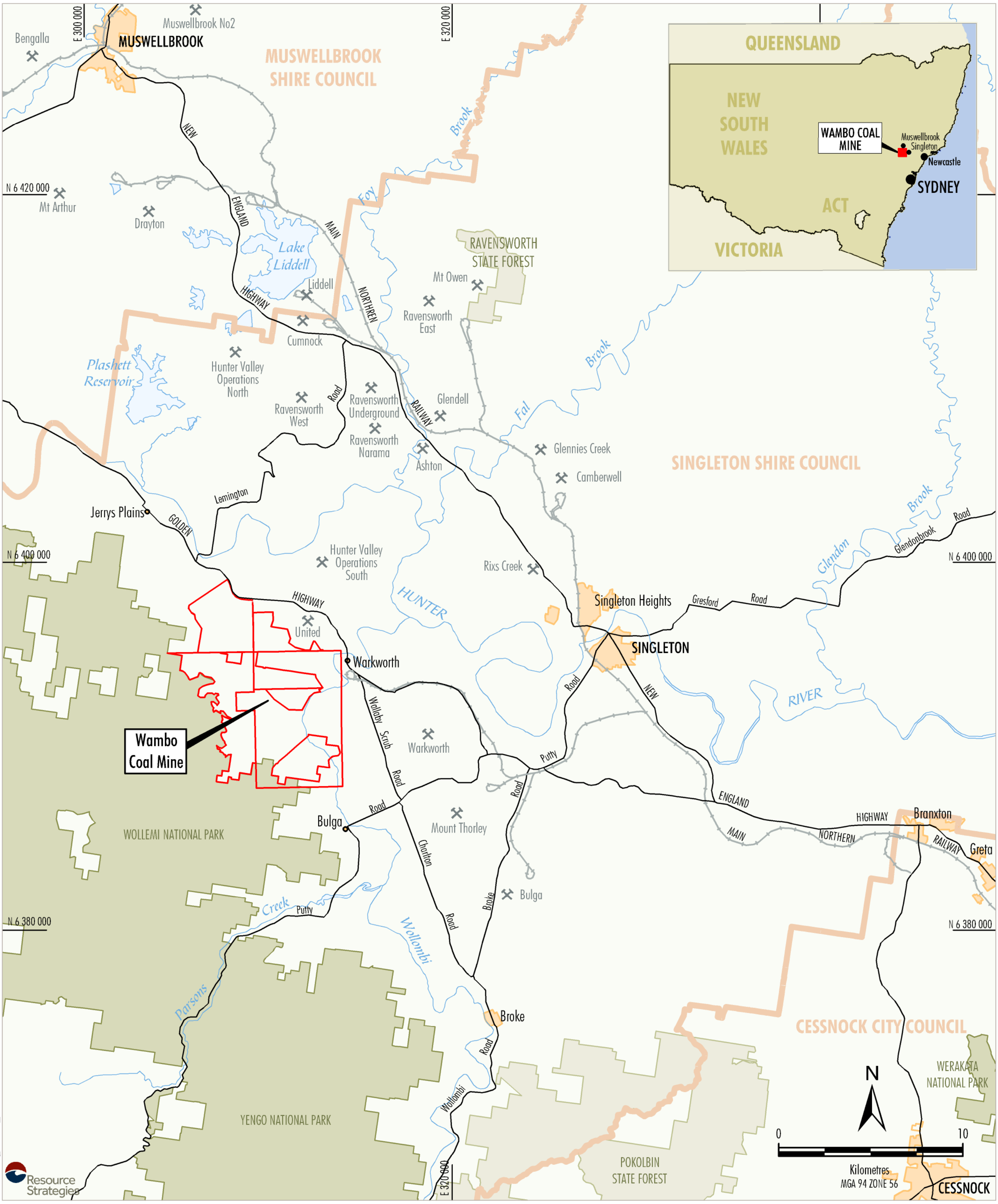
This Annual Review is distributed to a range of stakeholders including government authorities, Singleton Council and members of the WCPL Community Consultative Committee (CCC). A copy of the Annual Review will be made available on the Peabody Energy website (www.peabodyenergy.com).

1.1 Mine Contacts

The contact details of key WCPL personnel who are responsible for the environmental management of the Mine are listed in **Table 1.**

Table 1: Contact Details of Key WCPL Personnel

Name	Role	Phone No.
Steven Peart	Manager, Environment and Community	(02) 6570 2209
Albert Scheepers	General Manager	(02) 6570 2208



LEGEND

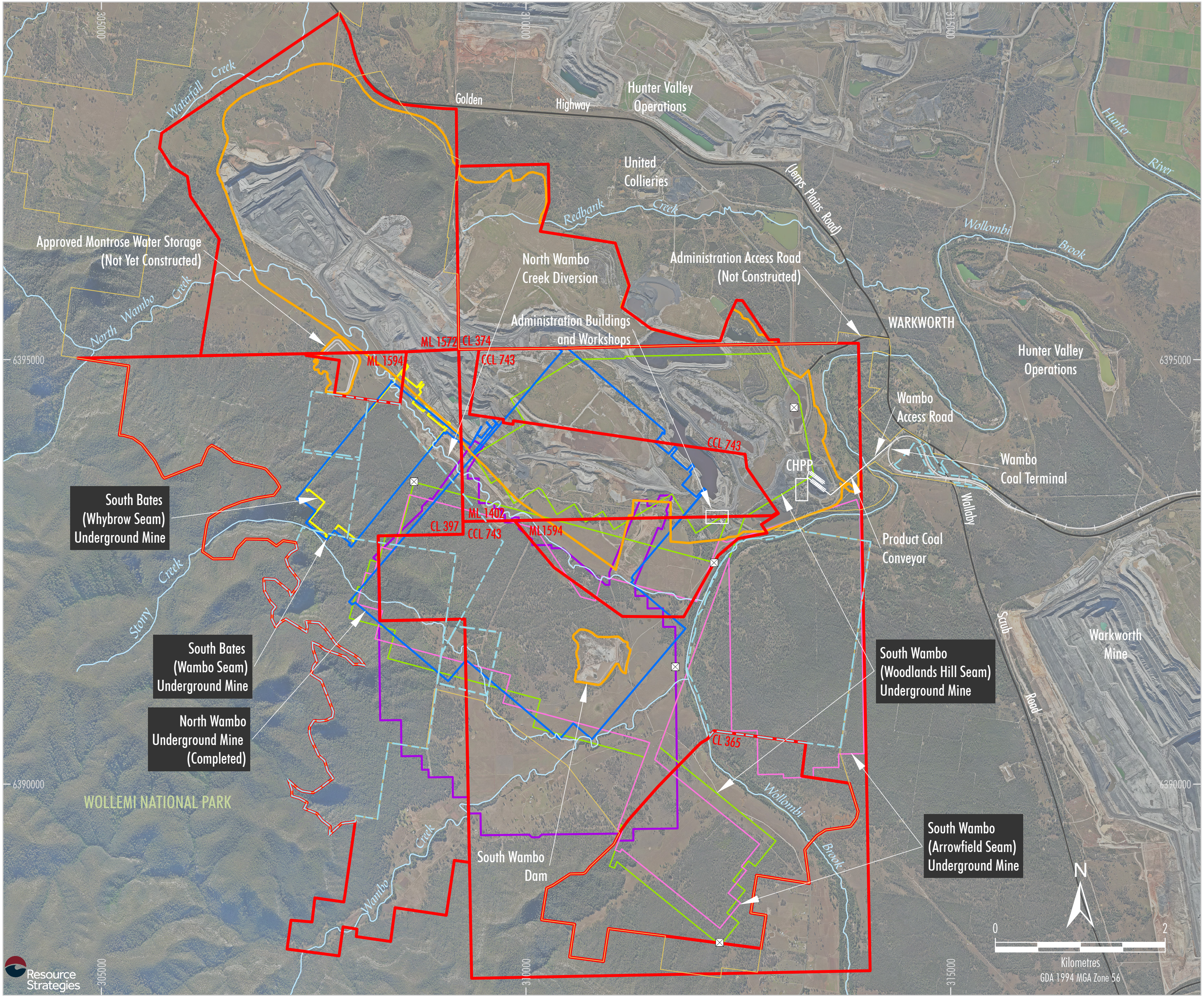
- Mining and Coal Lease Boundary
- Local Government Boundary
- Mining Operation

Source: Geoscience Australia (2009)

WAMBO COAL MINE

Regional Location

Figure 1



LEGEND

- Mining and Coal Lease Boundary
- WCPL Owned Land
- Existing/Approved Surface Development Area

Approved Underground Development

- Whybrow Seam
- Wambo Seam
- Woodlands Hill Seam
- Arrowfield Seam
- Previous Underground Workings in Whybrow Seam
- Approved Ventilation Shaft
- Remnant Woodland Enhancement Program (RWEP) Area

Source: Department of Lands (July 2009); WCPL (2016); WCPL Orthophoto (July 2016)

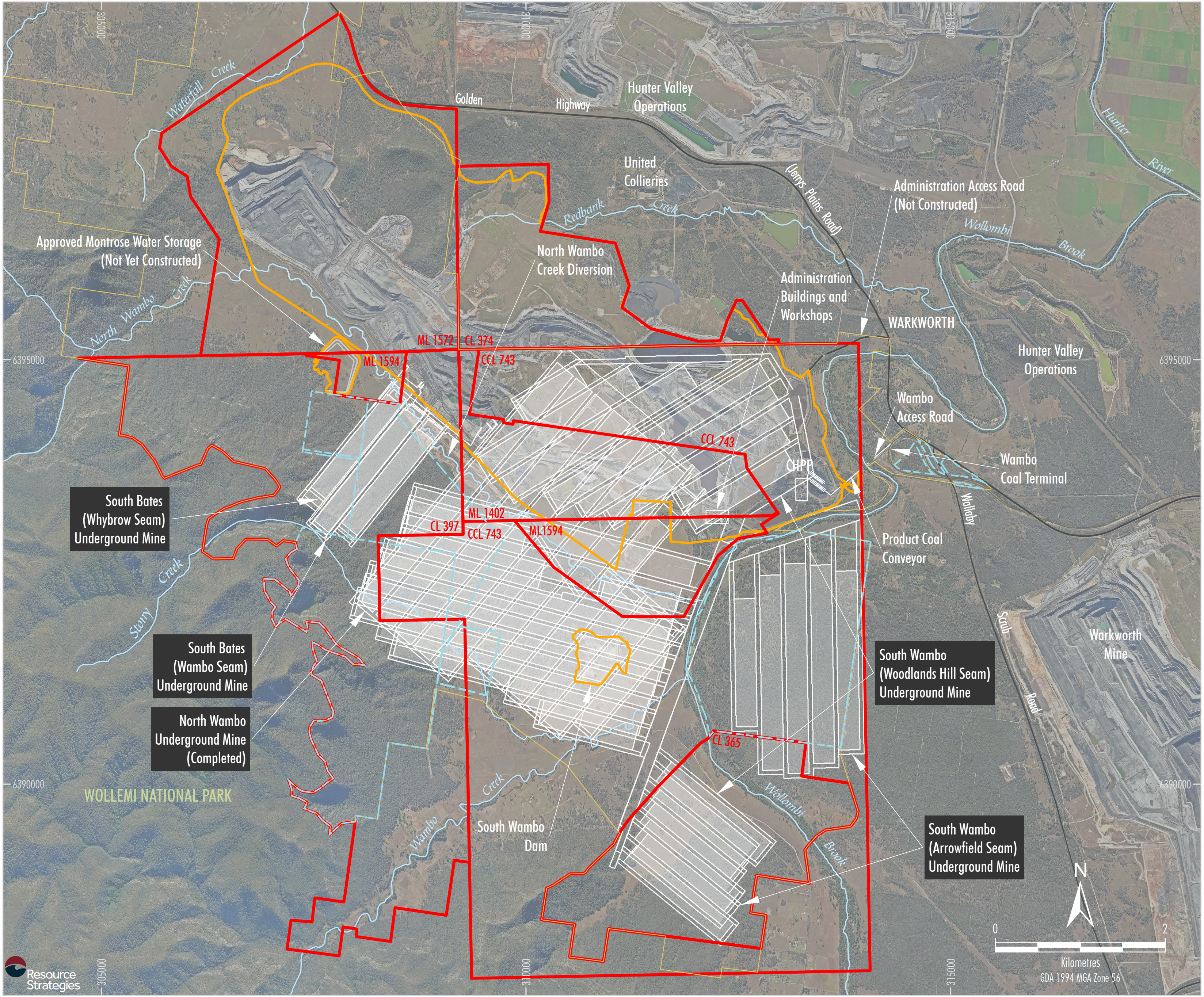
Peabody ENERGY

W A M B O   C O A L   M I N E

Approved Wambo Coal Mine General Arrangement

Figure 2

WAM-09-15_AR 2016_201A



LEGEND
- Mining and Coal Lease Boundary
- WCPL Owned Land
- Existing/Approved Surface Development Area
- Approved Underground Development
- Remnant Woodland Enhancement Program (RWEP) Area

Source: Department of Lands (July 2009); WCPL (2016); WCPL Orthophoto (July 2016)

Peabody ENERGY

W A M B O   C O A L   M I N E

Approved Wambo Coal Mine Longwall Layout

Figure 3

WAM-09-15_AR 2016_202A

2.0 Approvals

2.1 Current Approvals

WCPL has a number of statutory approvals, leases and licences that regulate activities at the Mine (**Tables 2 and 3**). Conditions from WCPL's approvals that specifically relate to this Annual Review are detailed in **Appendix A.**

Table 2: WCPL's Statutory Approvals

Type	Description	Issued By[1]	Issue Date	Expiry Date
Development Approval	DA 305-7-2003[2]	DPE	04/02/2004	04/02/2032
Development Approval	DA 177-8-2004[3]	DPE	16/12/2004	16/12/2025
EPBC Approval[4]	EPBC 2003/1138	DoEE	23/11/2004	31/12/2029
Mining Lease	ML1402	DRE	23/09/1996	14/08/2022
Mining Lease	ML1572	DRE	21/12/2005	20/12/2026
Mining Lease	ML1594	DRE	01/05/2007	30/04/2028
Consolidated Coal Lease	CCL743	DRE	09/03/1990	14/08/2022
Coal Lease	CL365	DRE	19/09/1990	19/09/2032
Coal Lease	CL374	DRE	06/12/1991	21/03/2026
Coal Lease	CL397	DRE	04/06/1992	04/06/2034
Exploration Licence	A444[5]	DRE	04/10/2007	16/05/2016
Exploration Licence	EL7211	DRE	22/01/2013	29/09/2019
Environment Protection Licence	EPL529	EPA	13/07/2015	-
S101 Approval[6]	Approval to discontinue use of the North East Tailings Dam (NETD)	DRE	03/09/2009	-

1. DoEE = Federal Department of the Environment and Energy, DRE = Division of Resources and Energy (a division of NSW Department of Industry), EPA = NSW Environment Protection Authority.
2. DA305-7-2003 has been modified 14 times since the original approval was granted in 2004. The last modification, for approval to extend/relocate mining in the South Wambo Underground Mine and to extend the life of the mine until 2032, was granted in December 2016.
3. DA177-8-2004 has been modified twice since the original approval was granted in 2004. The last modification, for approval to establish a locomotive provisioning facility adjacent to the WCPL Rail Loadout Facility, was granted in February 2012.
4. EPBC = *Environment Protection and Biodiversity Conservation Act 1999.*
5. A444 is an Authority to Prospect granted under the *Coal Mining Act 1973*, and is deemed to be an Exploration Licence for the purposes of the *Mining Act 1992*. An application to renew A444 was submitted to DRE on 16 May 2016 and is currently under review.
6. Section 101 of the *Coal Mine Health and Safety Act (CMHSA) 2002.*

Table 3: WCPL's Water Licences

Licence Number	Description	Valid To	Extraction Limit	Conversion Status
Hunter Regulated River Water Source				
WAL 718	Hunter River Pump	Perpetuity	1000 shares (high security)	Converted
WAL 8599	N/A	Perpetuity	6 shares (high security)	Converted
WAL 8600	N/A	Perpetuity	868 shares (general security)	Converted
WAL 8604	N/A	Perpetuity	240 shares (supplementary water)	Converted
Hunter Unregulated and Alluvial Water Sources (Lower Wollombi Brook Water Source)				
WAL18437	Wollombi Brook Pump	Perpetuity	350 shares	Converted
WAL 23897	Well No. 2	Perpetuity	70 shares	Converted
North Coast Fractured and Porous Rock Groundwater Sources (Sydney Basin - North Coast Groundwater Source)				
WAL 39738[1] (20BL132753)	Old Well No. 1	29/07/2018	243 shares	Converted
20BL167738[#1]	Dewatering Bore	11/09/2015	57 ML/year	DPI-Water to confirm status
WAL 39735[1] (20BL168643)	Dewatering Bore	7/08/2018	40 shares	Converted
20BL168017[1]	Dewatering (Bore No. 2)	21/05/2017	750 ML/year (20PT910929)	DPI-Water to confirm status
20BL172061[#1]	Dewatering (Bore No. 2a)	22/03/2014		
20BL173040[1]	Dewatering Bore	21/05/2017		
20BL172156[1]	Dewatering	3/05/2019	98 ML/year	DPI-Water to confirm status
WAL 39803[1] (20BL166910)	Dewatering (Bore No. 1)	21/05/2017	450 shares	Converted
20BL173032[1]	Dewatering Bore	30/11/2016		
20BL173033[1]	Dewatering Bore	30/11/2016		
20BL173034[1]	Dewatering Bore	30/11/2016		
20BL173035[1]	Dewatering Bore	30/11/2016		
20BL173844[1]	Dewatering Bore	04/09/2019	9 ML/year	DPI-Water to confirm status
20BL168997	Piezometer	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL168998	Piezometer	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL168999	Piezometer	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL169000	Piezometer	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL170638	Piezometer	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172237	Monitoring Bore (GW14, GW18, GW21)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172238	Monitoring Bore (GW12)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172240	Monitoring Bore (GW15)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172242	Monitoring Bore (GW16, GW17)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172244	Monitoring Bore (GW20)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status

Licence Number	Description	Valid To	Extraction Limit	Conversion Status
20BL172255	Monitoring Bore (GW22)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172256	Monitoring Bore (GW13)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172257	Monitoring Bore (GW19)	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL172332	Piezometer	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL173290	Monitoring Bore	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL173291	Monitoring Bore	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL173292	Monitoring Bore	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL173293	Monitoring Bore	Perpetuity	NA -Groundwater monitoring	DPI-Water to confirm status
20BL009818	Bore	Perpetuity	NA - Stock	DPI-Water to confirm status
20BL009819	Bore	Perpetuity	NA - Stock	DPI-Water to confirm status
20BL009820	Bore	Perpetuity	NA - Stock	DPI-Water to confirm status
20BL009821	Bore	Perpetuity	NA - Stock	DPI-Water to confirm status
20BL143779	Bore	Perpetuity	NA - Stock/Domestic	DPI-Water to confirm status

WAL = water access licence, ML/year = megalitres per year.

\# Renewal lodged.

1. In mid-2015, WCPL applied to the Department of Primary Industries – Water (DPI-Water) to combine all of its groundwater licences that contained an extraction entitlement into a single licence. The purpose of this licence was to streamline mining activities and simplify the reporting of extraction against licensed entitlements. As such, WCPL was licensed to extract a total of 1,647 ML from all groundwater sources under the *Water Act 1912*. This combined licence was confirmed to be active by DPI-Water in correspondence received on the 18 February 2016, the status of its' conversion to licences under the *Water Management Act 2000* is yet to be advised by DPI-Water.

2.2 Changes to Approvals

During the reporting period the following changes were made to WCPL's approvals:

- DA 305-7-2003 was modified once:
  - In December 2016 to facilitate a realignment and extension/relocation of the South Wambo Underground Mine, an increase in the underground mine ROM coal production rate and an extension in the life of the open cut operations and the life of mine.
- WCPL's Extraction Plan for South Bates Underground Longwalls 11 to 13 was submitted in October 2015, revised in January 2016 and approved in February 2016.
- The Mining Operations Plan (MOP)/Rehabilitation Management Plan was amended on four occasions during the reporting period; once in January, twice in April and once in November. MOP Amendment D was approved in November 2016.

2.3 Environmental Management System

WCPL operates an Environmental Management System to manage compliance and advance continual improvement across the Mine. During the reporting period, a number of management plans were revised and submitted for approval. A summary of the status of required management plans is presented in **Table 4.**

In accordance with Schedule 6, Condition 12 of DA 305-7-2003, copies of these management plans have been made available to the public on the Peabody Energy website (www.peabodyenergy.com).

Table 4: Status of WCPL's Environmental Management Plans

Management Plan	Status	Approved Version[1]
North Wambo Extraction Plan for Longwalls 8 to 10A (and associated component plans)	Approved – 2015	April 2015
South Bates Underground Mine Extraction Plan for Longwalls 11 to 13 (and associated component plans)	Approved – 2016	February 2016
Environmental Management Strategy	Approved – 2009	Version 3 (Jan 09)
Blast Management Plan[2]	Approved – 2015	Version 6 (Nov 15)
Noise Management Plan	Approved – 2014	Version 6 (Feb 14)
Air Quality & Greenhouse Gas Management Plan	Approved – 2014[3]	Version 3 (Feb 14)
Flora and Fauna Management Plan	Approved – 2014[4]	Version 8 (Jun 14)
Bushfire Management Plan	Approved – 2014	Version 4 (Aug 13)
Site Water Management Plan[5]	Approved – 2015	Various[5] (Nov 15)
MOP/Rehabilitation Management Plan	Approved – 2016	Amendment D (Nov 16)[6]
Conservation Management Plan (European)	To be revised in 2017	Version 2 (July 2012)

1. Approved version as at the end of the reporting period.
2. Includes WCPL's Blast Fume Management Strategy (Version 3).
3. A revised version of the Air Quality & Greenhouse Gas Management Plan was prepared by WCPL and submitted for approval in 2016.
4. A revised version of the Flora and Fauna Management Plan (Biodiversity Management Plan) was prepared by WCPL and submitted for approval in October 2016.
5. Includes WCPL's Surface Water Monitoring Program (Version 9), Groundwater Monitoring Program (Version 10), Erosion and Sediment Control Plan (ESCP) (Version 7), Surface and Groundwater Response Plan (Version 9) and Site Water Balance (Version 1). A revised version of the ESCP (Version 8) was prepared by WCPL and submitted for approval in April 2016.
6. The MOP was modified on four occasions during the reporting period; once in January, twice in April and once in November. MOP Amendment D was approved in November 2016.

In accordance with Schedule 6, Condition 6 of DA305-7-2003, WCPL will review and, if necessary, revise the strategies, plans and programs required under DA305-7-2003 within three months of the submission of this Annual Review to relevant government regulators.

3.0 Operations Summary

3.1 2016 Mining Operations

The Mine operates seven days a week, 24 hours a day on a rotating shift basis. WCPL's total hours of operation for the reporting period were approximately 7600 hours.

During the reporting period, the following mining operations were undertaken at the Mine:

- North Wambo Underground (now complete):
  - Longwall 8b (17 November 2015 – 31 January 2016).
- South Bates Underground (current mining area):
  - Longwall 11 (17 February 2016 – 2 July 2016); and
  - Longwall 12 (4 August 2016 – 19 December 2016).
- Open Cut:
  - Continued mining operations in the Montrose Pit (including mining of previously sterilised coal caused by the April 2015 rain event and blasting of the Montrose Ridge);
  - Commencement of operations in Montrose East in October 2016 (including pit development, removal of topsoil, construction of erosion and sediment controls, placement of the out of pit dump and extraction of ROM coal); and
  - Commencement of South Wambo Boxcut in September 2016 (including dewatering of Chitter Dam, removal of sediment and overburden and commencement of ROM coal extraction).

Table 5 shows the production summary for 2016, compared to the production for 2015 and the forecast production for 2016 and 2017. ROM coal and saleable product in 2016 were higher than previously forecast due to changes to mine scheduling approved as part of MOP Amendment C approved in June 2016.

Table 5: Production Summary

Material	Unit[1]	Approved limit (specify source)	2015 reporting period (actual)	2016 reporting period (forecast)	2016 reporting period (actual)	2017 reporting period (forecast)
Waste Rock/ Overburden	bcm	-	26,031,388	26,801,227	26,704,560	31,500,000
ROM Coal/ Ore	Mt	14.7[2]	9.2	8.4	9.4	9.4
Coarse Reject	Mt	-	2.7	2.5	2.3	2.3
Fine Reject (Tailings)	Mt	-	0.58	0.45	0.8	0.8
Saleable Product	Mt	15[3]	5.8	5.7	6.3	6.1

1. bcm = bank cubic metres, Mt = million tonnes.
2. DA305-7-2003, Condition 7 Schedule 3.
3. DA177-8-2004, Condition 6 Schedule 3. Refers to product coal transported off-site.

During the reporting period, a total of 6.4 Mt of coal was transported off-site via rail (no coal was hauled off-site by trucks). Of this railed volume, 6.3 Mt was saleable product mined in 2016 and 0.1 Mt was stockpiled on-site from 2015. **Figure 4** shows the coal transported off-site on a weekly basis.

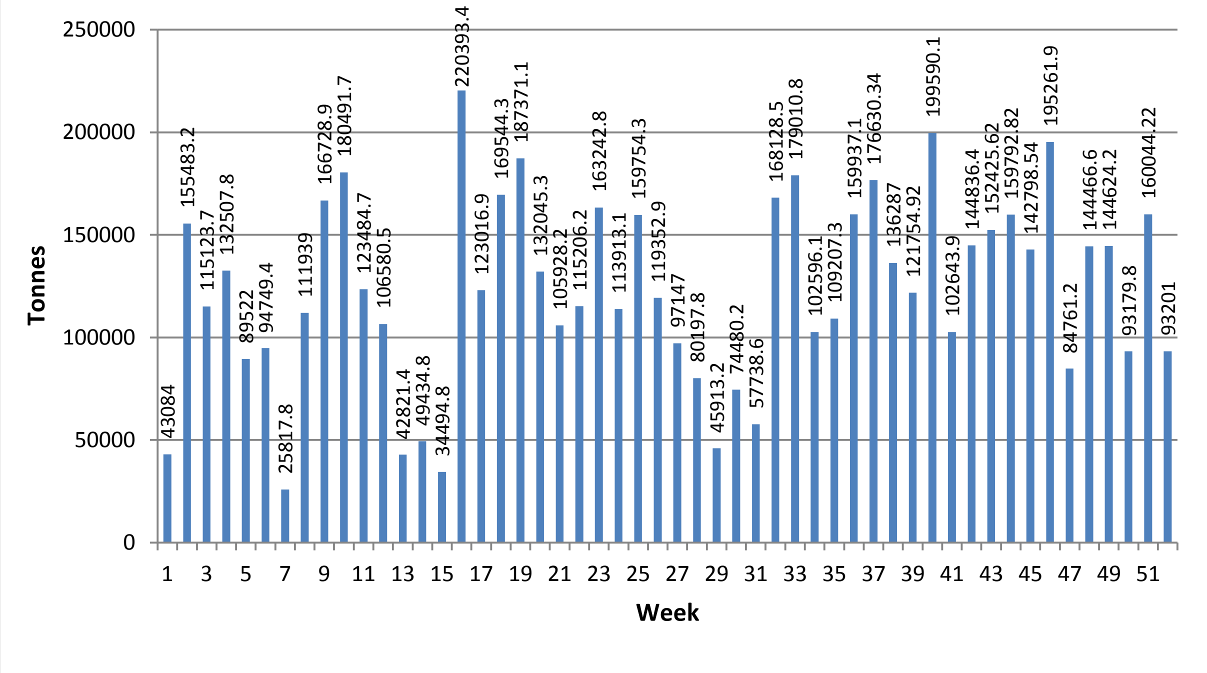


Figure 4: Coal Transported Off-site during the Reporting Period

3.2 Next Reporting Period

During the next reporting period:

- Mining will continue in the South Wambo Underground Boxcut (forecast to be completed in June 2017);
- Mining will continue in Montrose East (forecast to be completed in November 2017);
- Mining will continue to the north in Montrose Pit, in accordance with the MOP (2015-2020) plans;
- Mining operations will commence in the Roses Pit (forecast for commencement in November 2017); and
- Mining will commence in South Bates Underground Longwall 13 (January 2017), Longwall 14 (June 2017) and Longwall 15 (November 2017).

4.0 Actions required from previous Annual Review

A number of actions and improvements were identified in the WCPL 2015 Annual Review (Annual Environmental Management Report or AEMR) for completion during 2016. Additional actions were also requested by NSW government authorities following their review of the WCPL 2015 AEMR. These actions are summarised in **Table 6**.

Table 6: Actions from the 2015 Annual Review

Action/Improvement required from previous Annual Review	Requested by	Action taken by the Operator	Where discussed in Annual Review
A full review and update of the following plans and strategies:	WCPL	-	-
• Bushfire Management Plan;		During the reporting period, WCPL commissioned a Bushfire Risk Assessment of the Mine. The Bushfire Management Plan is scheduled to be updated in 2017.	Section 5.16
• Air Quality and Greenhouse Gas Management Plan;		The Air Quality and Greenhouse Gas Management Plan (AQGGMP) was revised and submitted for approval in 2016.	Section 5.3
• Flora and Fauna Management Plan (to be renamed the Biodiversity Management Plan);		The Flora and Fauna Management Plan (FFMP) (to be renamed the Biodiversity Management Plan) was reviewed and revised during the reporting period. The Biodiversity Management Plan was submitted to DPE in October 2016.	Section 5.6
• Environmental Management Strategy; and		The Environmental Management Strategy is scheduled for review during 2017.	Section 11.0
• MOP (to include revised mining and rehabilitation plans and rehabilitation performance criteria and monitoring requirements).		The MOP was revised during the reporting period to include revised mining and rehabilitation plans and rehabilitation performance criteria and monitoring requirements.	Section 7.0
WCPL will update the Surface Water Monitoring Program to reflect changes made to the stream flow monitoring program in 2015.		The Surface Water Monitoring Program was revised in December 2016 (Version 10) and submitted with the draft Extraction Plan for South Bates Underground Mine Longwalls 11 to 16.	Section 6.1
Installation of GPS units on site water carts pending review of budgets.		GPS units were not installed during the reporting period due to budget constraints. WCPL is investigating alternative measures to monitor the frequency and movement of water carts across the site.	Section 5.3.4
Finalisation of the Voluntary Conservation Agreements for the Biodiversity Offset Areas;		The content of the Voluntary Conservation Agreements (VCAs) were finalised during the reporting period and the VCAs are currently awaiting execution.	Section 5.6.2

Action/Improvement required from previous Annual Review	Requested by	Action taken by the Operator	Where discussed in Annual Review
Development of an Aboriginal Cultural Heritage Management Plan;		During the reporting period WCPL developed a Heritage Management Plan for the Mine, to consolidate all statutory requirements into one document and assist in the management of Aboriginal cultural heritage on-site.	Section 5.7
Commissioning of an audit of the HRSTS discharge system to ensure its effectiveness;		The Hunter River Salinity Trading Scheme (HRSTS) discharge system was reviewed during 2016. This review consisted of updating the communication hardware in consultation with Water NSW, calibration of instrumentation and development of operating procedures. Upon completion of this review, the guidelines for a HRSTS audit will be developed and an audit commenced in 2017.	Section 6.3.4
A new blast monitoring system and service provider will be sourced to minimise non recorded events associated with poor 3/4G phone reception. A tender for this system was issued in 2015 with review of proposals to be completed in February 2016. A provider will be engaged and the new system installed by March 2016 (approximately); and		Four blast monitoring stations were installed during the reporting period to monitor impacts of blasting. The performance of these systems will be reviewed during the next reporting period.	Section 5.2.3
A new dust monitoring system will be installed pending the outcome of discussions between EPA and DPE. This new system will monitor PM10 and PM2.5 particulates with monitors relocated to more closely monitor emitted particulates up and down wind of the Mine. As part of this change in monitoring the EPA is proposing that all existing dust monitoring is replaced with Beta Attenuation Monitor units (BAMS). The timing of this and subsequent variations to the EPL are determinant on when the EPA finalises their consultation with the DPE and its outcome.		During the reporting period, the AQGGMP was revised and submitted for approval. As part of this plan, the dust monitoring system has been revised.	Section 5.3.4
The 2015 Annual Review stated that a Topsoil Management Procedure was developed and implemented in 2014 and the procedure would be subject to review in 2016.		The Topsoil Management Procedure was revised in 2016.	Section 5.14
Aerial seeding will be considered as an option for reseeding of rehabilitation scheduled for 2016.		Aerial seeding was not considered to be a viable option during the reporting period.	Section 7.1.7

Action/Improvement required from previous Annual Review	Requested by	Action taken by the Operator	Where discussed in Annual Review
An audit of known subsidence impacts will be undertaken during the next reporting period to determine if these have self-repaired, are stable but pose a risk to long-term sustainable land use, or are deteriorating in condition.		An audit of known subsidence impacts was commissioned and commenced during the reporting period. The audit will be completed during the next reporting period.	Section 5.9.3
A scope of works to progress subsidence repairs will be developed in alignment with the subsidence audit in 2016.		The audit of known subsidence impacts will be completed during the next reporting period. Following completion of the audit, the scope of works to progress subsidence repairs will be developed.	Section 7.1.7
As a result of actions requested by DPE in 2015, an independent Rehabilitation Audit was commenced in December 2015 by GHD.	DPE	The rehabilitation audit was completed and the report finalised in June 2016. An update on the status of the audit recommendations has been included.	Section 9.4
Include in the Annual Environment Management Report, for the 2016 reporting period, an update on the status of the audit recommendations, including: 1. Matters that have been addressed in MOP amendments. 2. A strategy and timeframe for addressing matters that are still outstanding (ie no reporting or monitoring mechanisms, or completion criteria). 3. Matters that are subject to further refinement (pending the results of monitoring).	DRE[1,2]	An update on the status of the audit recommendations has been included.	Section 9.4
A program to the satisfaction of the Director Environmental Sustainability that includes timing is developed for the existing rehabilitation areas that do not meet the requirement of the consent conditions as reflected in the Mining Operations Plan. The plan is to be submitted to DRE by 1 December 2016 and progress towards implementation of actions is to be reported in the AEMR for 2016.		As advised by DRE, this requirement is satisfied as MOP Amendment D (approved November 2016) which is also compliant with DA305-7-2003.	-
A program is developed to manage contamination of laydown areas for equipment. The plan is to be submitted to DRE by 1 December 2016 and progress towards implementation of actions is to be reported in the AEMR for 2016 reporting period.		A report was issued to DRE on 1 December 2016. The report detailed that WCPL had removed all equipment from site contributing to the identified contamination and remediated the hydrocarbon spill.	-
The continued monitoring of subsidence and repair is reported in the AEMR for 2016 reporting period.		Monitoring of subsidence and repairs has been reported.	Section 5.9.3

1. Letter from DRE to WCPL re 2016 Rehabilitation Audit, dated 4 August 2016.
2. Letter from DRE to WCPL re 2015 AEMR, dated 25 August 2016.

5.0 Environmental Performance

5.1 Noise

Noise Impact Assessment Criteria for the Mine are defined in Table 9 of DA305-7-2003 (Condition 6, Schedule 4), Table 2 of DA177-8-2004 (Condition 3, Schedule 4) and EPL 529 (Condition L4). Additional noise conditions relating to land acquisition, operating hours, rail noise, noise monitoring and WCPL's Noise Management Plan (NMP) are also detailed in these approval documents.

5.1.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the approval criteria for noise is included in **Table 7.**

Table 7: Approval Criteria for Noise

Criteria[1]	dBA	Land Number[2]
Day - $L_{Aeq\ (15\ min)}$	35	All land
Evening/Night - $L_{Aeq\ (15\ min)}$	41	94
	40	3, 4B, 15B, 16, 25, 28A & B, 33, 39, 40 & 254A
	39	5, 6, 7, 37, 48
	38	1, 17, 18, 38, 49, 63, 75, 91
	37	27, 43, 137, 163, 246
	36	13B, 178, 188, 262A, B & C
	35	All other residential or sensitive receptors[3]
Night - $L_{A1\ (1\ min)}$	50	All land

Note: dBA = A-weighted decibels.

1. Criteria as per Condition 6, Schedule 4 of DA305-7-2003.
2. Properties identified in Table 9 of DA305-7-2003 (Condition 6, Schedule 4).
3. Excluding the receptors listed in Condition 1, Schedule 4 of DA305-7-2003.

A summary of the Environmental Impact Statement (EIS) predictions for noise is included in **Appendix B**, along with WCPL's performance against these predictions during 2016. For more information on the EIS predictions refer to the EIS (Resource Strategies 2003).

In addition to the statutory requirements detailed in **Table 7**, WCPL is also required to meet additional requirements detailed within the approved WCPL NMP. These requirements include reporting of monthly attended monitoring results on WCPL's website (or when there is an exceedance of criteria) and provision of results to the WCPL CCC.

5.1.2 Performance during the Reporting Period

During the reporting period, WCPL complied with all statutory noise conditions and requirements detailed in the WCPL NMP.

Monitoring was undertaken in accordance with the WCPL NMP. No exceedances or non-compliances were recorded for attended noise monitoring during the reporting period. Results were published on the WCPL website and details of non-compliances were provided to the WCPL CCC during meetings, in accordance with the WCPL NMP.

Twelve (12) complaints were received regarding noise from the Mine during the reporting period (**Section 8.3**).

WCPL did not receive any written requests for acquisition from the landowners of the land listed in Table 1 of DA305-7-2003 (Condition 1, Schedule 4) nor did it exceed the Land Acquisition Criteria listed in Table 10 of DA305-7-2003 (Condition 7, Schedule 4).

5.1.2.1 Comparison with EIS Predictions

An annual report summarising WCPL's 2016 attended noise monitoring data and comparisons against the EIS noise predictions is included in **Appendix B** (Global Acoustics 2017)**.**

A comparison of measured and predicted (2003 EIS) night-time noise levels indicate that the levels vary greatly, however it is noted that the comparison did not take into account operational activities at the time of monitoring compared to predicted scenarios (**Appendix B**).

5.1.3 Trends and Key Management Implications

Noise levels from WCPL complied with the relevant criteria at all monitoring sites during the 2016 attended monitoring surveys. Noise levels recorded in 2016 are generally consistent with levels recorded during the previous three reporting periods (**Appendix B**). As with previous reporting periods, wind speeds and/or temperature inversion conditions were at levels greater than which the development consent conditions would apply for the mine activities in some instances.

No environmental performance or management issues arose in regards to noise during the reporting period.

5.1.4 Implemented or Proposed Management Actions

WCPL will continue to implement the noise management measures detailed in the WCPL NMP.

During the reporting period, WCPL identified an opportunity to further improve the Mine's environmental performance through the sound attenuation of three 789 trucks. WCPL modified the three trucks during the reporting period in preparation for installation of the sound attenuation equipment, with installation scheduled for 2017.

5.2 Blasting

Air Blast Overpressure Limits and Ground Vibration Impact Assessment Criteria for the Mine are defined in Tables 12 and 13 of DA305-7-2003 (Conditions 11 and 12, Schedule 4), Tables 3 and 4 of DA177-8-2004 (Conditions 8 and 9, Schedule 4) and EPL 529 (Condition L5). Additional conditions relating to blasting hours and frequency, property inspections, assessments and investigations, cumulative impacts, operating conditions, blasting near the Wambo Homestead Complex (WHC), blast monitoring, blast fume and WCPL's Blast Management Plan (BMP) are also detailed in these approval documents.

5.2.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the approval criteria for blasting is included in **Table 8.**

Table 8: Approval Criteria for Blasting

Parameter	Criteria[1]	Allowable Exceedance
Airblast Overpressure Level dB (Lin Peak)	115	5% of the total number of blasts over a 12 month period
	120	0%
Ground Vibration Peak Particle Velocity (mm/s)[2]	5	5% of the total number of blasts over a 12 month period
	10	0%

1. Criterion as per Conditions 11 & 12, Schedule 4 of DA305-7-2003.Criteria must not be exceeded at any residence on privately-owned land.
2. For St Philip's Church, WCPL shall ensure that ground vibration peak particle velocity generated by the Mine does not exceed 2.5 millimetres per second (mm/s).

A summary of the EIS predictions for blasting is included in **Section 5.2.2.1**, along with WCPL's performance against these predictions during 2016. For more information on the EIS predictions refer to the EIS (Resource Strategies 2003).

In addition to the statutory requirements detailed in **Table 8,** WCPL is also required to meet additional requirements detailed within the approved WCPL BMP. These requirements include annual reporting on performance against the performance indicators detailed within the approved WCPL BMP (**Table 9**)**.**

Table 9: Blast Management Plan Performance Indicators

Performance Indicator
Blast monitoring results show 100% compliance with the Blast Criteria.
Blast monitoring results show 100% compliance with the 5 mm/s criteria applied to Wambo Homestead Complex.
No 'Rating 3' fume events leaving the Approved Surface Development Area (Project Area) or closed portion of a public road.
No 'Rating 4' or 'Rating 5' fume events.

5.2.2 Performance during the Reporting Period

Air blast overpressure and ground vibration levels recorded during the monitoring program complied with the approved criteria at all monitoring locations during all captured blasts (**Sections 5.2.3** and **10.6**). A summary of the blast monitoring data is included in **Appendix C**.

No blast fume events with Rating 3 (as defined in the *Australian Explosives Industry and Safety Group [AEISG], Code of Practice - Prevention and management of blast generated NOx Gases in surface blasting*) were recorded leaving the Approved Surface Development Area (Project Area) or closed portion of a public road during the reporting period. No Rating 4 or Rating 5 (AEISG) fume events were recorded at the Mine during the reporting period.

During the reporting period, WCPL failed to comply with the requirement to monitor all blasts at the Mine (**Section 10.6** details the non-compliance). WCPL complied with all other statutory blast conditions and requirements detailed in the WCPL BMP, including monitoring of performance against the performance indicators listed in **Table 9.**

Four (4) complaints were received regarding blasting (vibration and fume) from the Mine during the reporting period (**Section 8.3**).

5.2.2.1 Comparison with EIS Predictions

A comparison of WCPL's blast performance against the Year 13 predictions (Resource Strategies 2003) is summarised in **Table 10.**

Table 10: Comparison of EIS Predictions and 2016 Monitoring Data – Blasting

Land Holder	Midpoint Distance to Dwellings[1]	Predicted levels		Maximum recorded level during 2016		Closest WCPL Blast Monitor to Land Holder
		Peak Linear Airblast (dB re 20 µPa)	PVS Vibration	Airblast	Ground Vibration	
2 Lambkin	4,500 m	112 dBL	1.6 mm/s	113.6 dBL	0.33 mm/s	BM03[2]
25 Fenwick	3,300 m	114 dBL	1.9 mm/s	113.6 dBL	0.33 mm/s	BM03[2]
13(B) Skinner	1,000 m	123 dBL	4.0 mm/s	N/A[3]	N/A[3]	N/A[3]
24 Long	600 m	127 dBL	5.4 mm/s	N/A[3]	N/A[3]	N/A[3]

Note: dB = decibels, µPa = micropascals, PVS = peak vector sum, m = metres, dBL = low frequency noise level.

1. Based on planned production/mine progression
2. BM03 is used for performance based monitoring only. It is located on WCPL owned land to the south of the Mine.
3. This property is now owned by WCPL.

During the reporting period, a maximum air blast overpressure level of 113.6 dBL was recorded at BM03 (29 January 2016). This was below the predicted airblast overpressure level for Fenwick (114 dBL) but slightly above the predicted airblast overpressure level for Lambkin (112 dBL). For comparison, the overpressure level recorded at the other WCPL blast monitors during this blast was:

- Not recorded at BM01 (approximately 3 km north of BM03);
- 95.7 dBL at BM02 (approximately 5 km north east of BM03); and
- 104.5 dBL at BM05 (approximately 10 km north east of BM03).

The maximum ground vibration level of 0.33 mm/s was recorded at BM03 on 16 August 2016. This is well below the predicted levels for both Lambkin and Fenwick.

It should be noted that BM01 and BM03 are used for performance based monitoring only.

5.2.3 Trends and Key Management Implications

There were 106 blasts recorded during 2016, compared with 79 in 2015, 75 in 2014 and 62 in 2013. Air blast overpressure and ground vibration levels recorded during the 2016 blasts were similar to those recorded in the previous reporting periods. No exceedances of the blasting limits have been recorded at WCPL during the last four reporting periods.

During the reporting period, blasting was undertaken within 2 km of the WHC on five occasions. Ground vibration and air blast levels were recorded for each event, and did not exceed the blasting limits for the WHC.

WCPL achieved a capture rate of 97% for overpressure and 100% for vibration during the reporting period[1]. Failure to capture overpressure was primarily due to the reliability of the 3G/4G connection due to the Mine's location within a known mobile phone black spot location (Warkworth is identified in the Australian Government's "Mobile Black Spot Database of Reported Black Spot Locations", updated 25 February 2016). The increased capture rate for vibration is due to monitors having an in-built trigger system functionality for user set vibration limits.

The issue with the data capture rate for blasting has been an ongoing issue at WCPL over the last few years. In 2015, WCPL recorded a data capture rate of 90% for overpressure and 97% for vibration, in 2014 the capture rate was 95% for overpressure and 97% for vibration and in 2013 the capture rate was 92% for overpressure and 97% for vibration. The WCPL blast monitoring system was replaced in June 2016 and, following installation of the new system (which includes four new blast monitoring stations), capture rate has been 100% for both overpressure and vibration.

5.2.4 Implemented or Proposed Management Actions

During the next reporting period WCPL will continue to implement the approved WCPL BMP.

WCPL will also review the performance of the new blast monitoring stations during the next reporting period.

5.3 Air Quality

Air Quality Criteria for the Mine are defined in Tables 2, 3 and 4 of DA305-7-2003 (Condition 4, Schedule 4), Tables 5, 6 and 7 of DA177-8-2004 (Condition 14, Schedule 4) and EPL 529 (Condition P1). Additional conditions relating to air quality, odour and greenhouse gas emissions, land acquisition, operating conditions, WCPL's AQGGMP and Pollution Reduction Program are also detailed in these documents.

5.3.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the approval criteria for air quality is included in **Table 11.**

A summary of the EIS predictions for air quality is included in **Section 5.3.2.1**, along with WCPL's performance against these predictions during 2016. For more information on the EIS predictions refer to the EIS (Resource Strategies 2003).

In addition to the statutory requirements detailed in **Table 11**, WCPL is also required to meet additional requirements, in accordance with the approved WCPL AQGGMP. These requirements include reporting of greenhouse gas monitoring data in the Annual Review (**Section 5.4**).

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1 Homestead (structural monitoring) and Harris (performance monitoring) monitors have been excluded from the above calculations due to not being compliance based monitoring points.

Table 11: Approval Criteria for Air Quality

	Pollutant	Averaging Period	Criterion [a, b]
Long-term Impact Assessment Criteria	TSP	Annual	[c]90 µg/m^3
	PM_{10}	Annual	[c]30 µg/m^3
	Deposited Dust[d]	Annual	[e]2 g/m^2/month (maximum increase)
			[c]4 g/m^2/month (maximum total)
Short-term Impact Assessment Criteria	PM_{10}	24 hour	[c]50 µg/m^3

Note: TSP = Total Suspended Particles, PM_{10} = particulate matter with a diameter less than 10 micrometers, µg/m^3 = micrograms per cubic metre, g/m^2/month = grams per square metre per month.

a. Criterion as per Condition 4, Schedule 4 of DA305-7-2003 and Condition 14, Schedule 4 of DA177-8-2004. This criterion must not be exceeded at any residence on privately-owned land or on more than 25% of any privately-owned land.

b. Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed by the Secretary.

c. Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources).

d. Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method.

e. Incremental impact (i.e. incremental increase in concentrations due to the development on its own)

5.3.2 Performance during the Reporting Period

Air quality monitoring was undertaken during the reporting period, in accordance with the approved WCPL AQGGMP.

During the reporting period, WCPL complied with all statutory conditions relating to air quality, with the exception of the collection and analysis of depositional dust levels from a number of dust deposition gauges (D07 in April 2016, D20 in November 2016 and D23 in March 2016) (**Section 10.5**). WCPL complied with all additional air quality requirements detailed in the WCPL AQGGMP.

All of WCPL's PM_{10} monitors recorded annual averages below the compliance criteria of 30 µg/m^3 for the year. There were no exceedances of the 24 hour compliance criteria (50 µg/m^3) recorded during 2016.

During the reporting period a PM_{10} reading was missed five times. During these missed events, WCPL's three other PM_{10} monitors captured all data. This equates to a 99.7% capture rate for the PM_{10} monitoring system. At no point during the monitoring period was more than one monitoring point down. Failure to capture data can be attributed to hardware and software failures caused by power outages. A summary of the air quality monitoring data is included in **Appendix C.**

The annual average TSP concentration at all four monitoring locations did not exceed the long term impact annual average criteria of 90 µg/m^3 at any residence on any privately owned land.

Seven (7) complaints were received regarding dust from the Mine during the reporting period (**Section 8.3**).

During the reporting period, the WCPL Environmental Department provided training to the open cut workforce, which included appropriate measures and actions to manage dust emissions.

Throughout 2016, WCPL shut down or modified its open cut operations proactively as required in response to adverse wind conditions.

WCPL did not receive any written requests for acquisition from the landowners of the land listed in Table 1 of DA305-7-2003 (Condition 1, Schedule 4) nor did it exceed the Land Acquisition Criteria listed in Tables 5 to 7 of DA305-7-2003 (Condition 5, Schedule 4).

There were no incidents relating to air quality, odour or greenhouse gas during the reporting period.

5.3.2.1 Comparison with EIS Predictions

The EIS (Resource Strategies 2003) included predicted cumulative TSP, PM_{10} and dust deposition levels for three operational scenarios (Years 2, 7 and 9). The Year 7 and 9 scenarios best represent current operations at the Mine.

A summary of the predicted cumulative annual average TSP, PM_{10} and dust deposition levels for the Year 7 and 9 scenarios at the residences assessed in the EIS (Resource Strategies 2003) air quality assessment, that are most representative of the WCPL air quality monitoring sites, is provided in **Table 12**. The monitored annual average TSP, PM_{10} and dust deposition levels during 2016 are also provided in **Table 12**.

Table 12: Comparison of EIS Predictions and 2016 Monitoring Data – Air Quality

Parameter	Receiver		EIS Prediction		2016 Monitoring
	Monitoring Site	EIS Residence	Year 7 (2011)	Year 9 (2013)	
Annual Average TSP (µg/m^3)	HV01	19B (L Kelly)	46.7	40.5	47.8
	HV02	WCPL	12.6	13.4	47.7
	HV03	33 (DJ Thelander & JA O'Neill)	17.6	20.0	39.5
	HV04	40 (KM Muller)	32.8	30.5	56.6
Annual Average PM_{10} (µg/m^3)	AQ01 (PM01)	19B (L Kelly)	39.2	34.5	15.6
	AQ02 (PM02)	WCPL	11.0	11.8	17.5
	AQ03 (PM03)	33 (DJ Thelander & JA O'Neill)	16.2	18.1	14.1
	AQ04 (PM04)	40 (KM Muller)	29.1	26.6	16.3
Average Annual Deposited Dust (g/m^2/month)	D01	No Representative Dwelling Modelled	N/A	N/A	3.7
	D03	20 (Jerrys Plains Coal Terminal)	1.0	0.78	2.8
	D07	No Representative Dwelling Modelled	N/A	N/A	3.9
	D09	No Representative Dwelling Modelled	N/A	N/A	2.6
	D11	2 (W & D Lambkin)	0.35	0.35	2.3

Parameter	Receiver		EIS Prediction		2016 Monitoring
	Monitoring Site	EIS Residence	Year 7 (2011)	Year 9 (2013)	
	D12	51 (CM Hawkes Pty Ltd)	1.81	2.09	3.3
	D17	41B (Jelopo Pty Ltd)	0.31	0.33	1.4
	D19	19B (L Kelly)	1.48	1.10	2.5
	D20	WCPL	0.36	0.36	1.6
	D21	33 (DJ Thelander & JA O'Neill)	0.36	0.42	1.7
	D22	40 (KM Muller)	0.73	0.73	2.2
	D23	WCPL	0.28	0.28	1.4
	D24	75 (BA Barnes)	0.23	0.24	1.0
	D25	37 (IA & JE Lawry)	0.38	0.48	2.8
	D26	24 (AJ Long)	0.68	0.34	1.9

The annual average TSP concentrations at the four monitoring locations were above the predicted cumulative TSP concentrations at the relevant residences assessed in the EIS (Resource Strategies 2003) (**Table 12**). This is consistent with the 2014 and 2015 results.

The annual average PM_{10} concentrations at the four monitoring locations were below the predicted cumulative annual average PM_{10} concentrations at the relevant residences assessed in the EIS (Resource Strategies 2003) with the exception of AQ02 (WCPL owned residence). This is also consistent with the 2014 and 2015 results.

The monitored dust deposition rates were above the predicted cumulative dust deposition rates at the relevant residences assessed in the EIS (Resource Strategies 2003) (**Table 12**). This is consistent with the 2014 and 2015 results.

The difference between the predicted and monitored TSP, PM_{10} and dust deposition levels is considered to be due to a number of factors:

- natural variability in background air quality (e.g. dust storms and bush fires);
- current WCPL mine layout/progression is similar but not the same as the modelled scenarios; and
- the EIS (Resource Strategies 2003) cumulative predictions included emissions from surrounding mining operations (i.e. United Colliery, Hunter Valley Operations and Warkworth Mine) but did not include emissions from general background sources as indicated by background monitoring to avoid double counting of existing mining-related emissions.

5.3.3 Trends and Key Management Implications

There are no air quality, odour or greenhouse gas management implications arising from WCPL's operations for the reporting period.

5.3.3.1 TSP

TSP levels recorded by WCPL's four High Volume Air Samplers (HVAS) during the reporting period were all lower than those recorded in 2014 and 2015 and generally consistent with levels recorded in the previous five reporting periods, as shown in **Table 13** and **Figure 5**. The data shows there was a general increase in recorded TSP levels from 2011 to 2014, and has been generally declining in recent years.

Table 13: TSP Annual Averages (µg/m^3) (2011-2016)

HVAS	2011	2012	2013	2014	2015	2016
HV01	56.7	64.8	61	66	54.8	47.8
HV02	48.8	61.4	62	58	51.5	47.7
HV03	49.0	38.9	41	48	40.6	39.5
HV04	41.0	58.6	49	63	60.6	56.6

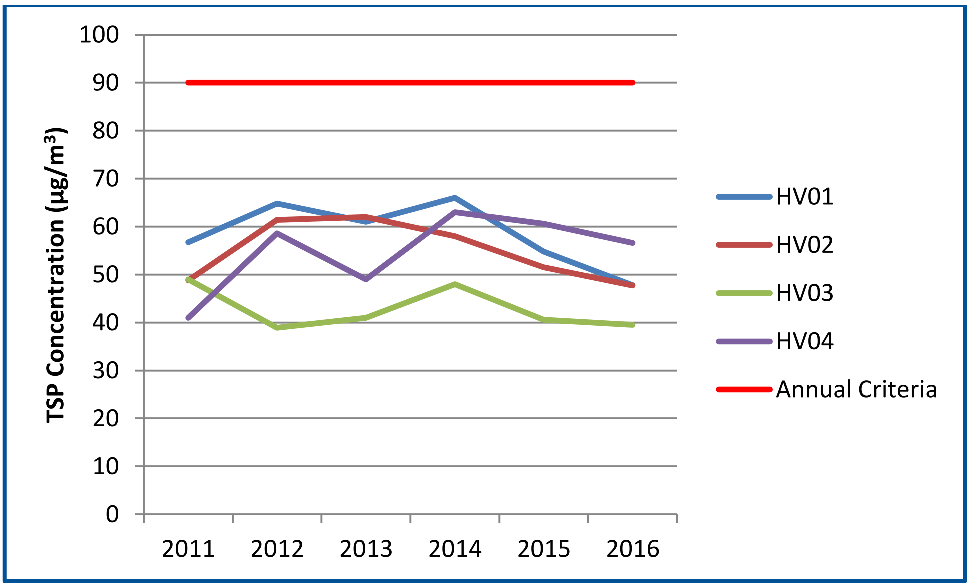

Figure 5: TSP Annual Averages (2011-2016)

Compared to the EIS predictions for Year 9 (**Table 12**) (Resource Strategies 2003), WCPL's recorded TSP levels (**Table 13**) are higher than the levels predicted.

5.3.3.2 PM$_{10}$

PM$_{10}$ concentrations recorded by WCPL's four Tapered Element Oscillating Microbalance Analyser (TEOM's) during the reporting period were lower than those recorded during 2012, 2013 and 2014 and were similar to those reported in 2011 and 2015 as shown in **Table 14** and **Figure 6.** The data shows that PM$_{10}$ concentrations in general rose from 2011 to 2012 however there has been a steady decline in recent years, with levels in 2016 steady or slightly higher than 2015.

Table 14: PM$_{10}$ Annual Averages (µg/m^3) (2011-2016)

TEOM	2011	2012	2013	2014	2015	2016

TEOM	2011	2012	2013	2014	2015	2016
AQ01 (PM01)	16.8	21.0	19.3	18.0	15.7	15.6
AQ02 (PM02)	17.2	21.1	22.3	19.0	16.0	17.5
AQ03 (PM03)	16.7	16.6	16.5	15.3	12.9	14.1
AQ04 (PM04)	16.2	18.3	16.8	17.7	16.5	16.3

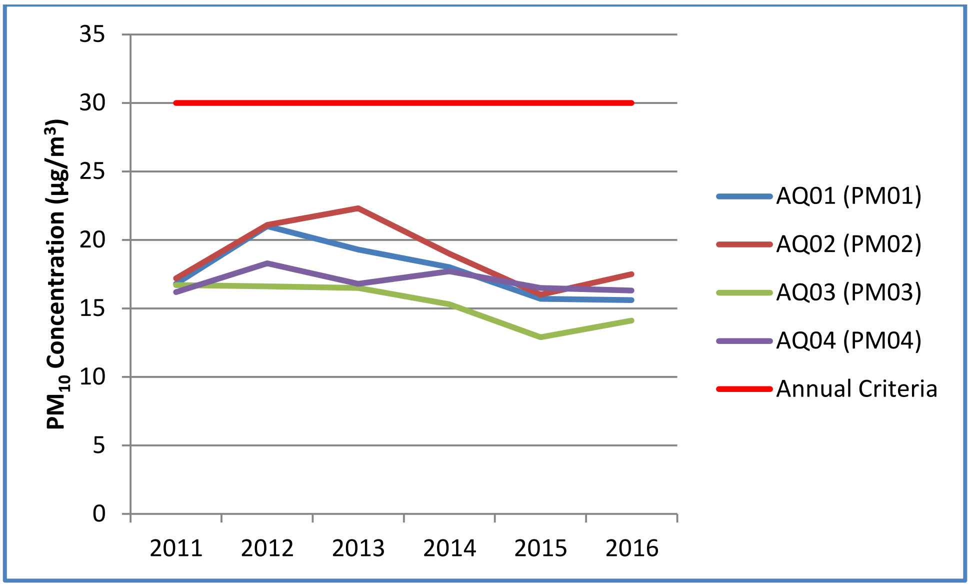

Figure 6: PM_{10} Annual Averages (2011-2016)

5.3.3.3 Dust deposition

Dust deposition levels recorded by WCPL's 15 dust deposition gauges (DDGs) during the reporting period remained consistent with levels recorded in the previous four reporting periods as shown in **Table 15.**

Table 15: Dust Deposition Annual Averages (g/m^2/month) (2011-2016)

DDG	2011	2012	2013	2014[1]	2015[1]	2016[1]
Privately Owned Land						
D24	1.1	1	1.1	1.4	1.4	1.0
D17	1.4	1.7	2.8	1.8	1.7	1.4
D22	1.2	1.4	2.0	2.2	2.0	2.2
D25	1.6	2.2	2.7	2.7	2.6	2.8
D21	1.2	1.4	1.9	1.9	2.0	1.7
D11	2.0	2.2	2.2	2.5	2.2	2.3
WCPL Owned Land						
D01	8.1	15.8	8.8	2.9	2.8	3.7
D03	3.0	2.2	2.8	3.0	3.0	2.8
D07	5.2	5.0	5.0	6.0	5.4	3.9
D09	3.7	4.5	3.9	2.0	3.3	2.6
D12	2.8	3.2	2.9	3.3	3.3	3.3
D19	2.5	2.9	3.1	2.9	3.1	2.5

DDG	2011	2012	2013	2014[1]	2015[1]	2016[1]
D20	1.4	1.7	1.7	1.8	1.6	1.6
D23	2.0	1.8	1.8	2.1	1.8	1.4
D26	1.2	1.6	1.3	2.0	2.1	1.9

1. Throughout the period of sampling it was noted some of the dust gauges contained various sources of foreign material including bird droppings, insects, sticks and other organic matter when analysed. Contamination was assessed based on field observations, laboratory observations, and historical data and wind patterns. All monthly dust results deemed to be contaminated were excluded from the annual average.

5.3.4 Implemented or Proposed Management Actions

A number of proposed dust mitigation measures were identified in the 2015 Annual Review for implementation during the reporting period. These measures included:

- Fitting water carts with GPS tracking devices to monitor frequency and movement of water carts across the site;
- Environmental Department to conduct training sessions with site Open Cut Examiners (OCEs) in 2016 to drive changes in operator behaviour and improve risk identification relating to dust generation on-site; and
- Installation of a new dust monitoring system for PM_{10} and particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$) pending the outcome of discussions between EPA and DPE.

Water carts were not fitted with GPS units during the reporting period due to budgeting constraints. WCPL is currently reviewing alternative measures to monitor the frequency and movement of water carts across the site.

In order to further minimise dust generation on haul roads around the Mine, WCPL's Environmental Department conducted training sessions with site OCE's in 2016 to drive changes in operator behaviour and improve risk identification relating to dust generation on-site.

WCPL will continue to implement the approved WCPL AQGGMP. During the reporting period, the AQGGMP was revised and submitted for approval. As part of this plan, the dust monitoring system has been revised. The performance of the revised dust monitoring system will be reviewed during the next reporting period.

5.4 Greenhouse Gas

5.4.1 Approval Criteria/EIS Predictions and Management Plan Requirements

There is no approval criterion for greenhouse gas emissions in WCPL's statutory approvals.

A summary of the EIS predictions for carbon dioxide (CO_2) emissions is included in **Section 5.4.2**, along with WCPL's performance against these predictions from 2013 to 2016. For more information on the EIS predictions refer to the EIS (Resource Strategies 2003).

WCPL is required to report greenhouse gas monitoring data in the Annual Review, in accordance with the approved WCPL AQGGMP.

5.4.2 Performance during the Reporting Period

Greenhouse gas monitoring was undertaken during the reporting period, in accordance with the approved WCPL AQGGMP. WCPL calculates and reports on greenhouse gas emissions at the end of every financial year, hence the summary data provided in **Table 16** below is for the period 1 July 2015 – 30 June 2016. Monitoring data for the second half of the 2016 reporting period will be included in the 2017 Annual Review.

A total of 648,679 tonnes of CO_2 was emitted by the Mine's ventilation systems in 2016 compared to the predicted 2,380,053 tonnes for 2016.

Table 16: Comparison of EIS Predictions and Monitoring Data – Greenhouse Gas

Parameter	Monitoring Point	Monitoring Frequency	Emissions Calculated	Calculated CO_2-e tonnes for 2013 - 2014	Calculated CO_2-e tonnes for 2014 - 2015	Calculated CO_2-e tonnes for 2015 – 2016	EIS predicted CO_2-e tonnes for 2016[1]
Ventilation Systems							
Methane	Main Ventilation Shaft	Real-time continuous	Emission factor to convert from tonnes of CH4 to tonnes of CO_2-e	591,362	703,596	618,127	
Carbon Dioxide	Main Ventilation Shaft	Real-time continuous	Tonnes of CO_2-e	23,205	26,750	30,552	
Total				**614,567**	**730,346**	**648,679**	**2,380,053**
Other (Diesel and Electrical Power)							
Diesel Use	Calculated from invoices	Annually	Emission factor to convert from kL use to tonnes of CO_2-e	98,084	92,935	97,983	
Oil Use	Calculated from invoices	Annually	Emission factor to convert from kL use to tonnes of CO_2-e	39 (plus 3,652 kL not combusted)[2]	280 (plus 321 kL not combusted)	339 (plus 104 kL not combusted)	
Grease Use	Calculated from invoices	Annually	Emission factor to convert from kL use to tonnes of CO_2-e	0 (plus 4,880 kL not combusted)[2]	0 (plus 63 kL not combusted)	0 (plus 42 kL not combusted)	
Electricity Use	Calculated from invoices	Annually	Emission factor to convert from kWh use to tonnes of CO_2-e	79,869	78,576	76,506	
ROM Coal Production	Calculated from weight meter and survey	Monthly	Fugitive emissions factor based on ROM production[3]	70,183 (UG Stockpile residual emissions) 12,155 (OC Fugitives)	59,124 (UG Stockpile residual emissions) 31,899 (OC Fugitives)	80,543 (UG Stockpile residual emissions) 24,634 (OC Fugitives)	
Sub-Total				**260,330**	**262,814**	**280,005**	**252,606**
Total				**874,897**	**993,160**	**928,684**	**2,632,659**

Note: CO_2-e = carbon dioxide equivalent, CH4 = methane, kL = kilolitres, OC = Open Cut, UG = Underground, kWh = kilowatt hours.

1. Refer to Tables 16 and 17 of Appendix B of the WCPL EIS (Resource Strategies 2003).
2. Anomalous results recorded during 2014 for non-combustible grease and oil use are believed to be due to human error in internal accounting procedures.
3. Wambo Open Cut uses Method 2 in situ measured emissions calculations for fugitive emissions. This involves the application of a gas model to as-mined pit shells for the year to generate the measured emissions number.

The emissions predictions in the 2003 EIS were based on the assumption that the simultaneous mining of two longwalls (Wambo and Arrowfield/Bowfield) in conjunction with Arrowfield/Bowfield gas drainage would occur during 2016. During this reporting period, only one longwall was operational which accounts for actual emissions only being approximately 30% of the predicted volumes.

A total of 280,005 tonnes of CO_2 was emitted from the operation from all other sources. This is slightly higher than the predicted 252,606 tonnes for 2016.

5.4.3 Trends and Key Management Implications

Levels of total CO_2 emissions monitored from the main ventilation shafts in 2016 were approximately 10% lower than the equivalent period in 2015 and were similar to levels in 2014.

Annual emissions from diesel and other sources associated with production-related electrical generation have overall remained relatively consistent with EIS predictions and between reporting periods.

5.4.4 Implemented or Proposed Management Actions

WCPL did not undertake any targeted energy saving projects during 2016, however energy efficiency is considered during the design and construction of haul roads and mine planning.

5.5 Meteorology

WCPL are required to maintain a meteorological monitoring station at the Mine and monitor the parameters specified in Table 11 of DA305-7-2003 (Condition 10, Schedule 4) and Condition M4 of EPL 529, using the specified units of measure, averaging period, frequency and sampling method described in the tables.

WCPL's meteorological monitoring station is located approximately 350 m east of the WCPL administration building. WCPL maintains the station in accordance with Australian Standard (AS) 2923-1987. The following parameters are monitored by the station, in accordance with WCPL's statutory conditions:

- Temperature (at 2 m and 10 m);
- Rainfall;
- Lapse rate[2];
- Wind speed (at 10 m);
- Wind direction (at 10 m);
- Solar radiation (at 10 m);
- Humidity; and
- Sigma theta.

[2] WCPL calculates the lapse rate from measurements made at 2 m and 10 m, in accordance with DA305-7-2003.

Table 17 summarises the annual rainfall, temperature and wind direction data for 2016, compared to the previous two reporting periods.

Table 17: Environmental Performance – Meteorology (2014-2016)

	2014	2015	2016
Rainfall (mm)	556.44	789.49	721.18[2]
Maximum Temperature (°C)[1]	45.3 (Nov)	40.8 (Nov)	41.6 (Dec)
Minimum Temperature (°C)[1]	-1.7 (June)	-0.85 (June)	-3.4 (July)
Mean Temperature (°C)[1]	18.11	19.17	18.4
Predominant Wind Direction	E/SE (summer) W/NW (winter)	S/SE (summer) W/SW (winter)[3]	S/SE (summer) SW (winter)

Note: mm = millimetres, °C = degrees Celsius, E = East, SE = South-east, W = West, NW = North-west, SW = South-west.

1. Measured at 2 m above ground.
2. The wettest month was January (210 mm). The driest month was August (12.8 mm).
3. The winter data (2015) was influenced by the use of the Charlton Ridge weather station which may explain the change in weather direction as WCPL's weather station was experiencing software issues.

5.6 Biodiversity

WCPL has an approved FFMP for the Mine which was extensively reviewed in 2013 and approved in 2014 (Version 8). The FFMP documents management practices aimed at minimising the potential impacts on flora and fauna as a result of WCPL's operations. The FFMP includes a Vegetation Clearance Protocol and Threatened Species Management Protocol, which are managed through WCPL's Surface Disturbance Permit. The FFMP also outlines the management actions for all biodiversity management domains on-site, including the RWEAs and Open Cut Woodland Revegetation area, as well as the annual Flora and Fauna Monitoring Program.

WCPL are required to implement the biodiversity offset strategy summarised in Table 16 of DA305-7-2003 (Condition 40, Schedule 4). Management of the offset areas, or RWEAs, is undertaken in accordance with WCPL's approved FFMP.

In 2015, WCPL commenced a major review of the FFMP (to be renamed the Biodiversity Management Plan) and associated monitoring program. The Biodiversity Management Plan was revised to be consistent with the *Hunter Valley Coal Mines - Best Practice Guidelines for Biodiversity Offset Management Plans* (DPE, 2014) and was submitted to DPE and DoEE during the reporting period. As part of this review, WCPL also developed new performance targets for rehabilitated areas and RWEAs. These draft targets, developed during the 2015 monitoring program and using data collected previously in vegetation relatively undisturbed by mining activities, are included in **Section 5.6.1**.

5.6.1 Approval Criteria/EIS Predictions and Management Plan Requirements

Performance measures for subsidence impacts on biodiversity are detailed in Condition 22, Schedule 4 of DA305-7-2003 (**Section 5.9.2**).

WCPL are required to monitor and report on biodiversity in accordance with the conditions of DA305-7-2003, DA177-8-2004, EPBC2003/1138 and the approved WCPL FFMP.

In 2015, WCPL engaged Eco Logical Australia Pty Ltd (Eco Logical) to review and revise the monitoring program and performance criteria contained within the approved FFMP, to increase efficiency while ensuring an effective monitoring program that satisfies WCPL's statutory approval conditions. As part of this review WCPL is transferring across to a combined Landscape Function Analysis (LFA)/Biometric monitoring methodology. This methodology seeks to provide quantitative data that will accurately detail the progress of rehabilitation and inform accurate management decisions. Whilst the new performance criteria (or targets) are still in draft format, WCPL has sought approval for the new Biodiversity Management Plan (including these draft targets) during the reporting period and hence WCPL has adopted these targets and used them to assess the Mine's performance for 2016. These draft performance targets are included in **Table 18** and **Table 19.**

Table 18: Draft Performance Targets for Biodiversity (LFA)

Rehabilitation Type	LOI[1]	SI[1]	INFI[1]	NI[1]
Pasture	>0.93	>61	>29	>25
Woodland	>0.87	>59	>43	>36
North Wambo Creek Diversion (NWCD)	>0.84	>62	>41	>37

1. LOI = landscape organisation index, SI = stability index, INFI =infiltration, NI = nutrient index.

Table 19: Draft Performance Targets for Biodiversity (Biometric)

	Attribute[1]								
	NNS	NOS	NMS	NGCG	NGCS	NGCO	EPC	OR	FL
Rehabilitation									
Older Woodland Areas with a canopy of Sugar Gum	>15	15-40	5-40	5-15	5-10	5-15	<20	1	5
Areas of Narrow-leaved Ironbark – Bull Oak - Grey Box open forest	>20	10-40	5-10	15-50	5-10	5-40	<20	1	-
RWEAs									
PCT1658[2]	>20	10-40	10-50	4-20	5-30	5-35	<10	1	-
PCT42[2]	>20	10-50	10-50	20-60	1-5	5-30	<10	1	-
PCT1603[2]	>25	10-40	5-10	15-20	5-10	5-40	<5	1	-
PCT1604[2]	>35	15-40	5-20	30-50	5-15	5-40	<5	1	-
PCT1584[2]	>45	15-45	5-40	5-40	10-20	5-20	<5	1	-
PCT1176[2]	>21	15-40	5-30	5-30	0-25	2-10	<5	1	-

1. NNS = the number of native plant species (native to NSW), NOS (%) (including *E.cladocalyx*) = projected native foliage cover of canopy, NMS (%)(including *A.saligna*) = projected native midstorey cover, NGCS = native groundcover of grasses, NGCS = native groundcover of shrubs, NGCO = native groundcover of other plant types (sedges, herbs etc.), EPC = exotic plant cover, OR = overstorey regeneration over the whole vegetation zone, FL= length of fallen logs >10 cm diameter within the vegetation plot.
2. PCT1658: Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak – Coast Banksia woodland on sands of the Warkworth area, PCT42: River Red Gum/River Oak riparian woodland wetland in the Hunter Valley, PCT1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter, PCT1604: Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter, PCT1584: White Mahogany - Spotted Gum – Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley and PCT 1176: Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion.

5.6.2 Performance during the Reporting Period

VCAs for the offset areas were drafted in consultation with the Office of Environment and Heritage (OEH) during 2015, in accordance with Condition 41, Schedule 4 of DA305-7-2003. WCPL and OEH finalised the content of the VCAs during the reporting period and the VCAs are currently awaiting execution.

During the reporting period, WCPL commissioned Eco Logical to monitor the fauna and vegetation structure within the RWEAs. This monitoring forms part of WCPL's revised biodiversity monitoring program. A copy of the 2016 Annual Flora and Fauna Monitoring Report (Eco Logical 2017a) is included in **Appendix D.**

The monitoring data collected during the reporting period indicates that remnant woodland sites appear to be generally performing well, with few weeds and meeting the draft performance criteria in **Table 18** and **Table 19** (Eco Logical 2017a). Dieback of *Angophora floribunda* (Smooth-barked Apple) was observed within the Warkworth Sand area of RWEA 'A' and was considered to be due to natural causes such as insect attack (Eco Logical 2017a).

As reported in the 2015 Annual Review, the NWCD area is not yet meeting the draft performance criteria with further management required to achieve a net increase in the quantity of riparian vegetation at North Wambo Creek following the diversion, as stated in the draft NWCD Rehabilitation Plan (Eco Logical 2017a). During the reporting period, 250 tree guards were installed around trees seeded as a part of the 2015 NWCD rework.

During 2016, WCPL trialled the "Rapid Appraisal of Riparian Condition" methodology (Jansen *et. al.* 2005) to assess the condition of North Wambo, South Wambo and Stony Creek. Due to this change and previous changes to the scoring methodology, it was not possible to directly compare the current riparian condition scores to previous years (Eco Logical 2017a). The field observations and data collected suggest that no dramatic changes have occurred since the previous monitoring, however Eco Logical recommended limiting of grazing in riparian zones be continued and planting of riparian vegetation where appropriate (Eco Logical 2017a).

During the reporting period WCPL undertook an audit of fence lines within the RWEAs to identify remnant fence lines that can be readily removed without vegetation and ground disturbance. As a result of this audit, approximately 1 km of internal fence line was removed from RWEA A during the reporting period.

Aquatic monitoring was conducted by Niche Environment and Heritage during the reporting period to assess the river health of drainages occurring above the North Wambo Underground Mine area, open cut operations and associated infrastructure. These drainages include North Wambo Creek, Wambo Creek (also known as South Wambo Creek), Waterfall Creek and Wollombi Brook. A copy of the Annual Environmental Reporting 2016 Aquatic Ecosystem Monitoring (Niche 2016) is included in **Appendix E**.

The aquatic monitoring indicated that upper South Wambo Creek had good stream health (Band A) while Waterfall Creek (Band C) and sites within the North Wambo Creek stream realignment (Band D) exhibited poor stream health. Although poor, there were some signs of growth of riparian vegetation and macrophytes within the North Wambo Creek stream realignment (Niche 2016).

A sediment dam failure in January 2016 (**Section 10.1**) caused sediment deposition in a tributary of Waterfall Creek, however no apparent impact on the macroinvertebrate communities within Waterfall Creek was observed (Niche 2016).

5.6.3 Trends and Key Management Implications

WCPL-owned land continues to provide habitat for a large diversity of bird species, including six species listed on the EPBC Act and/or *Threatened Species Conservation Act, 1995* as vulnerable or endangered and several migratory species. Analysis of trends over time is problematic as the number of monitoring sites, survey effort, observers and timing of surveys has differed between 2007 and 2016 (Eco Logical 2017a).

Bird assemblages in 2016 appear to be broadly similar to the previous two years (2015 and 2014) and also 2009. Some of the differences in the species recorded between years are due to nomadic honeyeaters, waterbirds and lorikeets or irregular migratory species such as the Cicadabird, that are present during monitoring surveys in some years but absent in others (Eco Logical 2017a). Both Double-barred Finches and Red Browed Finches were absent from the 2016 survey but were recorded previously in 2009, 2014 and 2015. The reasons behind the absence of these finches in 2016 are unclear but may be due to changes in resource availability, such as grass seed and water (Eco Logical 2017a).

While broad comparisons and observations have been made (primarily between the last three years), the results of longer term monitoring, using consistent methods and statistical analysis to detect trends in bird distribution and abundance over time, will be more meaningful in separating trends in bird distribution and abundance from short-term fluctuations (Eco Logical 2017a).

The aquatic monitoring report (Niche 2016) found that comparison with previous survey data showed no significant temporal trends attributable to current catchment management. Ephemeral streams (North Wambo, South Wambo and Waterfall creeks) are particularly susceptible to variations in water availability, which in turn affect the availability of aquatic habitat and lead to changes to water quality associated with a drying system. These changes ultimately result in changed aquatic faunal communities. Ephemeral stream ecology, and its extremes need to be considered carefully when interpreting and managing the health of waterways within Wambo Coal land (Niche 2016).

5.6.4 Implemented or Proposed Management Actions

The revised FFMP (Biodiversity Management Plan) was finalised and submitted to DPE for approval during the reporting period.

During the reporting period, minor relocations of floristic and habitat monitoring locations were made to better align with flora community boundaries. No changes were made to VCA monitoring locations.

Changes were also made to the riparian monitoring sample sites and transects to provide better spatial coverage and to be consistent with landholder boundaries.

5.7 Aboriginal Heritage

WCPL manages Aboriginal heritage on-site in accordance with a number of Aboriginal Heritage Impact Permits (AHIPs) issued by the OEH. Any Aboriginal objects salvaged under these permits are managed in accordance with a Care Agreement.

During the Surface Disturbance Permit assessment process, WCPL undertake a due diligence assessment to ensure that no artefacts that may have been identified in the area are damaged.

WCPL completed the following Aboriginal archaeological surveys during 2016:

- Due diligence surveys (including desktop assessment and Aboriginal Heritage Information Management System [AHIMS] search) of the Redbank Hill Access Rd, Le Baron Dump areas and Redbank Hill Coal Investigation area in preparation for open cut coal investigation and continued mining operations.
- Due diligence surveys (including site inspections and AHIMS search) of approximately 92 exploration sites within WCPL Coal and Mine Lease boundaries.
- Due diligence surveys prior to the excavation of 15 shallow soil test pits which resulted in two pit locations being revised as a result of new archaeological finds.
- Due diligence surveys (including field survey and AHIMS search) for proposed drilling works in the South Bates Extension Area.
- Due diligence surveys (including AHIMS search) for 13 proposed drill sites within A444 and EL7211 Exploration Lease areas.
- Surveys in November 2016 in support of an Aboriginal Cultural Heritage Assessment for the South Bates Extension Modification.

The due diligence surveys completed during 2016 identified minimal or no impact to Aboriginal heritage from the proposed works. WCPL plans to continue due diligence surveys as required during the next reporting period. No change in the current procedure is planned.

During 2016, South East Archaeology was engaged by WCPL to reassess the 12 reported grinding groove locations and one potential scarred tree within the Mine, specifically to identify whether they relate to Aboriginal occupation or were formed from natural or other processes (such as non-indigenous land use impacts). South East Archaeology (2016a) concluded that ten of the reported groove locations are the consequence of natural erosion and weathering processes and are not of Aboriginal origin or associated with Aboriginal occupation. Further assessment of Wambo Site 117 (unable to be relocated) and Wambo Site 473 (origin unable to be confirmed as Aboriginal or non-Aboriginal) was considered to be required (South East Archaeology, 2016a). South East Archaeology (2016b) conclude the scarred tree was not of Aboriginal origin due to the age and shape of the scar and the absence of axe-marks.

Subsequently, South East Archaeology was engaged by WCPL to conduct a supplementary assessment of Wambo Site 117 and Wambo Site 473. The supplementary report concluded that Wambo Site 117 and Wambo Site 473 were not of Aboriginal origin (South East Archaeology, 2016c).

The status of the 12 previously listed grinding groove and scarred tree sites have been updated in AHIMS to reflect the revised assessment (i.e. the sites are now recorded as not of Aboriginal origin).

Condition 51, Schedule 4 of DA305-7-2003 requires WCPL to develop a conservation agreement (as part of the conservation agreement for biodiversity offsets discussed in **Section 5.6.2** above) for the management of Aboriginal cultural heritage in RWEA A in consultation with the Aboriginal communities and OEH. The content of the VCAs was finalised during the reporting period, and the VCAs are currently awaiting execution.

During the reporting period WCPL developed a Heritage Management Plan for the Mine, to consolidate all statutory requirements into one document and assist in the management of Aboriginal cultural heritage on-site. The draft Heritage Management Plan was distributed for consultation to Aboriginal parties registered at the Mine and is planned for finalisation in the next reporting period.

5.8 Non-Aboriginal Heritage

WCPL is required to prepare a Conservation Management Plan (CMP) for the WHC in accordance with Conditions 58 and 59, Schedule 4 of DA305-7-2003. A CMP was prepared by WCPL in 2006 and reviewed in 2012 by heritage consultants Godden Mackay Logan. The CMP is due for review in 2017.

An annual photographic record of the elevations of all structures at the WHC was also lodged with the NSW Heritage Office, Singleton Council and DPE on 28 October 2016, in accordance with Condition 62, Schedule 4 of DA305-7-2003.

During the reporting period, WCPL undertook blasting that was within 2 km of the WHC during the reporting period. Blasting was undertaken in accordance with the approved WCPL BMP and results of monitoring undertaken at the WHC indicated compliance with all criteria.

5.9 Subsidence

5.9.1 Extraction Plans

During the reporting period, WCPL received approval for an Extraction Plan for the South Bates Underground Longwalls 11-13. The Extraction Plan was submitted in October 2015, revised in January 2016 and approved in February 2016. During the reporting period, WCPL prepared an Extraction Plan for the South Bates Underground Longwalls 11-16 (by way of updating the approved Extraction Plan for the South Bates Underground Longwalls 11-13 to include Longwalls 14-16). The Extraction Plan for South Bates Underground Longwalls 11-16 was submitted to DPE in January 2017.

5.9.1.1 Extraction Plan for North Wambo Underground Longwalls 8-10A

WCPL received approval from DPE on 24 June 2015 for the extraction plan for North Wambo Underground Longwalls 8-10A. DPE requested in their letter of approval that WCPL undertake further review and revision of the WCPL Groundwater Monitoring Plan (GWMP) in consultation with the NSW Office of Water (now DPI-Water) by 30 September 2015. A revised GWMP was submitted to DPE in September 2015 and approved by DPE on 27 November 2015.

The following documents were required to be updated to incorporate the extraction plan for North Wambo Underground Longwalls 8-10A:

- Inrush Management Plan (as part of the notification under clause 33 of the Work Health and Safety [Mines] Regulation, 2014); and
- MOP (as required under the conditions of the ML).

The Inrush Management Plan is reviewed and updated internally prior to commencement of mining for each longwall panel. The Inrush Management Plan is scheduled for review again upon sealing of the North Wambo Underground.

The following reporting is required to be undertaken as part of the extraction plan for North Wambo Underground Longwalls 8-10A:

- Subsidence Management Status Reports - to be updated fortnightly and submitted (by email) if new impacts are identified or upon request, to DPE (Manager, Mining Projects), DRE (Subsidence Executive Officer) and the NSW Dams Safety Committee (DSC) (Executive Engineer) (where the longwall face is within the DSC Notification Area of the Wambo South Water Dam or the North East Tailings Dam).
- Six Monthly Report - to be updated annually for the period 1 January to 31 July and submitted (by email) to DPE (Manager, Mining Projects), DRE (Subsidence Executive Officer), Mine Subsidence Board (MSB) (District Manager), OEH/EPA (General Contact) and DPI-Water (Manager Strategic Stakeholder Liaison).
- Annual Review - to be updated annually for the period 1 January to 31 December and submitted (by email and post) to DPE (Manager, Mining Projects), DRE (Subsidence Executive Officer), DRE (Director – Environmental Sustainability), MSB (District Manager), OEH/EPA (General Contact), DPI-Water (Manager Strategic Stakeholder Liaison), Singleton Shire Council (General Manager) and CCC Members.

The component management plans of the extraction plan for North Wambo Underground Longwalls 8-10A reference components of a number of existing Environmental Management Plans (EMPs) to avoid duplication. If these EMPs are revised separately in accordance with DA305-7-2003 the EMPs in the extraction plan for North Wambo Underground Longwalls 8-10A will be updated accordingly.

5.9.1.2 Extraction Plan for South Bates Underground Longwalls 11-13

Modification 15 for the South Bates Underground (Whybrow Seam) Longwalls 11-13 was submitted to DPE in October 2015, revised in January 2016 and approved in February 2016.

The following reporting is required to be undertaken as part of the extraction plan for South Bates Underground Longwalls 11-13:

- Incident Report – to be prepared as required and submitted (by email) to DPE (Manager, Mining Projects), DRE (Subsidence Executive Officer), MSB (District Manager) and other regulators as specified in management plans.
- Subsidence Management Status Reports - to be updated fortnightly and submitted (by email) if new impacts are identified or upon request, to DPE (Manager, Mining Projects), DRE (Subsidence Executive Officer) and OEH (National Parks and Wildlife Service [NPWS]).
- Six Monthly Report - to be updated annually for the period 1 January to 31 July and submitted (by email) to DPE (Manager, Mining Projects), DRE (Subsidence Executive Officer), MSB (District Manager), OEH/EPA (General Contact/National Parks and Wildlife Service) and DPI-Water (Manager Strategic Stakeholder Liaison).
- Annual Review - to be updated annually for the period 1 January to 31 December and submitted (by email and post) to DPE (Manager, Mining Projects), DRE (Subsidence Executive Officer), DRE (Director – Environmental Sustainability), MSB (District Manager), OEH/EPA (General Contact/National Parks and Wildlife Service), DPI-Water (Manager Strategic Stakeholder Liaison), Singleton Shire Council (General Manager) and CCC Members.

The component management plans of the extraction plan for the South Bates Underground Longwalls 11-13 reference components of a number of existing EMPs to avoid duplication. If these EMPs are revised separately in accordance with DA305-7-2003, the EMPs in the extraction plan for South Bates Underground Longwalls 11-13 will be updated accordingly.

5.9.1.3 Extraction Plan for South Bates Underground Longwalls 14-16

A Modification application for South Bates Underground (Wambo Seam) Longwalls 14-16 was submitted to DPE in July 2015 (DA305-7-2003 MOD 15) and approved on 10 November 2015.

During the reporting period, WCPL prepared an Extraction Plan for the South Bates Underground Longwalls 11-16 (by way of updating the approved Extraction Plan for the South Bates Underground Longwalls 11-13 to include Longwalls 14-16). The Extraction Plan for South Bates Underground Longwalls 11-16 was submitted to DPE in January 2017. The extraction plan for these panels is yet to be approved.

5.9.2 Approval Criteria/EIS Predictions and Management Plan Requirements

In accordance with DA305-7-2003 (Tables 14A and 14B), WCPL must ensure that there are no exceedances of the Subsidence Impact Performance Measures detailed in **Table 20.**

Underground mining was undertaken at the North Wambo Underground Mine in Longwall 8b (now complete) and in South Bates Underground Longwalls 11 and 12 during the reporting period.

No longwall panels encroached upon the Wollombi Brook, Warkworth Sands Woodland Community or the White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodland Community.

Table 20: Subsidence Impact Performance Measures

Aspect	Performance Measures
Water - Wollombi Brook	Negligible subsidence impacts. Negligible environmental consequences. Controlled release of excess site water only in accordance with EPL requirements.
Biodiversity - Wollemi National Park	Negligible subsidence impacts. Negligible environmental consequences.
Biodiversity - Warkworth Sands Woodland Community	Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.
Biodiversity - White Box, Yellow Box, Blakely's Red Gum Woodland/ Grassy White Box Woodland Community	Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.
Biodiversity - Other threatened species, populations or communities	Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.
Heritage – Wambo Homestead Complex	Negligible impact on heritage values, unless approval has been granted by the Heritage Branch and/or the Minister.
All Built Features	Always safe. Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.
Public Safety	No additional risk.

South Bates Underground Longwalls 11 and 12 undermined the NWCD during the reporting period. These longwalls were offset from the base of the Wollemi National Park escarpment by a 26.5 degree angle of draw. No impacts to the escarpment were observed during the reporting period (**Section 5.9.3**).

Wambo does not have approval for undermining of the WHC and as such no evidence of subsidence related impacts were identified during the reporting period. No impacts to non-Mine built features or threats to public safety resulting from the discussed mining activities were identified during the reporting period.

5.9.3 Performance during the Reporting Period

During the reporting period, WCPL undertook longwall mining in the North Wambo Underground Longwall 8b and in the South Bates Underground Longwalls 11 and 12 (**Section 3.1**). Subsidence monitoring was undertaken in accordance with the approved Extraction Plan for North Wambo Underground Longwalls 8-10A and the approved Extraction Plan for South Bates Underground Longwalls 11-13.

Table 21 summarises the actual versus predicted subsidence results for South Bates Underground Longwalls 11 and 12. Review of the actual versus predicted subsidence results for North Wambo Underground Longwall 8b will be completed during the next reporting period and reported in the WCPL 2017 Annual Review. The monitoring shows that the actual maximum subsidence recorded for South Bates Underground Longwalls 11 and 12 was similar to the predicted range.

Table 21: Subsidence Monitoring – Actual versus Predicted for South Bates Underground Longwalls 11 and 12

Monitoring Line ID	Predicted S_{max} (mm)[1]	Actual S_{max} (mm)	Difference (mm)	Consistent With Predicted Range
South Bates Underground Longwall 11[1]				
7XL	1,825	1,613	-212	Y
CL11B-Line	1,850	1,887	37	Y
South Bates Underground Longwall 12[2]				
7XL	1,950	1,648	-302	Y

1. *South Bates Underground Mine Subsidence Review Report for South Bates WYLW11* (Mine Subsidence Engineering Consultants [MSEC], 2016).
2. *South Bates Underground Mine Subsidence Review Report for South Bates WYLW12* (MSEC, 2017).

An audit of known subsidence impacts was commissioned and commenced during the reporting period to determine if the known subsidence impacts have self-repaired, are stable but pose a risk to long-term sustainable landuse, or are deteriorating in condition. The results of the audit will be reported in the next reporting period.

Baseline cliff top mapping of the Wollemi National Park that may be impacted by the mining of South Bates Underground Longwalls 11-16 was undertaken during 2015 utilising an Unmanned Aerial Vehicle (Microdrone MD4-1000) and a high resolution camera along a designated route. Photos were taken of the cliff top at designated intervals and stitched to form a high resolution panoramic image which can be used to assess subsidence. The route has been recorded and programmed to be repeatable from year to year. The cliffs associated with the Wollemi Escarpment were visually inspected using drones that were flown in January 2016, June 2016 and February 2017. There were no cliff instabilities identified along the escarpment from these surveys.

Visual inspections of the NWCD were carried out by WCPL and MSEC during the extraction of South Bates Underground Longwall 11. MSEC (2016) concluded:

> *Surface cracking was also observed in the sides of the embankments of the creek diversion. The largest deformations were observed near the bend in the alignment near the middle of the longwall. It is noted, that there was also natural erosion in the sides of the creek diversion that were not the result of mining.*
>
> *...*
>
> *It is considered that the observed surface deformations along the creek diversion are within those assessed (i.e. predicted) in Report No. MSEC692.*

Ground movements are also measured using LiDAR surveys. MSEC (2016 and 2017) considered that ground movements, as a result of mining South Bates Underground Longwalls 11 and 12 was not monitored in 2016 due to insufficient time for settling to occur. The extent of and measured using the LiDAR surveys, were consistent with predictions.

Visual inspections of surface impacts above South Bates Underground Longwalls 11 and 12 were conducted by WCPL. MSEC (2016 and 2017) considered that the observed surface deformations recorded above South Bates Underground Longwalls 11 and 12 during these visual inspections were consistent with the predictions.

Eco Logical (2017b) considered the subsidence impacts observed during flora, fauna and riparian condition monitoring conducted during 2016 and determined that no impacts or environmental consequences to the Warkworth Sands Woodland Community or the White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodland Community were observed. Minor cracking of the land surface was observed within the Central Hunter Box – Ironbark Woodland and other areas of woodland overlying South Bates Underground and an area of grassland overlying North Wambo Underground was observed to be accumulating surface water. Impacts to vegetation within South Bates Underground and North Wambo Underground appear to be negligible (Eco Logical 2017b).

Eco Logical (2017b) also noted that, while many of the smaller cracks and depressions are likely to self-repair over time, some of the observed cracks may act as pitfall traps for reptiles and would need to be remediated to prevent unwanted impacts (where access with light vehicles would be possible without additional damage to vegetation).

5.9.4 Trends and Key Management Implications

It is considered by MSEC (2016) that the observed ground movements for South Bates Underground Longwalls 11 and 12 were consistent with predictions. Identified subsidence impacts will continue to be monitored and proactively repaired.

5.9.5 Implemented or Proposed Management Actions

During the next reporting period WCPL will continue to implement the approved extraction plans for South Bates Underground Longwalls 11-13. WCPL has also prepared an Extraction Plan for the South Bates Underground Longwalls 11-16 (by way of updating the approved Extraction Plan for the South Bates Underground Longwalls 11-13 to include Longwalls 14-16). The Extraction Plan for South Bates Underground Longwalls 11-16 was submitted to DPE in January 2017. The extraction plan for these panels is yet to be approved.

5.10 Exploration

During the reporting period, 161 exploration holes were drilled in WCPL's licensed exploration and mine lease areas (160 complete and 1 abandoned). Of these holes, 136 were non-core and 25 were core holes. Thirteen (13) holes were drilled within EL7211 and A444 and as such these holes were subject to the Exploration Activity Application and Assessment Process as part of the Part 5 approval process. The remainder were drilled within WCPL's mining leases and were managed under WCPL's site surface disturbance permit system.

Rehabilitation of exploration sites is undertaken continuously throughout the exploration program and immediately upon backfilling of logged holes. Preliminary rehabilitation has been completed and inspected for 127 sites within mine and exploration leases. The remaining 33 sites will be inspected to determine rehabilitation status during the next reporting period. All exploration sites within EL7211 and A444 have been rehabilitated and inspected.

5.11 Waste

Waste management at WCPL is undertaken by a licensed waste management company under the basic principles of Total Waste Management System (TWMS). Significant benefits of TWMS include:

- Segregation of waste at the source;
- Expansion of recycling capabilities;
- Reduction in the risk of contaminating non-hazardous waste;
- Comprehensive monthly reports detailing volumes, recycling, disposal and transportation of waste; and
- Improved data capture to increase the efficiency and accuracy when reporting.

During the reporting period, a total of 2,709,881 kg of waste was generated by the Mine. Of this, 71.77% was recycled and 28.23% was taken to landfill or disposed of off-site as hazardous waste.

The total waste removed from site in 2016 was more than in 2015 and 2013 (2,252,922 kg and 1,615,289 kg, respectively) but less than 2014 (4,860,142 kg) (**Figure 7**). The main reasons for the differences in waste reported by the Mine are:

- The waste report for January 2016 incorrectly included sediment-laden water pumped from various on-site locations (and disposed of on-site) in the recycled effluent figure. This water should not have been included in WCPL’s waste report. If this water is removed from the 2016 waste report the total waste generated in 2016 would be less.
- The 2014 waste report incorrectly included sediment-laden water pumped from various on-site locations (and disposed of on-site) in the recycled effluent figure. This water should not have been included in WCPL’s waste report. If this water is removed from the 2014 waste report the total waste generated in 2014 would be significantly less.
- The 2014 waste report also included 668,723 kg of waste recycled from the wash bay. There was no waste removed from the wash bay in 2015 or 2016.

The overall recycling rate for 2016 (71.77%) was more than reported in 2015 (67.87%) but less than that reported for 2014 (82.82%) and 2013 (82.1%), however it is noted that the recycling rate for 2014 was heavily influenced by the incorrect inclusion of sediment-laden water in the recycled effluent figure for 2014.

In February 2016, WCPL transitioned between waste contractors.

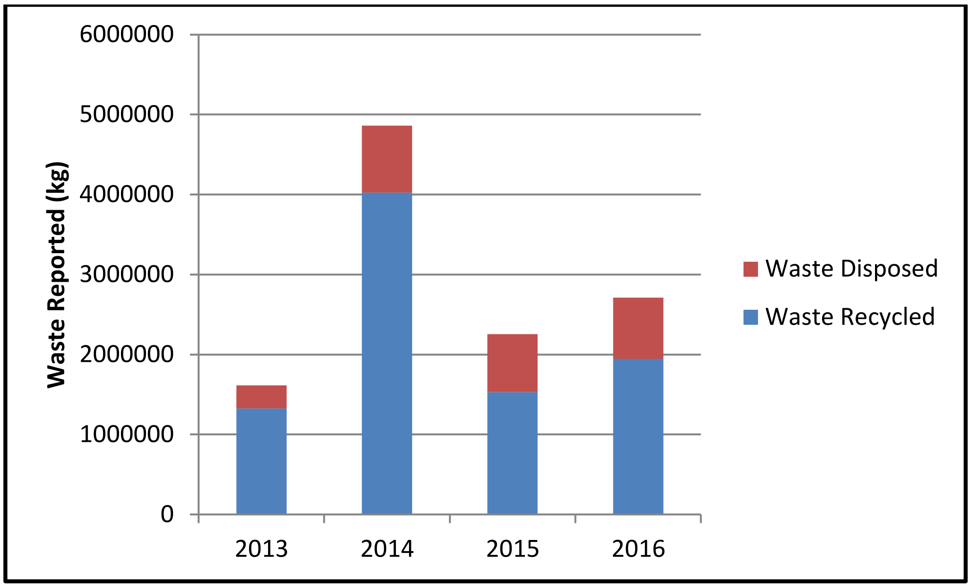

Figure 7: Waste Volumes (2013-2016)

5.12 Visual Amenity and Lighting

All mobile lighting plants are strategically positioned to avoid light being directed towards WCPL's neighbours and other identified potential sensitive receptors.

During the reporting period, WCPL continued to monitor lighting impacts along the Montrose Ridge as mining continued to the north. As a result of this monitoring, WCPL has installed low light lighting plant and ensures frequent communication of potential lighting impacts at pre-start meetings.

There were six (6) complaints received during the reporting period relating to lighting impacts from WCPL's mining operations (**Section 8.3**).

5.13 Contaminated Land

No contaminated land event, that posed a potential or material harm to the environment, occurred during the reporting period. Where possible, any contaminated material is managed on-site in the site bio-remediation area.

5.14 Topsoil Management

During the reporting period, WCPL undertook an inventory of topsoil stockpiles on-site, including location, volume and condition. This inventory (as at the end of the reporting period) is summarised in **Table 22** below. Topsoil stockpile locations, as at the end of the reporting period, are shown on **Figure 8.**

Table 22: Topsoil Inventory

Topsoil Reference	Location	Volume (m^3)	Condition
1	Sarah Marie Dump	33,543	Vegetated
2	Sarah Marie Dump	2,940	Vegetated
3	Ridge Dump	13,352	Vegetated
4	Sarah Marie Dump	6,525	Vegetated
5	Charlies Hole Dump	10,770	Vegetated
6	Sarah Marie Dump	8,869	Vegetated
7	Sarah Marie Dump	8,039	Vegetated
-	RL 160 Rehab	-	Used
-	RL 160 Rehab	-	Used
-	RL 160 Rehab	-	Used
-	RL 160 Rehab	-	Used
-	Cow Dump	-	Used
-	Inpit - Montrose Backfill	-	Used
-	Ahead of South Bates Pit	-	Used
-	Rug Dump Rehab	-	Used
-	Bates South Haul Road	-	Used
-	Cow Dump	-	Used

Note: m^3 = cubic metres.

Topsoil is managed at the Mine in accordance with the Wambo Coal Topsoil Management Procedure. During the reporting period, WCPL completed a review of the Topsoil Management Procedure and, as a result, developed a revised Topsoil Management Procedure.

WCPL will continue to manage topsoil at the Mine in accordance with the Topsoil Management Procedure.

5.15 Weed and Pest Management

During the reporting period, WCPL undertook a vertebrate pest management program. The aim of the program was to target the wild dogs, pigs and foxes that had been reported in and surrounding the Warkworth area. While the program was considered to be successful (in that 47 baits were taken by the target species [wild dogs and foxes] and eight pigs captured), it was concluded that there continues to be wild dog / fox activity in the area and that vertebrate pest management programs should continue to be undertaken in the future to keep the populations under control.

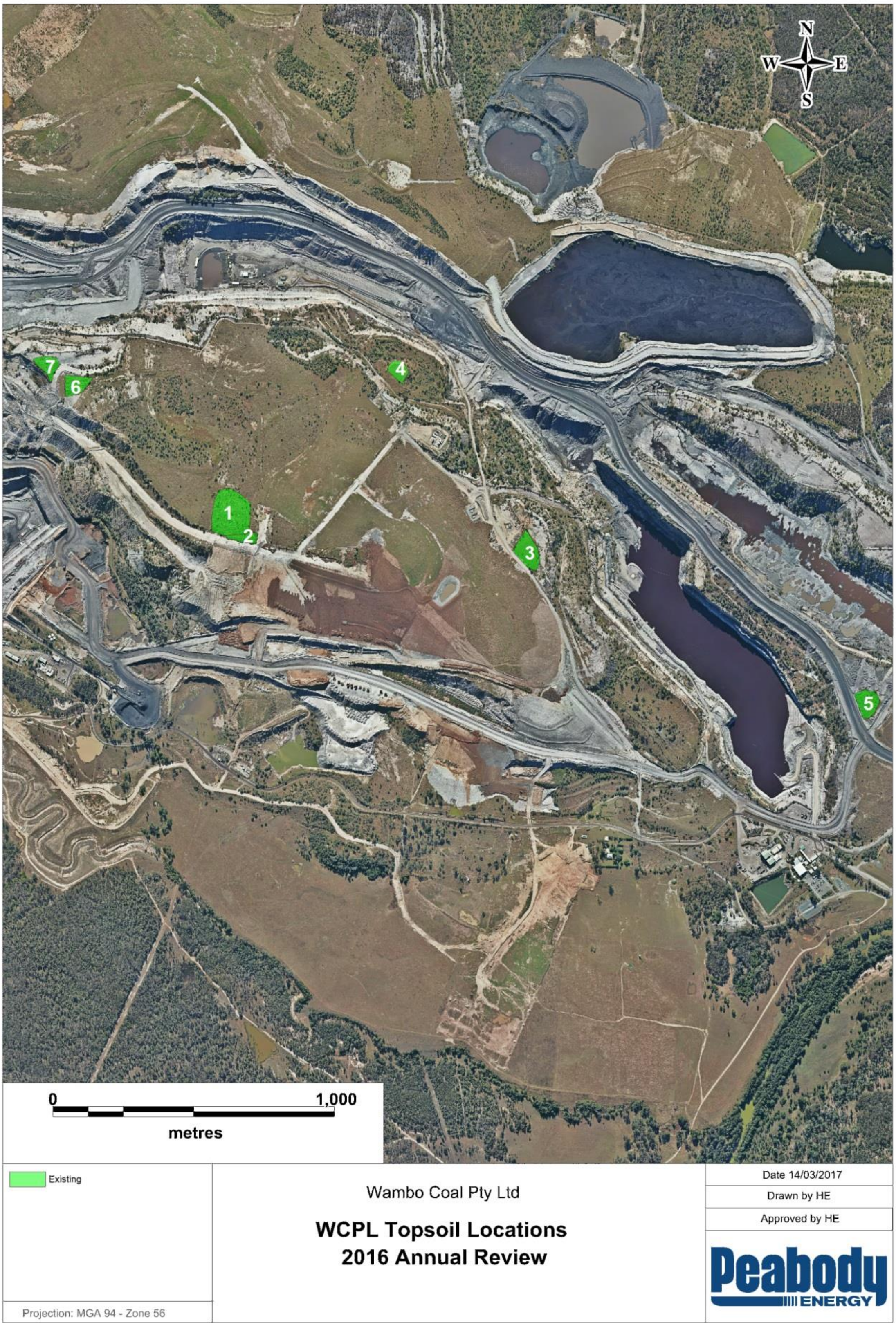

Figure 8: WCPL Topsoil Locations

During the reporting period, an inspection of the NWCD was conducted on 3 February 2016. The inspection identified that vegetation cover had improved significantly, having a stabilising effect and reducing erosion. At the time of the inspection, weeds did not form a large proportion of the vegetation on-site. A number of ongoing management measures were recommended, including:

- Selective weed control, involving spot spraying with herbicide (target species include Galenia, Blue Heliotrope, Bathurst and Noogoora burrs).
- Monitoring of species growth and establishment.
- Tree plantings (tube stock).
- Monitoring of erosion (repair to be undertaken after the heavy storm rain).
- On-going management of pest animals and kangaroos to prevent excessive grazing of establishing vegetation.

LFA undertaken in 2016 found that landscape organisation scores appear to have either increased slightly or remained constant since the previous monitoring conducted in 2015. Visual observations indicate that the rework of the NWCD initiated in 2015 has successfully reduced the presence of invasive weed species (primarily Galenia) due to the planting of native seed species. WCPL will continue the rework of the NWCD in 2017.

Weed management conducted during the reporting period included 20 days of weed spraying in RWEA A, specifically targeting Tiger Pear (*Opuntia aurantica*) and African Boxthorn (*Lycium ferocissimum*).

Pest and weed management will continue as required throughout 2017 on-site and on agistment managed properties.

5.16 Bushfire Management

No grassfires or bushfires were reported within the Mine during the reporting period. WCPL undertakes proactive grass slashing and maintenance around all site infrastructure and boundary fences where practical.

During the reporting period, WCPL undertook a Bushfire Risk Assessment of the Mine. The assessment concluded that the Mine has inherent and maintained bushfire mitigation features that provide a high level of bushfire preparedness. Notwithstanding the following actions were recommended:

- In cooperation with NSW Rural Fire Service (RFS) and NPWS, mechanically remove vegetation within the 1 m clearance either side of the fire trail (fire trail should be 4 m wide with 1 m clearance either side). Additionally, ensure that vertical clearance along the fire trail is greater than 4 m.
- Construction of suitable access for 4WD and fire trucks at the North Wambo Creek crossing should commence immediately.
- WCPL should confirm access arrangements (i.e. locked gates) along the fire trail with NSW RFS (Bulga).

- Provide residents on WCPL-owned land with a suitable document or package detailing actions required to improve their awareness and preparedness for bushfire protection and response.
- Radiant heat shielding to be installed on the eastern elevation of pump infrastructure A4, and exposed electrical components and cables to be protected with a fire rated cable tray.

In addition to the above, it was recommended that WCPL designate a dam suitable for filling aerial vehicles (i.e. helicopters) and include the identification of water resources for fire control in the Bushfire Management Plan scheduled for update during 2017.

5.17 Spontaneous Combustion Management

There were no spontaneous combustion incidents at the Mine during the reporting period. Inspections for spontaneous combustion form part of daily WCPL inspections across the three main operating areas (i.e. Open Cut, Underground and Coal Handling and Preparation Plant [CHPP]). WCPL will continue to monitor for signs of spontaneous combustion in the next reporting period.

6.0 Water Management

Water quality discharge criterion for the Mine is defined in Table 15 of DA305-7-2003 (Condition 24, Schedule 4) and EPL 529 (Condition L2). Additional conditions relating to water supply, water and salt balances, discharge volume, effluent application to land, monitoring and recording requirements (including for the HRSTS), the NWCD, Chitter Dump Dam, South Wambo Dam, WCPL's Water Management Plan and independent water audits are also detailed in these documents. WCPL must also operate in accordance with the conditions of various water licences issued under the *Water Act 1912* and *Water Management Act 2000* as well as conditions of DA177-8-2004.

During the reporting period, WCPL updated the ESCP (Version 8) and submitted the plan to DPE for approval in April 2016.

6.1 Surface Water Monitoring

WCPL undertakes surface water monitoring at the Mine in accordance with the approved Surface Water Monitoring Program (SWMP), which is a component of the WCPL Water Management Plan. The SWMP has been developed to ensure WCPL complies with its statutory conditions relating to surface water monitoring at the Mine.

The SWMP was revised in December 2016 (Version 10) and submitted with the draft Extraction Plan for South Bates Underground Mine Longwalls 11-16.

6.1.1 Approval Criteria/EIS Predictions and Management Plan Requirements

WCPL's EPL 529 details the approval criteria for off-site water discharges (**Section 6.3.1**).

WCPL has developed impact assessment criteria for surface water quality and stream flow as part of the approved SWMP (Version 9). Where actual site specific water quality monitoring data is available, the criteria have been set based on the 20th and 80th percentile for the available dataset. Where insufficient data is available, WCPL has adopted the applicable Australian and New Zealand Environment and Conservation Council (ANZECC) default guidelines values for slightly to moderately disturbed ecosystems (ANZECC, 2000) or the Water Quality Objectives for the Hunter River. Applicable criteria are included in **Table 23** and **Table 24.**

Triggers for the local mine site ephemeral creeks in the approved SWMP are based on the unexpected absence of flow in climatic situations when flows would be expected. The triggers would be met if there was no flow recorded at the flow monitoring site either on the day or the day after the recorded rainfall was equal to or greater than the nominated amount.

Table 23: Surface Water Quality Impact Criteria[1]

Sampling Site	Parameter[2]	Lower Limit	Upper Limit
SW02 – Wollombi Brook	pH	7.4	8.1
	EC (µS/cm)	599	1,947
	TSS (mg/L)	17 (low flow) to 308 (high flow)[3]	
SW05 – North Wambo Creek	pH	7.3	7.9
	EC (µS/cm)	1,155	2,246
	TSS (mg/L)	53 (low flow) to 1,110 (high flow)[3]	
SW07 – Wambo Creek	pH	7.4	7.9
	EC (µS/cm)	360	724
	TSS (mg/L)	29 (low flow) to 331 (high flow)[3]	
SW08 – Stony Creek	pH	6.8	7.4
	EC (µS/cm)	288	416
	TSS (mg/L)	5 (low flow) to 15 (high flow)[3]	
SW39 – Waterfall Creek	pH	7.3	7.8
	EC (µS/cm)	159	429
	TSS (mg/L)	582 (low flow) to 1,922 (high flow)[3]	

1. From Table 11, Version 9 of the WCPL SWMP.
2. EC = electrical conductivity, TSS = total suspended solids, µS/cm = microSiemens per centimetre, mg/L = milligrams per litre.
3. Low flow condition based on 80th percentile of recorded concentrations and high flow criteria based on maximum recorded concentrations.

Table 24: Surface Water Flow Impact Assessment Condition[1]

Watercourse and flow monitoring site	Daily rainfall when flow commenced on 80% of recorded occasions
Stony Creek (FM13)	20 mm
South Wambo Creek (FM15)	20 mm
North Wambo Creek (FM4)	20 mm

1. From Table 10, Version 9 of the WCPL SWMP.

In addition to the surface water monitoring requirements detailed in **Table 23** and **Table 24,** WCPL is also required to meet additional requirements, in accordance with the approved SWMP. These requirements include annual reporting on performance against the performance indicators detailed within the approved WCPL SWMP (**Table 25**)**.**

Table 25: Surface Water Monitoring Program Performance Indicators

Performance Indicator
Number of complaints received relating to surface water.
Number of non-compliances received relating to surface water.
Number of exceedances of surface water impact assessment criteria[1].
Number of reportable environmental incidents relating to surface water.

1. An exceedance occurs when water quality results exceed the 80th Percentile Trigger Value (**Table 23**) after three consecutive sampling events.

6.1.2 Performance during the Reporting Period

WCPL reported the following events relating to surface water during the reporting period:

- An incident involving uncontrolled discharge from a temporary sediment dam in January 2016.
- A non-compliance involving unmetered discharges from Eagles Nest Dam in January 2016.

These events are discussed in further detail in **Section 10.0.**

An exceedance of the surface water quality triggers is considered to have occurred when water quality results exceed the 80th Percentile Trigger Value (**Table 23**) after three consecutive sampling events.

WCPL recorded no exceedances of the surface water quality impact assessment criteria during the reporting period.

No complaints relating to surface water were received during the reporting period.

A summary of the surface water quality monitoring data is included in **Appendix C.**

In December 2016, WCPL installed a new flow monitoring station (now FM15, previously FM5) to replace a flow monitoring station that had been destroyed in February 2013, and relocated a flow monitoring station (now FM16, previously FM6) that was identified as being unusable in 2015. A map showing the current flow monitoring stations is included in **Figure 9**.

In conjunction with the relocation/installation, a cross and long section survey was also performed. From these surveys the cease to flow point was established, a theoretical flow rate curve and a stream bed profile chart were produced. Further details on the installation of the new flow monitoring stations along with the monitoring data from these stations is included in the AECOM report in **Appendix F** (AECOM 2017).

Stream flow data was recorded at all of WCPL's flow monitoring stations during the reporting period, with the exception of FM5 (South Wambo Creek), which was destroyed during a flood flow event in February 2013 and replaced by FM15 in December 2016, and FM6, which has been historically unreliable and was replaced by FM16 in December 2016.

Flow data recorded for FMs 6 and 9 during the reporting period is deemed unreliable due to damaged loggers and identified monitoring locations becoming unsuitable as a result of the 2015 April flood events. Unreliable data has not been included in this report and affected flow monitoring stations have been replaced (**Section 10.7**).

There were no recordable flow events observed on FM15 or FM16 since they were replaced on 14 December 2016.

It is proposed to review the flow impact assessment conditions (**Table 24**) in 2017 following the installation of new flow monitoring stations in 2016 and in consideration of site conditions.

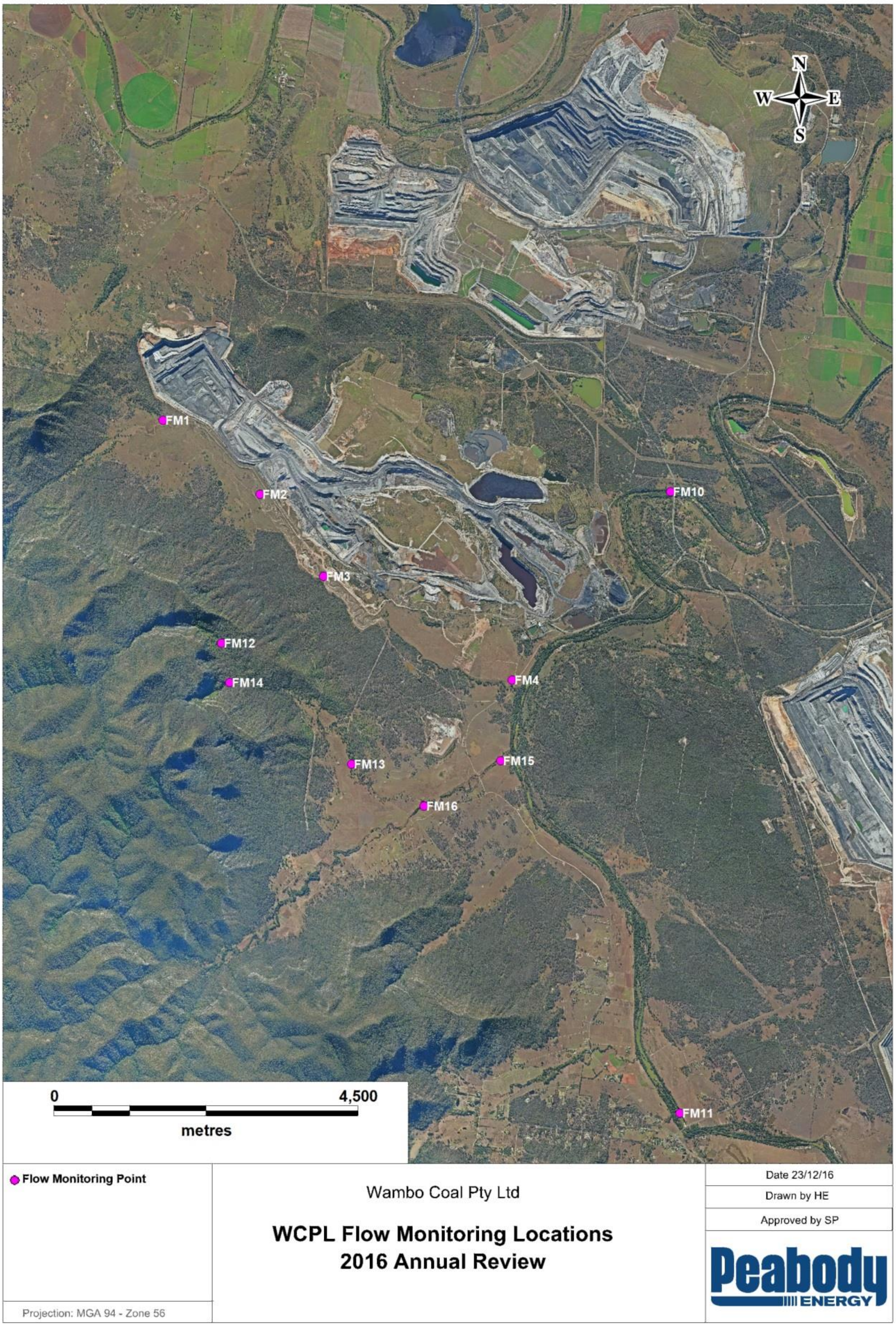

Figure 9: WCPL Flow Monitoring Locations

6.1.3 Trends and Key Management Implications

During the reporting period, WCPL failed to continuously monitor stream flow at three locations, in accordance with the approved SWMP:

- FM5 (South Wambo Creek – downstream near the confluence of Wollombi Brook);
- FM6 (South Wambo Creek – downstream); and
- FM9 (South Wambo Creek – upstream).

This is a non-compliance with WCPL's Water Management Plan requirements. Further details on this non-compliance are provided in **Section 10.7.**

6.1.4 Implemented or Proposed Management Actions

Flow monitoring stations FM5 and FM6 were replaced with FM15 and FM16, respectively, in December 2016.

During the next reporting period, WCPL will continue to implement the approved SWMP (Version 9) or the revised version (Version 10) if approved.

6.2 Groundwater Monitoring

WCPL undertakes groundwater monitoring at the Mine in accordance with the approved GWMP, which is a component of the WCPL Water Management Plan. The GWMP has been developed to ensure WCPL complies with its statutory conditions relating to groundwater monitoring at the Mine.

Version 10 of the GWMP was approved by DPE on 27 November 2015.

6.2.1 Approval Criteria/EIS Predictions and Management Plan Requirements

The GWMP includes triggers for groundwater levels and quality in shallow bores. These triggers have been developed using statistical analysis of baseline monitoring data and data acquired to 2014 (from a number of monitoring bores on and around the Mine site) and the predicted effects presented in the EIS (Resource Strategies 2003) and subsequent Environmental Assessments. The trigger values are not assessment criteria but are used to initiate investigations into the groundwater levels or groundwater quality as reported by the groundwater monitoring program. A summary of the groundwater triggers for shallow bores, as detailed in WCPL's approved GWMP (Version 10), is included in **Table 26.**

On 16 May 2016, WCPL self reported a non-compliance with a condition of A444. Condition 12.d) of A444 requires that a Groundwater Monitoring and Modelling Plan be approved by the Minister prior to prospecting operations involving the construction and use of boreholes. Further information regarding the non-compliance is available in **Section 10.8**.

Table 26: Water Quality and Level Trigger Values – Shallow Bores

Bore	Depth to Groundwater (mBTOC[1])		Conductivity (µS/cm)	pH	
	Min (10th percentile)	Max (90th percentile)	Maximum (Three Consecutive Bi-Monthly Exceedances)	Minimum (Two Consecutive Bi-Monthly Exceedances)	Maximum (Two Consecutive Bi-Monthly Exceedances)
P106	6.6	10.7	941	6.7	7.9
P109	4.6	6.7	NA	NA	NA
P114	5.4	7.6	6,141	6.5	7.8
P116	4.8	7.3	5,972	6.6	7.5
P202	7.8	9.6	8,172	6.7	7.7
P206	16.1	21.6	2,630	7.3	8.1
P301[2]	NA	NA	NA	NA	NA
P315	4.4	9.1	552	6.0	7.4
GW02	5.8	8.5	715	6.7	7.4
GW08[3]	NA	NA	NA	NA	NA
GW09[3]	NA	NA	NA	NA	NA
GW11	4.0	6.5	592	6.8	7.5
GW12	9.9	12.9	NA	NA	NA
GW13	4.8	5.4	4,370	6.9	7.1
GW15	10.4	11.1	730	6.7	7.2
GW16[4]	NA	NA	NA	NA	NA
GW17[4]	NA	NA	NA	NA	NA
P16	7.1	7.8	10,832	7.0	7.7
P20	7.1	8.2	10,625	7.0	7.6

1. mBTOC = metres below top of casing.
2. P301 is predicted to go dry by HydroSimulations (2014).
3. Specific trigger levels for GW08 and GW09 have not been established, however, if GW08 and GW09 do not recover within 12 months of the cessation of dewatering pumping (ceased in early 2016), WCPL may consider installing replacement bores that allow monitoring of the alluvium and underlying Interburden material. The levels in GW08 and GW09 will be monitored in 2017, and trigger levels established if appropriate.
4. GW16 and GW17 are located upstream of the NWCD and in close proximity to the approved open cut. There are no groundwater users located in the vicinity of North Wambo Creek upstream of the NWCD. Therefore, a trigger level for these two bores is not considered warranted. Monitoring data will be reviewed annually at these bores.

In addition to the groundwater monitoring triggers detailed in **Table 26,** WCPL is also required to meet additional requirements, in accordance with the approved GWMP, Extraction Plan for the North Wambo Underground Longwalls 8-10A and Extraction Plan for the South Bates Underground Longwalls 11-13. These requirements include annual reporting on performance against the performance indicators detailed within the approved WCPL GWMP (**Table 27**).

Table 27: Groundwater Monitoring Program Performance Indicators

Performance Indicator
The performance indicators will be considered to have been exceeded if Wambo receives complaints from groundwater users.
The performance indicators will be considered to have been exceeded if monitoring data suggests significant divergences away from the modelled groundwater.
The performance indicators will be considered to have been exceeded if pumping of water from the North Wambo Underground Mine roadways requires regular pumping at rates higher than normal.
The performance indicators will be considered to have been exceeded if the groundwater levels in alluvial bores exceed the groundwater level criteria listed in Table 9 of the GWMP.
The performance indicators will be considered to have been exceeded if the groundwater quality in alluvial bores exceeds the groundwater quality criteria listed in Table 10 of the GWMP.

Groundwater monitoring data from the Permian monitoring bores is assessed and reviewed as part of the Annual Review. Data is also used to validate the groundwater model.

6.2.2 Performance during the Reporting Period

Monitoring of groundwater levels and quality in alluvial and Permian bores was undertaken in accordance with WCPL's approved GWMP (Version 10). A number of trigger level exceedances were recorded for groundwater levels and EC during the reporting period (**Table 28**). These exceedances are summarised in **Section 6.2.3** and discussed further in the report *Wambo Annual Review Groundwater Analysis* (HydroSimulations 2017a) (**Appendix G**).

Table 28: Groundwater Trigger Level Exceedances[1]

Bore	Number of Trigger Level Exceedances		
	Depth to Groundwater - Min (10th percentile)	Depth to Groundwater - Max (90th percentile)	EC
P109	2		
P114		6	1
P202	1		
P206	1		
P315	1		
GW02	2		
GW11		1	
GW12		1	
GW13		4	
GW15	5		
P16	1		
Total	**13**	**12**	**1**

1. From Table 3 of the report *Wambo Annual Review Groundwater Analysis* (HydroSimulations 2017a) (**Appendix G**).

Hydrographs for relevant groundwater monitoring bores were assessed to determine whether observed trends were due to weather or mining and shallow bores were assessed for compliance with the groundwater level and water quality performance indicators (HydroSimulations 2017a).

No bores were decommissioned during the reporting period.

No complaints from groundwater users were received during the reporting period.

6.2.3 Trends and Key Management Implications

Groundwater monitoring data collected during the reporting period has been reviewed and assessed against the triggers in the approved GWMP (**Table 26**) by HydroSimulations (2017a). There were 13 instances where the water level recorded in WCPL's monitoring bores did not meet the 10^{th} percentile criteria. Baseline monitoring data used to create the trigger levels (from July 2003 until August 2007) were taken during a period of lower than average rainfall. From October 2007 to 2016, a period of generally greater than average rainfall has been observed. As such, instances where trigger levels exceed the minimum (10^{th} percentile) levels in the 2016 monitoring period should not be attributed to WCPL's activity. A high rainfall event in January 2016 that has taken some months to recover from is consistently the cause of the trigger exceedance (HydroSimulations 2017a).

P114, GW11, GW12 and GW13 exceeded the trigger level for the 90^{th} percentile (maximum) depth to groundwater a total of 12 times during the reporting period.

As reported previously, the low groundwater levels at P114 are a clear effect from the mining of North Wambo Underground Longwall 10A and are consistent with the latest model predictions (HydroSimulations 2017a).

The groundwater level at GW11 was above the minimum depth-to-water trigger in February 2016, and below the maximum depth-to-water trigger in December 2016. HydroSimulations (2017a) concluded that further readings are required to clarify the response at GW11. Given a separation of 3.5 km between GW11 and South Bates Underground Longwall 12, the effect is unlikely to be related to mining of the South Bates Underground (HydroSimulations 2017a).

GW12 exhibits an ongoing mining effect from North Wambo Underground longwall extraction, with a trigger exceedance occurring in February 2016 as the bore reported dry. A recovery of approximately 2.5 m was observed with the above average rainfall in early 2016 and no further trigger exceedances were observed (HydroSimulations 2017a).

GW13 is located on the eastern side of Wollombi Brook about 3 km from WCPL's North Wambo Underground workings. The four trigger events at GW13 occurred from June to December 2016 and were all less than 0.2 m below the prescribed trigger level. The decline is likely to be due to the approaching Warkworth open cut rather than Wambo mining (HydroSimulations 2017a).

P114 has recorded four consecutive bi-monthly EC values greater than the trigger level in the 2016 monitoring period. As was discussed in the 2015 *Wambo Annual Review Groundwater Analysis* (HydroSimulations 2016), P114 is situated partially in weathered regolith and underlying Permian overburden. As groundwater level has declined due to Longwall 10A extraction, the water table is now located in source rock with a much higher salinity (HydroSimulations 2017b).

No exceedances of the pH level triggers were recorded during the reporting period.

HydroSimulations also conducted an assessment against the performance indicators for North Wambo Underground Longwalls 8-10A and South Bates Underground Longwalls 11-13. It was concluded by HydroSimulations (2017c) that the subsidence impact performance measure of *Negligible impact to Wollombi Brook* was upheld for the extraction of North Wambo Underground Longwalls 8-10A.

It was concluded by HydroSimulations (2017b) that further assessment of flows at Wollombi Brook would be required to identify the cause of zero flow downstream at FM10 and measurable flow upstream at FM11. The observed exceedances of the groundwater level and EC performance indicators did not result in an exceedance of the subsidence impact performance measure of *Negligible impact to Wollombi Brook*.

Hydrographs within the Permian groundwater bores were reviewed by HydroSimulations, in combination with a review of subsidence parameters and WCPL's groundwater model. Additional detail is available in **Appendix G**.

WCPL will continue to monitor the bores in accordance with the approved GWMP.

6.2.4 Implemented or Proposed Management Actions

During the next reporting period WCPL will continue to implement the approved GWMP.

The groundwater levels at GW08 and GW09 will be monitored during 2017 and trigger levels established if appropriate. If the two bores do not recover within 12 months of the cessation of dewatering pumping (ceased early 2016), WCPL may consider installing replacement bores that allow monitoring of the alluvium and underlying Interburden material.

Additional monitoring will be undertaken to investigate the saline water in P114. This monitoring will include (HydroSimulations 2017):

- The collar level at P114 be re-surveyed to assess the amount of subsidence caused by mining of Longwall 10A.
- Monthly monitoring of P114 if EC and groundwater level triggers are exceeded during the next measurement.
- Full chemical analysis of water from the area of ponding in the vicinity of P114 to compare with the chemistry at P114.
- Measurement of soil water EC and chemistry for comparison with the chemistry at P114, to clarify the source of salinity at P114.

In addition to the above, further investigation will be undertaken in relation to the observed flows at Wollombi Brook to identify the cause of zero flow downstream at FM10 and measurable flow upstream at FM11 during periods of low flow.

6.3 HRSTS Discharges

WCPL is permitted to discharge water to the Hunter River in accordance with the conditions of EPL 529 and the HRSTS guidelines. These guidelines include the following conditions:

- Notification from DPI-Water of discharge opportunity must be received;
- Flow of water in Wollombi Brook at the DPI-Water Bulga Gauging Station (FM11) needs to be more than 500 ML/day;
- pH will be measured continuously throughout the discharge with an inline instrument;
- EC will be measured continuously in µS/cm throughout the discharge with an instrument designed to measure between 0 and 10,000 µS/cm; and
- TSS will be measured once a day during discharge. A representative sample will be collected every day and sent to the lab for analysis.

WCPL has 35 credits under the HRSTS following the 2016 auction.

6.3.1 Approval Criteria/EIS Predictions and Management Plan Requirements

A summary of the approval criteria for off-site discharges (from EPL 529) is included in **Table 29.**

Table 29: EPL 529 Approval Criteria for Off-site Discharge

Parameter	Criteria[1]
pH	6.5-9.5[2]
TSS	120 mg/L[2]
EC	N/A
Volume	250 ML/day

1. Criteria as per EPL 529.
2. 100th percentile concentration limit.

6.3.2 Performance during the Reporting Period

During the reporting period, WCPL discharged a total of 416 ML of water from Licensed Discharge Point (LDP) No. 4 in accordance with the conditions of EPL 529 and the HRSTS, as shown in **Table 30**. At the time of these discharges, WCPL held 48 credits under the HRSTS and an additional 146 credits (for a total of 194) were traded from Hunter Valley Operations for the discharge blocks on 9, 10 and 11 January 2016.

Table 30: Environmental Performance – HRSTS Discharges

Block Number/ Credit Holder	Discharge Start	Discharge Stop	Maximum Allowable Volume Discharge (ML)	Actual Volume Discharged (ML)	Maximum Allowable Salt Discharge (tonnes)	Actual Salt Discharge (tonnes)
2016-007(3)	6/01/2016 13:00	7/01/2016 13:00	139.7	79.8	445.0	190.8
2016-008(3)	7/01/2016 13:00	8/01/2016 13:00	111.5	73.5	290.2	191.4
2016-009(3)	8/01/2016 13:00	9/01/2016 13:00	70.2	62.1	210.5	186.3
2016-010(2)	9/01/2016 13:00	10/01/2016 13:00	188.8	46.0	623.1	151.8
2016-010(2)*	9/01/2016 13:00	10/01/2016 13:00		2.9		9.6
2016-011(1)	10/01/2016 13:00	11/01/2016 13:00	101.6	25.0	335.2	82.5
2016-011(1)*	10/01/2016 13:00	11/01/2016 13:00		19.7		65.0
2016-012(1)	11/01/2016 13:00	12/01/2016 13:00	59.4	14.0	196.1	46.2
2016-012(1)*	11/01/2016 13:00	12/01/2016 13:00		17.0		56.1
2016-25(2)	24/01/2016 13:00	25/01/2016 13:00	19.67	18.9	50.3	48.4
2016-26(1)	25/01/2016 13:00	26/01/2016 13:00	60.14	56.9	153.9	145.6
Total			**750.9**	**416**	2304.4	1173.6

* WCPL obtained additional discharge credits.

All water discharged from LDP No.4 during the reporting period was discharged under normal HRSTS conditions. WCPL complied with the HRSTS guideline conditions and EPL 529 approval criteria (**Table 29**) during all discharges.

Water monitoring results for the off-site discharges are summarised in **Appendix C** (site reference is SW15)**.**

Under the HRSTS/EPL 529, WCPL is required to monitor volume continuously throughout a discharge event. WCPL was not successful in obtaining continuous volume readings at the discharge point, as required under clause M7.1 of EPL 529 due to a faulty meter (**Sections 6.3.4** and **10.4**).

6.3.3 Trends and Key Management Implications

There were 11 discharge events recorded in 2016, compared to six in 2015, one in 2014 and 27 in 2013. Volumes recorded during licensed discharges in 2016 (range 2.9 to 79.8 ML/day) were higher than those recorded in 2015 (range 12.6 to 38.5 ML/day) and 2014 (9.6 ML) and lower than those recorded in 2013 (range 9.9 to 92.7 ML/day).

The total volume of water discharged in 2016 (416 ML) was greater than that discharged in 2015 (140.1 ML) and 2014 (9.6 ML) but less than that discharged in 2013 (1221.44 ML).

Field pH values recorded during licensed discharges in 2016 (range 8.8 to 9.2) were generally consistent with those recorded in the previous three years (i.e. 2015 [range 8.01 to 8.90], 2014 [8.84] and 2013 [8.66 to 9.23]).

Field TSS values recorded during licensed discharges in 2016 (range 41.6 to 77.9 mg/L) were generally consistent with those recorded in the previous three years (i.e. 2015 [range 28 to 70 mg/L], 2014 [85 mg/L] and 2013 [range 20 to 111 mg/L]).

Field EC values recorded during licensed discharges in 2016 (range 3985 to 5409 µS/cm) were consistent with those recorded in the previous three years (i.e. 2015 [range 3538 to 4679 µS/cm], 2014 [6122 µS/cm] and 2013 [range 3069 to 7940 µS/cm]).

6.3.4 Implemented or Proposed Management Actions

A written report of the activities undertaken by WCPL under the HRSTS (for the period 1 July 2015 to 30 June 2016) was submitted to the EPA on 29 August 2016, in accordance with Condition R4 of EPL529.

WCPL operates and maintains communication equipment which makes the conductivity and flow measurements available to NSW DPI-Water. During the initial period of discharge under the HRSTS on 7 January 2016, WCPL identified minor electrical issues with the radio communications between WCPL and NSW DPI-Water. Discharge was immediately ceased and a radio technician and electrical engineer were engaged to inspect and remedy communication problems. Following corrective actions and positive confirmation with DPI-Water that communications were operational, HRSTS discharges re-commenced.

On 7 January 2016, WCPL was discharging during an authorised discharge event under the HRSTS in which the continuous in line instrumentation at Point 4 (as defined in EPL 529) failed to continuously monitor the flow of the water being discharged (**Section 10.4** for more details).

The HRSTS discharge system was reviewed during 2016. This review consisted of updating the communication hardware in consultation with Water NSW, calibration of instrumentation and development of operating procedures.

Upon completion of this review, the guidelines for a HRSTS audit will be developed and an audit commenced in 2017.

During the next reporting period, WCPL forecasts that it will use all of its available HRSTS credits, as dictated by River Register releases.

6.4 North Wambo Creek Diversion Discharge Flows

The NWCD Plan was approved by the then NSW Department of Planning (now DPE) in April 2008. A requirement of the approval was to comply with the requirements of the then Department of Water and Energy (now DPI-Water). These requirements included reporting on the performance of the NWCD annually in the Annual Review.

During the reporting period WCPL monitored flow within the North Wambo Creek at four FM locations:

- FM1, upstream of the NWCD;
- FM2, middle of the NWCD, downstream of FM1 (reinstated in 2015);
- FM3, middle of the NWCD, downstream of FM2; and
- FM4, downstream of the NWCD.

The number of flow events recorded at each monitoring site for 2016 is provided in **Table 31**. There were no recordable flow events at FM1 or FM4 (including the backup sensors) during the period 1 February 2016 to 31 December 2016. Flow monitoring data is included in the AECOM report included in **Appendix F.**

Table 31: NWCD Discharge Flow Monitoring – 2016

Flow Monitoring Station	No. of Flow Events Recorded	Maximum Stream Height Recorded (m)	Maximum Theoretical Flow rate Recorded (ML/day)
FM2	11	0.207	12
FM3	5	0.116	3.7

6.5 Water Take

In mid-2015, WCPL applied to DPI-Water to combine all of its groundwater licences that contained an extraction entitlement into a single licence. The purpose of this licence was to streamline mining activities and simplify the reporting of extraction against licensed entitlements. As such, WCPL is licensed to extract a total of 1,647 ML from all groundwater sources under the *Water Act 1912* (**Table 32**). This combined licence was confirmed to be active by DPI-Water in correspondence received on 18 February 2016. DPI-Water is in the process of converting this licence into an entitlement under the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016, under the *Water Management Act, 2000*.

Water take from porous rock groundwater sources was 1,331 ML during the reporting period, which is less than WCPL's permitted annual take of 1,647 ML under the *Water Act 1912.*

WCPL maintains a variety of Access Licences under the *Water Management Act 2000* which consist of High, General and Supplementary securities, as detailed in **Table 32**. During the reporting period, WCPL extracted a total of 271 ML of water from the Wollombi Brook under WAL 18437.

No water was used for irrigation purposes during the reporting period (from licence 20WA200632).

Table 32: Environmental Performance – Water Take

<table>
<tr><th>Licence Number</th><th>Description</th><th>Share Component or Entitlement</th><th>Passive take/ inflows (ML)</th><th>Active pumping (ML)</th><th>Total (ML)</th></tr>
<tr><td colspan="6">Hunter Regulated River Water Source</td></tr>
<tr><td>WAL 718</td><td>Hunter River Pump</td><td>1000 shares
(high security)</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>WAL 8599</td><td>N/A</td><td>6 shares
(high security)</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>WAL 8600</td><td>N/A</td><td>868 shares
(general security)</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>WAL 8604</td><td>N/A</td><td>240 shares
(supplementary water)</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="6">Hunter Unregulated and Alluvial Water Sources (Lower Wollombi Brook Water Source)</td></tr>
<tr><td>WAL 18437</td><td>Wollombi Brook Pump</td><td>350 shares</td><td>0</td><td>271</td><td>271</td></tr>
<tr><td>WAL 23897</td><td>Well No. 2</td><td>70 shares</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="6">North Coast Fractured and Porous Rock Groundwater Sources (Sydney Basin - North Coast Groundwater Source)</td></tr>
<tr><td>WAL 39738
(20BL132753)</td><td>Old Well No. 1</td><td>243 shares</td><td rowspan="13">1,069</td><td rowspan="13">262</td><td rowspan="13">1,331</td></tr>
<tr><td>20BL167738[1]</td><td>Dewatering Bore</td><td>57 ML/year</td></tr>
<tr><td>WAL 39735
(20BL168643)</td><td>Dewatering Bore</td><td>40 shares</td></tr>
<tr><td>20BL168017[1]</td><td>Dewatering
(Bore No. 2)</td><td rowspan="3">750 ML/year</td></tr>
<tr><td>20BL172061</td><td>Dewatering
(Bore No. 2a)</td></tr>
<tr><td>20BL173040</td><td>Dewatering Bore</td></tr>
<tr><td>20BL172156[1]</td><td>Dewatering</td><td>98 ML/year</td></tr>
<tr><td>WAL 39803
(20BL166910)</td><td>Dewatering
(Bore No. 1)</td><td rowspan="5">450 shares</td></tr>
<tr><td>20BL173032[1]</td><td>Dewatering Bore</td></tr>
<tr><td>20BL173033[1]</td><td>Dewatering Bore</td></tr>
<tr><td>20BL173034[1]</td><td>Dewatering Bore</td></tr>
<tr><td>20BL173035[1]</td><td>Dewatering Bore</td></tr>
<tr><td>20BL173844[1]</td><td>Dewatering Bore</td><td>9 ML/year</td></tr>
</table>

1. Conversion status to be confirmed by DPI-Water.

6.6 Compensatory Water

WCPL did not provide any compensatory water to any water users during the reporting period.

6.7 Site Water Balance

WCPL reviewed the Site Water Balance at the end of the reporting period, in accordance with the requirements of the WCPL Water Management Plan. A summary of the WCPL site water balance for 2016 is provided in **Table 33**.

Table 33: 2016 Site Water Balance

Water Sources	Volume (ML)
Hunter River	0
Wollombi Brook	271
United Collieries	118
Rainfall/Runoff	1905
Underground Seepage	262
Open Cut Seepage	1069
Total Water Inputs	**3625**
Water Usage	**Volume (ML)**
Dust Suppression	596
CHPP Consumption	1720
Underground	60
United	0
Workshop Water	45
Domestic Usage	2
Total Water Usage	**2423**
Water Loss	**Volume (ML)**
Evaporation – Mine Water & Tailings Dam	711.213
HRSTS Discharge	416
Seepage	979
Water Balance	**-904.213**

A total of 271 ML was extracted from Wollombi Brook during 2016. This is above the EIS forecast annual average extraction volume of 106 ML (Resource Strategies 2003). When combined with water sourced from the United Collieries (118 ML), this brings the total volume of water imported to approximately 11% of the total water input. This is higher than the EIS forecast of an average of 2.6% (Resource Strategies 2003) however, this increase is consistent with the identified trend of increases in water imports as coal production increases.

A total of 1,905 ML of runoff from rainfall was intercepted during the reporting period. Underground and open cut seepage represented 7.2% and 29.5% of total supply compared to a forecast of 13.8% and 28.5% respectively (Resource Strategies 2003).

No water was exported off-site during the reporting period.

WCPL discharged 416 ML of water during the reporting period. Discharges during the reporting period were undertaken in compliance with the HRSTS. WCPL used all available HRSTS credits during the reporting period.

6.8 Erosion and Sediment Control

6.8.1 Management Plan Requirements

WCPL has developed an ESCP to address the relevant consent conditions and regulatory requirements.

Version 7 of the ESCP was approved by DPE on 27 November 2015.

6.8.2 Performance during the Reporting Period

During the reporting period WCPL complied with all requirements detailed in the ESCP (Version 7), however one reportable incident was recorded relating to erosion and sediment control. The incident occurred in January 2016, and involved an uncontrolled release from a sediment dam (**Section 10.1**).

No complaints were received relating to erosion and sediment control in 2016.

As described in **Section 5.15**, an inspection of the NWCD was undertaken by Neil Nelson Agvice Pty Ltd on 3 February 2016, and noted that vegetation cover had improved significantly, having a stabilizing effect and reducing erosion (Neil Nelson Agvice Pty Ltd 2016). Recommendations made following the inspection included the continued monitoring of erosion and repair of the controls following the heavy storm recently experienced.

6.8.3 Trends and Key Management Implications

In January 2016, following a period of significant rainfall, there was an uncontrolled release of water from a temporary sediment dam at the Mine. Additional detail is provided in **Section 10.1**.

6.8.4 Implemented or Proposed Management Actions

During the reporting period, the Montrose East 1 and Montrose East 2 sediment basins and associated contour drains were constructed to control all sediment laden runoff from Montrose East and out of pit dump areas. Collected water is pumped back into the mine water system.

As part of the Rug Dump Rehab final landform design the construction of approximately 2.7 km of contour drains, a 250 m long rock lined channel and two sediment basins was commenced during 2016. The works, scheduled for completion in 2017, will facilitate clean water runoff from site.

7.0 Rehabilitation

7.1 Rehabilitation Performance during the reporting period

7.1.1 Status of Mining and Rehabilitation at the Completion of the Reporting Period

Proposed rehabilitation and disturbance activities for the reporting period are detailed in WCPL's approved MOP Amendment D (2015-2020) and summarised in **Table 34.**

Table 34: Actual versus Proposed Rehabilitation Activities (2016)

	2016 Proposed	2016 Actual
Total Disturbance (ha)	101.4	93.29
Total Rehabilitation (ha)	103.4[1]	101.33
Cumulative Rehabilitation (ha)	549.9	547.83

Note: ha = hectares.

1. Rehabilitation of 52.79 ha at Rug Dump, 23.1 ha at the Homestead Back Fill Project, 17.3 ha at Montrose/Wombat Dump and 10.2 ha at RL160.

Details of mining operations completed at the Mine during the reporting period are included in **Section 3.1.** At the end of the reporting period, the total mine disturbance was 8.11 ha less than the forecast disturbance area and the total rehabilitation undertaken was 2.07 ha less than the forecast rehabilitation area. These discrepancies were due to updates to mine planning and scheduling (as per MOP Amendment D [2015-2020]).

At the end of the reporting period, WCPL was actively mining in the following areas (as shown on **Figure 10**):

- South Bates Underground Longwall 12 (completed 19 December 2016) and Longwall 13 (scheduled to commence in January 2017);
- Montrose Pit (up to Strip 37);
- Montrose East (commenced in October 2016, up to Strip 20); and
- South Wambo Boxcut (commenced in September 2016, up to Strip 10).

Rehabilitation targets were met during the reporting period, including the completion of rehabilitation that was originally planned for 2015.

On 27 June 2016, WCPL was issued with a condition requiring the development of a rehabilitation strategy for the North East Tailings Dam to the satisfaction of the Minister for Industry, Resources & Energy (for inclusion in a MOP). WCPL finalised and submitted the North East Tailings Dam Rehabilitation Strategy to DRE on 21 November 2016. Works associated with the North East Tailings Dam Rehabilitation Strategy are anticipated to commence with the construction of a trial abutment during 2017, with additional works to be undertaken if the trial is successful. **Figure 11**, **Figure 12** and **Figure 13** show photographs of rehabilitation undertaken at Rug Dump during the reporting period.

A key issue that was considered to have the potential to impact on successful rehabilitation in the reporting period was area availability during sowing season in response to climactic weather events that may affect scheduling of mining activities earlier in the year. Area availability was not found to impact on successful rehabilitation during the reporting period.

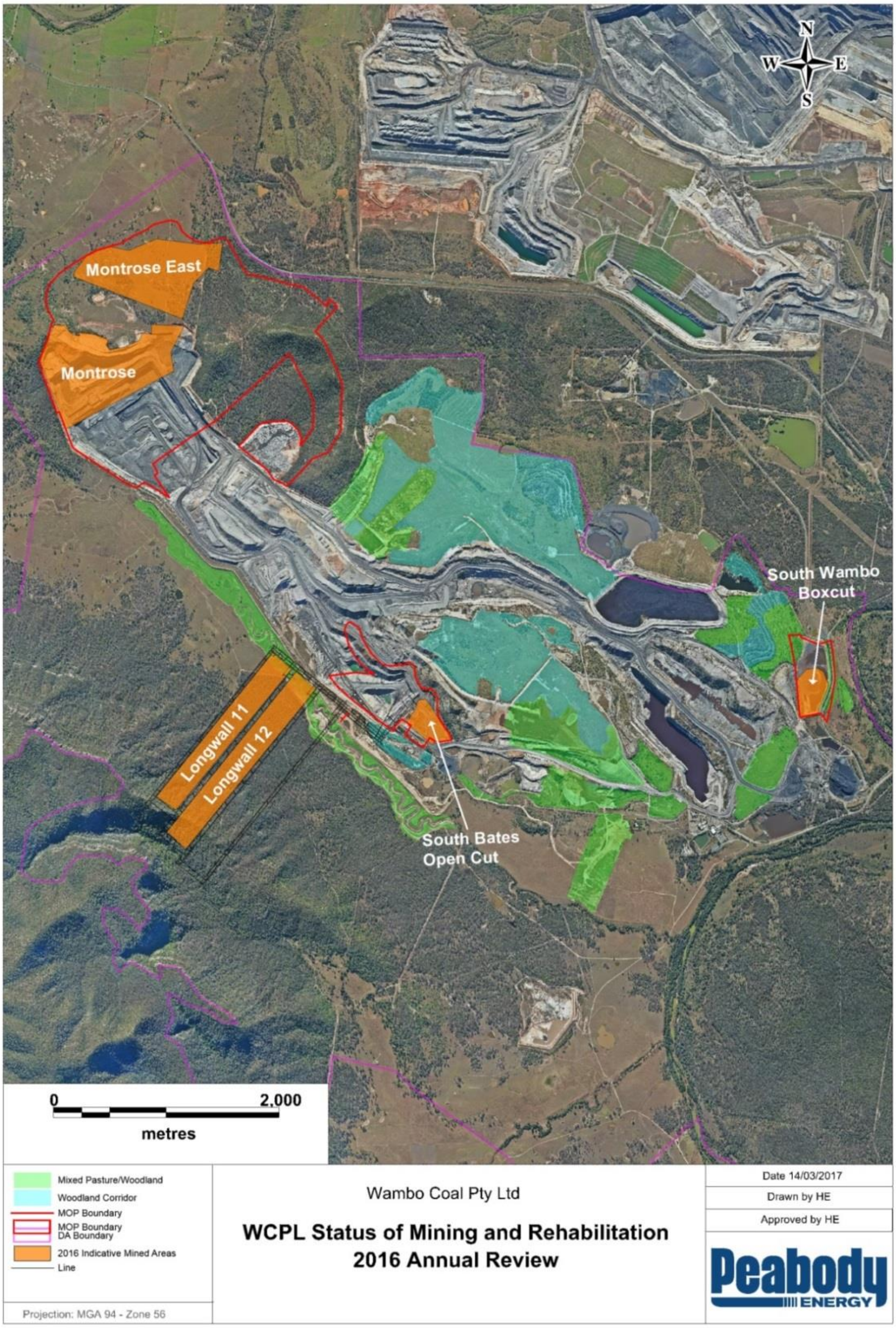

Figure 10: WCPL Status of Mining and Rehabilitation

Figure 11: Rug Dump Rehabilitation (2016)

Figure 12: Rug Dump Rehabilitation (2016)

Figure 13: Rug Dump Rehabilitation (2016)

7.1.2 Agreed Post Rehabilitation Land Use

The agreed post rehabilitation land use for the Mine is detailed in WCPL's EIS (Resource Strategies 2003), DA305-7-2003 and MOP Amendment D (2015-2020). The final landform for WCPL proposes a balanced rehabilitation outcome which recognises the alternative land uses that exist in the region, and therefore aims to establish the potential for both sustainable agriculture and endemic woodland habitat. The proposed design of final landforms and the revegetation strategy is described in MOP Amendment D (2015-2020).

WCPL's Conceptual Mine Closure Plan (CMCP) will be submitted to DPE in the first half of 2017.

All rehabilitation activities undertaken during the reporting period were undertaken with consideration to the agreed post rehabilitation land use goals.

7.1.3 Key Rehabilitation Performance Indicators

Table 35 summarises WCPL's rehabilitation status at the end of the reporting period, compared to the previous reporting period, as well as the forecast for the next reporting period.

Land being prepared for rehabilitation in 2017 is consistent with the scheduled rehabilitation detailed in MOP Amendment D (2015-2020).

7.1.4 Renovation or Removal of Buildings

No buildings were renovated or removed during the reporting period.

7.1.5 Other Rehabilitation Activities

In consultation with DRE an extensive audit of historical exploration works commenced during 2015. The scope of the audit was to identify all historical exploration sites, rehabilitate as required and relinquish the sites to DRE. Of the identified sites:

- 9 sites were rehabilitated;
- 21 sites were inspected by DRE;
- 8 sites were identified as suitable for relinquishment by DRE; and
- 13 sites were identified as mined through.

Table 35: 2016 Rehabilitation Status and Forecast for 2017

Mine Area Type	Previous Reporting Period (Actual) (ha)	This Reporting Period (Actual) (ha)	Next Reporting Period (Forecast) (ha)
A. Total mine footprint[1]	1,686	1,755.3	1,824
B. Total active disturbance[2]	1,169	1,192	1185.5
C. Land being prepared for rehabilitation[3]	55	0	0
D. Land under active Rehabilitation[4]	462	563.3	638.5
E. Completed rehabilitation[5]	0	0	0

1. Total mine footprint includes all areas within a mining lease that either have at some point in time or continue to pose a rehabilitation liability due to mining and associated activities. As such it is the sum of total active disturbance, decommissioning, landform establishment, growth medium development, ecosystem establishment, ecosystem development and relinquished lands (as defined in DRE MOP/Rehabilitation Management Plan [RMP] Guidelines). Please note that subsidence remediation areas are excluded.
2. Total active disturbance includes all areas ultimately requiring rehabilitation such as: on-lease exploration areas, stripped areas ahead of mining, infrastructure areas, water management infrastructure, sewage treatment facilities, topsoil stockpile areas, access tracks and haul roads, active mining areas, waste emplacements (active/unshaped/in or out-of-pit), and tailings dams (active/unshaped/uncapped).
3. Land being prepared for rehabilitation – includes the sum of mine disturbed land that is under the following rehabilitation phases – decommissioning, landform establishment and growth medium development (as defined in DRE MOP/RMP Guidelines).
4. Land under active rehabilitation - includes areas under rehabilitation and being managed to achieve relinquishment – includes the following rehabilitation phases as described in the DRE MOP/RMP Guidelines – "ecosystem and land use establishment" (area seeded OR surface developed in accordance with final land use) and "ecosystem and land use sustainability" (revegetation assessed as showing signs of trending towards relinquishment OR infrastructure development).
5. Completed rehabilitation – requires formal sign-off by DRE that the area has successfully met the rehabilitation land use objectives and completion criteria.

During this reporting period the scope of the audit was finalised and a total of 222 sites associated with historical exploration were identified in A444 and 17 in EL7211. The sites were identified as requiring inspection, possible rehabilitation and eventual relinquishment. Of these, 28 sites were inspected as part of the preliminary *WCPL_01_16 EL7211 & A444 Exploration Licences – Audit of Rehabilitated Exploration Sites*. This document will form the basis of the A444 focussed audit due to commence during the next reporting period and historical exploration rehabilitation/relinquishment efforts. Both the EL7211 and A444 audits will be submitted to DRE in 2017.

During the reporting period an additional 13 exploration sites were drilled within EL7211 and A444 as approved by DRE under the Part 5 approval process. These sites were fully rehabilitated and are subject to ongoing inspections prior to a targeted relinquishment in 2017.

In late 2015, WCPL commenced the removal of infrastructure from the North Wambo Underground – Homestead Inpit, ahead of utilising the pit for site water storage. During the reporting period, WCPL completed the removal of all infrastructure and services from the North Wambo Underground – Homestead Inpit.

WCPL have developed completion criteria for rehabilitation sites as part of the revised Biodiversity Management Plan (to replace the FFMP). These criteria have also been included in the latest revision of the MOP (Amendment D), which was approved by DPE in November 2016.

A Topsoil Management Procedure was developed and implemented in 2014. During 2016, WCPL undertook a major revision of the Topsoil Management Procedure. The Topsoil Management Procedure details management measures for topsoil including weed control and preferential use of topsoil from woodland areas for woodland rehabilitation.

7.1.6 Variations in Activities Proposed in the MOP

During the reporting period, rehabilitation was undertaken in accordance with the activities proposed in MOP Amendment D (2015-2020).

7.1.7 Trials, Research Projects and Other Initiatives

During the reporting period, the MOP Amendment D (2015-2020) was updated to include revised mining and rehabilitation plans, and rehabilitation performance criteria and monitoring requirements.

As part of the FFMP review conducted during 2015 and 2016, WCPL developed a new flora and fauna monitoring program based on a combined LFA/Biometric monitoring methodology. This methodology seeks to provide quantitative data that will accurately detail the progress of rehabilitation and inform accurate management decisions. The revised FFMP was submitted to DPE for approval in October 2016.

During 2015 and 2016, WCPL investigated the viability of aerial seeding as an option for the revegetation of the NWCD. Aerial seeding was eliminated as a viable option due to the cost involved and the fact that access was readily available for purpose built throwers and hand seeding.

The following rehabilitation trials were undertaken during the reporting period:

- capping studies of North East Tailings Dam;
- incorporation of organic matter with topsoil material; and
- application of gypsum to improve soil sodicity along NWCD and rehabilitation outcomes.

As described in **Section 7.1.1**, WCPL finalised and submitted the North East Tailings Dam Rehabilitation Strategy to DRE on 21 November 2016. Works associated with the North East Tailings Dam Rehabilitation Strategy are anticipated to commence with the construction of a trial abutment during 2017, with additional works to be undertaken if the trial is successful.

Monitoring of the effectiveness of the incorporation of organic matter in topsoil and the application of gypsum to improve soil sodicity occurred as part of the annual biodiversity monitoring program. The LFA and visual observations conducted indicate an improvement from previous years, although monitoring will continue to assess long term performance. The trial will continue to be implemented for Stage 2 rehabilitation works at the NWCD that are scheduled for 2017.

A subsidence repair trial was undertaken in 2015 to repair select surface cracking in response to subsidence from Longwalls 10 and 10A. In parallel with the subsidence audit (**Section 5.9.3**), a scope of works to progress subsidence repairs at the Mine is being developed and will be completed during the next reporting period.

7.1.8 Key Issues That May Impact Successful Rehabilitation

A key issue that may impact on successful rehabilitation in the next reporting period is area availability during sowing season in response to climatic weather events that may affect scheduling of mining activities earlier in the year.

7.1.9 Rehabilitation Audit

In 2015, WCPL engaged GHD to undertake an audit of the rehabilitated areas on-site. The scope of the audit includes the following:

- Identify the areas where rehabilitation has been undertaken by year;
- Assess the quality of each of the identified rehabilitation areas against rehabilitation performance criteria/final land use;
- Identify the rehabilitation phase for each rehabilitation area (e.g. decommissioning, landform establishment, growth medium development, ecosystem and land use establishment etc.);
- Develop a scope of works to be undertaken to progress the rehabilitation to the next phase (e.g. growth medium to ecosystem development etc.); and
- Where the audit is unable to identify closure criteria, the program is to include development of these.

The audit commenced in December 2015 and the audit report was finalised in June 2016 and submitted to the DRE (**Section 9.4**).

7.2 Actions for the next reporting period

7.2.1 Final Rehabilitation Outcomes

Completion criteria for rehabilitation on-site have been developed as part of the new Biodiversity Management Plan (to replace the FFMP) and have been incorporated into the latest MOP Amendment D (2015 – 2020). These completion criteria were developed using a combined LFA/Biometric monitoring methodology, utilising a combination of site specific analogue sites and DRE developed community benchmarks where analogue sites within the local region are not present. Approval of MOP Amendment D (2015 – 2020) was granted in November 2016.

WCPL's CMCP will be submitted to DPE in the first half of 2017.

7.2.2 Rehabilitation Trials, Research Projects and Other Initiatives

The following rehabilitation trials will continue in 2017:

- Capping trials of North East Tailings Dam (in accordance with the North East Tailings Dam Rehabilitation Strategy);
- Incorporation of organic matter with topsoil material; and
- Application of gypsum to improve soil sodicity along NWCD and rehabilitation outcomes.

A subsidence repair trial was undertaken in 2015 to repair select surface cracking in response to subsidence from Longwalls 10 and 10A. A scope of works to progress subsidence repairs will be developed in alignment with the outcomes of the subsidence audit in 2017.

Implementation of rehabilitation recommendations from the A444 and EL7211 historical exploration audit will be scheduled for 2017.

7.2.3 Proposed Rehabilitation in the Next Reporting Period

The following areas, detailed in MOP Amendment D (2015-2020), are scheduled for rehabilitation during the next reporting period:

- Montrose East Out of Pit Dump (31.5 ha);
- Baron Zone Dump (7.7 ha);
- Son of Montrose Entrance (5.3 ha);
- RL110 (12.7 ha);
- Rug Dump (12.9 ha); and
- RL160 (5.0 ha).

Subsidence repair trials will continue into 2017 and will be undertaken in accordance with any recommendations made in the audit of subsidence impacts.

8.0 Community

WCPL operates a 24 hour Community Enquiry Line (02 6570 2245), a Blasting information Hotline (02 8250 5205), a SMS text messaging Blast notification service and a dedicated community email account (wambocommunity@peabodyenergy.com), to enable community members to make enquiries or lodge complaints regarding the operation of the Mine.

8.1 Community Engagement Activities and Initiatives

8.1.1 Community Consultative Committee

The WCPL CCC is made up of residents from the surrounding district, a representative of Singleton Council and WCPL management. The CCC representatives act as the point of contact between the mine and the community. The CCC is chaired by an independent chairperson.

During the reporting period WCPL held three CCC meetings:

- Tuesday 12 April;
- Tuesday 30 August; and
- Wednesday 7 December.

Minutes of these meetings are available on the Peabody Energy website (www.peabodyenergy.com).

8.1.2 Community Information Sessions

These sessions are an opportunity for local residents to meet senior mine personnel to discuss current and future operations where possible. Advertisements are published in the Singleton Argus and flyers are delivered to the surrounding district to notify interested community stakeholders to attend.

During the reporting period, WCPL conducted an open community information session on 6 July 2016.

8.1.3 Newsletters

One newsletter was published during the reporting period in September 2016 and provided a general update on WCPL operations. This newsletter is available on the Peabody Energy website (www.peabodyenergy.com).

8.1.4 Other Community Engagement Activities

WCPL provided sponsorship for the Singleton Hall of Fame awards in October 2016. Members of the WCPL management team attended the event, participating in the selection and announcement of winners on the night.

8.2 Community Contributions

During the reporting period WCPL supported the following organisations:

- Wildlife Aid Inc;
- Hunter Coal Festival;
- Camp Quality;
- Westpac Rescue Helicopter (Westpac Rescue Charity Knockout competition);
- Cystic Fibrosis NSW; and
- Cancer Council.

8.3 Community Complaints

WCPL received a total of 29 community complaints for the reporting period, including four (4) for blasting, twelve (12) for noise, seven (7) for dust and six (6) for lighting impacts. The total number of complaints is similar to those received in the 2013 and 2014 reporting periods, but is greater than the number of complaints received in 2015 (**Figure 14**).

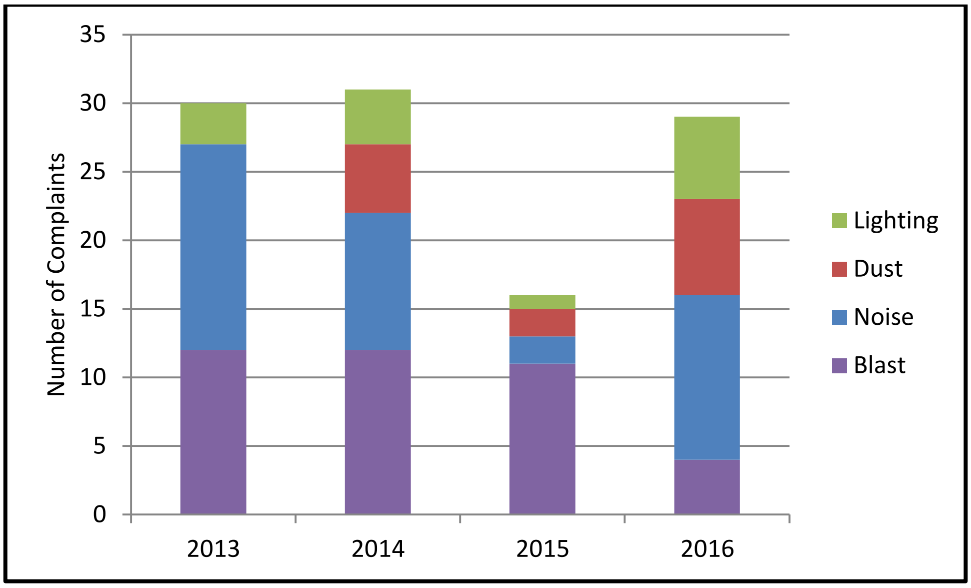

Figure 14: Community Complaints (2013-2016)

Complaints relating to blasting have previously been relatively consistent, with 12 complaints recorded in 2013 (nine [9] of these for blast fume, three [3] for noise and vibration), 12 recorded in 2014 (three [3] for blast fumes, seven [7] for noise and vibration, one [1] for dust and [1] general) and 11 recorded in 2015 (all for vibration). In 2016, there was a reduction in complaints received relating to blasting, with only four (4) received (three [3] for vibration and one [1] for fume). The reduction in complaints is considered to be due to the review and implementation of the updated Blast Management Plan at the end of 2015. In addition, a greater focus on pre-blast meteorological assessments, fume management, blast designs, planning and monitoring are considered to have contributed to the reduction in blasting complaints.

The number of noise complaints increased in 2016, when compared to 2015, in response to operations moving closer to sensitive receivers. All complaints were reviewed and noise levels assessed against available data. WCPL is confident that it complied with all noise compliance criteria as supported by monthly attended noise monitoring results.

In response to a complaint received on 20 October 2016, in relation to noise and blasting, the EPA contacted WCPL and requested a detailed report on relevant WCPL operations.

During the reporting period, the number of dust complaints received increased from two (2) in 2015 to seven (7). This is considered to be associated with operations commencing in Montrose East Pit in October 2016, a more exposed location. Dust complaints typically related to visible dust leaving the site. When requested, detailed reports on WCPL operations were provided to the DPE and EPA (during November and December 2016), regarding the status of WCPL operations at the time of the complaints.

During 2016, a total of six (6) complaints were received relating to lighting. Three (3) of the complaints were made by the same resident as in previous years and related to lighting plant operating in the open cut pit at night. One (1) of the complaints also related to lighting plant operating in the open cut pit at night and two (2) complaints related to light from general operations (i.e. lighting plant, truck lights and excavator lights) conducted during the night. All of the lighting complaints received in 2013, 2014 and 2015 were from one (1) resident, who lives in close proximity to the mining operations. The complaints related to impacts from lighting plants operating in the open cut pit at night.

Following a complaint received relating to lighting on 5 November 2016, DPE requested a report from WCPL detailing how operations were being managed in accordance with the requirements of DA305-7-2003, DA177-8-2004 and associated management plans. DPE also requested a detailed report on WCPL operations in response to a lighting complaint received on 17 and 18 December 2016. WCPL provided detailed reports to DPE in November 2016 and January 2017.

A summary of the detailed reports provided to the DPE and EPA in response to complaints is provided in **Section 10.9**.

9.0 Independent Audit

9.1 2014 Independent Environmental Audit for Development Approvals

An Independent Environmental Audit (IEA) was undertaken by Hansen Bailey in November 2014 to assess compliance against DA305-7-2003 and DA177-8-2004. The audit also assessed compliance against EPL529 and ML1572. The audit report was finalised in March 2015 and submitted to DPE in accordance with Condition 7, Schedule 6 of DA305-7-2003.

Following submission of the audit report, DPE requested that WCPL operations at the Mine during the period 11 June 2011 and 1 January 2012 also be audited. This audit was also undertaken by Hansen Bailey and a subsequent addendum to the IEA was submitted to DPE in April 2015. A copy of the audit report is available on the Peabody Energy website (www.peabodyenergy.com).

Fifteen (15) non-compliances were identified during the audit, including nine (9) which were classed as "administrative". The report included 47 recommendations for improvement (27 were administrative). **Table 36** summarises the recommendations from this audit and WCPL's progress against the action plan developed to address these recommendations. The next IEA for DA305-7-2003 and DA177-8-2004 is due in 2017.

9.2 2015 Independent Environmental Audit for EPBC 2003/1138

An IEA was undertaken by Umwelt in February 2015 to assess compliance against EPBC 2003/1138, the Biodiversity Offset Strategy (BOS) required by DA305-7-2003, and the commitments made in WCPL's FFMP. The audit report was finalised in May 2015 and submitted to DoEE and DPE in accordance with Condition 4 of EPBC 2003/1138 and Condition 50, Schedule 4 of DA305-7-2003. A copy of the audit report is available on the Peabody Energy website (www.peabodyenergy.com).

Two (2) non-compliances were identified during the audit. The report included 14 recommendations for improvement. **Table 37** summarises the recommendations from this audit and WCPL's progress against the action plan developed to address these recommendations. The next IEA for EPBC 2003/1138 and the BOS is due in 2020.

9.3 2015 Independent Environmental Audit for South Bates Underground Extraction Plan

In 2015, WCPL commissioned Bruce Hebblewhite (subsidence), WRM Water & Environment (surface water) and Dundon Consulting Pty Ltd (groundwater) to undertake an independent audit of the subsidence, surface water and groundwater impacts prior to the submission of an Extraction Plan for Longwalls 11-13, in accordance with Condition 37, Schedule 4 of DA305-7-2003. The report was finalised in June 2015 and submitted to DPE. **Table 38** summarises the recommendations from this audit.

9.4 2016 Independent Rehabilitation Audit for Annual Environment Management Report

In 2015, WCPL commissioned GHD to undertake an independent audit (GHD 2016) of the rehabilitation at the Mine to identify any potential deficiencies of the rehabilitation and improvement strategies. The audit report was finalised in June 2016 and submitted to DRE. **Table 39** provides an update on the status of the audit recommendations, including:

- Matters that have been addressed in MOP amendments.
- A strategy and timeframe for addressing matters that are still outstanding.
- Matters that are subject to further refinement (i.e. pending the results of monitoring).

Table 36: Actions from the 2014 IEA for DA305-7-2003 and DA177-8-2004

No.	Risk Ranking	Recommendation	Action Plan Progress
Previous Audit			
1	Administrative	Review actions recommended by previous audit (2011) which have not been completed. Update management plans as required to address recommendations that are relevant to contemporary operations.	Ongoing.
DA305-7-2003			
2	Administrative	Include reporting measure to minimise greenhouse gas emissions in the Annual Review (Schedule 4, Condition 3).	Complete - Refer **Section 5.4**.
3	Administrative	Ensure that the implementation and maintenance for required noise attenuation of plant and equipment is documented (Schedule 4, Condition 8).	Ongoing – Refer **Section 5.1**.
4	Administrative	Revise the North Wambo Creek Diversion Plan to include the required section on mechanism for the return of intercepted groundwater (Schedule 4, Condition 31(c)).	Ongoing.
5	Low	Ensure that design for return of groundwater is in place for the North Wambo Creek Diversion Plan (Schedule 4, Condition 31(c)).	Ongoing.
6	Moderate	Engage a specialist to complete the required Reject Emplacement Strategy document, in consultation with DRE (Schedule 4, Condition 22G).	The reject emplacement strategy was submitted for approval in September 2014.
7	Administrative	Include HRSTS compliance forecasts in Annual Reviews (Schedule 4, Condition 26).	Complete - Refer **Section 6.3.4**.
8	Administrative	Revised Site Water Management Plans should be finalised as soon as practical and submitted for consultation with required agencies (Schedule 4, Conditions 29(f)), 30).	Complete.
9	Moderate	Finalise the Final Void Strategy as soon as possible in 2015 for DPE and SSC approval, and consultation to occur with DRE (Schedule 4, Condition 39).	A draft Final Void Management Plan was submitted to DPE in June 2016. A review of the plan will be required on the basis that the final landform is currently under review as a component of the United & Wambo Open Cut Coal Mine Project (SSD 7142).
10	Moderate	Submit the oral history report document for the Wambo Homestead Complex as soon as practical in 2015 (Schedule 4, Condition 60).	Complete.
11	Moderate	Confirm which, if any moveable Non-Aboriginal items identified in the Wambo EIS should be conserved (Schedule 4, Condition 70).	Nil – relocation of moveable European heritage items is not proposed.
12	High	Ensure Montrose Tree screen areas are regularly watered and mulched as necessary to ensure quick growth and effectiveness in mitigating visual impacts (Schedule 4, Condition 82).	Ongoing.

No.	Risk Ranking	Recommendation	Action Plan Progress
13	Administrative	Ensure all data, analyses and other information required to be reported on an annual basis is documented in accordance with consent conditions (Schedule 6, Condition 5).	Complete.
14	Administrative	Place responses to the 2011 independent audit and this document on the Wambo website (Schedule 6, Condition 12).	2011 IEA superseded by 2014 IEA. 2014 IEA on WCPL website.
15	Moderate	Undertake regular training on blast fume management with relevant personnel to ensure pre-blast checks are undertaken (Schedule 4, Condition 2).	Complete – All aspects of blasting is managed by the Drill and Blast Superintendent. This includes forecast monitoring, blast sizing and design and compliance with the BMP.
16	Administrative	Review the Surface Disturbance Permit (SDP) form checklist to include a figure which shows the disturbance associated with the SDP, MOP disturbance boundary and the approval Surface Development Area from Figure 2 of the North Wambo Underground Modification EA (or modified version) (Schedule 3, Condition 2).	Complete.
17	Administrative	Remove consent condition requiring payment of S94 contributions when the consent is next modified (Schedule 3, Condition 11).	Complete. Condition 11, Schedule 3 was deleted by DA305-7-2003 MOD 12.
18	Administrative	Remove consent condition to requiring payment of community enhancement funds for the Warkworth / Jerrys Plains area when the consent is next modified (Schedule 3, Condition 12).	Complete. Condition 12, Schedule 3 was deleted by DA305-7-2003 MOD 12.
19	Administrative	Amend consent condition to remove reference to Kannar property when the consent is next modified (Schedule 4, Condition 7).	Complete. Condition 7, Schedule 4 was modified by DA305-7-2003 MOD 12 to include a note explaining that property 23C has been acquired and is now mine-owned.
20	Administrative	Amend consent condition to remove reference to properties 23, 31, 51, and 56 when the consent is modified (Schedule 4, Condition 10)	Complete. It is understood that this recommendation relates to Condition 1, Schedule 4. Condition 1, Schedule 4 was modified by DA305-7-2003 MOD 12 to include a note explaining that these properties were acquired and are now mine-owned.
21	Administrative	Do not include discussion of exceedances of impact criterion on mine owned land in the Annual Reviews (Schedule 4, Condition 4).	Noted.
22	Administrative	Remove conditions relating to the haulage of product coal by public roads as this activity has been superseded (Schedule 4, Conditions 74-78)	Complete. Conditions 74, 76, 77 and 78, Schedule 4 were deleted by DA305-7-2003 MOD 12 and Condition 75, Schedule 4 was revised.
23	Low	Consider removing DD gauges as long as next closest receiver has a DD between them and operation (Schedule 4, Condition 4).	Noted.
24	Moderate	Review of real-time noise monitoring sites is recommended to ensure ongoing effectiveness as a management tool for Wambo operations (Schedule 4, Condition 6).	Complete.

No.	Risk Ranking	Recommendation	Action Plan Progress
25	Moderate	Investigate options to integrate the predictive weather (Weatherzone) and real-time monitoring (Sentinex) elements of the noise and air quality management systems to enhance the predictive abilities of the system prior to operations going through Montrose Ridge (Schedule 4, Conditions 5B, 8).	Incomplete. System integration has not occurred due to insufficient time as Weatherzone was reengaged in late 2016.
26	Moderate	Commission a second remote camera for the visual monitoring of in-pit equipment locations and dust emissions consistent with Table 14 of the Air Quality and Greenhouse Gas Management Plan (Schedule 4, Conditions 5C).	A second in pit camera was purchased and commissioned in 2016 focussing on the Montrose East and Montrose pit areas.
27	Moderate	Commission a noise monitoring specialist to provide advice on an alternate representative location for the Muller monitor where it is less affected by traffic noise and consideration of a directional element (Schedule 4, Condition 9).	Not complete in 2015. Will be reviewed as part of the NMP review in 2016.
28	Administrative	Maintain a register to document timing and scale of any operational changes made in response to adverse conditions or noise alarms from monitoring units and document this in future Annual Reviews (Schedule 4, Condition 8).	The open cut maintains a register of actions taken in response to adverse atmospheric conditions as part of the OC Supervisor Shift Reports. These shift reports are issued daily to site personnel and detail equipment movements during the day and night shifts.
29	Administrative	Maintain a register to document timing and scale of any operational changes made to minimise cumulative noise impacts and document this in future Annual Reviews (Schedule 4, Condition 9).	The open cut maintains a register of actions taken in response to adverse atmospheric conditions as part of the OC Supervisor Shift Reports. These shift reports are issued daily to site personnel and detail equipment movements during the day and night shifts.
30	Moderate	Use best endeavours to resolve data sharing agreement for co-ordination of blast times, particularly in relation to monitors to the NW of the open cut area to assist in management of noise and air quality of northern receivers (Schedule 4, Condition 18).	Surrounding sites are notified of WCPL blasting dates and times by email. These sites are Hunter Valley Operations, Mount Thorley Warkworth (MTW) and United. Informal data sharing agreement exists between mines.
31	Administrative	Include mapping and specific description impact performance for threatened ecological communities (Boxgum woodland and WSW) in future SMP reviews (Schedule 4, Condition 22)	Complete and ongoing.
32	Administrative	Review the approval Rehabilitation Management Plan to ensure consistency with the approved Extraction Plans (Schedule 4, Condition 22).	Complete - MOP Amendment D now forms the Rehabilitation Management Plan.
33	Low	Review SW monitoring sites in consultation with relevant regulators and remove redundant sites from monitoring program (Schedule 4, Condition 35).	Complete.
34	Low	Update signage of the Keeping Place for Aboriginal cultural heritage items to ensure that the area is well defined (Schedule 4, Condition 53).	Complete.
35	Administrative	Consider seeking recovery of funding contribution to HACHTF if regulators confirm that it has not been expended, or if it has, seek the documented outcome of the Trust Fund (Schedule 4, Condition 56).	Will be reviewed in 2017.

No.	Risk Ranking	Recommendation	Action Plan Progress
36	Low	Notify owners of private residences that were predicted to experience high visual impacts to their right to visual mitigation under consent condition, if not already provided (Schedule 4, Condition 83).	Complete.
37	High	Seek expert advice from noise and air specialists to confirm that predictions remain valid with the change in mine plan progression (in comparison to Wambo EIS) proposed by Wambo (Schedule 4, Condition 84).	Undertaken as part of the approval modification process.
38	Administrative	2014 Annual Review to include a discussion of actions undertaken to mitigate off-site lighting impacts (Schedule 4, Condition 85).	Complete.
39	Administrative	Report on greenhouse gas emissions and minimisation actions in the Annual Review (Schedule 4, Condition 87).	Complete.
40	Administrative	Report on the effect of growth medium trials on rehabilitation performance in the 2015 Annual Review (Schedule 4, Condition 94A).	Complete – LFA and Biometric completion criteria was developed in 2015. This information will be reviewed to determine the effectiveness of rehabilitation in varying mediums.
41	Administrative	Investigate the viability of aerial seeding or other cost effective 'interim' rehabilitation strategies to reduce dust emissions and report on their feasibility in the Annual Review (Schedule 4, Condition 94B)	Complete/ongoing – refer **Section 7.1.7**.
42	Low	Prepare revised Rehabilitation Management Plan in accordance with consultation requirements for agencies (Schedule 4, Condition 94B).	Complete - MOP Amendment D now forms the Rehabilitation Management Plan.
43	Low	Review the approved EMS in 2015 (Schedule 6, Condition 1).	To be completed in the next reporting period.
DA177-8-2004			
44	Administrative	Seek final correspondence from RMS confirming their requirements (or otherwise) for the upgrade of the Golden Highway / Wallaby Scrub Road intersection (Schedule 4, Condition 19).	No longer required as MTW have received DPE approval to mine through Wallaby Scrub Road. There has been ongoing correspondence between WCPL and RMS on this issue.
45	Administrative	Include the rail loop and refuelling facility in future lighting reviews of the Wambo site.	Noted - Next lighting review scheduled for 2017.
EPL529			
46	Administrative	Review premises map referred in EPL conditions and update at next variation to reflect current operations if there is any inconsistency (Condition A2.1).	Noted.
ML1572			
47	Administrative	Request amendment to Condition 21 Trees and Timber (a-c) or removal from the document at the next renewal of the ML (Condition 21).	Noted – currently the subject of discussions with the EPA.

Table 37: Actions from the 2015 IEA for EPBC 2003/1138, the BOS and FFMP

No.	Recommendation	Action Plan Progress
EPBC 2003/1138		
1	Wambo should ensure that approval is sought and granted for all future activities in the RWEP area A. Alternatively, Wambo could seek a general agreement with the Minister for the activities that are permitted within RWEP Area A, without Wambo needing to specifically get approval prior to each activity.	Noted.
2	Wambo should ensure that approval is sought and granted for all future activities in the RWEP areas. Alternatively, Wambo could seek a general agreement with the Minister for the activities that are permitted within RWEP Area A, without Wambo needing to specifically get approval prior to each activity. This agreement may be obtained by revising the FFMP to clearly identify which activities are permitted within the RWEP areas and the environmental controls to manage these activities, and where necessary, the further approvals that need to be obtained. The revised FFMP should be provided to the Minister for approval.	Noted.
3	Prior to undertaking any further activities within the RWEP areas, Wambo should revise the FFMP to clearly identify which activities are permitted within the RWEP areas and the environmental controls to manage these activities, and where necessary, the further approvals that need to be obtained. The revised FFMP should be provided to the Minister for approval.	FFMP (including Vegetation Clearance Protocol [VCP]) was updated during the reporting period and submitted to DPE for approval – Refer **Section 5.6**.
Biodiversity Offset Strategy (Conditions 44-50, Schedule 4 of DA305-7-2003)		
4	Update the FFMP to include more specific management measures relating to subsidence impacts in the RWEP areas.	FFMP (including VCP) was updated during the reporting period and submitted to DPE for approval – Refer **Section 5.6**.
5	Update the Vegetation Clearance Protocol (VCP) to address the control of weeds during clearing activities.	
6	The FFMP should be revised to include more targeted management strategies for each RWEP area in consideration of the habitat features present.	
7	Complete the annual reviews of the performance of the FFMP.	Complete - Refer **Section 5.6**.
8	Complete future audits within the required timeframe or obtain approval from the Minister for an extension to the timeframe.	Noted.
FFMP		
9	It is recommended that Wambo update site processes/procedures to ensure nesting/breeding times for species known to occur and likely to occur on site are known and considered in the timing of clearing activities.	FFMP (including surface disturbance permit) was updated during the reporting period and submitted to DPE for approval – Refer **Section 5.6**.
10	It is recommended that Wambo install nest boxes and structures in accordance with the FFMP and/or commission an ecological assessment to determine the extent of hollow resources currently occurring in the Wambo land holding, particularly in offset areas and make recommendations regarding the identification of any areas that are low in hollow resources that could therefore benefit from the introduction of nest boxes.	Nest boxes planned for installation in 2017.

No.	Recommendation	Action Plan Progress
11	Wambo should include reporting on the specific flora and fauna management strategies/management measures implemented during the year in each AEMR.	Complete - Refer **Section 5.6**.
12	Wambo should ensure that approval is sought and granted for all future activities in the RWEP area A. Alternatively, Wambo could seek a general agreement with the Minister for the activities that are permitted within RWEP Area A, without Wambo needing to specifically get approval prior to each activity.	Noted.
13	Improve documentation of rehabilitation monitoring processes. Wambo could consider developing an inspection checklist to address the relevant requirements and document corrective actions.	Rehabilitation monitoring is undertaken annually. In 2015 WCPL developed LFA and biometric benchmarks to assist with the effectiveness of monitoring. Additionally a review of the rehabilitation monitoring program was undertaken -this is currently being finalized. The biodiversity monitoring consultants record their findings during this process.
14	Wambo should complete incident notifications as required of the FFMP. Alternatively, if this was not the intention of the FFMP, the FFMP should be revised to reflect the intended reporting requirements and relevant legislative requirements and the revised FFMP provided to the Ministers for approval.	FFMP (including VCP) was updated during the reporting period and submitted to DPE for approval – Refer **Section 5.6**.

Table 38: Actions from the 2015 IEA for South Bates Underground Longwalls 11-13 Extraction Plan

No.	Recommendation	Action Plan Progress
Coal Mine Subsidence		
1	Some minor apparent errors or discrepancies in the LW7 End of Panel Report regarding tilt data should be investigated and rectified for LW7, as well as ensuring that such apparent errors are not present in the later End of Panel reports.	Complete and resent to DRE.
2	Given the limited amount of multi-seam longwall mining in Australia, it is imperative that the maximum amount of subsidence data is gathered from such operations, and in particular, from Wambo. This data should be used to continue to review existing techniques, and conduct ongoing research to further develop the understanding of such behaviour, in order to improve the prediction algorithms and methodologies available. This should be a priority for future subsidence research, and in particular, the understanding of three seam operations requires significant further research and development, due to the lack of reliable validation data at present. Until such work is conducted, predictions of this type of subsidence behaviour should be regarded with due caution and should include a significant level of conservative assessment.	The Subsidence Monitoring Program for the South Bates Underground Mine has been prepared in consultation with DRE.
Surface Water		
3	To meaningfully interpret trends in the monitoring data in terms of the possible impacts of the project on loss of baseflow, water quality measurements need to be coupled with reliable streamflow measurements.	Following the audit, WCPL has reviewed its flow gauging stations. As a result, new gauging stations have been installed on Stony Creek (and one of its tributaries).
4	The Surface Water Management Plan sets trigger levels, however, there are no actions proposed for when levels are exceeded. If future monitoring indicates that the potential trends identified in this report are statistically significant, an investigation should be undertaken to identify the cause and the potential consequences.	Trigger Action Response Plans (TARPs) are included in WCPL's Surface and Groundwater Response Plan (SGWRP), which forms part of WCPL's Water Management Plan. The SGWRP was updated following this audit. The revised SGWRP was approved by DPE on 27 November 2015.
5	The accuracy of streamflow data is not adequate for assessing changes in low flows through the impacted reaches. The geometry and character of streams is such that the flow rating curves are unlikely to be sufficiently accurate to measure small changes in baseflow. Consideration should be given to installing low flow measuring flumes and undertaking flow gauging to calibrate the rating curves.	Following the audit, WCPL has reviewed its flow gauging stations. As a result, new gauging stations have been installed on Stony Creek (and one of its tributaries).

No.	Recommendation	Action Plan Progress
6	Areas of subsidence which are not free-draining were observed during the site visit. Water collected in these areas is likely to be lost to evaporation. While the quantity of water involved is probably small, it is not clear that these catchment losses were properly accounted for as part of the previous impact assessment. Areas of standing water should be identified and appropriate actions taken if they are found to be significant.	The EIS (Resource Strategies 2003) predicted that ponding would occur in low-lying areas above the underground mining areas. As part of WCPL's recent modification (MOD 12), existing and predicted topographical depressions have been identified and assessed. In many instances, it is preferable to minimise works to re-grade areas in order to allow drainage of topographic depressions, as such works have the potential to lead to other problems, such as erosion.
7	The available stream cross-sections and long-sections are not adequate for identifying areas potentially impacted by subsidence and designing appropriate mitigation measures. The collection of survey data in the impacted reach should be targeted at collating high quality data in the areas likely to be impacted by subsidence. Consideration should be given to preparing surface level impact maps rather than 1-dimensional cross-sectional strings. This should be complemented by a comprehensive photographic geomorphic field monitoring program to proactively monitor for future damage and the success of mitigation works.	The approved Extraction Plan for the South Bates (Whybrow Seam) Underground Mine included obtaining a detailed photographic geomorphic record and review of 3-dimensional surface level maps for the NWCD in advance of, and following, mining beneath the NWCD (to incorporate the recommendations of this audit). WCPL has commissioned Alluvium Consulting to monitor subsidence impacts on the Diversion.
Groundwater		
8	It is recommended that Wambo investigate the cause(s) of the water level and water quality changes at GW08 and GW09, and if appropriate recommend response actions.	An investigation into the declining water levels in bores GW08 and GW09 was undertaken during 2015 and reported in the 2015 Annual Review.
9	It is recommended that the groundwater impact assessment criteria be reviewed, and re-defined in terms of the minimum impact considerations described in the Aquifer Interference Policy for highly productive and less productive groundwater.	The SGWRP was updated following this audit. The revised SGWRP was approved by DPE on 27 November 2015.
10	It is further recommended that annual reporting in the AEMR be expanded to include a consideration of longer-term trends or changes, rather than limiting the analysis to the current year's data only	A consideration of longer-term trends and changes in groundwater levels and quality is discussed in **Section 6.2** and **Appendix G**.

Table 39: Actions from the 2016 Rehabilitation Audit

No.	Recommendation	Action Plan progress
1	Defining rehabilitation activities and who is responsible for doing each activity is a key component of both rehabilitation and maintenance. Roles and responsibilities should be assigned for each rehabilitation activity including maintenance activities. These should be developed in the MOP and communicated to relevant site personnel.	Roles and responsibilities for rehabilitation activities are detailed in MOP Amendment D. These roles and responsibilities have been communicated to the relevant site personnel.
2	The Initial Post-Establishment Monitoring Checklist or an adapted version of the checklist should be used to confirm and record any deviations from the proposed rehabilitation method/ activities for each rehabilitation area. There is currently no review process to confirm that overburden has been characterised, topsoil tested etc. Characterisation is important to determine amelioration rates.	The Initial Post-Establishment Monitoring Checklist or an adapted version of the checklist will be developed and used during the next reporting period to confirm and record any deviations from the proposed rehabilitation method/ activities for each rehabilitation area.
3	The Rehabilitation Register should be reviewed, with information added to bring it up to date and continued to be maintained at least annually.	The Rehabilitation Register will be reviewed annually and updated accordingly.
4	The Topsoil Management Procedure would benefit from the development of a checklist/ ITP with key activities to ensure that requirements are undertaken in accordance with the procedure.	This will be incorporated in the next revision of the Topsoil Management Procedure.
5	Ensure that site personnel with responsibilities for topsoil removal and management are identified and are aware of their role and the need for communication with the Environment and Community Manager (or representative).	Responsibilities have been detailed in the latest version of the Topsoil Management Procedure, and relevant personnel made aware of their responsibilities.
6	Review the topsoil suitability key parameters and testing requirements and update the Topsoils Management Procedure accordingly.	This will be incorporated in the next revision of the Topsoil Management Procedure.
7	Undertake a topsoil audit of existing topsoil stockpiles to establish the volume and condition of stored topsoil. Use this information to prioritise future utilisation of topsoil resource.	An audit of existing topsoil stockpile volumes was undertaken in 2015 and in 2016. The current version of the Topsoil Management Procedure requires the condition of topsoil stockpiles to be assessed prior to reuse if the stockpile is greater than five years old.
8	Undertake an internal an audit of topsoil stockpiles and associated documentation to assess if topsoil stockpiles are being managed in accordance with the Topsoil Management Procedure.	An internal audit of topsoil stockpile management will be undertaken during the next reporting period.
9	Review the landform and drainage of existing rehabilitated areas (area at the top RL160) to identify flow paths and ensure that surface water does not enter the mine water system and ensure that water is directed to designed water storage areas.	Revision of landform drainage is ongoing across WCPL as commenced in 2016 with a goal to ensure clean water drainage reports to on-site storages off-site where possible.
10	Construction of landform to the specifications for slope gradient and lengths should be undertaken during landform shaping.	MOP Amendment D specifies performance indicators and completion criteria for slope gradient and lengths.
11	Review of the current final landform design against water management and erosion performance and update documentation accordingly, as required.	Revision of landform drainage is ongoing across WCPL as commenced in 2016 with a goal to ensure clean water drainage reports to on-site storages off-site where possible.

No.	Recommendation	Action Plan progress
12	Consider testing soil key parameters prior to reuse of stockpiled soil as the soil parameters will change within the soil over time.	The Topsoil Management Procedure requires an assessment of topsoil quality prior to reuse if a stockpile is greater than five years old.
13	Consider various topsoil depths based on the soil complex to be utilised. Various reuse topsoil depths would be based on pre-stripping topsoil survey.	Topsoil stripping depths are defined in the Topsoil Management Procedure and MOP Amendment D for various soil types. MOP Amendment D requires that topsoil replacement average depths of at least 100 mm.
14	Ensure that the sampling techniques in the Topsoil Management Procedure and the Completion Criteria are consistent and that ranges provided in the Topsoil Management Procedure can be ameliorated or develop/ progress during rehabilitation to meet the Completion Criteria.	The Topsoil Management Procedure and the Completion Criteria are consistent.
15	Floristic and fauna habitat monitoring contained in the Flora and Fauna Management Plan should be referenced in both the MOP.	MOP Amendment D includes reference to the monitoring contained within the FFMP.
16	EFA indices should be presented in the annual monitoring report and assessed for each individual transect.	The Annual Flora and Fauna Monitoring Report 2016 (**Appendix D**) provides detailed reporting and analysis of the LFA. This includes individual analysis for each transect, comparisons against previous monitoring at individual sites and the presentation of historical data to allow the functional status of each transect to be compared between years to establish if the rehabilitation is trending towards a functional system.
17	EFA provides an indicator and should not be averaged across sites. There is more benefit in identifying the ecosystem function of individual sites than vegetation communities. The next annual monitoring report should reflect this.	
18	An EFA indicator should only be compared against indicators from previous monitoring at each individual transect site. The next annual monitoring report should reflect this.	
19	EFA indices should be presented and assessed for each individual transect in the annual monitoring report. The format of the Annual Monitoring Reports for 2006, 2007 and 2008 allows the functional status of each transect to be compared between years to establish if the rehabilitation is trending towards a functional system. Reporting EFA indices in this fashion should be recommenced in future annual monitoring reports.	
20	Weed density trigger added to the TARP and appropriate management response including maintenance spot weed spraying.	The TARP in MOP Amendment D includes a trigger for exotic cover and appropriate management measures, including maintaining seasonal weed spraying measures as required by the FFMP.
21	Incorporate seed germination testing in the MOP and ensure that certificates for all seed collected or supplied by an external contractor is obtained. This provides quality assurance of seed and expected germination rates.	Seed germination testing will be incorporated in the next amendment to the MOP. WCPL currently ensures that certificates for all seed collected or supplied by an external contractor are obtained.

No.	Recommendation	Action Plan progress
22	Looking at the indices for each (transect) landscape across various indicators (stability, infiltration and nutrient cycling), it is also possible to detect where problems or weaknesses are occurring and management and maintenance actions are required. The TARP should therefore be used in conjunction with the EFA and floristic and fauna habitat monitoring results to identify management and maintenance actions.	Triggers and actions in MOP Amendment D have been developed based on the LFA and floristic and fauna habitat monitoring detailed in the FFMP.
23	Trigger values should be developed for the seven consequence/ hazards that do not currently have triggers (topsoil chemistry, waste rock chemistry, unable to cap tailings dam, poor establishment, species diversity and composition for woodland corridors and pasture/woodland areas, weeds).	Trigger values have been developed for all consequence/hazards described in the TARP in MOP Amendment D.
24	Reference in the MOP should be made to the floristic and fauna habitat monitoring of rehabilitated areas in the Flora and Fauna Management Plan.	MOP Amendment D includes reference to the monitoring of rehabilitated areas contained within the Flora and Fauna Management Plan.
25	The rehabilitation monitoring program and TARP should be closely integrated to ensure that monitoring identifies the potential for unsuccessful rehabilitation and triggers appropriate management and maintenance responses.	The TARP in MOP Amendment D includes specific reference to the rehabilitation monitoring including triggers for appropriate management and maintenance in the event unsuccessful rehabilitation is identified.
26	Slashing or controlled grazing is recommended for dense monoculture pastures such as those dominated by Rhodes grass. Depending on the length of time the grassland rehabilitation areas have been established and the seed mix used, reseeding with desirable species and/ or tube stock planting could be undertaken.	The status of the monoculture grassland rehabilitation areas will be reviewed and, if suitable, consideration will be given to reseeding with desirable species and/or undertaking tube stock planting.

10.0 Incidents and Non-compliances during the Reporting Period

WCPL reported a single incident during the reporting period. This incident related to an uncontrolled release of water from a temporary sediment dam (**Section 10.1**).

Five (5) non-compliances were recorded by WCPL during the reporting period. These non-compliances were recorded against EPL529, DA305-7-2003 and A444 (refer **Statement of Compliance** at the front of this document) and relate to the following events:

- Unmetered discharges (6) and failure to maintain discharge point communication equipment from Eagles Nest Dam during January 2016 (**Section 10.4**);
- Failure to monitor dust deposition in March, April and November 2016 (**Section 10.5**);
- Failure to monitor blasts (8 times for overpressure, 100% capture rate following installation of the new blast monitoring system in June 2016) (**Section 10.6**);
- Failure to monitor stream flow in South Wambo Creek (FM5, FM6 and FM9) (**Section 10.7**); and
- Conducting prospecting operations involving the construction and use of boreholes prior to having a Groundwater Monitoring and Modelling Plan approved by the Minister (**Section 10.8**).

In addition to the above, DPE and EPA requested detailed reports on WCPL operations following the receipt of a number of complaints in 2016. A summary of these reports is provided in **Section 10.9**.

10.1 Sediment Dam Failure

In January 2016, following a period of significant rainfall, there was an uncontrolled release of water from a temporary sediment dam at the Mine. WCPL reported the incident to the EPA and has complied with all directions in relation to the incident.

Following the incident, WCPL has undertaken a review of its on-site systems and submitted a revised ESCP to DPE. The revised ESCP includes measures to monitor, manage and mitigate the risk of similar incidents in the future.

10.2 Failure to record 24hr averages of PM10 data

EPL Monitoring Point 13 had five instances throughout the year where daily 24hr averages were incomplete. Three of these occasions were due to a faulty air conditioner unit within the monitoring hardware. The final two occasions were due to local power outages due to storms or scheduled maintenance.

EPL Monitoring Point 15 had one instance throughout the year where daily 24hr averages were incomplete. This was due to localised power outages as a result of a storm within the area.

Consultants, involved with monitoring units' maintenance and operation, provided calculated 24hr averages to supplement WCPL's missing data. On none of these days were PM10 levels elevated above a PM10 24hr average of 50 µg/m^3. The air conditioner unit was subsequently repaired.

10.3 Failure to continuously monitor weather data

Between 25 May 2016 and 31 May 2016, continuous weather data failed to be captured due to a software failure when data download was initiated. WCPL's weather data was subsequently supplemented with data from an adjacent mine site to ensure records were complete and accurate. In 2016, WCPL installed of new weather monitoring station to improve reliability of the system.

10.4 Unmetered Discharge from Eagles Nest Dam

A number of discharges of water that were not continuously metered occurred during January 2016 from WCPL's Eagles Nest Dam. This is a non-compliance with WCPL's statutory and management plan requirements.

Unmetered discharges were reported from the following approved HRSTS discharge blocks:

- 2016-007(3);
- 2016-008(3);
- 2016-009(2);
- 2016-010(2);
- 2016-011(1); and
- 2016-012(1).

On 7 January 2016, WCPL was discharging during an authorised discharge event under the HRSTS in which the continuous in line instrumentation at Point 4 (as defined in EPL 529) failed to continuously monitor the flow of the water being discharged. WCPL has maintained the in line instrumentation in a proper and efficient condition and concluded that an unidentifiable technical failure was the cause. The in line instrumentation passed all tests during verification processes in May 2015 (conducted following the April 2015 storm event) and in November 2015 (annual maintenance verification inspection). The discharge event that commenced on 7 January 2016 was the first time the unit was operational since the November 2015 verification process. As such, at the time of commencing discharge, WCPL was of the belief that the unit was maintained in a proper and efficient condition.

At all times, water quality readings were able to be captured. However, due to the faulty flow meter, discharge volumes had to be estimated (using the vertical flow trajectory method).

No impact to the Wollombi Brook was observed or reported as a result of this incident.

This non-compliance was reported to DPE and EPA in accordance with WCPL's statutory approvals and approved Water Management Plan. A show cause notice was issued by the EPA for these unmetered discharges. WCPL furnished all required information as requested by the EPA.

10.5 Failure to Monitor Dust Deposition

Depositional Dust Gauges D07, D20 and D23 failed to record a result in April 2016, November 2016 and March 2016, respectively, due to the vial being broken. The vials were identified as being broken upon collection with no evidence available as to the cause.

10.6 Failure to Capture All Blast Data

A total of 106 blasts were undertaken at the Mine during the reporting period. In accordance with statutory and management plan requirements, WCPL are required to monitor ground vibration and overpressure at specified monitoring locations during all blasts. During the reporting period, WCPL achieved a capture rate of 97% for overpressure and 100% for vibration. The capture rate for overpressure is a non-compliance with statutory and management plan requirements for blast monitoring.

Failure to capture overpressure was primarily due to the reliability of the 3G/4G connection due to the Mine's location within a known mobile phone black spot location (Warkworth is identified in the Australian Government's "Mobile Black Spot Database of Reported Black Spot Locations", updated 25 February 2016). The increased capture rate for vibration is due to monitors having an in-built trigger system functionality for user set vibration limits.

To address the non-compliances, WCPL replaced the blast monitoring system in June 2016 and, following installation of the new system, capture rate has been 100% for both overpressure and vibration.

10.7 Failure to Monitor Stream Flow

During the reporting period WCPL failed to continuously monitor stream flow at three locations, in accordance with the approved SWMP:

- FM5 (South Wambo Creek – downstream near the confluence of Wollombi Brook);
- FM6 (South Wambo Creek – downstream); and
- FM9 (South Wambo Creek – upstream).

This is a non-compliance with WCPL's Water Management Plan requirements.

Flow monitoring station FM5 was destroyed during a flood flow event in February 2013 and was replaced in December 2016 (now FM15).

Flow data recorded for FMs 6 and 9 during the reporting period is deemed unreliable due to damaged loggers and identified monitoring locations becoming unsuitable as a result of the 2015 April flood events. Unreliable data has not been included in this report and affected flow monitoring stations are in the process of being replaced. Flow monitoring station FM6 was relocated in December 2016 (now FM16).

In conjunction with the replacement/relocation of FM5 and FM6 (now FM15 and FM16), a cross and long section survey was also performed at each of the locations. From these surveys, the cease to flow point was established, and a theoretical flow rate curve and stream bed profile chart were produced.

No recordable flow events were observed on FM15 or FM16 since their installation/relocation on 14 December 2016.

10.8 Conduct of Relevant Prospecting Operations Prior to Approval of the Appropriate Plan

On 16 May 2016, WCPL self reported a non-compliance with Condition 12.d) of A444. Condition 12.d) of A444 requires that a Groundwater Monitoring and Modelling Plan be approved by the Minister prior to prospecting operations involving the construction and use of boreholes.

On 21 February 2017, DRE issued WCPL with an Official Caution and requested that WCPL take immediate steps to ensure that the above situation was rectified to regain compliance.

WCPL is currently consulting with DPI-Water in relation to the Groundwater Monitoring and Modelling Plan and will submit the plan to DRE for approval in 2017.

10.9 Requests for Information

During the reporting period, requests for information were made by DPE and EPA following a number of complaints received by WCPL (**Section 8.3**). A summary of the information requests is provided in **Table 40**.

Table 40: DPE and EPA Requests for Information

Date of Complaint	Relevant Agency	Summary of Detailed Report
Noise and Blasting		
20 October 2016	EPA	EPA contacted WCPL on 21 October 2016 in relation to a noise complaint and blast enquiry received by EPA, and requested a detailed report on relevant WCPL operations. A summary is provided below: • A blast was conducted on 28 September 2016 in the Montrose Pit. The peak air blast overpressure and peak particle velocity was recorded on all blast monitors. The nearest monitors indicated compliance with the relevant airblast and ground vibration limits. • Real-time noise monitoring from the relevant night was reviewed and low frequency noise levels determined. Low frequency noise levels were determined to be within the operational parameters during the evening and night periods on 20 October 2016.
Lighting		
5 November 2016	DPE	DPE contacted WCPL on 7 November 2016 in relation to a lighting complaint received directly by DPE on 5 November 2016, and requested a detailed report on relevant WCPL operations. A summary is provided below: • The complainant noted that they could see light directly from the lighting plants, dump trucks and orange and blue flashing lights. • Lighting plant and flashing orange and blue lights are deployed for operational safety purposes, and at times are likely to be visible by members of the community due to the elevation of early development works in Montrose East. • As a result of the complaint, the following additional actions were implemented: o WCPL initiated a trial of a low lighting impact plant. o WCPL commissioned the installation of a remote camera to monitor operations in the Montrose East Pit. o WCPL has continued communications regarding lighting plant at pre-start meetings. o WCPL operational personnel will undertake nightly lighting surveillance to ensure no direct off-site lighting impacts are occurring. o WCPL offered to meet with the complainant to further communicate the mining schedule and controls to minimise lighting impacts. Over the next three to four months, WCPL believes that visible lighting impacts will reduce due to the lower elevation of mining behind the initial waste rock emplacement.

Date of Complaint	Relevant Agency	Summary of Detailed Report
17 and 18 December 2016	DPE	DPE contacted WCPL on 21 December 2016 in relation to lighting complaints received on 17 and 18 December 2016, and requested a detailed report on relevant WCPL operations. A summary is provided below: • The complainant noted that they could see light directly from an excavator that increased and decreased as the machine slewed. • Following the complaint WCPL implemented additional lighting controls and committed to having a representative working from the property located at 2021 Golden Highway every Friday (starting 27/1/2016). Over the next three to four months, WCPL believes that visible lighting impacts will reduce due to the lower elevation of mining behind the initial waste rock emplacement.
Dust		
5 November 2016	DPE	DPE contacted WCPL on 7 November 2016 in relation to a dust complaint received on 5 November 2016, and requested a detailed report on relevant WCPL operations. A summary is provided below: • The complainant noted that dust was coming from WCPL operations, which was unacceptable given the weather conditions. The complainant stated that operations continued during high winds. • Topsoil stripping and mining operations commenced in Montrose East in October 2016. It has been noted by WCPL that the initial base of weathering material consists of fine silts and clays that under low humidity, high temperature and windy conditions, has the potential for elevated levels of visible dust. • Prior to, and during the day of 5 November 2016, WCPL implemented a number of air quality management controls consistent with DA305-7-2003 and the approved AQGGMP. • As a result of the complaint, the following additional actions were implemented: o WCPL commissioned the installation of a remote camera to monitor operations in the Montrose East Pit. o WCPL has continued communications regarding unacceptable dust levels and the need to modify or cease operations in unfavourable conditions at pre-start meetings. o WCPL have continued to focus on the early and progressive rehabilitation of the Montrose East waste rock dump. o WCPL offered to meet with the complainant to further communicate the mining schedule and controls to minimise dust impacts.

Date of Complaint	Relevant Agency	Summary of Detailed Report
8 November 2016	DPE	DPE contacted WCPL on 9 November 2016 in relation to a dust complaint received on 8 November 2016 (and photographs showing high dust levels emanating from the north of WCPL's open cut operations), and requested a detailed report on relevant WCPL operations. A summary is provided below: • The complainant noted that dust was coming from WCPL operations, which was unacceptable given the weather conditions. The complainant stated that operations continued during high winds. • Prior to, and during the day of 8 November 2016, WCPL implemented a number of air quality management controls consistent with DA305-7-2003 and the approved AQGGMP. • Between approximately 5.30 pm and 6.00 pm on 8 November 2016, a strong southerly change affected the operation. WCPL implemented the cessation of all operations between approximately 6.00 pm and 6.50 pm in response to the strong southerly change and potential for elevated dust risk.
23 November 2016	EPA	EPA contacted WCPL on 29 November 2016 in relation to a dust complaint received by EPA on 23 November 2016, and requested that WCPL investigate the complaint and provide a detailed report on relevant WCPL operations. A summary is provided below: • WCPL did not receive any direct community complaints or enquires in relation to dust levels on or about the time and date of the complaint made to EPA. • Whilst no direct action was taken in response to a complaint on 23 November 2016 (as no complaint was received by WCPL on the day), actions were taken by WCPL operational personnel to reduce dust emissions on the day, in accordance with DA305-7-2003 and the approved AQGGMP. This included: o Communication in pre-start meetings of the increased visibility and dust risk associated with Montrose East. o Communication in pre-start meetings regarding authorisation to modify or cease operations. o Modifying and stopping operations due to an assessed dust risk during the day of 23 November 2016 (Excavator 214 ceased operation for 20 minutes). o Operating during north-westerly wind conditions (favourable) to retain generated dust onsite. o Prioritising water carts to manage dust impacts from Montrose East. o Maintaining and responding to real-time dust risk alerts. o Monitoring and ensuring compliance with WCPL's air quality criteria.

Date of Complaint	Relevant Agency	Summary of Detailed Report
30 November 2016	EPA	EPA contacted WCPL on 1 December 2016 in relation to a dust complaint received by EPA on 1 December 2016 (regarding WCPL operations on 30 November 2016). EPA requested that WCPL investigate the complaint and provide a detailed report on relevant WCPL operations. A summary is provided below: • The complainant alleged to be affected by dust from the high dumps during the southerly change during the afternoon of 30 November 2016. • Whilst no direct action was taken in response to a complaint on 30 November 2016 (as no complaint was received by WCPL on the day), actions were taken by WCPL operational personnel to reduce dust emissions on the day, in accordance with DA305-7-2003 and the approved AQGGMP. This included: o Minimising the exposed area associated with the Montrose East pit to the area required for current operations only. o Communication in pre-start meetings of the increased visibility and dust risk associated with Montrose East. o Communication in pre-start meetings regarding authorisation to modify or cease operations. o Modifying and stopping the operation of all four excavators between 3.20 pm and 4.10 pm. Excavators 12 and 14 recommenced operations at 5.02 pm and 5.00 pm respectively, due to their locations down low in the main Montrose Pit. Excavators 11 and 13 recommenced operations at 7.24 pm and 8.56 pm, respectively (following the electrical storm and rainfall). o Prioritising water carts to manage dust impacts from Montrose East. o Maintaining and responding to real-time dust risk alerts. o Monitoring and ensuring compliance with WCPL's air quality criteria.

Date of Complaint	Relevant Agency	Summary of Detailed Report

3 December 2016	DPE	DPE contacted WCPL on 6 December 2016 in relation to a dust complaint received by DPE on 3 December 2016 and requested a detailed report on relevant WCPL operations. A summary is provided below:
		• The complainant noted that excessive dust was coming from WCPL operations during unsuitable weather conditions.
		• An analysis of available data indicates a strong southerly change peaked around 4.00 pm.
		• Whilst no direct action was taken in response to a complaint on 3 December 2016 (as no complaint was received by WCPL on the day), actions were taken by WCPL operational personnel to reduce dust emissions on the day, in accordance with DA305-7-2003 and the approved AQGGMP. This included:
		  ○ Minimising the exposed area associated with the Montrose East pit to the area required for current operations only.
		  ○ Communication in pre-start meetings of the increased visibility and dust risk associated with Montrose East.
		  ○ Communication in pre-start meetings regarding authorisation to modify or cease operations.
		  ○ Modifying and stopping operations due to an assessed dust risk during the day of 3 December 2016 (operation of Excavator 213 was modified to minimise dust generation).
		  ○ Prioritising water carts to manage dust impacts from Montrose East.
		  ○ Maintaining and responding to real-time dust risk alerts.
		  ○ Monitoring and ensuring compliance with WCPL's air quality criteria.
		• WCPL is preparing a briefing document regarding operations in Montrose East for distribution to potentially affected community members. The communication will invite community members to participate in one-on-one consultation regarding potential impacts.
		• WCPL is considering opportunities to set up and maintain a community drop in centre on Jerrys Plains Road to enable community members to drop in and talk about current operations.

11.0 Activities to be Reported in the next Reporting Period

The following activities will be undertaken and reported on during the next reporting period:

- In accordance with Condition 7, Schedule 6 of DA305-7-2003, WCPL will commission and pay the full cost of an IEA.
- An audit of known subsidence impacts was commissioned and commenced during the reporting period to determine if the known subsidence impacts have self-repaired, are stable but pose a risk to long-term sustainable land use, or are deteriorating in condition. The results of the audit will be reported in the next reporting period.
- WCPL will seek approval for the Extraction Plan submitted for South Bates Underground Longwalls 11-16.
- WCPL will submit a CMCP to DPE in the first half of 2017.
- WCPL will undertake a lighting review, including the rail loop and refuelling facility.
- WCPL will use the Initial Post-Establishment Monitoring Checklist (or an adapted version of the checklist) to confirm and record any deviations from the proposed rehabilitation method/activities for each rehabilitation area.
- WCPL will undertake an internal audit of topsoil stockpile management to assess if topsoil stockpiles are being managed in accordance with the Topsoil Management Procedure.
- Works associated with the North East Tailings Dam Rehabilitation Strategy, including the construction of a trial abutment and any additional works undertaken (if the trial is successful).
- Subsidence repair trials will be undertaken in accordance with any recommendations made in the audit of known subsidence impacts.
- WCPL will undertake a review and update of the following management plans and strategies:
    - Environmental Management Strategy.
    - Conservation Management Plan for the WHC.

Where required, updated management plans and strategies will be submitted to relevant government authorities for approval and uploaded to the WCPL website.

12.0 References

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- South East Archaeology, 2016b. *Wambo Coal Mine, Hunter Valley, New South Wales: Reassessment of Previously Reported Scarred Tree Wambo Site 312.* Report prepared for Wambo Coal Pty Ltd. April 2016.
- South East Archaeology, 2016c. *Wambo Coal Mine, Hunter Valley, New South Wales: Reassessment of Previously Reported Grinding Groove Locations – Supplementary Report in Relation to Wambo Sites 117 and 473.* Report prepared for Wambo Coal Pty Ltd. July 2016.

APPENDIX A – APPROVAL CONDITIONS SPECIFICALLY RELATING TO THE ANNUAL REVIEW

Approval	Condition	Description	Where addressed in Annual Review
DA305-7-2003	Condition 25, Schedule 4	Each year, the Applicant must: (a) review the site water balance for the development against the predictions in the EIS; (b) re-calculate the site water balance for the development; (c) assess current and forecast compliance with the rules of the Hunter River Salinity Trading Scheme; and (d) report the results in the Annual Review.	Sections 6.3.4 and 6.7
DA305-7-2003	Condition 49, Schedule 4	The Applicant must: (a) review the performance of the Flora and Fauna Management Plan annually, in consultation with the Hunter Coalfield Flora & Fauna Advisory Committee (when established); and (b) revise the document as necessary to take into account any recommendations from the annual review.	Section 5.6
DA305-7-2003	Condition 79, Schedule 4	The Applicant must: (a) keep records of the: - amount of coal transported from the site each year; and - number of coal haulage truck movements generated each day by the development; and (b) include these records in the Annual Review.	Section 3.1
DA305-7-2003	Condition 87, Schedule 4	For the life of the development, the Applicant must: (a) monitor the greenhouse gas emissions generated by the development; (b) investigate ways to reduce greenhouse gas emissions generated by the development; (c) report on greenhouse gas monitoring and abatement measures in the Annual Review, to the satisfaction of the Secretary.	Section 5.4
DA305-7-2003	Condition 88, Schedule 4	For the life of the development, the Applicant must: (a) monitor the amount of waste generated by the development; (b) investigate ways to minimise waste generated by the development; (c) implement reasonable and feasible measures to minimise waste generated by the development; and (d) report on waste management and minimisation in the Annual Review, to the satisfaction of the Secretary.	Section 5.11

Approval	Condition	Description	Where addressed in Annual Review
DA305-7-2003	Condition 5, Schedule 6	By the end of March each year, the Applicant must submit a report to the Department reviewing the environmental performance of the development to the satisfaction of the Secretary. This review must: (a) describe the development (including any rehabilitation) that was carried out in the previous calendar year, and the development that is proposed to be carried out over the current calendar year; (b) include a comprehensive review of the monitoring results and complaints records of the development over the previous calendar year, which includes a comparison of these results against: - the relevant statutory requirements, limits or performance measures/criteria; - the monitoring results of previous years; and - the relevant predictions in the EIS; (c) identify any non-compliance over the previous calendar year, and describe what actions were (or are being) taken to ensure compliance; (d) identify any trends in the monitoring data over the life of the development; (e) identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and (f) describe what measures will be implemented over the current calendar year to improve the environmental performance of the development.	This Annual Review
DA305-7-2003	Condition 6, Schedule 6	Within 3 months of: (a) the submission of an annual review under Condition 5 above; … the Applicant must review, and if necessary revise, the strategies, plans, and programs required under this consent to the satisfaction of the Secretary.	Section 2.3
DA305-7-2003	Condition 12, Schedule 6	From the end of June 2011, the Applicant shall: (a) make copies of the following publicly available on its website: … - the annual reviews of the development; ...; and (b) keep this information up-to-date, to the satisfaction of the Secretary.	Section 1.0

Approval	Condition	Description	Where addressed in Annual Review
DA177-8-2004	Condition 4, Schedule 6	Within 1 year of the date of this consent, and annually thereafter, the Applicant shall submit an Annual Review on the development to the Director-General and relevant agencies. This report must: (a) identify the standards and performance measures that apply to the development; (b) include a summary of the complaints received during the last year, and compare this to the complaints received in previous years; (c) include a summary of the monitoring results on the development during the last year; (d) include an accurate record of the amount of product coal transported on the development over the last year on a weekly basis; (e) include an analysis of these monitoring results against the relevant: - impact assessment criteria; - monitoring results from previous years; and - predictions in the SEE; (f) identify any trends in the monitoring over the life of the development; (g) identify any non-compliance during the last year; and, if necessary, (h) describe what actions were, or are being taken, to ensure compliance.	This Annual Review
DA177-8-2004	Condition 8, Schedule 6	From 31 May 2012, the Applicant shall: (a) make copies of the following publicly available on its website: … - the annual reviews (over the last 5 years); …; and (b) keep this information up-to-date, to the satisfaction of the Director-General.	Section 1.0
S101 Approval (NETD)	Condition h)	The North East Tailings Dam shall be reported on within the Annual Environmental Management Report for Wambo Coal. Consideration shall also be given to the rehabilitation performance for this site.	Sections 7.1.7 and 7.2.2

Approval	Condition	Description	Where addressed in Annual Review
CL365, CL397	Condition 3(f)	(f) The lease holder must prepare a Rehabilitation Report to the satisfaction of the Minister. The report must: (i) provide a detailed review of the progress of rehabilitation against the performance measures and criteria established in the approved MOP; (ii) be submitted annually on the grant anniversary date (or at such other times as agreed by the Minister); (iii) be prepared in accordance with any relevant annual reporting guidelines published on the Department's website at www.resources.nsw.gov.au/environment. Note. The Rehabilitation Report replaces the Annual Environmental Management Report.	This Annual Review
CCL743, ML1402	Conditions 4-5	The lease holder must lodge Environmental Management Reports (EMR) with the Director-General annually or at dates otherwise directed by the Director-General. The EMR must: a) report against compliance with the MOP; b) report on progress in respect of rehabilitation completion criteria; c) report on the extent of compliance with regulatory requirements; and d) have regard to any relevant guidelines adopted by the Director-General.	This Annual Review

Approval	Condition	Description	Where addressed in Annual Review
ML1594, ML1572, CL374	Condition 3	(1) Within 12 months of the commencement of mining operations and thereafter annually or, at such other times as may be allowed by the Director-General, the lease holder must lodge an Annual Environmental Management Report (AEMR) with the Director-General. (2) The AEMR must be prepared in accordance with the Director-General's guidelines current at the time of reporting and contain a review and forecast of performance for the preceding and ensuing twelve months in terms of: a) the accepted Mining Operations Plan; b) development consent requirements and conditions; c) Department of Environment and Conservation and Department of Planning licences and approvals; d) any other statutory environmental requirements; e) details of any variations to environmental approvals applicable to the lease area; and f) where relevant, progress towards final rehabilitation objectives. (3) After considering the AEMR the Director-General may, by notice in writing, direct the lease holder to undertake operations, remedial actions or supplementary studies in the manner and within the period specified in the notice to ensure that operations on the lease area are conducted in accordance with sound mining and environmental practice. (4) The lease holder shall, as and when directed by the Minister, co-operate with the Director-General to conduct and facilitate review of the AEMR involving other government agencies and the local council.	This Annual Review
Water Licence 20AL200631, 20AL203044, 20AL201457	Condition 1	The licence holder must provide the Minister with figures recording the quantity of water taken via the nominated water supply works approval, when required to do so, and in the form specified by the Minister.	Section 6.5

Approval	Condition	Description	Where addressed in Annual Review
Water Licence 20WA200632	Condition 9	The account holder must provide the Minister, in the approved form, with the following information when requested: A) A report detailing the quantity of water taken through the authorised work(s) and recorded by the approved measuring device, or where the work does not have a measuring device fitted to it, advise the Minister of the duration of any pumping, and B) Where the water is used for irrigation, the area of land irrigated, the planting date, area and yield of all crops grown on the property for each season. These details must include: i) The volume of water taken from the water source and applied directly to crops and/or pasture; ii) The volume of water taken from the water source and held in on-farm storages; iii) The volume of water taken from on-farm storages and applied to crops (including pasture); iv) The type and area of each crop (including pasture) irrigated; v) The method of irrigation for each class of crop and/or pasture; and vi) The volume of water applied to each individual class of crop and/or pasture.	Section 6.5

APPENDIX B – ANNUAL NOISE MONITORING REPORT

Wambo Coal Mine
Annual Report

Environmental Noise Monitoring
1 January to 31 December 2016

Prepared for
Wambo Coal Pty Limited

Global Acoustics

Noise and Vibration Analysis and Solutions

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Wambo Coal Mine – Annual Report

Environmental Noise Monitoring
1 January to 31 December 2016

Reference: 17017_R01
Report date: 23 February 2017

Prepared for

Wambo Coal Pty Limited
PMB 1
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Prepared by

Global Acoustics Pty Ltd
PO Box 3115
Thornton NSW 2322

Prepared:	Ronni Maciejowski Acoustics Technician	QA Review:	Katie Weekes Environmental Scientist (Acoustics)

Global Acoustics Pty Ltd ~ Environmental noise modelling and impact assessment ~ Sound power testing ~ Noise control advice ~ Noise and vibration monitoring ~ OHS noise monitoring and advice ~ Expert evidence in Land and Environment and Compensation Courts ~ Architectural acoustics ~ Blasting assessments and monitoring ~ Noise management plans (NMP) ~ Sound level meter and noise logger sales and hire

EXECUTIVE SUMMARY

Global Acoustics was engaged by Wambo Coal Pty Ltd to provide a summary of the monthly environmental noise surveys conducted around Wambo Coal Mine (WCM), and the Wambo Coal Rail Spur (WCRS) from 1 January to 31 December 2016. The mine and spur operate under separate development consents and have been monitored separately. Reporting, however, has been combined in this document.

WCM was granted consent (DA 305-7-2003) in February 2004, which enables the extension of current open cut and underground mining operations. The latest modification to this consent was approved in October 2016.

The WCRS consists of two Development Applications (DA's):

- The Wambo Rail Loop (DA 177-8-2004); and
- The Wambo Rail Line (DA 235/97).

The relevant sections of these consents are reproduced in Appendix A.

The *Wambo Coal Environmental Management System, Noise Monitoring Plan* (EMP011, February 2014) was prepared in accordance with Schedule 4 of both consents. The Noise Monitoring Plan (NMP) indicates that monitoring will be conducted for WCM and WCRS activities, and the noise levels to be used for assessment.

Attended environmental noise monitoring described in this report was undertaken at four sites on a one night per month basis during 2016. The survey purpose was to quantify and describe the existing acoustic environment around WCM and WCRS and compare results with relevant development consent conditions.

Noise levels from WCM and WCRS complied with relevant criteria at all sites during the attended noise monitoring.

It is noted that wind speeds and/or temperature inversion conditions were at levels greater than which development consent conditions would apply for WCM and WCRS activities in some instances.

There have been no significant changes in noise level trends over the past three years.

Predicted noise levels from Year 9 were compared against actual noise levels during 2016. Results of the comparison indicate that meteorological conditions included in the EIS modelled predictions did not regularly occur during attended monitoring. When meteorological conditions were relevant, results show that WCM was generally well under the predicted levels.

Global Acoustics Pty Ltd

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Appendices

1 INTRODUCTION

1.1 Background

Global Acoustics was engaged by Wambo Coal Pty Ltd to provide a summary of the monthly environmental noise surveys conducted around Wambo Coal Mine (WCM), and the Wambo Coal Rail Spur (WCRS) from 1 January to 31 December 2016. The mine and spur operate under separate development consents and have been monitored separately. Reporting, however, has been combined in this document.

Wambo Coal operates both open cut and underground mining operations from their mine at Warkworth, NSW. The open cut operations include use of heavy mobile equipment in open cut pits, on haul roads and on waste rock emplacements. The underground operations have surface facilities. Both operations utilise a coal handling and preparation plant (CHPP) including conveyors, bins and other material-handling infrastructure.

The WCRS is located between Mt Thorley and Warkworth Village, New South Wales (as shown in Figure 1) and includes the following components:

- a product coal stockpile and reclaim area, product coal conveyor, train load-out bin, rail loop and a rail spur from the Wambo Coal Mine to Mount Thorley; and
- rail transport of product coal to the market, an intermittent activity that can take place at any time; and
- a locomotive refuelling facility.

A noise survey around both the WCM and the WCRS is required monthly as detailed in the Noise Management Plan (NMP).

Attended environmental noise monitoring described in this report was undertaken at four sites on a one night per month basis during 2016. Figure 1 shows the monitoring locations.

The survey purpose was to quantify and describe the existing acoustic environment around WCM and WCRS and compare results with relevant limits.

1.2 Monitoring Locations & Frequency

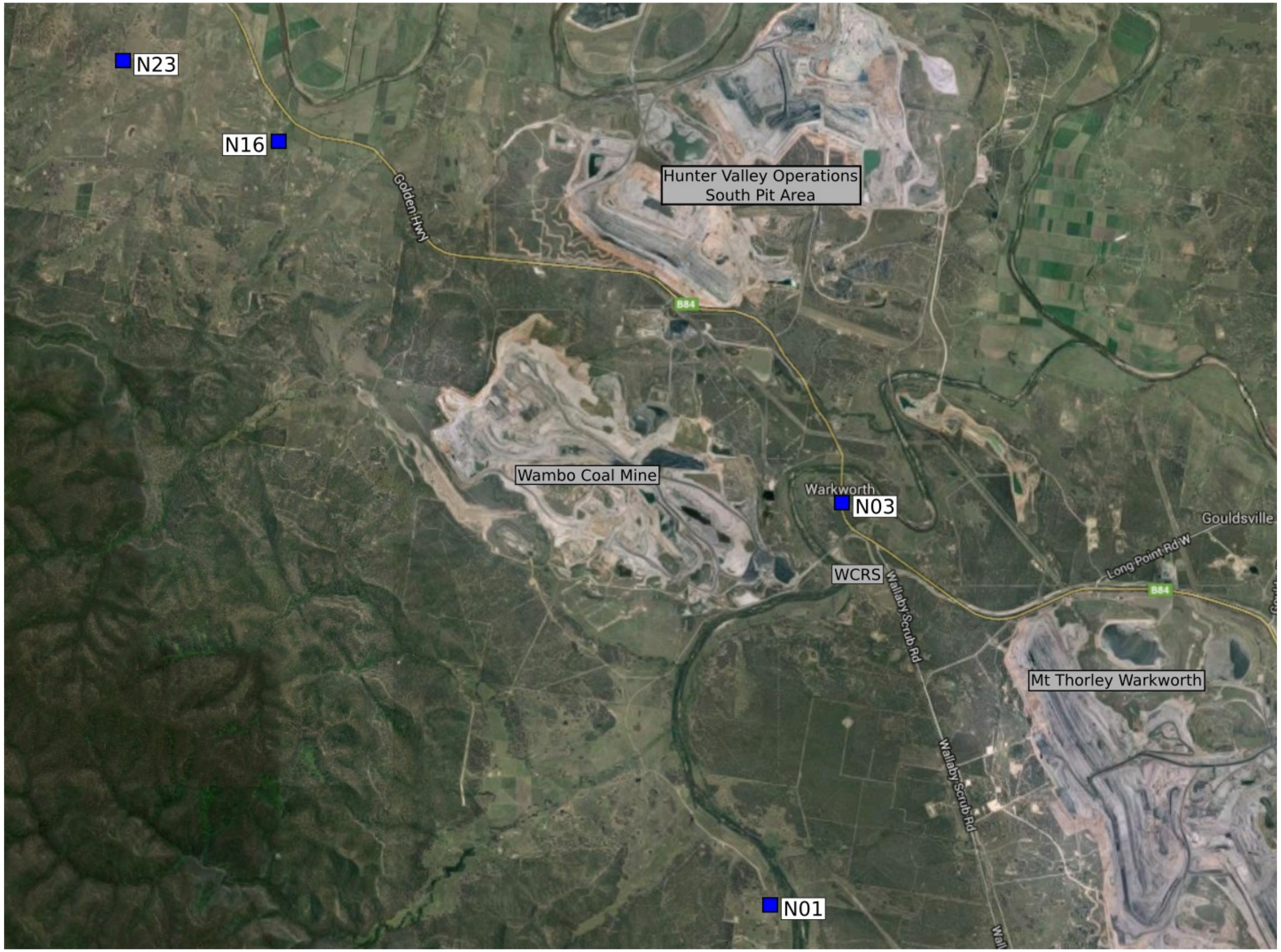
Attended noise monitoring was conducted at a total of four locations for WCM and the WCRS. There are also two real-time monitors (from a total of four) at other locations. Table 1.1 outlines the monitor type and frequency for the noise monitoring locations; attended monitoring locations are shown in Figure 1.

Table 1.1: WAMBO COAL MONITORING LOCATIONS & FREQUENCY[1,2]

Site Reference	**Site Location**	**Monitor Type**	**Consent Requirements**	**Frequency [1]**
N01	*Lambkin Residence*	Attended	Mine Development Consents	Monthly
N03	*Kelly Residence*	Real-time & Attended	Mine and Rail Spur Development Consent	Continuous & Monthly
N16	*Muller Residence*	Real-time & Attended	Mine Development Consent	Continuous & Monthly
N20	Thelander Residence	Real-time	Mine Development Consent	Continuous
N21	Wambo South Residence	Real-time	Mine Development Consent	Continuous
N23	*Redmanvale Road*	Attended	Mine Development Consent	Monthly

Notes:

1. *Sourced from the Draft Wambo Coal Noise Monitoring Plan -EMP011, February 2014; and*
2. *Attended locations are shown in italics.*



Source: Google Maps

Figure 1: WCM Attended Noise Monitoring Sites

1.3 Terminology & Abbreviations

Some definitions of terms and abbreviations, which may be used in this report, are provided in Table 1.2.

Table 1.2: TERMINOLOGY & ABBREVIATIONS

Descriptor	Definition
L_A	The A-weighted root mean squared (RMS) noise level at any instant
L_{A10}	The noise level which is exceeded for 10 percent of the time, which is approximately the average of the maximum noise levels
L_{A90}	The level exceeded for 90 percent of the time, which is approximately the average of the minimum noise levels. The L_{A90} level is often referred to as the "background" noise level and is commonly used to determine noise criteria for assessment purposes
L_{Aeq}	The average noise energy during a measurement period
dB(A)	Noise level measurement units are decibels (dB). The "A" weighting scale is used to describe human response to noise
SPL	Sound pressure level (SPL), fluctuations in pressure measured as 10 times a logarithmic scale, the reference pressure being 20 micropascals
ABL	Assessment background level (ABL), the 10^{th} percentile background noise level for a single period (day, evening or night) of a 24 hour monitoring period
RBL	Rating background level (RBL), the background noise level for a period (day, evening or night) determined from ABL data
Hertz (Hz)	Cycles per second, the frequency of fluctuations in pressure, sound is usually a combination of many frequencies together
VTG	Vertical temperature gradient in degrees Celsius per 100 metres altitude. Estimated from wind speed and sigma theta data
SC	Stability Class. Estimated from wind speed and sigma theta data
Day	This is the period 7:00am to 6:00pm
Evening	This is the period 6:00pm to 10:00pm
Night	This is the period 10:00pm to 7:00am

2 DEVELOPMENT CONSENT

2.1 Wambo Coal Mine Development Consent

WCM was granted consent (DA 305-7-2003) in February 2004, which enables the extension of current open cut and underground mining operations. The latest modification to this consent was approved in October 2016. The relevant sections of this modification are reproduced in Appendix A.

The *Wambo Coal Environmental Management System, Noise Monitoring Plan* (EMP011, February 2014) was prepared in accordance with Schedule 4. The NMP indicates that monitoring will be conducted for WCM activities, and the noise levels to be used for assessment. Monitoring for noise from mining activities is undertaken at the properties numbered N01, N03, N16 and N23.

It should be noted that properties N01 and N03 are subject to acquisition upon request, as detailed in Schedule 4, Condition 1 of DA 305-7-2003. As such, there are no operational noise goals that apply to these properties.

Table 2.1 summarises relevant noise assessment criteria for WCM.

Table 2.1: WAMBO COAL MINE NOISE CRITERIA

Location	Day $L_{Aeq,15minute}$ dB	Evening / Night $L_{Aeq,15minute}$ dB	Night $L_{A1,1minute}$ dB
N01 [2]	NA	NA	NA
N03 [2]	NA	NA	NA
N16 [1]	35	40	50
N23 [1]	35	38	50

Notes:

1. *Criteria from Development Consent DA 305-7-2003; and*
2. *N01 and N03 are acquisition upon request and criteria are NA 'not applicable'.*

While the consent does not specify noise limits under which the above criteria apply, the NSW EPA environment protection licence (EPL No. 529) specifies that the limits apply under the following meteorological conditions:

- wind speeds of up to 3 m/s at 10 metres above ground level; or
- temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level.

2.2 Wambo Coal Rail Spur Development Consent

The WCRS consists of two Development Applications (DA's):

- The Wambo Rail Loop (DA 177-8-2004), modified in February 2012 to include a rail refuelling facility; and
- The Wambo Rail Line (DA 235/97).

The *Wambo Coal Environmental Management System, Noise Management Plan* (EMP011, February 2014) was prepared in accordance with Schedule 4. The NMP indicates that monitoring will be conducted for WCRS activities, and the noise levels to be used for assessment. The relevant sections of the consents are reproduced in Appendix A.

Monitoring for noise from rail activities has previously been undertaken at properties numbered N01, N24 and N25 for rail pass-by noise. Locations N24 and N25 have been removed from the monitoring program following long-term demonstrated compliance. Monitoring is still undertaken at N01 as part of the mine consent, however, monitoring of the rail activities is no longer required. As detailed in the NMP, monitoring at these locations will recommence following any complaints or if there is a change in rolling stock.

It should be noted that properties at N01 are subject to acquisition upon request, as detailed in Schedule 4, Condition 1 of DA 305-7-2003. As such, there are no operational noise goals that apply directly to this property.

Quarterly monitoring of the rail loading facility is no longer undertaken at N03, due to a demonstrated history of compliance. Should anything change with the procedure for refuelling or a resident complaint be received, further monitoring will be undertaken to determine changes to received noise levels.

2.3 INP Modifying Factors

Noise monitoring and reporting is carried out generally in accordance with the Environment Protection Authority (EPA) 'Industrial Noise Policy' (INP). Chapter 4 of the INP deals specifically with modifying factors that may apply to industrial noise. The most common modifying factors are addressed in detail below.

As detailed in L4.3 of the EPL:

> *The modification factors in Section 4 of the NSW Industrial Noise Policy shall also be applied to the measured noise levels where applicable.*

2.3.1 Tonality, Intermittent and Impulsive Noise

As defined in the Industrial Noise Policy:

> *Tonal noise contains a prominent frequency and is characterised by a definite pitch.*
>
> *Impulsive noise has high peaks of short duration and a sequence of such peaks.*
>
> *Intermittent noise is characterised by the level suddenly dropping to the background noise levels several times during a measurement, with a noticeable change in noise level of at least 5 dB. Intermittent noise applies to night-time only.*

Years of monitoring have shown that noise levels from mining operations, particularly those levels measured at significant distances from the source are relatively continuous. Given this, noise levels from WCM at the monitoring locations are unlikely to be intermittent. In addition, there is no equipment on site that is likely to generate tonal or impulsive noise as defined in the INP.

2.3.2 Low Frequency Noise

INP Method

As defined in the Industrial Noise Policy:

> *Low frequency noise contains major components within the low frequency range (20 Hz to 250 Hz) of the frequency spectrum.*

As detailed in Chapter 4 of the INP, low frequency noise should be assessed by measuring the site only C-weighted and site only A-weighted level over the same time period. The correction/penalty of 5 dB is applied *if the difference between the two levels is 15 dB or more*.

Broner Method

Low frequency noise can also be assessed using the method specified in the paper *"A Simple Method for Low Frequency Noise Emission Assessment"* (Broner JLFNV Vol29-1 pp1-14 2010). If the site only C-weighted noise level at a receptor exceeds the relevant modifying factor trigger, a 5 dB penalty (modifying factor) is added to predicted levels. This method is included to provide a comparison with the INP method.

Low Frequency Assessment Methods

Low frequency assessment methods are detailed in Table 2.2.

Table 2.2: LOW FREQUENCY ASSESSMENT METHODS AND MODIFYING FACTOR TRIGGERS

Method	Calculation Method	Night Period Modifying Factor Trigger	Day Period Modifying Factor Trigger
Broner, 2010	Site only L_{Ceq} to 250 Hz	>60	>65
INP, total	Site only Total L_{Ceq} minus Site only L_{Aeq}	>=15	>=15

The EPA is currently undertaking a review of the assessment of low frequency noise. While a Draft Industrial Noise Guideline (ING) was released in September 2015, low frequency noise results from WCM have been compared to the assessment methods and modifying factor triggers presented above. The applicability of these triggers has been considered when applying low frequency modifying factor corrections.

3 METHODOLOGY

3.1 Assessment Method

3.1.1 Overview

Noise monitoring was conducted at the nearest residences in accordance with the Environment Protection Authority (EPA) 'Industrial Noise Policy' (INP) guidelines and Australian Standard AS 1055 'Acoustics, Description and Measurement of Environmental Noise'. The mine was operating for all monitoring periods.

A measurement of $L_{A1,1minute}$ corresponds to the highest noise level generated for 0.6 second during one minute. In practical terms this is the highest noise level emitted from the Wambo Coal noise source during the entire measurement period (i.e. the highest level of the worst minute during the 15-minute measurement).

As indicated in the consent conditions, the $L_{A1,1minute}$ measurement should be undertaken at 1 metre from the dwelling façade and the $L_{Aeq,15minute}$ measurement within 30 metres of the dwelling. However, the direct measurement of noise at 1 metre from the façade is not practical during monitoring for this project. In most cases, monitoring near the residence is impractical due to barking dogs or issues with obtaining access. In all cases, measurements for this survey were undertaken at a suitable and representative location.

Meteorological data was obtained from the Wambo Coal Mine meteorological station. This allowed correlation of atmospheric parameters and measured noise levels. Ground level atmospheric condition measurement was also undertaken during attended monitoring.

3.1.2 Attended Noise Monitoring

Attended noise monitoring was conducted at all sites generally during night hours. While night period monitoring is the required time to measure the source of interest, we consider atmospheric conditions during the later stages of the evening period to be the same as those during the night period and so it is valid to compare results from this measurement to night period criteria. The duration of all measurements was 15 minutes.

Attended monitoring is preferred to the use of loggers when determining compliance with prescribed limits; it allows an accurate determination of the contribution, if any, to measured noise levels by the source of interest (in this case WCM and / or WCRS).

The terms 'Inaudible' (IA) or 'Not Measurable' (NM) may be used in this report. When site noise is noted as IA, no site noise was audible at the monitoring location. NM indicates that some site noise was audible, but indeterminate due to one of the following reasons:

- site noise levels were insignificant and unlikely, in many cases, to be even noticed; or

- site noise levels were masked by another relatively loud noise source, but were estimated to be less than L_{Aeq} 30 dB, which is insignificant in terms of any applicable criterion.

If site noise were NM due to masking but estimated to be significant in relation to a relevant criterion, we would employ methods as per the Industrial Noise Policy (e.g. measure closer and back calculate) to determine a value for reporting. All sites noted NM in this report are due to insignificant absolute values.

3.2 Meteorological Data

Meteorological data was obtained from the Wambo meteorological station. Atmospheric parameters included wind speed, wind direction, rainfall and sigma theta. This data allowed correlation of atmospheric parameters and measured noise levels. Meteorological data was available in 5 minute intervals.

When meteorological data is provided in less than 15-minute intervals, an analysis must be conducted to determine the meteorological conditions present for the majority of the measurement period and whether those conditions relate to noise criteria being applicable. In order to accurately compare 5-minute meteorological data to 15-minute noise level measurement periods, a rolling 15-minute meteorological interval was produced by converting each 5-minute meteorological interval into an average of the preceding three 5-minute intervals. The rolling 15-minute meteorological interval which most closely matched the 15-minute noise level measurement period was then adopted as the predominant meteorological conditions for that measurement period.

Where rolling averages could not be used (such as for VTG and stability class), the predominant condition, corresponding with the majority of 5-minute meteorological intervals, was adopted.

3.3 Weather Conditions

Weather conditions were recorded at each location during each noise level measurement. Although the consent is not specific as to where the meteorological data should be sourced, information from WCM has been used as it is measured with an elevated anemometer as is required by the consent. The anemometer at WCM is not overly distant from the monitoring locations and is considered to be representative of the general area. Wind speeds measured at 10 metres above ground are usually higher than those measured closer to ground level. In accordance with consent conditions, noise criteria only apply in wind speeds up to 3 metres per second.

4 RESULTS

There were a total of four monitoring locations during this survey as listed in Table 1.1 and shown on Figure 1.

4.1 Quarter 1, 2016

4.1.1 Total Noise Levels

Noise levels measured at each location during attended 15 minute surveys are provided in Table 4.1.

Table 4.1: MEASURED NOISE LEVELS – QUARTER 1, 2016[1]

Location	Start Date and Time	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A90} dB
N01	19/01/2016 00:00	52	51	50	48
N03	18/01/2016 23:30	49	47	46	44
N16	18/01/2016 23:02	57	52	51	48
N23	18/01/2016 22:37	46	44	43	42
N01	02/02/2016 23:51	46	44	42	40
N03	03/02/2016 00:46	43	41	40	38
N16	02/02/2016 23:47	47	46	44	42
N23	02/02/2016 23:10	55	45	45	40
N01	09/03/2016 23:50	48	45	43	42
N03	10/03/2016 01:46	50	48	47	45
N16	10/03/2016 01:01	47	46	44	41
N23	10/03/2016 00:17	44	41	40	38

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.1.2 Wambo Coal Mine Noise

Noise levels generated by activity at Wambo mine are shown in Table 4.2 and Table 4.3, where comparison of measured $L_{Aeq,15}$ minute and $L_{A1,1}$ minute levels for WCM is made with relevant noise criteria.

Table 4.2: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 1, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] $^0C/100m$	Criterion $L_{Aeq,15min}$ dB[1]	Criterion Applies? [3]	WCM $L_{Aeq,15min}$ dB [4,5]	Exceedance [6,8]
N01[2]	19/01/2016 00:00	0.7	4.1	NA	NA	35	NA
N03[2]	18/01/2016 23:30	0.6	4.1	NA	NA	34	NA
N16	18/01/2016 23:02	0.7	4.1	40	No	IA	NA
N23	18/01/2016 22:37	0.9	4.1	38	No	IA	NA
N01[2]	02/02/2016 23:51	1.6	3.0	NA	NA	NM	NA
N03[2]	03/02/2016 00:46	0.0	4.1	NA	NA	39	NA
N16	02/02/2016 23:47	1.4	4.1	40	No	35	NA
N23	02/02/2016 23:10	1.6	4.1	38	No	<30	NA
N01[2]	09/03/2016 23:50	0.6	4.1	NA	NA	<30	NA
N03[2]	10/03/2016 01:46	0.7	4.1	NA	NA	47	NA
N16	10/03/2016 01:01	0.1	4.1	40	No	<30	NA
N23	10/03/2016 00:17	0.8	4.1	38	No	IA	NA

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable (NA);*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
   - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
   - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level;*
4. *Estimated or measured $L_{Aeq,15minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures; and*
8. *Bold and red text indicate an exceedance of relevant criterion.*

Table 4.3: $L_{A1,1minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 1, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] °C/100m	Criterion $L_{A1,1min}$ dB[1]	Criterion Applies? [3]	WCM $L_{A1,1min}$ dB [4,5]	Exceedance [6,8]
N01[2]	19/01/2016 00:00	0.7	4.1	NA	NA	37	NA
N03[2]	18/01/2016 23:30	0.6	4.1	NA	NA	38	NA
N16	18/01/2016 23:02	0.7	4.1	50	No	IA	NA
N23	18/01/2016 22:37	0.9	4.1	50	No	IA	NA
N01[2]	02/02/2016 23:51	1.6	3.0	NA	NA	NM	NA
N03[2]	03/02/2016 00:46	0.0	4.1	NA	NA	42	NA
N16	02/02/2016 23:47	1.4	4.1	50	No	38	NA
N23	02/02/2016 23:10	1.6	4.1	50	No	<30	NA
N01[2]	09/03/2016 23:50	0.6	4.1	NA	NA	32	NA
N03[2]	10/03/2016 01:46	0.7	4.1	NA	NA	55	NA
N16	10/03/2016 01:01	0.1	4.1	50	No	NM	NA
N23	10/03/2016 00:17	0.8	4.1	50	No	IA	NA

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable;*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
   - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
   - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level;*
4. *Estimated or measured $L_{A1,1minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible "-" denotes no criterion;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable, or, there is no applicable criterion;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures; and*
8. *Bold and red text indicate an exceedance of relevant criterion.*

4.1.3 Low Frequency Assessment

Table 4.4 provides statistics for attended noise monitoring undertaken around WCM during Quarter 1, 2016.

Table 4.4: ATTENDED MEASUREMENT STATISTICS FOR WCM – QUARTER 1, 2016

Conditions	Total for Quarter 1, 2016
Number of measurements	12
Number of measurements where WCM was measurable, was within 5 dB of the relevant criterion and the relevant criterion applied	0

None of the 12 measurements occurred during which WCM was measurable (not "inaudible" or "not measurable"), was within 5 dB of the relevant criterion and where meteorological conditions resulted in criteria applying (in accordance with the consent). No further assessment of low frequency noise was undertaken.

4.2 Quarter 2, 2016

4.2.1 Total Noise Levels

Noise levels measured at each location during attended 15 minute surveys are provided in Table 4.5.

Table 4.5: MEASURED NOISE LEVELS – QUARTER 2, 2016[1]

Location	Start Date and Time	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A90} dB
N01	28/04/2016 23:20	42	41	39	36
N03	29/04/2016 01:22	43	41	39	37
N16	29/04/2016 00:02	47	46	43	39
N16[2]	29/04/2016 01:15	48	47	44	41
N23	29/04/2016 00:47	36	33	32	29
N01	18/05/2016 22:01	38	37	35	27
N03	18/05/2016 22:31	52	42	42	38
N16	18/05/2016 22:57	59	47	46	27
N23	18/05/2016 23:20	35	26	25	19
N01	23/06/2016 00:08	51	46	42	31
N03	22/06/2016 23:15	42	40	39	37
N16	22/06/2016 22:24	53	37	39	28
N23	22/06/2016 22:00	46	42	39	30

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM; and*
2. *Remeasure.*

4.2.2 Wambo Coal Mine Noise

Noise levels generated by activity at Wambo mine are shown in Table 4.6 and Table 4.7, where comparison of measured $L_{Aeq,15minute}$ and $L_{A1,1minute}$ levels for WCM is made with relevant noise criteria.

Table 4.6: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 2, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] $^0C/100m$	Criterion $L_{Aeq,15min}$ dB[1]	Criterion Applies? [3]	WCM $L_{Aeq,15min}$ dB [4,5]	Exceedance [6,8]
N01[2]	28/04/2016 23:20	0.1	4.1	NA	NA	IA	NA
N03[2]	29/04/2016 01:22	0.4	4.1	NA	NA	39	NA
N16	29/04/2016 00:02	0.4	4.1	40	No	43	NA
N16[9]	29/04/2016 01:15	0.3	4.1	40	No	44	NA
N23	29/04/2016 00:47	0.0	4.1	50	No	NM	NA
N01[2]	18/05/2016 22:01	2.9	0.5	NA	NA	25	NA
N03[2]	18/05/2016 22:31	2.8	-1.0	NA	NA	39	NA
N16	18/05/2016 22:57	3.0	-1.0	40	Yes	IA	Nil
N23	18/05/2016 23:20	3.4	-1.0	38	No	IA	NA
N01[2]	23/06/2016 0:08	3.0	-1.0	NA	NA	27	NA
N03[2]	22/06/2016 23:15	3.2	-1.0	NA	NA	NM	NA
N16	22/06/2016 22:24	2.6	-1.0	40	Yes	NM	Nil
N23	22/06/2016 22:00	2.9	-1.0	38	Yes	IA	Nil

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable (NA);*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
    - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
    - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level;*
4. *Estimated or measured $L_{Aeq,15minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures;*
8. *Bold and red text indicate an exceedance of relevant criterion; and*
9. *Remeasure.*

Table 4.7: $L_{A1,1minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 2, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] ºC/100m	Criterion $L_{A1,1min}$ dB[1]	Criterion Applies? [3]	WCM $L_{A1,1min}$ dB [4,5]	Exceedance [6,8]
N01[2]	28/04/2016 23:20	0.1	4.1	NA	NA	IA	NA
N03[2]	29/04/2016 01:22	0.4	4.1	NA	NA	45	NA
N16	29/04/2016 00:02	0.4	4.1	50	No	52	NA
N16[9]	29/04/2016 01:15	0.3	4.1	50	No	51	NA
N23	29/04/2016 00:47	0.0	4.1	50	No	NM	NA
N01[2]	18/05/2016 22:01	2.9	0.5	NA	NA	32	NA
N03[2]	18/05/2016 22:31	2.8	-1.0	NA	NA	43	NA
N16	18/05/2016 22:57	3.0	-1.0	50	Yes	IA	Nil
N23	18/05/2016 23:20	3.4	-1.0	50	No	IA	NA
N01[2]	23/06/2016 0:08	3.0	-1.0	NA	NA	35	NA
N03[2]	22/06/2016 23:15	3.2	-1.0	NA	NA	NM	NA
N16	22/06/2016 22:24	2.6	-1.0	50	Yes	NM	Nil
N23	22/06/2016 22:00	2.9	-1.0	50	Yes	IA	Nil

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable;*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
    - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
    - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level;*
4. *Estimated or measured $L_{A1,1minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible "-" denotes no criterion;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable, or, there is no applicable criterion;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures;*
8. *Bold and red text indicate an exceedance of relevant criterion; and*
9. *Remeasure.*

4.2.3 Low Frequency Assessment

Table 4.8 provides statistics for attended noise monitoring undertaken around WCM during Quarter 2, 2016.

Table 4.8: ATTENDED MEASUREMENT STATISTICS FOR WCM – QUARTER 2, 2016

Conditions	Total for Quarter 2, 2016
Number of measurements	13
Number of measurements where WCM was measurable, was within 5 dB of the relevant criterion and the relevant criterion applied	0

None of the 13 measurements occurred during which WCM was measurable (not "inaudible" or "not measurable"), was within 5 dB of the relevant criterion and where meteorological conditions resulted in criteria applying (in accordance with the consent). No further assessment of low frequency noise was undertaken.

4.3 Quarter 3, 2016

4.3.1 Total Noise Levels

Noise levels measured at each location during attended 15 minute surveys are provided in Table 4.9.

Table 4.9: MEASURED NOISE LEVELS – QUARTER 3, 2016[1]

Location	Start Date and Time	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A90} dB
N01	07/07/2016 22:00	39	35	33	31
N03	07/07/2016 22:30	54	41	49	31
N16	07/07/2016 22:57	52	36	38	29
N23	07/07/2016 23:22	35	31	30	28
N01	01/08/2016 23:59	42	38	36	34
N03	01/08/2016 23:16	52	42	40	34
N16	01/08/2016 22:23	61	50	48	23
N23	01/08/2016 22:00	43	34	32	25
N01	20/09/2016 00:08	48	47	44	39
N03	19/09/2016 23:23	44	41	39	37
N16	19/09/2016 22:24	56	47	43	28
N23	19/09/2016 21:50	42	36	34	32

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.3.2 Wambo Coal Mine Noise

Noise levels generated by activity at Wambo mine are shown in Table 4.10 and Table 4.11, where comparison of measured $L_{Aeq,15minute}$ and $L_{A1,1minute}$ levels for WCM is made with relevant noise criteria.

Table 4.10: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 3, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] ^{0}C/100m	Criterion $L_{Aeq,15min}$ dB[1]	Criterion Applies? [3]	WCM $L_{Aeq,15min}$ dB [4,5]	Exceedance [6,8]
N01[2]	07/07/2016 22:00	1.7	0.5	NA	NA	IA	NA
N03[2]	07/07/2016 22:30	1.7	-1.0	NA	NA	NM	NA
N16	07/07/2016 22:57	1.8	-1.0	40	Yes	28	Nil
N23	07/07/2016 23:22	1.1	3.0	38	Yes	29	Nil
N01[2]	01/08/2016 23:59	0.5	4.1	NA	NA	<30	NA
N03[2]	01/08/2016 23:16	0.7	-1.0	NA	NA	NM	NA
N16	01/08/2016 22:23	0.3	4.1	40	No	IA	NA
N23	01/08/2016 22:00	0.1	4.1	38	No	IA	NA
N01[2]	20/09/2016 00:08	2.3	0.5	NA	NA	<25	NA
N03[2]	19/09/2016 23:23	2.1	3.0	NA	NA	39	NA
N16	19/09/2016 22:24	1.8	0.5	40	Yes	IA	Nil
N23	19/09/2016 21:50	2.6	-1.0	38	Yes	IA	Nil

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable (NA);*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
   - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
   - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level;*
4. *Estimated or measured $L_{Aeq,15minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures; and*
8. *Bold and red text indicate an exceedance of relevant criterion.*

Table 4.11: $L_{A1,1minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 3, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] ^{0}C/100m	Criterion $L_{A1,1min}$ dB[1]	Criterion Applies? [3]	WCM $L_{A1,1min}$ dB [4,5]	Exceedance [6,8]
N01[2]	07/07/2016 22:00	1.7	0.5	NA	NA	IA	NA
N03[2]	07/07/2016 22:30	1.7	-1.0	NA	NA	NM	NA
N16	07/07/2016 22:57	1.8	-1.0	50	Yes	28	Nil
N23	07/07/2016 23:22	1.1	3.0	50	Yes	30	Nil
N01[2]	01/08/2016 23:59	0.5	4.1	NA	NA	<30	NA
N03[2]	01/08/2016 23:16	0.7	-1.0	NA	NA	NM	NA
N16	01/08/2016 22:23	0.3	4.1	50	No	IA	NA
N23	01/08/2016 22:00	0.1	4.1	50	No	IA	NA
N01[2]	20/09/2016 00:08	2.3	0.5	NA	NA	25	NA
N03[2]	19/09/2016 23:23	2.1	3.0	NA	NA	52	NA
N16	19/09/2016 22:24	1.8	0.5	50	Yes	IA	Nil
N23	19/09/2016 21:50	2.6	-1.0	50	Yes	IA	Nil

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable;*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
    - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
    - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level;*
4. *Estimated or measured $L_{A1,1minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible "-" denotes no criterion;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable, or, there is no applicable criterion;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures; and*
8. *Bold and red text indicate an exceedance of relevant criterion.*

4.3.3 Low Frequency Assessment

Table 4.12 provides statistics for attended noise monitoring undertaken around WCM during Quarter 3, 2016.

Table 4.12: ATTENDED MEASUREMENT STATISTICS FOR WCM – QUARTER 3, 2016

Conditions	Total for Quarter 3, 2016
Number of measurements	12
Number of measurements where WCM was measurable, was within 5 dB of the relevant criterion and the relevant criterion applied	0

None of the 12 measurements occurred during which WCM was measurable (not "inaudible" or "not measurable"), was within 5 dB of the relevant criterion and where meteorological conditions resulted in criteria applying (in accordance with the consent). No further assessment of low frequency noise was undertaken.

4.4 Quarter 4, 2016

4.4.1 Total Noise Levels

Noise levels measured at each location during attended 15 minute surveys are provided in Table 4.13.

Table 4.13: MEASURED NOISE LEVELS – QUARTER 4, 2016[1]

Location	Start Date and Time	L_{A1} dB	L_{A10} dB	L_{Aeq} dB	L_{A90} dB
N01	06/10/2016 22:36	44	40	38	33
N03	06/10/2016 23:36	46	42	40	38
N16	06/10/2016 23:03	46	39	35	23
N23	06/10/2016 22:33	33	28	27	25
N01	09/11/2016 22:24	51	51	47	44
N03	09/11/2016 23:00	41	39	37	35
N16	09/11/2016 23:20	38	36	34	31
N23	09/11/2016 22:47	40	38	36	35
N01	01/12/2016 23:54	46	44	42	39
N03	01/12/2016 23:38	50	46	44	42
N16	01/12/2016 22:47	46	43	42	39
N23	01/12/2016 22:17	41	40	38	37

Notes:

1. *Levels in this table are not necessarily the result of activity at WCM.*

4.4.2 Wambo Coal Mine Noise

Noise levels generated by activity at Wambo mine are shown in Table 4.14 and Table 4.15, where comparison of measured $L_{Aeq,15minute}$ and $L_{A1,1minute}$ levels for WCM is made with relevant noise criteria.

Table 4.14: $L_{Aeq,15minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 4, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] ^{0}C/100m	Criterion $L_{Aeq,15min}$ dB[1]	Criterion Applies? [3]	WCM $L_{Aeq,15min}$ dB [4,5]	Exceedance [6,8]
N01[2]	06/10/2016 22:36	1.3	3.0	NA	NA	<20	NA
N03[2]	06/10/2016 23:36	0.6	4.1	NA	NA	39	NA
N16	06/10/2016 23:03	1.1	0.5	40	Yes	<20	Nil
N23	06/10/2016 22:33	1.3	3.0	38	Yes	<20	Nil
N01[2]	09/11/2016 22:24	0.1	4.1	NA	NA	IA	NA
N03[2]	09/11/2016 23:00	0.0	4.1	NA	NA	36	NA
N16	09/11/2016 23:20	0.2	4.1	40	Yes	28	Nil
N23	09/11/2016 22:47	0.6	4.1	38	Yes	23	Nil
N01[2]	01/12/2016 23:54	0.1	4.1	NA	NA	<30	NA
N03[2]	01/12/2016 23:38	0.0	4.1	NA	NA	<30	NA
N16	01/12/2016 22:47	1.1	4.1	40	No	38	NA
N23	01/12/2016 22:17	0.8	4.1	38	No	IA	NA

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable (NA);*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
    - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
    - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level;*
4. *Estimated or measured $L_{Aeq,15minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures; and*
8. *Bold and red text indicate an exceedance of relevant criterion.*

Table 4.15: $L_{A1,1minute}$ GENERATED BY WCM AGAINST NOISE CRITERIA – QUARTER 4, 2016

Location	Start Date and Time	Wind Speed m/s	VTG[7] °C/100m	Criterion $L_{A1,1min}$ dB[1]	Criterion Applies? [3]	WCM $L_{A1,1min}$ dB [4,5]	Exceedance [6,8]
N01[2]	06/10/2016 22:36	1.3	3.0	NA	NA	25	NA
N03[2]	06/10/2016 23:36	0.6	4.1	NA	NA	48	NA
N16	06/10/2016 23:03	1.1	0.5	50	Yes	25	Nil
N23	06/10/2016 22:33	1.3	3.0	50	Yes	<20	Nil
N01[2]	09/11/2016 22:24	0.1	4.1	NA	NA	IA	NA
N03[2]	09/11/2016 23:00	0.0	4.1	NA	NA	41	NA
N16	09/11/2016 23:20	0.2	4.1	50	Yes	34	Nil
N23	09/11/2016 22:47	0.6	4.1	50	Yes	25	Nil
N01[2]	01/12/2016 23:54	0.1	4.1	NA	NA	<30	NA
N03[2]	01/12/2016 23:38	0.0	4.1	NA	NA	44	NA
N16	01/12/2016 22:47	1.1	4.1	50	No	45	NA
N23	01/12/2016 22:17	0.8	4.1	50	No	IA	NA

Notes:

1. *Development consent criterion;*
2. *Monitoring location is within Zone of Affectation, criterion not applicable;*
3. *The noise emission limits identified in the above table apply under meteorological conditions of:*
    - *Wind speeds of up to 3 m/s at 10 metres above ground level; or*
    - *Temperature inversion conditions of up to 3ºC/100m, and wind speeds of up to 2 m/s at 10 metres above ground level.*
4. *Estimated or measured $L_{A1,1minute}$ attributed to WCM;*
5. *NM denotes WCM audible but not measurable, IA denotes inaudible "-" denotes no criterion;*
6. *NA in exceedance column means atmospheric conditions outside conditions specified in development consent and so criterion is not applicable, or, there is no applicable criterion;*
7. *Vertical temperature gradient (VTG) calculated using sigma theta values according to INP procedures; and*
8. *Bold and red text indicate an exceedance of relevant criterion.*

4.4.3 Low Frequency Assessment

Table 4.16 provides statistics for attended noise monitoring undertaken around WCM during Quarter 4, 2016.

Table 4.16: ATTENDED MEASUREMENT STATISTICS FOR WCM – QUARTER 4, 2016

Conditions	Total for Quarter 4, 2016
Number of measurements	12
Number of measurements where WCM was measurable, was within 5 dB of the relevant criterion and the relevant criterion applied	0

None of the 12 measurements occurred during which WCM was measurable (not "inaudible" or "not measurable"), was within 5 dB of the relevant criterion and where meteorological conditions resulted in criteria applying (in accordance with the consent). No further assessment of low frequency noise was undertaken.

4.5 Review of Site Noise Level Trends

Trends in measured site noise levels incorporating data from start of Quarter 1 2014 to the end of Quarter 4 2016 were reviewed to assess changes in measured $L_{Aeq,15minute}$ and $L_{A1,1minute}$ levels for WCM over the past three years of regular attended monitoring.

Figures 2 to 5 display measured $L_{Aeq,15minute}$ and $L_{A1,1minute}$ levels for the four monitoring locations with linear trend lines included to show any changes in data measurements over the past 3 years.

It should be noted that for the purpose of graphing data, all measurements that were either inaudible (IA), not measurable (NM) , <30 dB or <20 dB, have been assigned a value of 0.

4.5.1 N01 - Lambkin

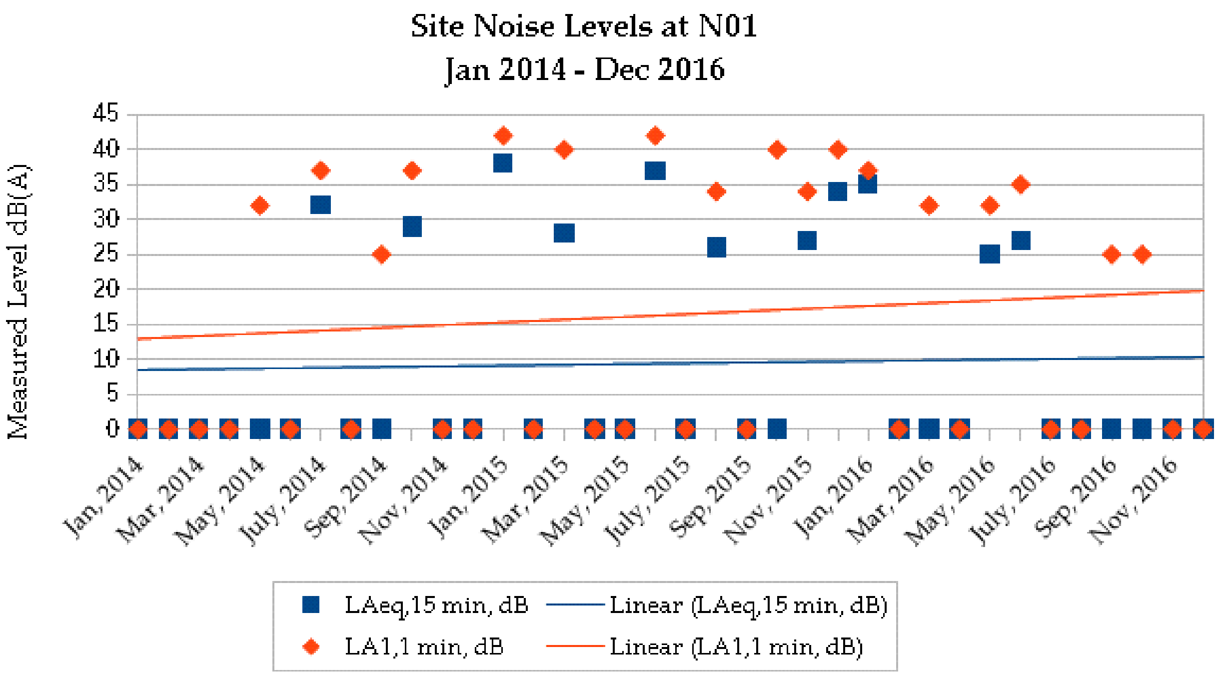


Figure 2: Summary of Measured Site Noise levels, N01 – Lambkin

There are no significant differences in measured site noise levels at monitoring location N01 over the 2014 to 2016 period.

Both $L_{Aeq,15minute}$ and $L_{A1,1minute}$ levels were fairly consistent over the monitoring period, with a slightly increasing trend for $L_{A1,1minute}$ levels, most likely due to a larger number of non-recordable measurements towards the earlier stages of the three year period. In the last 6 months of 2016, $L_{A1,1minute}$ levels were again very low or non-recordable.

4.5.2 N03 - Kelly

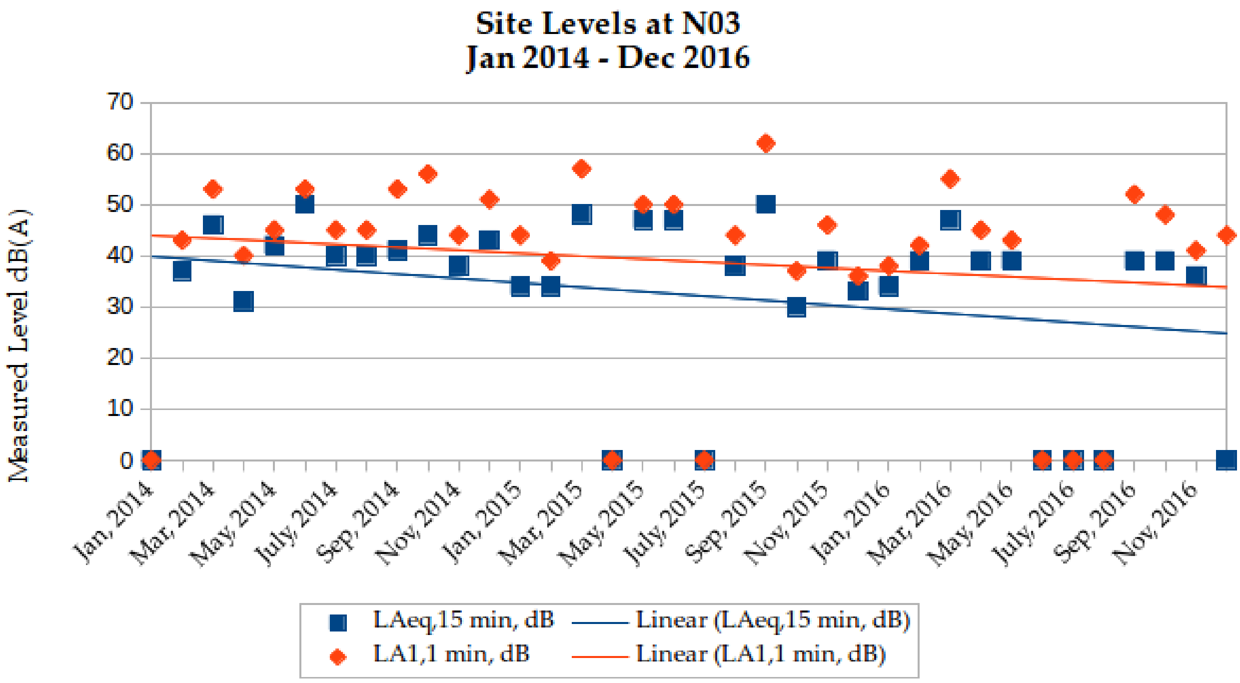


Figure 3: Summary of Measured Site Noise levels, N03 – Kelly

Due to N03 being the closest monitoring site to mine operations, this location had the least number of measurements that were noted as IA, NM or less than 30 dB, with only 7 monitoring events not having recordable values, with half of these occurring during 2016.

All measurement values were fairly consistent over the period, with a very slight downward trend.

4.5.3 N16 - Muller

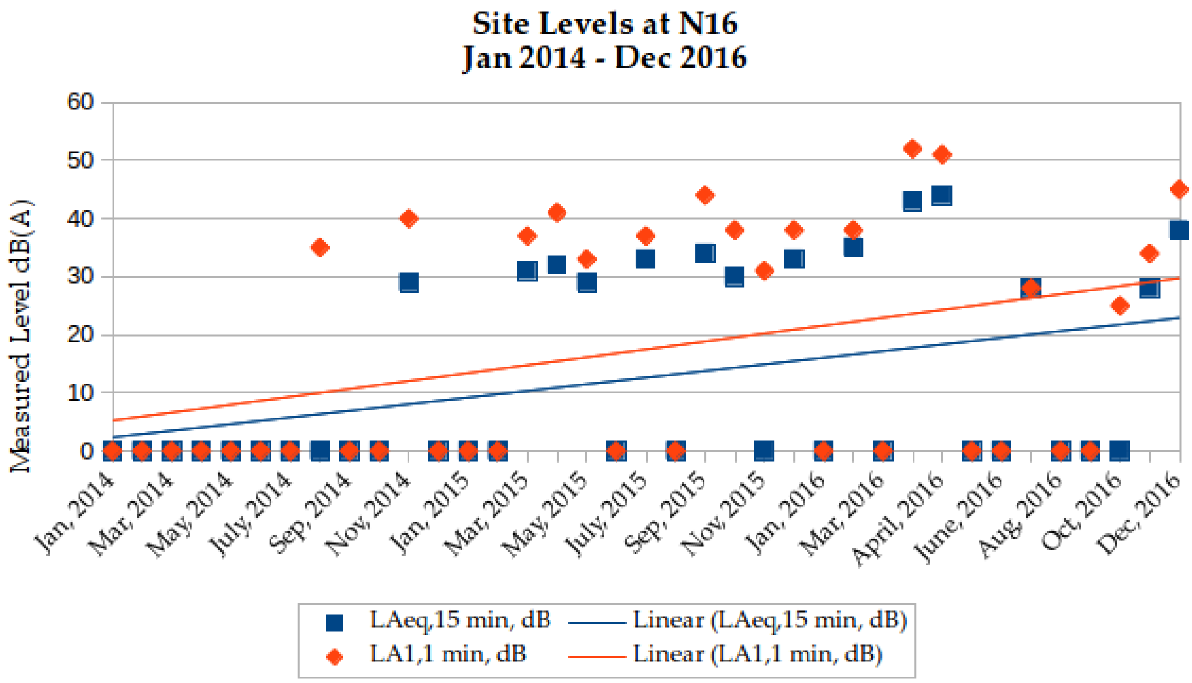


Figure 4: Summary of Measured Site Noise levels, N16 – Muller

Measured site noise levels at location N16 have shown a definite upward trend over the past three years. This is due to levels being either IA or NM for the majority of monitoring events during 2014. This can possibly be attributed to N16 being in the direction of pit progression.

Measured levels were fairly consistent over 2015, however during 2016 there was an increased number of non-recordable measurements again before an increasing trend in the late stages of 2016.

4.5.4 N23 - Carter

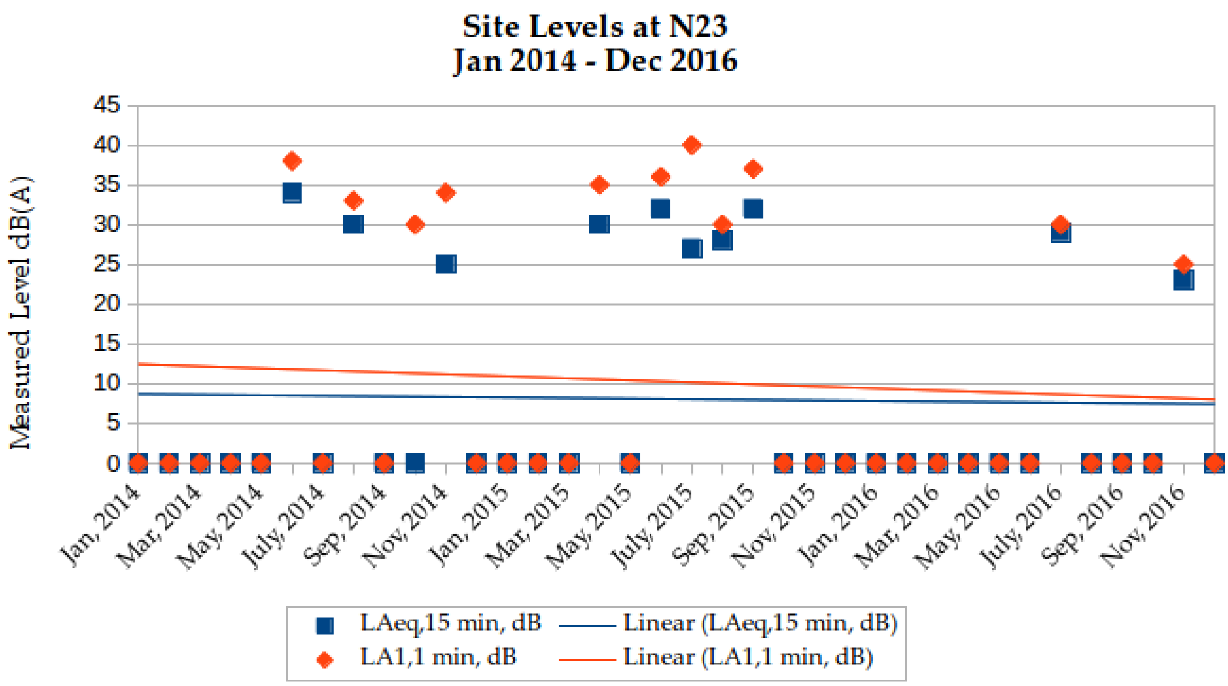


Figure 5: Summary of Measured Site Noise levels, N23 – Carter

Measured noise levels at monitoring location N23 have shown a very slight decreasing trend over the past 3 years. This is due to only 2 recordable measurements since late 2015, both in the second half of 2016. These measurements were also at relatively low levels compared to previous measured noise levels.

4.6 Comparison with EIS

Predicted Year 9 operational noise levels from Table 5.4.1 of the EIS (June 2003) are reproduced for the monitoring locations during the night period only as shown in Table 4.17.

Year 9 predictions have been used for comparison of measured levels. As detailed in the EIS, Year 9 operations are representative of the nearest open-cut operations to Bulga Village including Wambo and Arrowfield Seam underground, CHPP and train loading system operations (with train movement).

Table 4.17: WAMBO OPERATIONAL $L_{Aeq,15minute}$ dB EIS PREDICTIONS, YEAR 9

Location	Adverse SE Wind Summer, Autumn, Spring - Night	Adverse Inversion W Wind Winter - Night
N01, Lambkin	21	35
N03, Kelly	57 [3]	56 [3]
N16, Muller	37 [1]	25
N23, Redmanvale Road, Thelander	40 [2]	18

Source: Wambo EIS (June 2003)

Notes from Table 5.4.1 of EIS:

1. *Marginal Noise Management Zone 1 to 2 dBA above project specific criteria;*
2. *Moderate Noise Management Zone 3 to 5 dBA above project specific criteria; and*
3. *Noise Affectation Zone >5 dBA above project specific criteria.*

Table 3.2.3 of the EIS details applicable periods for predicted noise levels. This table has been reproduced below. It should be noted that data in Table 4.18 and Table 4.19 in this report detail the differences against predicted levels for the relevant seasons and periods. This comparison addresses wind speed, wind direction and temperature gradient. Air temperature and relative humidity have not been included in the comparison.

Table 3.2.3 Non-Adverse (Calm) and Adverse Noise Modelling Meteorological Parameters

Season	Period	Air Temp	Relative Humidity	Wind Velocity[1]	Temperature Gradient[1]
Non-Adverse Annual	Daytime	18°C	60%	0 m/s	0°C/100 m
Adverse Summer Autumn Spring	Evening and Night-time	12°C	75%	SE 3 m/s	0°C/100 m
Adverse Winter	Evening and Night-time	6°C	90%	W 2 m/s	3°C/100 m

Note 1: NSW INP (2000) default adverse wind speed 3 m/s and default inversion 3°C/100m plus 2 m/s wind.

Source: Wambo EIS (June 2003)

4.6.1 Year 9 Comparison

Measured operational levels have been compared to the predicted levels for Year 9 in the EIS for the relevant meteorological conditions. In the tables below, a positive difference is where the measured level is greater than the predicted level and a negative difference is where the measured levels are less than the predicted level. Notation used in the tables to denote differences is irrespective of the integer value sign. For example, the notation >-17 means the values are more than 17 dB less than the predicted level.

Table 4.18 provides the difference between measured and predicted levels with 3 m/s winds from the south east (SE) during the night period in summer, autumn and spring.

Table 4.18: 2016 WAMBO OPERATIONAL $L_{Aeq,15minute}$ dB DIFFERENCE AGAINST PREDICTED SE WIND CONDITIONS DURING SUMMER, AUTUMN AND SPRING – NIGHT, YEAR 9[1,2,4]

Location	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Sep 16	Oct 16	Nov 16	Dec 16
N01, Lambkin[5]	NR	NR	NR	NR	NR	NR	NR	NR	NR
N03, Kelly[6]	NR	NR	NR	NR	NR	NR	NR	NR	NR
N16, Muller	NR	NR	NR	NR	NR	NR	NR	NR	NR
N23, Redmanvale Road, Thelander	NR	NR	NR	NR	NR	NR	NR	-17[3]	NR

Notes:

1. *NR denotes met conditions not relevant, NA denotes not applicable, IA denotes conditions relevant but Wambo inaudible during monitoring, NM denotes conditions relevant but Wambo not measurable during monitoring;*
2. *SE wind conditions assumes winds at speeds between 0.1 and 3 m/s from a wind direction of 112.5 to 157.5 degrees during monitoring. Assumes no inversion conditions, i.e. the VTG is less than -0.5°C/100m (equivalent to stability categories A to D) during monitoring. All met data is taken from a height of 10 metres (meteorological station);*
3. *Wind conditions relevant, however, VTG is positive (greater than 0 degrees per 100 metres) during monitoring;*
4. *Measurements during Summer, Autumn and Spring only;*
5. *This property has been acquired by another mine, and, was previously acquisition (by Wambo) on request; no criteria applied there during 2016; and*
6. *Acquisition upon request.*

Table 4.19 provides the difference between measured and predicted levels with up to 2 m/s winds from the west (W) and a 3 degree per 100 metre vertical temperature gradient (VTG) during the night period in winter only.

Table 4.19: 2016 WAMBO OPERATIONAL $L_{Aeq,15minute}$ dB DIFFERENCE AGAINST PREDICTED W WIND CONDITIONS DURING WINTER - NIGHT, YEAR 9[1,2,4]

Location	June 16	July 16	August 16
N01, Lambkin[5]	NR	NR	NR
N03, Kelly[6]	NR	NR	NR
N16, Muller	NM[3]	NR	NR
N23, Redmanvale Road, Thelander	IA[3]	NR	NR

Notes:

1. *NR denotes met conditions not relevant, NA denotes not applicable, IA denotes conditions relevant but Wambo inaudible during monitoring, NM denotes conditions relevant but Wambo not measurable during monitoring;*
2. *W wind conditions assumes winds at speeds between 0.1 and 2 m/s from a wind direction of 247.5 to 292.5 degrees during monitoring. Inversion conditions assumes a 3°C/100m VTG during monitoring. All met data is taken from a height of 10 metres (meteorological station);*
3. *Wind from W direction, however all other meteorological conditions not relevant;*
4. *Measurements during Winter only;*
5. *This property has been acquired by another mine, and, was previously acquisition (by Wambo) on request; no criteria applied there during 2016; and*
6. *Acquisition upon request.*

As shown in the tables above, a comparison of predicted and measured levels from Wambo Year 9 operation shows very limited measurements that fall within meteorological conditions predicted. This comparison does not take into account operational activities at the time of monitoring compared to predicted scenarios.

5 CONCLUSION

5.1 Attended Noise Monitoring

Noise levels from WCM complied with the relevant criteria at all sites during 2016 attended monitoring.

There were no changes to train refuelling procedures so no monitoring for the WCRS was undertaken during 2016.

It is noted that wind speeds and/or temperature inversion conditions were at levels greater than which development consent conditions would apply for WCM activities in some instances.

5.2 Site Noise Level Trends

There have been no significant changes in noise level trends over the past three years.

5.3 Comparison with EIS

Predicted noise levels from Year 9 were compared against actual noise levels during 2016. Results of the comparison indicate that meteorological conditions included in the EIS modelled predictions did not regularly occur during attended monitoring. When meteorological conditions were relevant, results show that WCM was generally well under the predicted levels.

Global Acoustics Pty Ltd

APPENDIX

A DEVELOPMENT CONSENT

A.1 WAMBO COAL MINE DEVELOPMENT CONSENT

A.1.1 Relevant Wambo Coal Mine Development Consent Conditions

The relevant sections of the October 2016 modified conditions are reproduced below:

SCHEDULE 4
SPECIFIC ENVIRONMENTAL CONDITIONS

ACQUISITION UPON REQUEST

1. Upon receiving a written request for acquisition from the landowner of the land listed in Table 1, the Applicant must acquire the land in accordance with the procedures in conditions 9-11 of schedule 5:

Table 1: Land subject to acquisition upon request

2 – Lambkin	23A & B - Kannar
13C - Skinner	31A,B,C & D - Fisher
19A & B – Kelly	51 – Hawkes
22 – Henderson	56 - Haynes

Note: For more information on the numbering and identification of properties used in this consent, see Attachment 1 of the EIS for the Wambo Development Project. Lands titled 23A & B – Kannar, 31A,B,C & D – Fisher, 51 – Hawkes and 56 – Haynes have been acquired and are now mine-owned.

[1]NOISE

Noise Impact Assessment Criteria

6. The Applicant must ensure that the noise generated by the Wambo Mining Complex does not exceed the noise impact assessment criteria presented in Table 9.

Table 9: Noise impact assessment criteria dB(A))

Day $L_{Aeq(15\ minute)}$	Evening/Night $L_{Aeq(15\ minute)}$	Night $L_{A1(1\ minute)}$	Land Number
35	41	50	94 – Curlewis
			3 – Birrell

[1] Incorporates EPA GTAs

Day $L_{Aeq(15\ minute)}$	Evening/Night $L_{Aeq(15\ minute)}$	Night $L_{A1(1\ minute)}$	Land Number
35	40	50	4B – Circosta
			15B - McGowen/Caslick
			16 – Cooper
			23C – Kannar
			25 – Fenwick
			28A & B – Garland
			33 -Thelander/O'Neill
			39 – Northcote
			40 – Muller
			254A – Algie
35	39	50	5 – Strachan
			6 - Merrick
			7 - Maizey
			37 - Lawry
			48 - Ponder
35	38	50	1 - Brosi
			17 - Carter
			18 - Denney
			38 - Williams
			49 - Oliver
			63 - Abrocuff
			75 - Barnes
			91 - Bailey
35	37	50	27 - Birralee
			43 - Carmody
			137 - Woodruff
			163 - Rodger/Williams
			246 - Bailey
35	36	50	13B - Skinner
			178 - Smith
			188 - Fuller
			262A, B & C - Moses
35	35	50	All other residential or sensitive receptors, excluding the receptors listed in condition 1 above

Notes:

- Noise generated by the Wambo Mining Complex is to be measured in accordance with the relevant requirements, and exemptions (including certain meteorological conditions), of the NSW Industrial Noise Policy

Land Acquisition Criteria

7. If the noise generated by the Wambo Mining Complex exceeds the criteria in Table 10, the Applicant must, upon receiving a written request for acquisition from the landowner, acquire the land in accordance with the procedures in conditions 9-11 of schedule 5.

Table 10: Land acquisition criteria dB(A)

Day/Evening/Night $L_{Aeq(15\ minute)}$	Property
43	*94 - Curlewis*
	23C – Kannar
	254A - Algie
40	*All other residential or sensitive receptor, excluding the receptors listed in condition 1 above*

Note: Noise generated by the Wambo Mining Complex is to be measured in accordance with the notes presented below Table 9 above. Property 23C – Kannar has been acquired and is now mine-owned.

Operating Conditions

8. The Applicant must:
   (a) implement best management practice to minimise the operational, low frequency and traffic noise of the Wambo Mining Complex;

(b) operate a comprehensive noise management system for the Wambo Mining Complex that uses a combination of predictive meteorological forecasting and real-time noise monitoring data to guide the day to day planning of mining operations and the implementation of both proactive and reactive noise mitigation measures to ensure compliance with the relevant conditions of this consent;
(c) maintain the effectiveness of noise suppression equipment (if fitted) on plant at all times and ensure defective plant is not used operationally until fully repaired;
(d) ensure that noise attenuated plant (if used) is deployed preferentially in locations relevant to sensitive receivers;
(e) minimise the noise impacts of the Wambo Mining Complex during meteorological conditions when the noise limits in this consent do not apply;
(f) co-ordinate the noise management for the Wambo Mining Complex with the noise management at nearby mines (including HVO South, HVO North and Mt Thorley Warkworth mines) to minimise the cumulative noise impacts of these mines and the Wambo Mining Complex,

to the satisfaction of the Secretary.

Noise Management Plan

9. The Applicant must prepare a Noise Management Plan for the Wambo Mining Complex to the satisfaction of the Secretary. This plan must:
   (a) be prepared in consultation with the EPA, and submitted to the Secretary for approval by the end of June 2013;
   (b) describe the measures that would be implemented to ensure:
      - best management practice is being employed;
      - the noise impacts of the Wambo Mining Complex are minimised during meteorological conditions when the noise limits in this consent do not apply; and
      - compliance with the relevant conditions of this consent;
   (c) describe the proposed noise management system in detail;
   (d) include a monitoring program that:
      - uses a combination of real-time and supplementary attended monitoring measures to evaluate the performance of the Wambo Mining Complex;
      - adequately supports the proactive and reactive noise management system for the Wambo Mining Complex;
      - includes a protocol for determining exceedances of the relevant conditions in this consent;
      - evaluates and reports on the effectiveness of the noise management system for the Wambo Mining Complex;
      - provides for the annual validation of the noise model for the Wambo Mining Complex; and
   (e) include a protocol that has been prepared in consultation with the owners of nearby mines (including HVO South, HVO North and Mount Thorley Warkworth mines) to minimise the cumulative noise impacts of these mines and the Wambo Mining Complex.

The Applicant must implement the approved management plan as approved from time to time by the Secretary.

A.2 WAMBO RAIL SPUR DEVELOPMENT CONSENT

The relevant sections of the February 2012 modified conditions for the rail spur are reproduced below:

SCHEDULE 4
GENERAL ENVIRONMENTAL CONDITIONS

ACQUISITION UPON REQUEST

1. Upon receiving a written request for acquisition from the landowner of the land listed in Table 1, the Applicant shall acquire the land in accordance with the procedures in conditions 1-3 of schedule 5.

Table 1: Land subject to acquisition upon request

19 - L Kelly	55 - E & C Burley

Note: For more information on the numbering and identification of properties used in this consent, see Attachment 1A and Attachment 1B of the SEE for the Alterations to the Wambo Development Project – Rail and Train Loading Infrastructure.

2. While the land listed in Table 1 is privately owned, the Applicant shall implement all practicable measures to ensure that the impacts of the development comply with the predictions in the SEE, and the relevant conditions in this consent, at any residence on this land, to the satisfaction of the Director-General.

[1]NOISE

Noise Impact Assessment Criteria

3. The Applicant shall ensure that noise generated by the development, combined with noise generated by any development in the Wambo Mining Complex, does not exceed the noise criteria provided in Table 2, unless higher noise criteria are specified in the consent for the Wambo Coal Mine (DA 305-7-2003).

Table 2: Noise impact assessment criteria dB(A)

Day $L_{Aeq(15\ minute)}$	Evening/Night $L_{Aeq(15\ minute)}$	Night $L_{A1(1\ minute)}$	Land Number
35	35	50	All private residential or sensitive receptors, excluding the receptors listed in Table 1

Notes:
- *Noise generated by the project is to be measured in accordance with the relevant requirements, and exemptions (including certain meteorological conditions), of the NSW Industrial Noise Policy.*
- *For this condition to apply, the exceedance of the criteria must be systemic.*

Construction Hours

4. The Applicant shall ensure that all construction work is carried out from 7 am to 6 pm Monday to Saturday (inclusive) and 8 am to 6 pm Sundays and Public Holidays.

Operating Hours

5. The Applicant shall:
   (a) take all practicable measures to minimise train movements at the development on Friday evening (6 pm-9 pm) and Sunday morning (9 am-12 am);
   (b) report on the implementation and effectiveness of these measures,
   to the satisfaction of the Director-General.

Rail Noise

6. The Applicant shall seek to ensure that its rail spur is only accessed by locomotives that are approved to operate on the NSW rail network in accordance with noise limits L6.1 to L6.4 in RailCorp's EPL (No. 12208) and ARTC's EPL (No. 3142) or a Pollution Control Approval issued under the former *Pollution Control Act 1970*.

Noise Monitoring

7. The Applicant shall monitor the noise generated by the development, and noise generated by the Wambo Mine, in general accordance with the Noise Management Plan for the Wambo Mining Complex and the *NSW Industrial Noise Policy*.

7A. By 31 May 2012, the Applicant shall review and update the Noise Management Plan for the Wambo Mining Complex, including a noise monitoring protocol for evaluating compliance with the criteria in condition 3 above.

7B. During the first 12 months of operation of the Rail Refuelling Facility, the Applicant must conduct attended noise monitoring at the nearest private receptor during refuelling events, no less often than every three months.

A.3 WAMBO RAIL LINE DEVELOPMENT CONSENT

The relevant sections of the 1998 conditions for the rail line are reproduced below:

Operational Noise

8. The Applicant shall ensure noise emissions from the operations of the railway line when measured at any residence along the railway line corridor shall not exceed the following EPA criteria:

   (a) planning level of $L_{Aeq\ 24hr}$ 55dBA; and

   (b) maximum passby level of L_{Amax} 85dBA

   The noise criteria levels shall be measured under prevailing weather conditions in accordance with EPA requirements and to be consistent with EPA's requirements as applied to the New South Wales coal industry, or otherwise agreed to by the EPA.

9. Prior to the commencement of operations, the Applicant shall prepare in consultation with the EPA and Singleton Shire Council an Operational Noise Management Plan. The Operation Noise Management Plan shall demonstrate that all practical design and noise mitigation methods have been undertaken to achieve the noise levels specified in Condition 8.

APPENDIX C – ENVIRONMENTAL MONITORING DATA SUMMARIES

Date & Time	Blast ID	BM02 KELLY Peak Air Blast (dBL)	BM02 KELLY Peak Resultant (mm/s)	BM05 MULLER Peak Air Blast (dBL)	BM05 MULLER Peak Resultant (mm/s)	BM07 THELANDER Peak Air Blast (dBL)	BM07 THELANDER Peak Resultant (mm/s)
8/01/2016 9:19	M19WRC5	99.8	0.08	106.1	0.26	102.4	0.23
12/01/2016 11:05	M27WWA1	89.6	0.2	107.5	0.51	102	0.6
14/01/2016 11:11	M21WRA2	95.7	0.07	109.6	0.3	107.5	0.33
19/01/2016 15:19	BS9WRA2	90.9	0.42	102.2	0.09	102.8	0.13
21/01/2016 11:03	M21WRA3	96.3	0.05	111.8	0.38	106.3	0.31
28/01/2016 15:03	M20WMA3	90.9	0.09	103	0.57	92.9	0.65
29/01/2016 11:11	BS9WTA3	95.7	0.2	104.5	0.08	96.8	0.11
1/02/2016 15:05	M18WMA3	98.9	0.04	101.8	0.07	92.9	0.24
3/02/2016 15:09	M23WWA7	89.6	0.05	107	0.51	110.6	0.38
12/02/2016 13:26	M19WMA2, M21WRA4, M23WWA8	92	<0.48	114.8	0.84	115.7	1.03
16/02/2016 15:19	M23WWA9	92	0.23	110.7	0.33	108.8	0.42
19/02/2016 15:10	M22WWA8	94.2	0.12	115.8	0.49	107.5	0.31
24/02/2016 11:09	M21WRA5, M20WTA1	96.6	0.09	111	0.59	103.2	0.61
2/03/2016 11:31	M19WRC6, M18WTA1	90.9	0.15	107.9	0.3	110.1	0.35
11/03/2016 9:16	M21WRC1	103.3	0.08	115.8	0.67	110.3	0.64
18/03/2016 0:00	M21WRC2	96	0.05	105.9	0.34	102.4	0.48
18/03/2016 0:00	M24WWA3	102.3	0.11	102.6	1.43	103.6	1.84
23/03/2016 0:00	M22RCA8	94.2	0.05	106.6	0.32	105.2	0.26
23/03/2016 0:00	M19WMA3-2	NRR	<0.48	NRR	<0.48	NRR	<0.48
30/03/2016 0:00	M19WMA4-1	93.4	0.09	100.1	0.34	101.5	0.34
1/04/2016 15:05	M22RCA9	98.9	0.04	112.6	0.13	104.6	0.14
9/04/2016 9:14	M22RCA10	NRR	<0.48	NRR	<0.48	NRR	<0.48
11/04/2016 9:14	M19WWA4	92.9	0.08	101.4	0.39	97.5	0.37
15/04/2016 9:07	M18WTA2	98.2	0.13	107	0.28	103.6	0.27
15/04/2016 9:13	M21WRC3	95.7	0.11	102.6	0.28	105.8	0.36

Date & Time	Blast ID	BM02 KELLY Peak Air Blast (dBL)	BM02 KELLY Peak Resultant (mm/s)	BM05 MULLER Peak Air Blast (dBL)	BM05 MULLER Peak Resultant (mm/s)	BM07 THELANDER Peak Air Blast (dBL)	BM07 THELANDER Peak Resultant (mm/s)
21/04/2016 11:35	M21WMA1	100.2	0.11	114.6	1.01	107.8	0.83
21/04/2016 11:42	M24WWA10	92.9	0.07	110.6	0.78	110.8	1.1
22/04/2016 11:07	M22WWA6_RL152	91.4	0.24	106.6	0.28	102.4	0.13
28/04/2016 15:15	M19WMA4_2	90.9	0.16	100.6	0.39	98.2	0.36
29/04/2016 15:11	M19WMA5	91.4	0.25	101	0.18	97.5	0.16
4/05/2016 15:00	M_22RCA_2	87.8	0.03	NRR	<0.48	92.7	0.08
5/05/2016 15:04	M22WWA	81.3	0.05	99.6	0.09	89.9	0.11
9/05/2016 16:06	M_21WRC_1	99.2	0.05	105.4	0.39	103.6	0.41
11/05/2016 15:18	M_23RCA_6	98.9	0.07	108.6	0.5	102	0.68
13/05/2016 11:03	M_19WTA_4	95.3	0.19	103.3	0.3	95	0.42
13/05/2016 11:15	M_23RCA_7	87.4	0.05	100.1	0.53	98.2	0.31
17/05/2016 0:00	M_18WMA_8 & M_23RCA_9	88.9	0.05	101	0.14	98.9	0.19
20/05/2016 15:18	M_19WMA_8	81.3	0.12	101.4	0.3	94	0.27
20/05/2016 15:23	M_21WMA_10	82.9	0.24	105.4	0.42	101.1	0.4
20/05/2016 15:28	M_23RCA_9	79.4	0.05	102.2	0.28	98.9	0.28
25/05/2016 11:06	M_19WTA_17	NRR	<0.48	101	0.49	100.6	0.43
27/05/2016 16:03	M21_WMA_24	98.2	0.08	103.9	0.74	104.3	0.75
6/06/2016 11:02	M_24RCA_13	92.9	0.07	101.4	0.47	103.9	0.53
6/06/2016 11:08	M21WMA_16	93.4	0.07	101	0.76	103.6	0.68
9/06/2016 11:01	M21WMA_24	99.1	0.08	103.6	0.45	101.1	0.33
9/06/2016 11:08	M_19WTA_29	109.4	0.08	107	0.59	106.1	0.79
14/06/2016 15:07	M_24RCA_14	99.9	0.07	109	0.5	107.3	0.67
17/06/2016 15:06	M_14WMA_21	103.5	0.14	104	0.21	99	0.27
24/06/2016 15:15	M_15WMA_22	103.3	0.12	106.1	0.35	101.6	0.47
24/06/2016 15:20	M_18WMA_27	101.5	0.08	102	0.28	94.4	0.3
30/06/2016 15:06	M_15WMA_31	106.8	0.22	99.4	0.32	92.7	0.5

Date & Time	Blast ID	BM02 KELLY Peak Air Blast (dBL)	BM02 KELLY Peak Resultant (mm/s)	BM05 MULLER Peak Air Blast (dBL)	BM05 MULLER Peak Resultant (mm/s)	BM07 THELANDER Peak Air Blast (dBL)	BM07 THELANDER Peak Resultant (mm/s)
4/07/2016 15:11	M_24RCA_25	100.6	0.04	107.4	0.39	101.8	0.35
7/07/2016 11:07	M_19WTA_30	92.1	0.24	104.7	0.54	100.8	0.65
11/07/2016 15:04	M_16WMA_23	92.3	0.09	98.2	0.42	94.7	0.54
15/07/2016 11:09	M_21WTA_33	108.5	0.6	92.7	0.08	103.8	0.52
19/07/2016 15:03	M_24RCA_26	92.6	0.04	98.3	0.18	89.8	0.13
27/07/2016 15:04	M_21WTA_35	101.4	0.1	103.5	0.7	102	0.67
29/07/2016 15:08	M_18WTA_32	101.9	0.05	101	0.22	96.7	0.24
10/08/2016 15:10	M_21WTA_36	94.9	0.08	96.1	0.39	98.5	0.45
10/08/2016 15:13	M_23RCA_20	96.9	0.11	98.2	0.35	96.6	0.46
10/08/2016 15:15	M_18WTA_28	91.2	0.03	97.8	0.12	90.5	0.09
16/08/2016 15:39	M_14WTA_38	94	0.17	103.4	0.66	98.5	0.48
19/08/2016 11:00	M_23RCA_19	83.7	0.03	98.7	0.18	94.3	0.06
25/08/2016 11:03	M_14WTA_40	91.7	0.1	98.9	0.32	97.3	0.4
25/08/2016 11:05	M_18WTA_37	90.2	0.07	101.4	0.26	98.7	0.21
31/08/2016 11:08	M_20WTA_39	104.5	0.16	107.9	0.58	102.4	0.72
5/09/2016 15:11	BS_WWA_45	94.36	0.06	91.5	0.01	79.1	0.01
6/09/2016 15:09	M_23WWA_46	93.6	0.07	104	0.33	98.6	0.29
9/09/2016 11:03	M_22WRA_50	97.2	0.06	106	0.38	100	0.65
9/15/2016 15:15	M_20WTA_41	98.7	0.13	102.1	0.71	98	0.49
19/09/2016 15:04	M_22WRA_47	96.3	0.06	109.3	0.55	106.6	0.67
21/09/2016 14:59	M_22WRA_49	99.3	0.08	93	0.52	89.3	0.42
26/09/2016 16:24	M_15WTA_53	96.9	0.19	107.1	0.68	101	0.6
28/09/2016 11:07	M_22WRA_51	98.9	0.06	109.3	0.4	106.9	0.34
4/10/2016 15:00	M_20WTA_54	102.1	0.11	104.2	0.38	96.3	0.48
6/10/2016 15:32	M_19WTA_57	92.8	0.2	99	0.41	105.3	0.37
11/10/2016 11:13	M_22WRA_52	102.9	0.07	105.4	0.61	97.4	0.57

Date & Time	Blast ID	BM02 KELLY Peak Air Blast (dBL)	BM02 KELLY Peak Resultant (mm/s)	BM05 MULLER Peak Air Blast (dBL)	BM05 MULLER Peak Resultant (mm/s)	BM07 THELANDER Peak Air Blast (dBL)	BM07 THELANDER Peak Resultant (mm/s)
12/10/2016 15:34	M_19WTA_58	95	0.13	98.7	0.34	96.9	0.41
18/10/2016 16:12	M_23WRA_42	101.6	0.06	108.9	0.52	105.6	0.6
21/10/2016 11:38	M_20WTA_55	91.8	0.06	98.2	0.42	95.8	0.39
21/10/2016 11:43	M_23WRA_44	94.1	0.06	101.4	0.52	97.8	0.52
26/10/2016 15:33	M_20WTA_64	95.1	0.15	104.2	0.6	101.3	0.59
26/10/2016 15:41	ME_1WMA_65	95.5	0.05	103.2	0.52	96.4	0.24
2/11/2016 16:01	M_17WTA_59	101.8	0.22	103.2	0.42	96.5	0.44
2/11/2016 16:05	ME_1WMA_66	98.5	0.1	111.6	0.86	105	0.24
8/11/2016 11:01	M_22WRA_48	95.7	0.04	107	0.5	104.5	0.4
12/11/2016 9:16	M_16WTA_67	118.6	0.13	107.8	0.47	100.1	0.38
12/11/2016 9:12	ME_1WMA_69	99.7	0.08	108	0.84	96.9	0.4
18/11/2016 16:03	M_17WTA_68	92.4	0.06	98.9	0.23	95.1	0.21
18/11/2016 16:09	ME_1WMA_71	88.9	0.04	101.1	0.54	99.1	0.18
22/11/2016 11:11	M_22WRC_70	98.6	0.04	109.4	0.22	104.5	0.3
22/11/2016 11:15	ME_1WMA_72	93.7	0.15	102.6	0.38	96	0.15
28/11/2016 11:24	M_22WRC_74	92.8	0.03	102.6	0.23	100	0.23
28/11/2016 11:44	M_27WWA_63	94	0.08	105.9	0.97	97.7	1.02
2/12/2016 11:38	M_27WWA_60	97.6	0.38	92.2	0.11	100.9	0.06
2/12/2016 11:40	ME_1WMA_73	102.1	0.09	108.5	0.48	101	0.42
5/12/2016 12:28	GM_GMA0_77A	108.2	0.68	87.3	0.01	90.4	0.01
5/12/2016 13:25	GM_GMA0_77B	107.8	0.92	84.3	0.01	75.6	0.01
9/12/2016 11:08	M_22WRC_76	97.3	0.03	104.8	0.21	106.5	0.13
12/12/2016 11:05	GM_GMA0_78	111.1	1.55	96.7	0.02	84.6	0.02
14/12/2016 15:05	M_27WWA_62	102.3	0.07	100.8	0.7	98.3	0.96
14/12/2016 15:09	ME_1WMA_79	95	0.06	107.7	1.11	100.2	0.91
20/12/2016 15:36	ME_1WMA_82	98.2	0.05	105	0.43	97.6	0.27

Date & Time	Blast ID	BM02 KELLY Peak Air Blast (dBL)	BM02 KELLY Peak Resultant (mm/s)	BM05 MULLER Peak Air Blast (dBL)	BM05 MULLER Peak Resultant (mm/s)	BM07 THELANDER Peak Air Blast (dBL)	BM07 THELANDER Peak Resultant (mm/s)
20/12/2016 15:40	ME_1WMA_80	102.1	0.27	110.8	1.22	103.4	0.43
22/12/2016 15:03	GM_GMA0_81	103.8	1.79	102.6	0.02	96.1	0.02
30/12/2016 15:35	ME_1WMA_86	97.7	0.09	105.1	0.89	94.3	0.37

Date	D01			D03			D07		
	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio
Jan 16	12.5*	3.0	24	2.7	2.3	85	4.0*	2.0	50
Feb 16	3.7	2.3	62	10.9*	4.1	38	5.0*	3.2	64
Mar 16	6.1*	2.3	38	3.3	2.4	73	4.5*	2.8	62
Apr 16	14.2*	2.7	19	11.6*	3.4	29	Broken		
May 16	9.3*	4.0	43	20.0*	8.8	44	4.1*	2.4	59
Jun 16	8.4*	2.0	24	2.4	1.2	50	5.7*	2.9	51
Jul 16	11.6*	2.5	22	31.2*	13.3	43	5.0*	2.5	50
Aug 16	15.4*	5.0	32	0.7	0.7	100	3.3	2.2	67
Sep 16	7.5*	3.1	41	3.3	2.2	67	7.5*	5.5	73
Oct 16	13.0*	5.8	45	6.8*	3.0	44	5.5*	3.5	64
Nov 16	21.2*	7.3	34	4.7*	2.8	60	4.4*	2.6	59
Dec 16	30.9*	6.5	21	3.5	2.4	69	9.4*	4.4	47

Average (Contaminated)	12.8	3.9	30	8.4	3.9	46	5.3	3.1	58
Average	3.7	2.3	62	2.8	2.0	70	3.9	2.6	68

Date	D09			D11			D12		
	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio
Jan 16	2.4	1.3	54	2.2	1.8	82	2.4	1.6	67
Feb 16	4.8*	2.4	50	8.1*	7.2	89	3.5	2.6	74
Mar 16	2.6	1.6	62	2.7	2.1	78	4.8*	2.9	60
Apr 16	2.9	1.9	66	6.3*	2.9	46	9.3*	2.7	29
May 16	2.6	1.6	62	1.4	1.0	71	3.5	2.2	63
Jun 16	4.6*	2.1	46	2.7	2.1	78	2.4	1.8	75
Jul 16	4.4*	2.0	45	2.4	1.1	46	3.1	1.4	45
Aug 16	2.4	1.8	75	0.6	0.6	100	10.0*	4.7	47
Sep 16	4.9*	3.0	61	3.0	2.2	73	10.3	8.9	86
Oct 16	3.6	2.6	72	1.7	1.3	76	4.0*	2.5	63
Nov 16	8.3*	3.2	39	1.3	1.0	77	2.4	1.6	67
Dec 16	3.0	2.1	70	2.9	2.0	69	5.0*	3.4	68

Average (Contaminated)	3.9	2.1	55	2.9	2.1	72	5.1	3.0	60
Average	2.6	1.6	61	2.3	1.6	71	3.3	2.1	63

Date	D17			D19			D20		
	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio
Jan 16	1.5	0.8	53	1.8	1.2	67	0.5	0.4	80
Feb 16	4.6*	2.5	54	3.2	2.3	72	1.9	1.2	63
Mar 16	2.2	1.5	68	4.4*	2.9	66	1.7	1.1	65
Apr 16	1.7	0.7	41	4.2*	2.7	64	3.2	1.5	47
May 16	1.6	1.4	88	1.7	1.3	76	1.0	0.8	80
Jun 16	0.6	0.6	100	1.7	1.2	71	1.8	1.4	78
Jul 16	0.5	0.2	40	0.8	0.5	63	0.9	0.5	56
Aug 16	1.3	1.2	92	0.8	0.6	75	0.6	0.6	100
Sep 16	1.4	1.0	71	0.9	0.6	67	1.1	0.8	73
Oct 16	0.7	0.6	86	1.6	0.9	56	1.1	0.7	64
Nov 16	0.8	0.6	75	1.7	1.2	71	Broken		
Dec 16	2.7	1.6	59	3.0	1.9	63	2.2	1.6	73

Average (Contaminated)	1.6	1.1	65	2.2	1.4	67	1.5	1.0	66
Average	1.4	0.9	64	2.5	1.7	68	1.6	1.1	68

Date	D21			D22			D23		
	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio
Jan 16	1.5	1.3	87	1.6	1.2	75	1.6	1.2	75
Feb 16	2.3	1.7	74	2.4	1.6	67	3.5	1.1	31
Mar 16	3.3	2.5	76	3.9	2.8	72	Broken		
Apr 16	1.9	1.5	79	3.0	2.3	77	1.3	0.9	69
May 16	1.4	1.2	86	1.9	1.4	74	1.3	0.9	69
Jun 16	0.9	0.8	89	1.4	1.0	71	10.0*	3.5	35
Jul 16	0.4	0.3	75	1.1	0.5	45	4.3*	1.7	40
Aug 16	0.3	0.3	100	0.7	0.5	71	3.4	1.7	50
Sep 16	0.7	0.5	71	1.4	1.0	71	1.6	1.2	75
Oct 16	1.4	0.8	57	1.1	0.7	64	1.2	0.8	67
Nov 16	0.8	0.7	88	1.6	1.2	75	2.4	1.1	46
Dec 16	2.8	2.1	75	2.9	2.2	76	4.1*	2.2	54

Average (Contaminated)	1.5	1.1	77	1.9	1.4	71	3.2	1.5	47
Average	1.7	1.5	90	2.2	1.5	71	1.4	1.0	71

Date	D24			D25			D26		
	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio	Insoluble Solids (g/m^2 /month)	Ash Residue (g/m^2 /month)	AR/IS Ratio
Jan 16	0.9	0.7	78	2.3	1.8	78	1.3	1.0	77
Feb 16	1.1	0.5	45	2.6	2.1	81	2.3	1.7	74
Mar 16	1.7	0.9	53	5.8*	4.4	76	3.0	1.9	63
Apr 16	0.5	0.2	40	5.1*	3.9	76	3.2	1.9	59
May 16	1.5	1.3	87	1.7	1.3	76	1.2	0.8	67
Jun 16	0.6	0.4	67	1.4	1.0	71	1.4	1.0	71
Jul 16	1.0	0.3	30	0.9	0.4	44	0.7	0.2	29
Aug 16	0.3	0.2	67	0.6	0.5	83	0.7	0.4	57
Sep 16	3.3	3.0	91	1.6	1.3	81	1.6	1.2	75
Oct 16	1.5	0.8	53	1.5	1.1	73	0.9	0.6	67
Nov 16	2.6	0.9	35	1.2	0.9	75	1.5	0.9	60
Dec 16	1.3	1.0	77	3.1	2.4	77	1.9	1.3	68

Average (Contaminated)	1.4	0.9	63	2.3	1.8	76	1.6	1.1	65
Average	1.0	0.6	59	2.8	2.1	75	1.9	1.2	65

*- Contaminated

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
1/01/2016	18.5	18.5	17.4	17.4	18.8	18.8	20.4	20.4
2/01/2016	23.1	20.8	20.0	18.7	22.8	20.8	21.7	21.1
3/01/2016	15.5	19.0	12.7	16.7	13.6	18.4	17.6	19.9
4/01/2016	10.9	17.0	7.7	14.5	7.9	15.8	8.5	17.1
5/01/2016	4.0	14.4	2.8	12.1	2.8	13.2	2.8	14.2
6/01/2016	3.8	12.6	3.6	10.7	3.9	11.6	3.3	12.4
7/01/2016	10.4	12.3	9.2	10.5	9.6	11.3	10.9	12.2
8/01/2016	18.2	13.1	18.3	11.5	16.9	12.0	19.4	13.1
9/01/2016	25.8	14.5	24.4	12.9	26.7	13.7	27.8	14.7
10/01/2016	26.5	15.7	20.7	13.7	22.1	14.5	23.9	15.6
11/01/2016	21.3	16.2	25.2	14.7	18.3	14.9	23.8	16.4
12/01/2016	23.2	16.8	27.6	15.8	21.1	15.4	20.8	16.7
13/01/2016	**31.0**	17.9	**35.0**	17.3	**34.2**	16.8	**40.4**	18.6
14/01/2016	19.3	18.0	23.6	17.7	18.3	16.9	24.7	19.0
15/01/2016	5.8	17.2	5.9	16.9	6.0	16.2	5.9	18.1
16/01/2016	15.1	17.0	12.0	16.6	14.4	16.1	15.7	18.0
17/01/2016	8.8	16.5	7.9	16.1	7.9	15.6	11.7	17.6
18/01/2016	10.8	16.2	11.4	15.9	12.0	15.4	14.0	17.4
19/01/2016	13.8	16.1	19.7	16.1	9.5	15.1	13.4	17.2
20/01/2016	17.9	16.2	**33.0**	16.9	15.4	15.1	19.5	17.3
21/01/2016	19.9	16.4	**34.1**	17.7	18.2	15.3	19.9	17.4
22/01/2016	15.8	16.3	17.5	17.7	9.9	15.0	14.1	17.3
23/01/2016	14.3	16.2	9.3	17.3	**Invalid**	15.0	7.8	16.9
24/01/2016	27.5	16.7	22.8	17.6	22.5	15.3	23.4	17.1
25/01/2016	**32.7**	17.4	27.4	18.0	28.1	15.9	29.8	17.6
26/01/2016	28.3	17.8	15.5	17.9	17.9	16.0	17.7	17.7
27/01/2016	**Invalid**	17.8	13.7	17.7	12.6	15.8	18.2	17.7
28/01/2016	**Invalid**	17.8	12.3	17.5	10.4	15.6	12.6	17.5
29/01/2016	7.0	17.4	14.4	17.4	7.5	15.3	10.3	17.2
30/01/2016	19.3	17.4	19.5	17.5	16.6	15.4	20.1	17.3
31/01/2016	23.0	17.6	24.8	17.7	18.2	15.5	16.0	17.3
1/02/2016	18.3	17.7	25.0	18.0	13.7	15.4	13.0	17.2
2/02/2016	15.5	17.6	14.4	17.8	14.6	15.4	19.3	17.2
3/02/2016	22.6	17.7	23.6	18.0	18.6	15.5	25.6	17.5
4/02/2016	13.3	17.6	13.8	17.9	12.7	15.4	18.5	17.5

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
5/02/2016	19.5	17.7	21.2	18.0	18.6	15.5	26.6	17.8
6/02/2016	16.0	17.6	13.9	17.9	15.5	15.5	16.6	17.7
7/02/2016	17.8	17.6	15.6	17.8	21.2	15.6	24.1	17.9
8/02/2016	12.6	17.5	10.9	17.6	14.7	15.6	20.0	17.9
9/02/2016	14.2	17.4	15.1	17.6	18.2	15.7	19.7	18.0
10/02/2016	14.2	17.3	17.1	17.6	16.7	15.7	22.7	18.1
11/02/2016	17.2	17.3	15.3	17.5	16.2	15.7	**30.8**	18.4
12/02/2016	13.4	17.2	16.6	17.5	15.1	15.7	17.9	18.4
13/02/2016	11.4	17.1	15.3	17.4	18.4	15.8	23.0	18.5
14/02/2016	**Invalid**	17.1	27.0	17.6	21.3	15.9	25.9	18.7
15/02/2016	**31.0**	17.4	**37.4**	18.1	29.0	16.2	**34.6**	19.0
16/02/2016	27.8	17.6	**31.9**	18.4	23.2	16.3	23.1	19.1
17/02/2016	26.9	17.8	**31.2**	18.6	27.8	16.6	**31.7**	19.4
18/02/2016	26.3	18.0	26.8	18.8	28.9	16.8	30.0	19.6
19/02/2016	23.8	18.2	27.6	19.0	22.5	17.0	28.9	19.8
20/02/2016	23.8	18.3	24.6	19.1	21.7	17.1	**30.2**	20.0
21/02/2016	20.4	18.3	15.6	19.0	18.2	17.1	20.4	20.0
22/02/2016	19.4	18.3	14.5	18.9	24.1	17.2	19.3	20.0
23/02/2016	17.7	18.3	17.7	18.9	19.0	17.2	25.4	20.1
24/02/2016	21.6	18.4	28.6	19.1	18.2	17.3	25.1	20.2
25/02/2016	17.0	18.4	**31.2**	19.3	16.7	17.3	21.5	20.2
26/02/2016	**32.1**	18.6	**34.5**	19.6	**35.6**	17.6	**36.9**	20.5
27/02/2016	24.6	18.7	23.4	19.6	25.7	17.7	26.1	20.6
28/02/2016	19.7	18.7	20.3	19.7	22.7	17.8	27.5	20.7
29/02/2016	15.2	18.7	18.2	19.6	20.0	17.8	22.8	20.7
1/03/2016	14.0	18.6	16.4	19.6	16.9	17.8	19.7	20.7
2/03/2016	22.0	18.7	25.9	19.7	25.0	17.9	**31.8**	20.9
3/03/2016	21.7	18.7	29.3	19.8	24.9	18.1	28.0	21.0
4/03/2016	24.6	18.8	22.2	19.9	23.4	18.1	23.1	21.0
5/03/2016	26.0	18.9	18.3	19.8	21.6	18.2	28.8	21.1
6/03/2016	24.2	19.0	15.4	19.8	18.3	18.2	22.7	21.2
7/03/2016	24.8	19.1	24.2	19.8	19.2	18.2	23.1	21.2
8/03/2016	**32.9**	19.3	18.2	19.8	24.2	18.3	28.7	21.3
9/03/2016	20.1	19.3	20.1	19.8	14.6	18.3	20.5	21.3
10/03/2016	**34.5**	19.5	27.9	19.9	23.4	18.3	26.9	21.4

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
11/03/2016	29.9	19.7	26.9	20.0	22.5	18.4	26.6	21.5
12/03/2016	25.2	19.8	19.3	20.0	25.4	18.5	**30.8**	21.6
13/03/2016	25.4	19.9	17.6	20.0	20.9	18.5	29.9	21.7
14/03/2016	27.8	20.0	28.3	20.1	**37.1**	18.8	27.9	21.8
15/03/2016	10.8	19.8	11.4	20.0	11.0	18.7	15.3	21.7
16/03/2016	10.2	19.7	6.3	19.8	7.3	18.5	10.0	21.5
17/03/2016	17.3	19.7	13.0	19.7	14.2	18.5	16.9	21.5
18/03/2016	10.6	19.6	13.0	19.6	8.9	18.3	12.7	21.4
19/03/2016	14.0	19.5	10.6	19.5	11.4	18.2	12.0	21.2
20/03/2016	10.5	19.4	9.0	19.4	10.5	18.1	19.8	21.2
21/03/2016	7.1	19.2	6.7	19.2	6.1	18.0	11.5	21.1
22/03/2016	7.6	19.1	8.4	19.1	7.6	17.9	11.8	21.0
23/03/2016	14.5	19.0	16.0	19.1	15.5	17.8	21.6	21.0
24/03/2016	22.0	19.0	23.1	19.1	22.2	17.9	**36.0**	21.2
25/03/2016	20.8	19.1	26.7	19.2	12.7	17.8	20.1	21.2
26/03/2016	**30.8**	19.2	22.2	19.2	26.4	17.9	28.4	21.3
27/03/2016	26.7	19.3	18.0	19.2	23.6	18.0	29.3	21.3
28/03/2016	18.9	19.3	17.6	19.2	22.5	18.0	**34.8**	21.5
29/03/2016	17.4	19.3	19.2	19.2	20.0	18.1	23.7	21.5
30/03/2016	10.1	19.2	12.6	19.1	10.0	18.0	12.0	21.4
31/03/2016	10.0	19.1	12.6	19.1	10.1	17.9	12.0	21.3
1/04/2016	21.6	19.1	20.3	19.1	16.9	17.9	21.5	21.3
2/04/2016	16.5	19.1	18.3	19.1	19.9	17.9	26.3	21.4
3/04/2016	19.8	19.1	23.9	19.1	19.6	17.9	26.1	21.4
4/04/2016	**32.4**	19.2	**31.3**	19.2	**30.8**	18.1	**37.4**	21.6
5/04/2016	23.3	19.3	21.8	19.3	21.8	18.1	26.3	21.6
6/04/2016	23.6	19.3	**31.0**	19.4	21.7	18.1	**43.1**	21.9
7/04/2016	17.6	19.3	**36.2**	19.6	25.1	18.2	23.5	21.9
8/04/2016	**37.0**	19.5	**38.1**	19.7	**37.7**	18.4	**35.8**	22.0
9/04/2016	22.3	19.5	25.9	19.8	23.4	18.5	28.3	22.1
10/04/2016	23.7	19.5	18.4	19.8	21.5	18.5	27.4	22.1
11/04/2016	17.7	19.5	24.1	19.8	23.2	18.5	23.7	22.1
12/04/2016	25.6	19.6	**31.8**	20.0	26.3	18.6	28.1	22.2
13/04/2016	27.4	19.7	25.2	20.0	26.2	18.7	29.5	22.3
14/04/2016	15.8	19.6	15.4	20.0	13.6	18.6	18.5	22.2

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
15/04/2016	14.6	19.6	18.7	19.9	14.0	18.6	20.0	22.2
16/04/2016	15.4	19.5	27.4	20.0	13.0	18.5	24.7	22.2
17/04/2016	21.7	19.6	**35.4**	20.2	19.8	18.5	**32.3**	22.3
18/04/2016	**33.0**	19.7	28.0	20.2	24.6	18.6	**38.3**	22.5
19/04/2016	17.6	19.7	13.4	20.2	14.7	18.6	17.1	22.4
20/04/2016	18.8	19.7	12.0	20.1	14.0	18.5	16.8	22.4
21/04/2016	15.4	19.6	14.7	20.0	14.1	18.5	18.0	22.3
22/04/2016	16.0	19.6	24.9	20.1	17.4	18.5	20.4	22.3
23/04/2016	20.5	19.6	23.2	20.1	23.3	18.5	23.6	22.3
24/04/2016	9.4	19.5	10.0	20.0	9.7	18.4	13.1	22.3
25/04/2016	19.4	19.5	15.0	20.0	20.3	18.5	26.7	22.3
26/04/2016	17.0	19.5	11.7	19.9	14.8	18.4	24.9	22.3
27/04/2016	18.9	19.5	11.1	19.8	14.6	18.4	24.8	22.3
28/04/2016	13.3	19.4	11.0	19.8	10.1	18.3	22.1	22.3
29/04/2016	9.3	19.3	20.3	19.8	14.2	18.3	18.5	22.3
30/04/2016	13.7	19.3	29.2	19.8	18.5	18.3	23.3	22.3
1/05/2016	14.5	19.2	14.6	19.8	11.7	18.2	12.5	22.2
2/05/2016	7.6	19.1	6.9	19.7	5.7	18.1	5.7	22.1
3/05/2016	9.5	19.1	9.8	19.6	7.7	18.1	7.0	22.0
4/05/2016	8.8	19.0	8.6	19.5	6.1	18.0	7.0	21.9
5/05/2016	13.6	18.9	17.9	19.5	9.1	17.9	9.2	21.8
6/05/2016	11.5	18.9	19.6	19.5	8.8	17.8	10.9	21.7
7/05/2016	14.3	18.8	20.0	19.5	14.0	17.8	18.4	21.6
8/05/2016	25.4	18.9	**36.5**	19.7	25.7	17.8	**35.8**	21.8
9/05/2016	**31.0**	19.0	**37.7**	19.8	22.4	17.9	**32.2**	21.8
10/05/2016	18.0	19.0	20.3	19.8	13.6	17.8	18.4	21.8
11/05/2016	8.9	18.9	13.1	19.7	8.6	17.8	8.2	21.7
12/05/2016	8.5	18.8	16.5	19.7	8.4	17.7	8.3	21.6
13/05/2016	12.3	18.8	22.9	19.7	9.9	17.6	9.1	21.5
14/05/2016	9.3	18.7	19.7	19.7	7.1	17.6	6.8	21.4
15/05/2016	9.9	18.6	16.5	19.7	9.4	17.5	7.0	21.3
16/05/2016	10.7	18.6	26.6	19.8	8.8	17.4	8.4	21.2
17/05/2016	14.2	18.5	**46.0**	20.0	15.8	17.4	17.4	21.2
18/05/2016	12.9	18.5	**33.3**	20.1	12.8	17.4	9.8	21.1
19/05/2016	12.9	18.5	**43.6**	20.2	7.9	17.3	7.1	21.0

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
20/05/2016	17.1	18.5	29.3	20.3	15.1	17.3	14.5	20.9
21/05/2016	14.6	18.4	**49.0**	20.5	19.7	17.3	21.3	20.9
22/05/2016	26.4	18.5	25.6	20.5	**31.4**	17.4	**32.6**	21.0
23/05/2016	16.7	18.5	28.3	20.6	20.0	17.4	15.1	21.0
24/05/2016	5.6	18.4	21.8	20.6	16.8	17.4	11.4	20.9
25/05/2016	0.2	18.3	21.4	20.6	11.2	17.4	8.7	20.8
26/05/2016	0.9	18.1	**33.5**	20.7	10.5	17.4	8.9	20.8
27/05/2016	9.0	18.1	13.9	20.6	11.9	17.3	8.2	20.7
28/05/2016	6.6	18.0	15.1	20.6	5.7	17.2	5.5	20.6
29/05/2016	4.7	17.9	9.7	20.5	6.0	17.2	4.6	20.5
30/05/2016	5.9	17.8	10.9	20.5	4.4	17.1	4.3	20.4
31/05/2016	10.7	17.8	20.6	20.5	2.4	17.0	2.2	20.2
1/06/2016	20.0	17.8	12.1	20.4	14.8	17.0	17.6	20.2
2/06/2016	11.3	17.7	13.4	20.4	16.2	17.0	26.2	20.3
3/06/2016	11.4	17.7	14.0	20.3	23.3	17.0	**35.5**	20.4
4/06/2016	19.1	15.4	11.5	20.3	15.5	17.0	23.4	20.4
5/06/2016	9.1	15.4	5.0	20.2	4.6	16.9	5.8	20.3
6/06/2016	3.0	15.4	3.4	20.1	2.5	16.8	2.6	20.2
7/06/2016	7.4	15.3	9.6	20.0	6.2	16.8	6.5	20.1
8/06/2016	6.5	15.3	7.4	19.9	6.0	16.7	6.2	20.0
9/06/2016	6.4	17.4	11.6	19.9	4.9	16.6	5.0	19.9
10/06/2016	7.0	17.3	9.6	19.8	5.4	16.5	5.8	19.8
11/06/2016	5.1	17.2	8.0	19.7	4.2	16.5	4.4	19.7
12/06/2016	6.3	17.1	7.3	19.7	4.3	16.4	4.4	19.6
13/06/2016	12.2	17.1	11.2	19.6	12.1	16.4	17.1	19.6
14/06/2016	12.8	17.1	13.5	19.6	15.4	16.4	21.3	19.6
15/06/2016	7.1	17.0	12.5	19.5	6.1	16.3	6.2	19.5
16/06/2016	-99.0	FALSE	16.5	19.5	9.3	16.3	13.2	19.5
17/06/2016	7.8	16.3	13.6	19.5	6.5	16.2	7.6	19.4
18/06/2016	12.9	16.3	19.8	19.5	7.4	16.1	7.7	19.4
19/06/2016	10.8	16.2	8.2	19.4	5.9	16.1	6.8	19.3
20/06/2016	7.8	16.2	5.8	19.3	5.9	16.0	7.9	19.2
21/06/2016	4.8	16.1	4.2	19.2	4.1	16.0	4.3	19.1
22/06/2016	6.1	16.0	6.8	19.2	5.5	15.9	5.8	19.1
23/06/2016	6.0	16.0	8.4	19.1	4.9	15.8	5.1	19.0

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
24/06/2016	6.2	15.9	9.7	19.1	5.3	15.8	5.6	18.9
25/06/2016	5.4	15.9	5.6	19.0	3.9	15.7	4.0	18.8
26/06/2016	6.3	15.8	5.5	18.9	4.4	15.6	4.8	18.7
27/06/2016	6.9	15.8	10.9	18.9	5.3	15.6	5.7	18.7
28/06/2016	5.6	15.7	6.9	18.8	4.6	15.5	5.0	18.6
29/06/2016	7.2	15.7	9.9	18.7	5.2	15.5	5.5	18.5
30/06/2016	8.0	15.6	10.3	18.7	4.9	15.4	5.2	18.5
1/07/2016	9.6	15.6	14.6	18.7	6.6	15.4	10.4	18.4
2/07/2016	6.3	15.5	9.8	18.6	5.0	15.3	5.4	18.3
3/07/2016	6.7	15.5	13.0	18.6	5.6	15.2	5.2	18.3
4/07/2016	7.6	15.4	12.8	18.6	5.0	15.2	5.4	18.2
5/07/2016	8.6	15.4	21.6	18.6	7.7	15.2	12.0	18.2
6/07/2016	8.3	15.4	7.7	18.5	7.0	15.1	8.1	18.1
7/07/2016	4.3	15.3	4.8	18.5	3.9	15.0	4.2	18.0
8/07/2016	6.3	15.3	7.4	18.4	5.6	15.0	7.1	18.0
9/07/2016	7.0	15.2	7.3	18.3	6.1	15.0	6.8	17.9
10/07/2016	7.7	15.2	6.7	18.3	6.4	14.9	8.8	17.9
11/07/2016	11.7	15.2	10.3	18.2	8.9	14.9	14.2	17.9
12/07/2016	9.9	15.1	15.0	18.2	8.5	14.8	9.7	17.8
13/07/2016	7.3	15.1	12.4	18.2	6.6	14.8	6.1	17.8
14/07/2016	9.9	15.1	9.1	18.1	7.2	14.8	7.5	17.7
15/07/2016	8.2	15.0	13.3	18.1	6.6	14.7	6.8	17.6
16/07/2016	9.9	15.0	15.0	18.1	11.5	14.7	12.8	17.6
17/07/2016	16.4	15.0	12.9	18.1	14.7	14.7	13.3	17.6
18/07/2016	10.9	15.0	6.7	18.0	10.8	14.7	13.6	17.6
19/07/2016	9.9	15.0	10.5	18.0	6.7	14.6	7.2	17.5
20/07/2016	9.6	14.9	13.3	18.0	7.5	14.6	7.9	17.5
21/07/2016	5.2	14.9	4.4	17.9	4.3	14.6	5.0	17.4
22/07/2016	6.9	14.8	4.1	17.8	5.2	14.5	6.0	17.4
23/07/2016	7.9	14.8	9.6	17.8	6.0	14.5	6.3	17.3
24/07/2016	9.4	14.8	11.3	17.8	8.2	14.4	8.1	17.3
25/07/2016	7.7	14.7	7.3	17.7	6.6	14.4	6.7	17.2
26/07/2016	7.5	14.7	10.5	17.7	6.9	14.4	6.6	17.2
27/07/2016	7.7	14.7	10.9	17.6	7.0	14.3	6.5	17.1
28/07/2016	7.4	14.6	12.5	17.6	6.4	14.3	6.4	17.1

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
29/07/2016	7.0	14.6	10.9	17.6	5.8	14.3	5.7	17.0
30/07/2016	6.3	14.6	13.7	17.6	5.3	14.2	4.7	16.9
31/07/2016	8.7	14.5	10.8	17.5	8.7	14.2	9.5	16.9
1/08/2016	9.4	14.5	15.4	17.5	7.8	14.2	7.3	16.9
2/08/2016	11.0	14.5	15.0	17.5	8.4	14.1	7.8	16.8
3/08/2016	13.1	14.5	14.9	17.5	9.3	14.1	11.3	16.8
4/08/2016	7.3	14.5	7.7	17.4	8.2	14.1	9.3	16.8
5/08/2016	8.1	14.4	8.2	17.4	8.3	14.0	10.2	16.7
6/08/2016	7.9	14.4	7.3	17.4	9.4	14.0	13.1	16.7
7/08/2016	9.0	14.4	6.8	17.3	9.8	14.0	9.9	16.7
8/08/2016	10.3	14.4	8.7	17.3	8.6	14.0	13.8	16.7
9/08/2016	11.9	14.3	9.9	17.2	11.2	14.0	20.0	16.7
10/08/2016	13.4	14.3	13.8	17.2	10.0	14.0	9.9	16.7
11/08/2016	16.1	14.3	19.2	17.2	10.4	13.9	10.7	16.6
12/08/2016	8.8	14.3	8.0	17.2	6.1	13.9	5.9	16.6
13/08/2016	8.1	14.3	10.6	17.2	5.4	13.9	5.5	16.5
14/08/2016	9.6	14.3	11.1	17.1	7.3	13.8	7.2	16.5
15/08/2016	12.1	14.3	11.2	17.1	11.6	13.8	17.7	16.5
16/08/2016	14.8	14.3	20.9	17.1	16.5	13.8	25.6	16.5
17/08/2016	13.8	14.3	19.4	17.1	10.2	13.8	11.5	16.5
18/08/2016	13.4	14.3	25.3	17.2	9.6	13.8	9.5	16.5
19/08/2016	15.4	14.3	21.2	17.2	12.9	13.8	17.7	16.5
20/08/2016	18.3	14.3	26.2	17.2	16.2	13.8	14.5	16.5
21/08/2016	7.4	14.3	10.5	17.2	6.5	13.8	5.9	16.4
22/08/2016	10.3	14.2	14.7	17.2	7.4	13.8	6.6	16.4
23/08/2016	13.9	14.2	19.2	17.2	10.3	13.7	10.0	16.4
24/08/2016	7.8	14.2	6.7	17.2	7.8	13.7	12.4	16.4
25/08/2016	5.3	14.2	4.5	17.1	6.2	13.7	11.0	16.3
26/08/2016	5.3	14.1	5.0	17.0	3.5	13.6	3.7	16.3
27/08/2016	7.8	14.1	6.6	17.0	6.3	13.6	8.5	16.2
28/08/2016	9.2	14.1	11.3	17.0	6.5	13.6	6.6	16.2
29/08/2016	8.7	14.1	11.5	17.0	7.6	13.6	6.0	16.2
30/08/2016	15.4	14.1	14.7	16.9	13.8	13.6	18.6	16.2
31/08/2016	Invalid	14.1	17.8	17.0	15.5	13.6	23.0	16.2
1/09/2016	16.8	14.1	17.1	17.0	14.5	13.6	14.4	16.2

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
2/09/2016	6.4	14.0	7.9	16.9	4.5	13.5	6.4	16.2
3/09/2016	7.3	14.0	6.6	16.9	8.0	13.5	7.4	16.1
4/09/2016	7.0	14.0	7.1	16.8	5.5	13.5	6.0	16.1
5/09/2016	6.2	14.0	10.4	16.8	4.2	13.4	4.4	16.0
6/09/2016	7.9	13.9	13.2	16.8	6.6	13.4	8.3	16.0
7/09/2016	10.1	13.9	15.2	16.8	9.2	13.4	11.9	16.0
8/09/2016	20.1	13.9	17.3	16.8	18.5	13.4	20.0	16.0
9/09/2016	17.2	14.0	17.7	16.8	15.5	13.4	23.1	16.0
10/09/2016	19.3	14.0	21.8	16.8	14.3	13.4	16.1	16.0
11/09/2016	6.1	13.9	9.3	16.8	4.9	13.4	5.0	16.0
12/09/2016	7.4	13.9	11.5	16.8	6.1	13.4	7.6	16.0
13/09/2016	19.0	13.9	17.9	16.8	12.7	13.4	15.2	15.9
14/09/2016	21.1	14.0	25.5	16.8	17.3	13.4	17.0	16.0
15/09/2016	8.7	13.9	9.5	16.8	7.3	13.4	7.9	15.9
16/09/2016	6.6	13.9	7.4	16.7	4.3	13.3	4.5	15.9
17/09/2016	9.8	13.9	12.7	16.7	4.7	13.3	4.9	15.8
18/09/2016	11.0	13.9	12.7	16.7	7.5	13.3	12.7	15.8
19/09/2016	14.8	13.9	12.8	16.7	13.9	13.3	16.5	15.8
20/09/2016	5.8	13.9	7.8	16.7	4.3	13.2	4.8	15.8
21/09/2016	8.6	13.8	11.3	16.6	7.6	13.2	9.0	15.8
22/09/2016	11.1	13.8	10.0	16.6	8.3	13.2	11.6	15.7
23/09/2016	7.7	13.8	8.4	16.6	5.8	13.2	6.3	15.7
24/09/2016	9.7	13.8	15.2	16.6	12.4	13.2	11.9	15.7
25/09/2016	12.5	13.8	12.6	16.6	10.3	13.1	13.1	15.7
26/09/2016	8.0	13.8	8.2	16.5	6.9	13.1	6.7	15.7
27/09/2016	7.7	13.7	9.8	16.5	6.1	13.1	5.9	15.6
28/09/2016	18.2	13.8	14.1	16.5	7.9	13.1	7.3	15.6
29/09/2016	17.1	13.8	19.3	16.5	13.9	13.1	18.6	15.6
30/09/2016	13.8	13.8	15.4	16.5	15.9	13.1	26.8	15.6
1/10/2016	9.6	13.8	10.7	16.5	7.1	13.1	5.7	15.6
2/10/2016	11.7	13.8	12.4	16.5	6.6	13.0	5.7	15.6
3/10/2016	13.6	13.7	12.6	16.5	7.3	13.0	7.6	15.5
4/10/2016	9.6	13.7	16.0	16.5	7.7	13.0	7.4	15.5
5/10/2016	10.3	13.7	17.5	16.5	9.7	13.0	8.2	15.5
6/10/2016	14.0	13.7	24.5	16.5	11.6	13.0	10.4	15.5

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
7/10/2016	13.6	13.7	22.3	16.5	10.0	13.0	11.6	15.4
8/10/2016	18.6	13.7	24.6	16.5	18.6	13.0	16.6	15.5
9/10/2016	18.4	13.8	21.2	16.6	23.7	13.0	24.9	15.5
10/10/2016	20.7	13.8	28.0	16.6	18.8	13.1	18.9	15.5
11/10/2016	4.9	13.8	4.6	16.5	4.2	13.0	3.7	15.5
12/10/2016	7.5	13.7	12.1	16.5	6.5	13.0	6.8	15.4
13/10/2016	13.9	13.7	12.3	16.5	13.1	13.0	12.8	15.4
14/10/2016	14.2	13.7	14.1	16.5	14.1	13.0	16.7	15.4
15/10/2016	13.2	13.7	14.6	16.5	9.5	13.0	9.6	15.4
16/10/2016	23.5	13.8	24.5	16.5	16.4	13.0	15.3	15.4
17/10/2016	21.0	13.8	17.0	16.5	12.7	13.0	12.8	15.4
18/10/2016	7.3	13.8	8.5	16.5	5.9	13.0	6.1	15.4
19/10/2016	14.6	13.8	12.5	16.5	9.5	13.0	10.5	15.3
20/10/2016	19.8	13.8	19.5	16.5	18.6	13.0	20.4	15.4
21/10/2016	19.5	13.8	22.4	16.5	16.2	13.0	17.7	15.4
22/10/2016	6.2	13.8	6.8	16.5	4.3	13.0	4.2	15.3
23/10/2016	12.4	13.8	11.6	16.5	12.3	13.0	13.6	15.3
24/10/2016	11.3	13.8	13.3	16.5	9.0	13.0	11.6	15.3
25/10/2016	10.1	13.8	12.7	16.5	9.0	12.9	10.0	15.3
26/10/2016	14.0	13.8	15.8	16.4	9.0	12.9	9.8	15.3
27/10/2016	28.0	13.8	22.4	16.5	21.1	13.0	19.7	15.3
28/10/2016	13.2	13.8	14.0	16.5	13.0	13.0	15.9	15.3
29/10/2016	18.5	13.8	16.0	16.5	18.8	13.0	21.5	15.3
30/10/2016	16.7	13.8	16.6	16.5	13.3	13.0	16.7	15.3
31/10/2016	13.4	13.8	16.7	16.5	11.7	13.0	12.6	15.3
1/11/2016	18.0	13.8	18.0	16.5	16.5	13.0	20.6	15.3
2/11/2016	14.4	13.8	16.3	16.5	10.6	13.0	13.3	15.3
3/11/2016	16.0	13.9	18.8	16.5	12.5	13.0	15.6	15.3
4/11/2016	16.4	13.9	20.5	16.5	13.9	13.0	13.3	15.3
5/11/2016	24.0	13.9	28.4	16.5	14.3	13.0	12.4	15.3
6/11/2016	20.6	13.9	26.7	16.6	19.1	13.0	18.2	15.3
7/11/2016	21.4	13.9	25.3	16.6	19.1	13.0	18.5	15.3
8/11/2016	24.6	14.0	**31.1**	16.6	21.4	13.0	20.2	15.3
9/11/2016	17.1	14.0	17.7	16.6	16.0	13.1	18.8	15.4
10/11/2016	13.4	14.0	12.5	16.6	10.9	13.1	12.6	15.3

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
11/11/2016	21.0	14.0	22.4	16.6	22.1	13.1	23.9	15.4
12/11/2016	11.9	14.0	10.8	16.6	11.6	13.1	11.4	15.4
13/11/2016	14.3	14.0	10.9	16.6	8.6	13.1	8.3	15.3
14/11/2016	10.4	14.0	11.2	16.6	9.3	13.0	9.0	15.3
15/11/2016	12.5	14.0	12.7	16.6	11.6	13.0	11.0	15.3
16/11/2016	15.9	14.0	15.6	16.6	15.3	13.1	15.6	15.3
17/11/2016	16.4	14.0	16.8	16.6	17.3	13.1	17.9	15.3
18/11/2016	20.8	14.0	19.9	16.6	14.8	13.1	17.2	15.3
19/11/2016	29.0	14.1	**32.8**	16.6	27.5	13.1	26.9	15.4
20/11/2016	**31.5**	14.1	**34.3**	16.7	**33.0**	13.2	**33.0**	15.4
21/11/2016	25.6	14.2	25.7	16.7	26.4	13.2	**31.6**	15.5
22/11/2016	**32.9**	14.2	25.7	16.7	21.3	13.2	29.1	15.5
23/11/2016	29.3	14.3	**30.7**	16.8	26.3	13.3	**33.3**	15.6
24/11/2016	15.1	14.3	17.1	16.8	13.4	13.3	12.2	15.5
25/11/2016	19.2	14.3	23.0	16.8	15.1	13.3	17.5	15.5
26/11/2016	23.1	14.3	25.2	16.8	21.5	13.3	22.9	15.6
27/11/2016	**31.6**	14.4	**31.0**	16.9	**32.1**	13.4	**31.0**	15.6
28/11/2016	**32.1**	14.4	**34.0**	16.9	29.1	13.4	29.4	15.7
29/11/2016	27.4	14.4	**30.6**	17.0	25.1	13.5	24.1	15.7
30/11/2016	26.7	14.5	26.9	17.0	23.3	13.5	25.0	15.7
1/12/2016	18.4	14.5	19.9	17.0	13.9	13.5	20.4	15.7
2/12/2016	27.3	14.5	22.3	17.0	12.7	13.5	13.4	15.7
3/12/2016	**35.0**	14.6	**35.1**	17.1	**38.8**	13.6	**43.7**	15.8
4/12/2016	**34.4**	14.7	**36.3**	17.1	**36.8**	13.6	**37.6**	15.9
5/12/2016	**38.6**	14.7	**37.1**	17.2	**36.9**	13.7	**33.0**	15.9
6/12/2016	29.7	14.8	22.4	17.2	**32.3**	13.7	27.8	16.0
7/12/2016	11.6	14.8	11.1	17.2	10.8	13.7	11.2	15.9
8/12/2016	24.9	14.8	18.6	17.2	14.6	13.7	15.9	15.9
9/12/2016	17.7	14.8	17.7	17.2	15.9	13.7	12.3	15.9
10/12/2016	**33.4**	14.9	**30.6**	17.2	29.8	13.8	29.0	16.0
11/12/2016	27.8	14.9	25.8	17.3	24.7	13.8	25.8	16.0
12/12/2016	27.6	14.9	26.6	17.3	24.0	13.9	29.8	16.0
13/12/2016	28.5	15.0	29.8	17.3	22.7	13.9	19.1	16.0
14/12/2016	**37.4**	15.0	28.1	17.3	24.4	13.9	26.6	16.1
15/12/2016	14.7	15.0	10.4	17.3	13.3	13.9	13.8	16.1

Date of Run	PM01 - Coralie (Sentinex 19)		PM02 - Wambo Road (Caban) (Sentinex 20)		PM03 - Thelander (Sentinex 21)		PM04 - Muller (Sentinex 22)	
	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average	PM_{10} 24 Hour Result (ug/m^3)	YTD Average
16/12/2016	10.6	15.0	8.3	17.3	9.6	13.9	9.9	16.0
17/12/2016	19.2	15.0	19.1	17.3	9.3	13.9	9.0	16.0
18/12/2016	**38.5**	15.1	**30.6**	17.3	**32.6**	13.9	29.7	16.1
19/12/2016	24.4	15.1	19.8	17.4	20.8	14.0	22.0	16.1
20/12/2016	25.0	15.2	19.0	17.4	16.6	14.0	21.0	16.1
21/12/2016	27.9	15.2	**30.9**	17.4	23.6	14.0	21.3	16.1
22/12/2016	29.1	15.2	24.4	17.4	24.3	14.0	24.9	16.1
23/12/2016	**33.3**	15.3	23.8	17.4	22.4	14.0	23.6	16.2
24/12/2016	22.9	15.3	16.3	17.4	13.1	14.0	17.0	16.2
25/12/2016	11.9	15.3	11.4	17.4	9.8	14.0	10.4	16.1
26/12/2016	18.7	15.3	13.3	17.4	11.8	14.0	13.1	16.1
27/12/2016	27.0	15.3	22.6	17.4	19.2	14.0	24.0	16.2
28/12/2016	**39.9**	15.4	25.6	17.4	22.7	14.1	27.7	16.2
29/12/2016	25.5	15.4	25.5	17.5	16.6	14.1	19.7	16.2
30/12/2016	**48.8**	15.5	**34.9**	17.5	22.7	14.1	**31.9**	16.2
31/12/2016	37.5	15.6	31.4	17.5	26.6	14.1	28.1	16.3

Month	SW01 - Wollombi Brook Up					SW03 - Wollombi Brook Pump Out					
	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	O&G (mg/L)	Temp ©
Criteria	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jan-16	7.5	542	8	264	21.7	7.5	533	25	307	<5	21.2
Feb-16	7.5	779	<5	328	27.0	7.4	698	5	350	7	24.0
Mar-16	7.4	767	<5	432	25.0	7.4	726	<5	429	<5	24.8
Apr-16	7.4	887	<5	463	21.5	6.7	853	<5	412	<5	20.0
May-16	7.5	985	<5	528	12.6	7.7	898	<5	458	-	10.3
Jun-16	7.6	1055	<5	630	16.5	7.6	842	<5	468	-	16.4
Jul-16	7.6	842	11	-	11.8	8.1	823	<5	-	-	10.4
Aug-16	7.6	650	6	-	15.1	7.7	640	10	-	-	13.7
Sep-16	7.6	704	<5	-	18.5	8.0	698	6	-	-	17.4
Oct-16	7.4	784	6	-	20.5	7.5	747	11	-	-	17.9
Nov-16	7.9	833	5	-	24.7	7.9	884	8	-	-	24.3
Dec-16	7.7	838	10	-	23.1	7.6	899	14	-	-	22.3
Average	7.6	806	8	441	19.8	7.6	770	11	404	7	18.6

Month	SW02 - Wollombi Brook Down						SW40 - Wollombi Brook Upstream of SWC				
	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	O&G (mg/L)	Temp ©	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©
Criteria	7.4 - 8.1	599 - 1947	17 - 308	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jan-16	7.5	650	<5	326	<5	21.2	6.8	36	67	80	21.4
Feb-16	7.6	708	<5	356	13	26.2	7.6	669	<5	387	25.4
Mar-16	7.6	758	<5	417	<5	25.5	7.5	737	<5	440	25.5
Apr-16	7.6	906	<5	437	<5	20.7	7.4	854	<5	422	21.0
May-16	7.8	1085	<5	586	-	12.8	7.8	900	<5	460	12.7
Jun-16	7.7	1034	<5	590	-	16.2	7.7	856	5	548	16.7
Jul-16	7.7	818	10	-	-	11.8	7.7	818	8	-	11.4
Aug-16	7.7	625	<5	-	-	14.3	7.6	612	<5	-	15.1
Sep-16	7.8	729	<5	-	-	16.6	7.8	656	23	-	16.7
Oct-16	7.7	817	8	-	-	21.9	7.6	739	8	-	19.6
Nov-16	8.3	905	9	-	-	24.4	7.8	879	<5	-	22.5
Dec-16	7.9	930	<5	-	-	24.1	8.1	777	9	-	22.5
Average	7.7	830	9	452	13	19.6	7.6	711	20	390	19.2

Month	SW04 - North Wambo Creek Up					SW27/SW27a - North Wambo Creek Middle Lower				
	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©
Criteria	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jan-16	No Access due to wet weather					7.2	235	48	184	29.9
Feb-16	Dry					Dry				
Mar-16	Dry					Dry				
Apr-16	Dry					Dry				
May-16	Dry					Dry				
Jun-16	Dry					7.9	491	120	604	16.3
Jul-16	Dry					Dry				
Aug-16	Dry					Dry				
Sep-16	Dry					8.1	698	240		20.7
Oct-16	Dry					Dry				
Nov-16	Dry					Dry				
Dec-16	Dry					Dry				
Average	-	-	-	-	-	7.7	475	136	394	22.3

Month	SW32/SW32a- North Wambo Creek Pump					SW05 - North Wambo Creek Down				
	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©
Criteria	N/A	N/A	N/A	N/A	N/A	7.3 - 7.9	1155 -2246	53 - 1110	N/A	N/A
Jan-16	7.3	199	53	153	29.5	7.3	256	250	580	21.3
Feb-16	Dry					7.4	1175	7	642	21.2
Mar-16	7.5	319	432	202	23.5	Dry				
Apr-16	Dry					Dry				
May-16	Dry					Dry				
Jun-16	8.0	645	120	1270	16.6	Dry				
Jul-16	Dry					Dry				
Aug-16	Dry					Dry				
Sep-16	7.9	574	260		17.6	Dry				
Oct-16	Dry					Dry				
Nov-16	Dry					Dry				
Dec-16	Dry					Dry				
Average	7.7	434	216	542	21.8	7.4	716	129	611	21.3

Month	SW06 - South Wambo Creek					SW07 - South Wambo/Stony Creeks				
	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©
Criteria	N/A	N/A	N/A	N/A	N/A	7.4 - 7.9	360 - 724	29 - 331	N/A	N/A
Jan-16	6.8	119	53	131	21.2	7.1	201	96	179	21.4
Feb-16	7.1	534	12	268	23.2	7.5	641	<5	296	23.6
Mar-16	7.1	446	<5	295	22.2	7.4	583	<5	348	23.7
Apr-16	7.2	479	<5	249	21.1	Dry				
May-16	Dry					7.6	748	<5	384	12.5
Jun-16	7.3	829	8	282	16.6	7.3	458	<5	406	16.5
Jul-16	Dry					7.7	799	7	-	11.9
Aug-16	Dry					7.8	785	6	-	14.9
Sep-16	Dry					Dry				
Oct-16	Dry					Dry				
Nov-16	Dry					Dry				
Dec-16	Dry					Dry				
Average	7.1	481	24	245	20.9	7.5	602	36	323	17.8

Month	SW08 - Stony Creek					SW39 - Waterfall Creek				
	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©	pH	EC (uS/cm)	TSS (mg/L)	TDS (mg/L)	Temp ©
Criteria	6.8 - 7.4	288 - 416	5 - 15	N/A	N/A	7.3 - 7.8	159 - 429	582 - 1922	N/A	N/A
Jan-16	No Access due to wet weather					7.9	124	2600	863	21.3
Feb-16	6.7	399	<5	202	22.5	Dry				
Mar-16	Dry					Dry				
Apr-16	Dry					Dry				
May-16	Dry					Dry				
Jun-16	Dry					Dry				
Jul-16	Dry					Dry				
Aug-16	Dry					Dry				
Sep-16	Dry					Dry				
Oct-16	Dry					Dry				
Nov-16	Dry					Dry				
Dec-16	Dry					Dry				
Average	6.7	399	<5	202	22.5	7.9	124	2600	863	21.3

Date	HV01 - Coralie			HV02 - Wambo Road			HV03 - Thelander			HV04 - Muller		
	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average
6/01/2016	9.4		9.4	4.3		4.3	4.8		4.8	5.5		5.5
12/01/2016	69.2		39.3	81.7		43.0	56.2		30.5	59.2		32.4
18/01/2016	32.9		37.2	42.5		42.8	35.1		32.0	48.1		37.6
24/01/2016	50.3		40.5	53.2		45.4	54.4		37.6	69.8		45.7
30/01/2016	48.4	42.0	42.0	56.1	47.6	47.6	44.6	39.0	39.0	67.7	50.1	50.1
5/02/2016	37.5		41.3	42.5		46.7	48.8		40.7	98.6		58.2
11/02/2016	64.3		44.6	45.2		46.5	54.8		42.7	143		70.3
17/02/2016	64.7		47.1	70.5		49.5	101		50.0	115		75.9
23/02/2016	77.6		50.5	64.8		51.2	81.2		53.4	140		83.0
29/02/2016	53.6	59.5	50.8	49.9	54.6	51.1	74.0	72.0	55.5	105	120.3	85.2
6/03/2016	119		57.0	60.6		51.9	79.4		57.7	133		89.5
12/03/2016	119		62.2	60.0		52.6	97.2		61.0	152		94.7
18/03/2016	33.8		60.0	33.6		51.1	19.2		57.7	51.7		91.4
24/03/2016	74.2		61.0	63.6		52.0	82.2		59.5	179		97.7
30/03/2016	31.7	75.5	59.0	39.5	51.5	51.2	20.8	59.8	56.9	55.4	114.2	94.9
5/04/2016	63.5		59.3	81.1		53.1	65.8		57.5	213		102.3
11/04/2016	68.6		59.9	73.7		54.3	77.8		58.7	107		102.5
17/04/2016	45.7		59.1	49.6		54.0	80.1		59.9	109		102.9
23/04/2016	17.4		56.9	15.5		52.0	19.1		57.7	55.8		100.4
29/04/2016	52.8	49.6	56.7	78.5	59.7	53.3	31.5	54.9	56.4	70.8	111.1	98.9
5/05/2016	27.2		55.3	64.3		53.8	17.3		54.5	21.4		95.2
11/05/2016	16.6		53.5	47.9		53.6	15		52.7	14.6		91.6
17/05/2016	33.5		52.6	104		55.8	24.9		51.5	15.9		88.3
23/05/2016	61.2		53.0	75.6		56.6	29.8		50.6	32.4		86.0

Date	HV01 - Coralie			HV02 - Wambo Road			HV03 - Thelander			HV04 - Muller		
	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average
29/05/2016	29.1	33.5	52.0	63.3	71.0	56.9	10.2	19.4	49.0	7.7	18.4	82.8
4/06/2016	39.6		51.6	19.2		55.4	19.3		47.9	31.8		80.9
10/06/2016	8.7		50.0	26		54.3	4.2		46.2	5.5		78.1
16/06/2016	15.8		48.8	37.8		53.7	9.6		44.9	10.9		75.7
22/06/2016	17.4		47.7	20.2		52.6	1.2		43.4	2.1		73.1
28/06/2016	13.0	18.9	46.5	36.8	28.0	52.1	2.2	7.3	42.1	1.4	10.3	70.7
4/07/2016	23.3		45.8	73.4		52.7	17.1		41.3	26.5		69.3
10/07/2016	22.2		45.0	26		51.9	21.2		40.6	42.7		68.5
16/07/2016	45.2		45.0	28.8		51.2	34.1		40.4	28.9		67.3
22/07/2016	16.9		44.2	24.1		50.4	6.7		39.4	7.7		65.5
28/07/2016	13.3	24.2	43.3	37.4	37.9	50.0	8.3	17.5	38.5	5.2	22.2	63.8
3/08/2016	12.4		42.5	19.4		49.2	12.8		23.6	26.5		62.8
9/08/2016	33.3		42.2	44.3		49.1	19.7		19.3	42.7		62.2
15/08/2016	42.2		42.2	58.5		49.3	50.4		104.0	28.9		61.4
21/08/216	37		42.1	32.7		48.9	13.3		10.0	7.7		60.0
27/08/216	31.1	31.2	41.8	35.7	38.1	48.5	7.9	20.8	10.0	5.2	22.2	58.6
2/09/2016	17.1		41.2	18.9		47.8	15.2		10.0	18.7		57.6
8/09/2016	63.9		41.8	50.5		47.9	44.9		10.0	71		58.0
14/09/2016	13.7		41.1	19.4		47.2	10.4		10.0	11		56.9
20/09/2016	28.2		40.8	37.5		47.0	16.8		10.0	25.6		56.2
26/09/2016	22.6	29.1	40.4	32.7	31.8	46.7	12.6	20.0	10.0	10.8	27.4	55.1
2/10/2016	50.4		40.6	52.4		46.8	17.4		10.0	11.8		54.2
8/10/2016	51.3		40.8	73.8		47.4	58.7		10.0	46.3		54.0
14/10/2016	43.6		40.9	39.3		47.2	45.5		10.0	56.9		54.1

Date	HV01 - Coralie			HV02 - Wambo Road			HV03 - Thelander			HV04 - Muller		
	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average	TSP Result (ug/m^3)	Monthly Mean	YTD Average
20/10/2016	72.8		41.6	54.8		47.4	59.4		10.0	76.3		54.5
26/10/2016	50.8	53.8	41.7	52	54.5	47.5	22.2	40.6	10.0	29.5	44.2	54.0
2/11/2016	63.2		42.2	57.7		47.7	62		10.0	87.2		54.7
7/11/2016	77.6		42.8	76.8		48.2	55.5		10.0	52.5		54.7
17/11/2016	62.6		43.2	43.4		48.1	38.9		10.0	36		54.3
23/11/2016	81.7	71.3	43.9	21.7	49.9	47.6	92.2	62.2	10.0	75.5	62.8	54.7
1/12/2016	74.8		44.5	10		47.0	66.9		10.0	96.5		55.5
2/12/2016	87.8		45.3	31.5		46.7	75.1		10.0	86.6		56.0
7/12/2016	41.5		45.2	37.7		46.5	37.6		10.0	43.3		55.8
13/12/2016	93.4		46.0	90.3		47.3	67.1		10.0	55.6		55.8
19/12/2016	100		46.9	49.1		47.3	46.6		10.0	78.8		56.2
25/12/2016	48.4		47.0	39.5		47.2	33.3		10.0	40.2		55.9
31/12/2016	107	79.0	48.0	78.8	48.1	47.7	79	57.9	10.0	44	63.6	55.7

APPENDIX D – ANNUAL FLORA AND FAUNA MONITORING REPORT – 2016

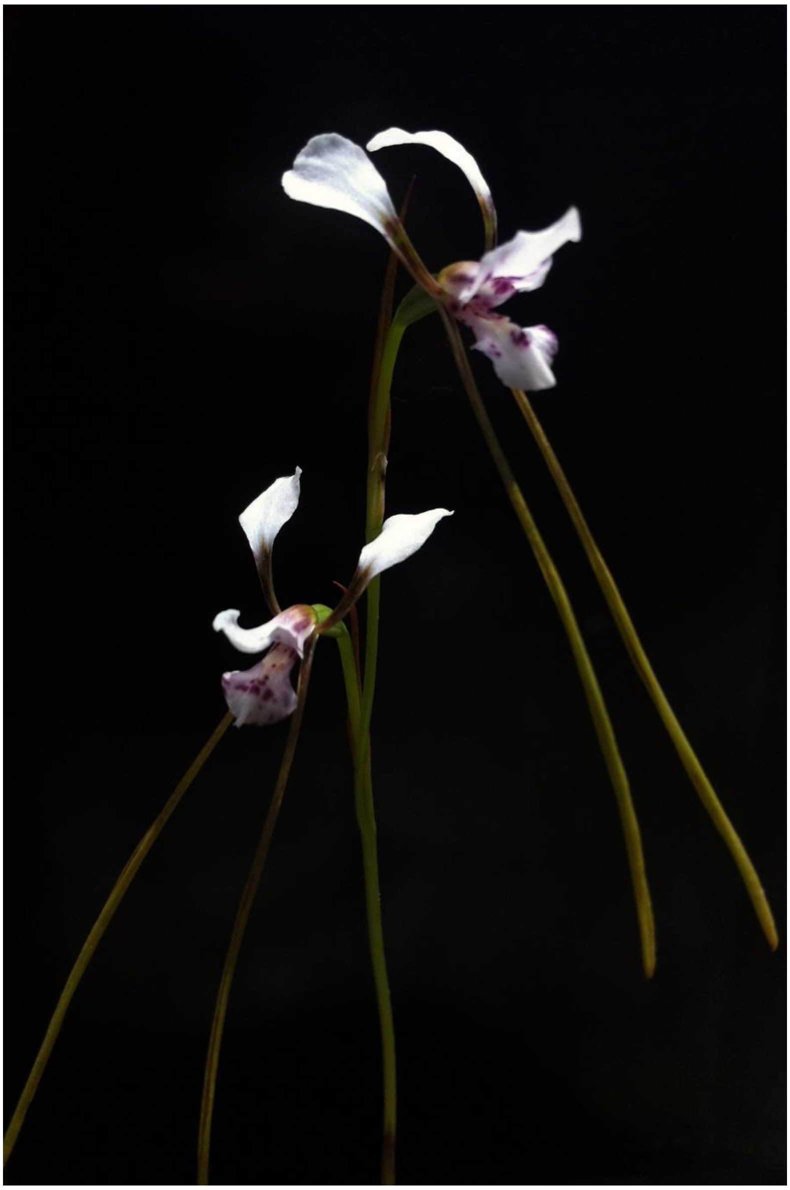
eco logical AUSTRALIA

Wambo Coal Mine

Annual Flora and Fauna Monitoring Report 2016 – Volume 1

Prepared for
Wambo Coal Pty. Ltd.

9 January 2017



DOCUMENT TRACKING

Item	Detail
Project Name	Wambo Coal Mine Annual Flora and Fauna Monitoring, 2016
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Reviewed by	Martin Sullivan
Approved by	Martin Sullivan
Status	Final
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Cover photo	Clockwise from left: A white donkey orchid - *Diuris alba* at Wambo, the vulnerable woodland bird *Chthonicola sagittata* (Speckled Warbler) and the State and Federally listed endangered community – Warkworth Sands Woodland. Photos by Gordon Patrick, Peter Knock and Daniel McKenzie.

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Abbreviations

Abbreviation	Description
AEMR	Annual Environmental Monitoring Report
BOA	Biodiversity Offset Area
BMP	Biodiversity Management Plan
BVT	Biometric Vegetation Type
CEEC	Critically Endangered Ecological Community
DBH	Diameter at Breast Height
DPI	NSW Department of Primary Industries
EEC	Endangered Ecological Community
ELA	Eco Logical Australia Pty Ltd
EPBC Act	Federal *Environment Protection and Biodiversity Conservation Act* 1999
EPC	Exotic Plant Cover
FL	The length of Fallen Logs >10 cm diameter
HBT	Hollow-bearing Tree
INFI	Infiltration Index
LFA	Landscape Function Analysis
LOI	Landscape Organisation Index
NGCG	Native Ground Cover - Grasses
NGCO	Native Ground Cover - Other
NGCS	Native Ground Cover - Shrubs
NI	Nutrient Index
NMS	Native Midstorey Cover – the projected native foliage cover of midstorey (%)
NOS	Native Overstorey – the projected native foliage cover of canopy (%)
NPS	The number of Native Plant Species
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
RWEA	Remnant Woodland Enhancement Area
RWEP	Remnant Woodland Enhancement Program
SI	Stability Index
SSA	Soil Surface Assessment
TSC Act	NSW *Threatened Species Conservation Act* 1995

Abbreviation	Description
VCA	Voluntary Conservation Area
WCPL	Wambo Coal Pty Ltd

Key findings

The following section details the key findings of the 2016 spring flora and fauna monitoring. Several different components make up this monitoring program. Floristic surveys, mine subsidence inspections, Landscape Function Analysis, riparian condition surveys and bird surveys were all conducted during October and November 2016.

Remnant woodland sites appear to be generally performing well, with few weeds and are meeting performance criteria. No overall decline in the number of native species was observed over time. Overall exotic cover scores from biometric transects show little variability and have remained consistently low during the last three years. However exotic species cover remains high in the River Red Gum / River Oak riparian woodland. Monitoring site V5-B4 (within the railway loop area) also had several weed issues that should continue to be managed.

Dieback of *Angophora floribunda* (Smooth-barked Apple) was observed within the Warkworth Sands area of Remnant Woodland Enhancement Area (RWEA) 'A'. While likely to be due to natural causes such as insect attack, this issue should be investigated and monitored over time to assess whether any management actions are required.

Subsidence impacts had noticeably increased since the previous year with several roads affected by cracks and small pits. Vegetation damage within RWEA areas was generally minor however this appeared most widespread near flora monitoring plot V6-B2c, where several 1 -1.5m deep holes and cracking was observed. Older subsidence impacts outside of RWEA areas included sag subsidence and water filled areas, which in some circumstances had caused the death of trees and altered the affected vegetation community. WCPL could consider the need for additional monitoring plots in the areas modelled to be affected by subsidence.

The North Wambo Creek diversion area has not yet met completion criteria for landscape function and although no decline in average landscape function analysis (LFA) indices was recorded from the previous monitoring to the present, this area will require additional management actions to ensure that all completion criteria are met in the near future. Woodland rehabilitation areas display a trend of improvement over time. However most LFA indices have not improved or declined slightly from 2014 to present and are currently falling below completion criteria. Ground cover remains very sparse at most woodland rehabilitation sites, with leaf litter and rocks often the only patch type.

Pasture rehabilitation was observed to be in good condition in regards to Landscape Organisation Index (LOI) with high cover of vegetation and other resource trapping patches. Average LOI scores were very similar to the previous year and remain high despite falling slightly below performance criteria. The remaining LFA indices are meeting performance criteria with the average infiltration and nutrient indices improving over time since monitoring began in 2006.

The "Rapid Assessment of Riparian Condition" methodology (Jansen et. al 2005) was trialled in 2016 to assess condition of condition of North Wambo, South Wambo and Stony Creek. Due this change and to previous changes to the scoring methodology over time it was not possible to directly compare the current riparian condition scores to previous years. However field observations and the data collected suggest that no dramatic changes had occurred since the previous monitoring event. Continuing to restrict grazing in the riparian zones and the planting of riparian vegetation is recommended where appropriate.

RWEA and other remnant woodland sites at Wambo Colliery continue to support a large diversity of bird species. One hundred and sixteen bird species have been recorded during timed bird surveys over the last three years, with 78 of these recorded in 2016. The total number of bird species detected each year has varied over time but those recorded in 2016 are consistent with previous years. Bird assemblages in 2016 appear broadly similar to the other years examined as part of this analysis. It is recommended WCPL develop a clear measurable objective for the bird monitoring program.

1 Introduction

Wambo Coal Pty Limited (WCPL) is situated approximately 15 kilometres west of Singleton, near the village of Warkworth, New South Wales. A range of open cut and underground mine operations have been conducted at WCPL since mining operations commenced in 1969. Mining under the current Development Consent (DA 305-7-2003) commenced in 2004 and permits both open cut, underground operations and associated activities to be conducted. As part of the development consent, a Remnant Woodland Enhancement Program (RWEP) has been established as a biodiversity offset for lands disturbed by open cut coal mining activities. The RWEP aims to conserve local and regional biodiversity by protecting and enhancing the habitat for flora and fauna within these areas through a conservation agreement.

HLA - Envirosciences Pty Ltd initially established a program to monitor the fauna and vegetation structure within the remnant woodland enhancement areas, as well as to monitor stream and riparian condition within North Wambo, Wambo and Stony Creeks with the aim of measuring and documenting status and change in ecological condition.

Eco Logical Australia (ELA) was commissioned by Wambo Coal Pty Ltd (WCPL) to undertake this monitoring program during spring 2016. This monitoring program is conducted in response to the 2004 development consent condition (DA 305-7-2003 Schedule 4 Condition 48) and informs Wambo Coal's Annual Environmental Monitoring Report (AEMR).

ELA's scope of works was to:

- collect floristic and fauna habitat data from established monitoring locations throughout land owned by WCPL, including remnant woodland enhancement areas (RWEA) (otherwise known as Biodiversity Offset Areas (BOA) or Voluntary Conservation Areas (VCA))
- conduct Landscape Function Analysis (LFA) at established sites along the North Wambo Creek diversion and mine rehabilitation areas
- conduct riparian condition monitoring at North Wambo, South Wambo and Stony Creeks
- conduct bird monitoring at established monitoring locations spread throughout land owned by WCPL, including RWEA's
- conduct an inspection of areas likely to be impacted by mine subsidence from underground workings
- document results, compare to performance criteria or past results (where relevant) and identify what and where management actions may be required.

1.1 Report structure

This report has been set out in the following manner:

- **Key findings** - summary of the key findings of the monitoring works and analysis
- **Introduction** - provides background information to the current report
- **Floristic and fauna habitat monitoring** - provides methods, results and interpretation of data, as well as recommendations regarding both remnant plant communities and woodland rehabilitation areas at Wambo
- **Subsidence Inspection** – provides observations of mine subsidence and details any impacts to vegetation and risks to fauna
- **Landscape function analysis** - provides methods, results, analysis and interpretation of data, with management recommendations for landscape function at the North Wambo Creek diversion, woodland rehabilitation areas and pasture rehabilitation areas
- **Riparian condition assessment** - provides methods, results and interpretation of data, as well as management recommendations for riparian transects at North Wambo, Stony and South Wambo Creeks.
- **Bird surveys and observations** - reports the location, and results from 2016 bird surveys. Data is compared with survey results from previous years

Raw data and photographs from monitoring sites are included in **Volume 2**.

2 Floristic monitoring

2.1 Introduction

The aim of floristic and fauna habitat monitoring is to measure the current condition of vegetation within the RWEA's in terms of floristics and habitat complexity. The results aim to provide direction to management of these areas and for the monitoring program in the future.

2.2 Methods

Data was collected by ELA ecologists Gordon Patrick, Daniel McKenzie and Alex Gorey between October 10 and 3 November, 2016. A standard biometric plot 50 x 20 m (**Figure 1**) was used to measure the following parameters and collect data following BioBanking methodology (DECC 2008):

- full floristic species list (including cover abundance scores) in a nested 0.04 ha plot (20 m x 20 m)
- canopy regeneration over whole vegetation zone
- estimation of projected native foliage cover of ground cover from 50 points and canopy and midstorey layer from 10 points along the 50 m transect
- occurrence and abundance of weed species in 0.04 ha plot (20 m x 20 m)
- number of hollow-bearing trees and length of logs (>10cm diameter) in the plot
- photo (at start and end of 50 m transect).

The abundance of each species in the 0.04 ha plot was estimated, using a modified Braun-Blanquet scale, as used in previous floristic monitoring at WCPL. These are listed below:

- 1 = few, small cover (<5%)
- 2 = numerous (<5%)
- 3 = 5 – 25%
- 4 = 25 – 50%
- 5 = 50 – 75%
- 6 = >75%.

All vascular plants species were recorded and identified to the lowest taxonomic level possible, with samples of unknown species collected for further identification where possible. Nomenclature followed the Flora of New South Wales (Harden 1992; 1993; 2000; 2002), and any subsequent recent taxonomic changes as presented on PlantNET (RBGDT 2015).

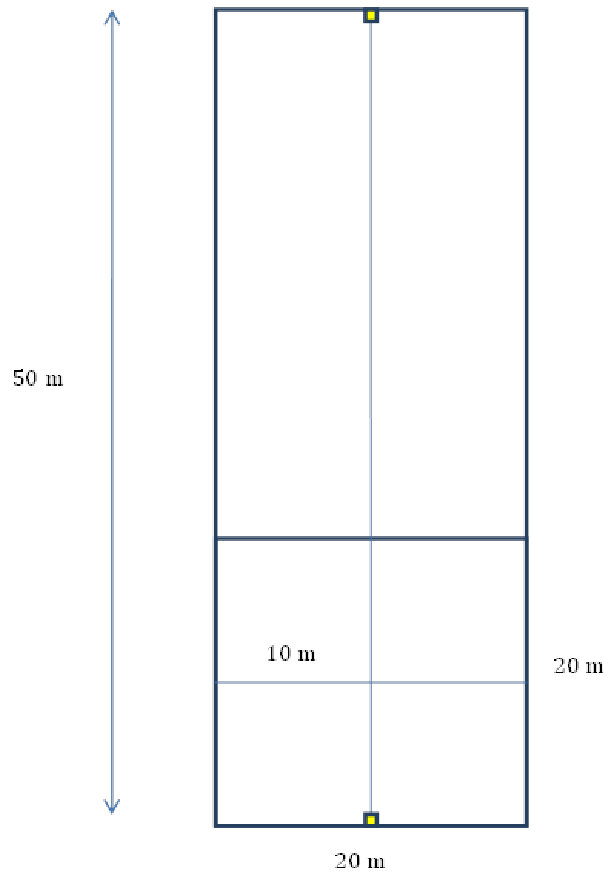

Figure 1: Biometric vegetation plot dimensions

Flora monitoring plots were located within the ten vegetation communities originally mapped and described by Orchid Research (2003). Since this time, a number of changes in vegetation mapping standards in NSW have occurred. Previously a set list of plant communities known as Biometric Vegetation Types (BVT) were used as a state-wide standard by the NSW Office of Environment and Heritage (OEH). These BVTs have now been modified and are known as Plant Community Types (PCT's). As such, the ten vegetation communities originally mapped and described by Orchid Research (2003) have been converted to their equivalent PCT within this report. Several of these communities are also listed under both State and Federal legislation as Endangered Ecological Communities (EECs) under different nomenclature. **Table 1** clarifies the conversion of vegetation communities.

Data was collected from the 34 locations previously surveyed as part of this monitoring program, with the exception of site V13-B1 which was moved slightly to the north-west to better sample the intended vegetation community in 2016. Floristic data was also collected from an additional four sites in woodland rehabilitation areas to measure biometric attributes in addition to landscape function analysis.

Monitoring plot V10–B1 was found to be located in Spotted Gum/Narrow-leaf Ironbark Forest, despite apparently being intended to sample the Slaty Gum/Narrow-leaf Ironbark community and has been included in the analysis of Spotted Gum/Narrow-leaf Ironbark Forest. This issue had not been identified in previous monitoring years.

Table 1: Original vegetation classification, plant community type classification and EEC status for each monitoring plot in remnant vegetation

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	EEC	Plot name
River Oak / Rough-barked Apple Forest	PCT 42: River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	Listed TSC Act, E: Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions	V1-A1
			V1-A2
			V1-B1
			V1-B2
			V1-B3
River Red Gum Woodland			V2-A1
			V2-B1
			V2-B2
Yellow Box / Blakely's Red Gum / Rough-barked Apple Forest			V3-B1
Coast Banksia / Rough-barked Apple / Blakely's Red Gum Forest	PCT 1653: Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area	Listed TSC Act, E: Warkworth Sands Woodland in the Sydney Basin Bioregion	V5-B1
			V5-B2
			V5-B3
			V5-B4
Narrow-leaf Ironbark/Grey Box/Bulloak/Honeymyrtle Forest	PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	Listed TSC Act, E: Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions, May also be listed under EPBC Act as Central Hunter Valley eucalypt forest and woodland, dependant on condition	V6-A1c
			V6-A3
			V6-B1
			V6-B1c
			V6-B2
			V6-B2c
			V6-B3
			V6-B4
Grey Gum/Narrow-leaf/ Ironbark/Bulloak/Honeymyrtle Forest			V11-B1
			V11-B2
Spotted Gum/Narrow-leaf	PCT 1604: Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass	Listed TSC Act, E: Central Hunter Ironbark - Spotted Gum - Grey Box Forest in the New	V9-A1

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	EEC	Plot name
Ironbark/Bulloak/Paperbark Forest	woodland of the central and lower Hunter	South Wales North Coast and Sydney Basin Bioregions, May also be listed under EPBC Act as Central Hunter Valley eucalypt forest and woodland, dependant on condition	V9-B1
			V9-B2
			V10-B1
Slaty Gum/Narrow-leaf Ironbark/Bulloak/Paperbark Forest	PCT 1176: Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	Listed TSC Act, V: Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion May also be listed under EPBC Act as Central Hunter Valley eucalypt forest and woodland, dependant on condition	V10-A1
			V10-A2
			V10-B3
White Mahogany/Rough-barked Apple Forest	PCT 1584: White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	-	V13-B1
Brush Wilga/Native Olive Shrubland	PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	Listed TSC Act, E: Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions	V14-A1
			V14-B1
			V14-B2

Cover/abundance floristic data for each plot was provided by WCPL from 2010 onwards with the exception of woodland rehabilitation which were only sampled for the first time by ELA in 2015. Biometric data was collected for the first time in 2014.

Data was examined for changes in native species richness within each sampled plant community over 7 years from 2010 to 2016 and cover of exotic species over the last 3 years (2014, 15 and 16). Major structural elements of each community (canopy and midstorey) of each community were compared over the previous three years. (2014, 2015 and 2016). Data from each vegetation community was compared to established performance criteria, biometric benchmarks and compared with reference sites outside of RWEA areas where possible.

Community condition benchmarks (developed by the NSW Office of Environment and Heritage (OEH) for each PCT) have been modified to provide realistic, ambitious but achievable performance criteria for each plant community. Monitoring results can then be compared to these performance criteria to determine if management actions are likely to be required. As existing woodland rehabilitation areas have been designed and implemented applying old techniques that do not reflect the current best practice of utilising species of local provenance, performance criteria for these older rehabilitation areas have been developed by modifying condition benchmarks for *Grey Box –Slaty Box shrub – grass woodland*, which is expected to have a similar vegetation structure, albeit different species composition, to the mature rehabilitated woodland community.

A green, yellow, amber and red colour system has been developed to rank each measured attribute according to performance and management actions required (**Table 2**). The structure of this table has been derived from (DECC 2008b). The number of hollow-bearing trees and length of fallen logs have been presented as a measure of fauna habitat attributes. However no performance criteria has been set for these attributes in remnant vegetation, as in situations where historical logging or clearing has been intensive, it may take many years for a suitable density of hollows and logs to form naturally.

Table 2: Colour ranking system for floristic attributes and performance targets

Attribute	Red (needs greater improvement)	Orange (in need of improvement)	Yellow (not meeting target but values still acceptable)	Green (excellent – within target range)
Native species richness	0–10%	>10 – <50% of target range	50 – <100% of target range	≥ target range
Native overstorey cover % (*pfc)	0 – 10% or >200% of target range	> 10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native mid-storey cover %(*pfc)	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native ground cover – grasses %	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native ground cover – shrubs %	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range
Native ground cover – other %	0 – 10% or >200% of target range	>10 – <50% or >150 – 200% of target range	50 – <100% or >100 – 150% of target range	within target range

Attribute	Red (needs greater improvement)	Orange (in need of improvement)	Yellow (not meeting target but values still acceptable)	Green (excellent – within target range)
Proportion of native overstorey species regenerating	0	0-0.5	0.5-1	1
Exotic cover	>66%	33-66	5-33	0-5%

Several abbreviations for measured attributes are used in tables throughout the following section. An explanation of these is provided below.

- NPS– the number of native plant species
- NOS (%) - projected native foliage cover of canopy
- NMS (%) – projected native midstorey cover
- NGCG (%) – native groundcover of grasses
- NGCS (%) – native groundcover of shrubs
- NGCO (%) – native groundcover of other plant types (sedges, herbs etc.)
- EPC (%)– exotic plant cover
- OR – proportion of overstorey species regenerating over the whole vegetation zone
- HBT – number of hollow-bearing trees present in the 20 x 50 m vegetation plot
- FL – length of fallen logs >10 cm diameter

In addition to those performance criteria listed above, Annexure C of the Voluntary Conservation Agreements (VCAs) for RWEA areas requires that WCPL aim for an exotic plant cover within the Conservation Areas that does not exceed the percentages detailed in **Table 3**.

Table 3: Exotic plant cover criteria for VCA areas

RWEA	Aim	Timing
Coal Terminal	Exotic plant cover within the Conservation Area must not be permitted to exceed : - 5% of the foliage cover at monitoring site CT1*; and - 15% of the foliage cover at monitoring site CT2*.	In Year 1 and at the end of Year 5
RWEAs A, B, C and D	Exotic plant cover within the Conservation Area must not be permitted to exceed : - 70% of the foliage cover at monitoring site A1 within Area A; - 20% of the foliage cover at monitoring site A2 within Area A; - 30% of the foliage cover at monitoring site A3 within Area A; - 10% of the foliage cover at monitoring site A4 within Area A; - 5% of the foliage cover at monitoring site B1 within Area B; - 5% of the foliage cover at monitoring site B2 within Area B; - 5% of the foliage cover at monitoring site C1 within Area C; and - 5% of the foliage cover at monitoring site D1 within Area D,	In Year 1
	Exotic plant cover within the Conservation Area must not be permitted to exceed : - 60% of the foliage cover at monitoring site A1 within Area A; - 15% of the foliage cover at monitoring site A2 within Area A; - 20% of the foliage cover at monitoring site A3 within Area A; - 5% of the foliage cover at monitoring site A4 within Area A; - 5% of the foliage cover at monitoring site B1 within Area B; - 5% of the foliage cover at monitoring site B2 within Area B; - 5% of the foliage cover at monitoring site C1 within Area C; and - 5% of the foliage cover at monitoring site D1 within Area D,	Years 2-5

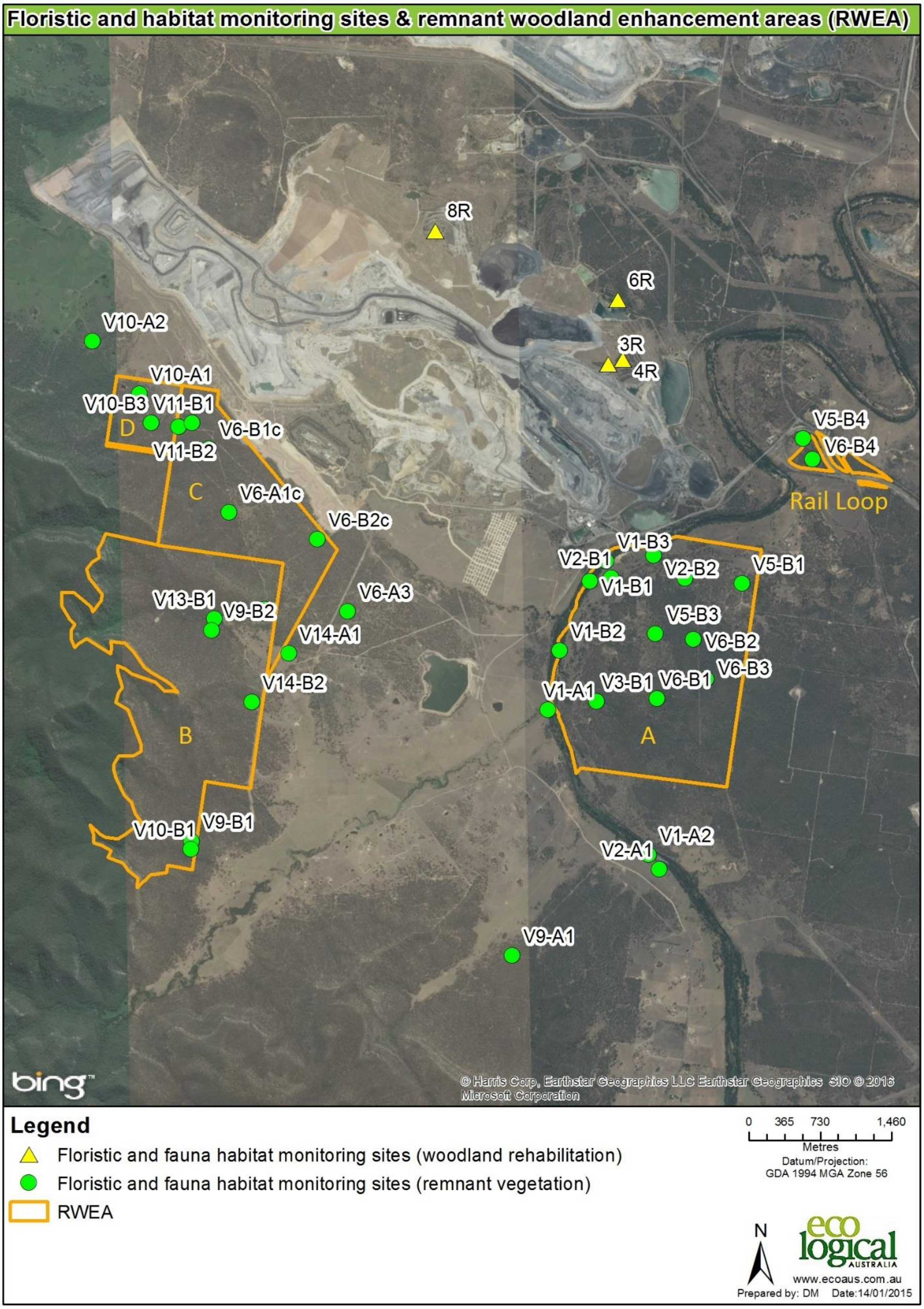

Figure 2: Floristic and habitat monitoring sites and RWEAs

2.3 Results

The floristic and biometric data collected during floristic and fauna habitat monitoring is summarised below, with the full floristic plot data and other data provided in **Volume 2**. Two endangered plant species populations were incidentally recorded within WCPL lands. These were a single individual of the *Cymbidium canaliculatum* (Tiger Orchid) population in the Hunter Catchment (in RWEA A) and the *Eucalyptus camaldulensis* (River Red Gum) population in the Hunter Catchment (observed on the Wollombi brook floodplain at several locations and on the banks of the lower section of North Wambo Creek).

2.3.1 River Red Gum / River Oak riparian woodland wetland in the Hunter Valley

This community is one of the most disturbed vegetation communities on WCPL land, as it occurs on more fertile soils on the banks and floodplains of Wollombi Brook, is naturally disturbed by flood events and has been historically used more intensively for agricultural purposes.

River Red Gum / River Oak riparian woodland is distinguished by an overstorey of *Eucalyptus camaldulensis*, *Casuarina cunninghamiana* subsp. *cunninghamiana* (River Oak), *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus melliodora* (Yellow Box) on floodplains and riparian areas. This PCT conforms to the NSW *Threatened Species Conservation Act 1995* (TSC Act) listed Endangered Ecological Community (EEC) *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions.* This community also contains the endangered Hunter Valley population of *Eucalyptus camaldulensis* (River Red Gum) listed under the TSC Act.

The River Red Gum / River Oak riparian woodland at Wambo is typical of other remaining stands throughout the Hunter Valley, with generally a high cover of weed species and a reduced number of native species (**Plate 1**).

Plate 1: River Red Gum / River Oak riparian woodland wetland on North Wambo Creek

Nine monitoring plots are located within this PCT. Three sites (V1-A1, V1-A2 and V2-A1) appear to have been intended as reference sites at the commencement of the monitoring program as they are located outside of RWEP areas.

V1 monitoring sites are located within *Casuarina cunninghamiana* (River Oak) dominated forest along the banks of Wollombi Brook. V2 monitoring sites are located on the partially cleared red gum dominated floodplains of Wollombi Brook and the V3 monitoring site is located in a slightly wetter site on the boundary of the floodplain and sand dunes.

Floristic results for this PCT were very similar to the previous year and monitoring sites within the RWEA generally meeting or coming close to meeting performance criteria (**Table 6**). The main management issue in this zone is the high cover of exotic species.

Exotic species cover was variable (20 - 70%) within the riparian zone of Wollombi Brook but was high at both reference and RWEA sites with an average of 45% exotic cover at V1 reference sites and 41% at V1 sites within RWEA A. The mean exotic plant cover at the two V2 sites within RWEA A averaged 75%, where common pasture weeds dominated these partially cleared habitats. Site V2-B1 was the worst performing monitoring site with a small cover of native species and a very high cover of exotics. In contrast, exotic species cover was very low at monitoring plot V3-B1 with only 2 exotic species recorded in the 20 x 20 monitoring plot.

Increases in the mean exotic cover were recorded between 2014 and 2016 but are unlikely to be statistically significant due to variance in the recorded exotic cover in this PCT in each year (**Figure 3**). This variance is illustrated below in **Table 4**. The causes behind this variability may be due to: slight changes in location of the biometric transect (as although the 20 x 20 plot is generally clearly marked, the start and end point of biometric transects are not), climatic variability and also the identification of exotic vs. native species is crucial to determining exotic species cover. Despite this variance in scores, exotic cover is quite high at most monitoring sites in this plant community in comparison to other plant communities at WCPL.

Table 4: Recorded exotic species cover 2014 – 2016 from biometric plots within riparian woodland

Plot Name	2014	2015	2016
V1-A1	29	8	20.5
V1-A2	15.5	50	70
V1-B1	11	50	36
V1-B2	1	52.5	66
V1-B3	25	24	20
V2-A1	81	54	52
V2-B1	95	52	84
V2-B2	37	54	66
V3-B1	0	0	0
Mean	36.81	43.06	51.81
SD	33.68	17.31	23.94
SE	11.91	6.12	8.46

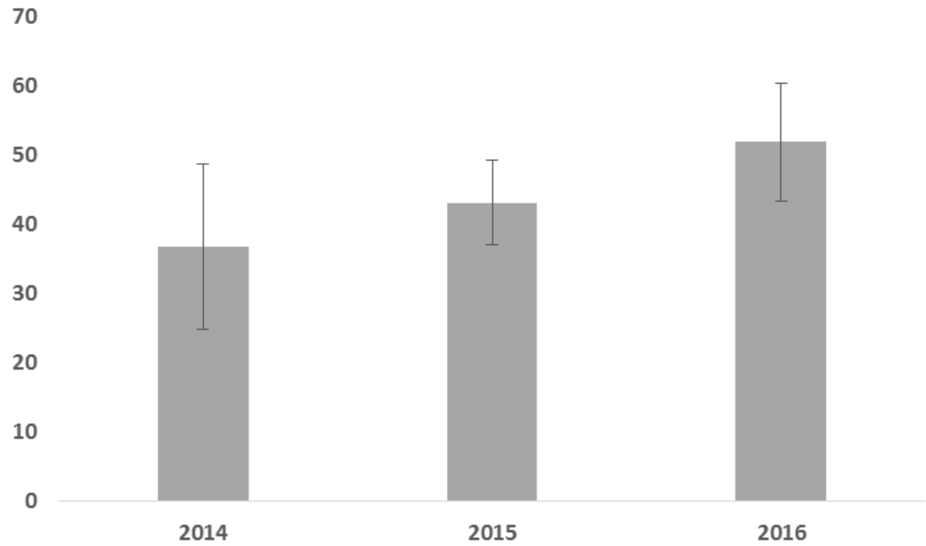

Figure 3: Mean recorded exotic species cover at riparian woodland sites 2014 – 2016. Error bars represent the standard error of the mean

Several declared weeds are present in the River Red Gum / River Oak riparian woodland PCT, these are listed in **Table 5** below along with their control class according to NSW Department of Primary Industries (DPI 2015)

Table 5: Declared weeds observed within the River Red Gum / River Oak riparian woodland PCT

Scientific Name	Common Name	Control Class	
Asparagus asparagoides	Bridal Creeper	4	Locally Controlled Weed The plant must not be sold, propagated or knowingly distributed
Echium plantagineum	Patterson's Curse	4	Locally Controlled Weed The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread
Lycium ferocissimum	African Boxthorn	3	Regionally Controlled Weed The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed.
Opuntia aurantica	Tiger Pear	4	Locally Controlled Weed The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed

Opuntia stricta	Prickly Pear	4	Locally Controlled Weed The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed
Salix species	Willows	4	Locally Controlled Weed The plant must not be sold, propagated or knowingly distributed
Senecio madagascariensis	Fireweed	4	Locally Controlled Weed The plant must not be sold, propagated or knowingly distributed

Cleared areas of the Wollombi Brook floodplain are not sampled as part of the monitoring program, however these areas have highest exotic cover and have been targeted by WCPL's weed control program. Herbicide treatment of *Opuntia* species was observed in RWEA A during the monitoring program (**Plate 2**).

Plate 2: *Opuntia humifusa* (Creeping Pear) infestation treated with herbicide in previously cleared areas of RWEA A

The number of native species observed within each monitoring plot in this PCT was variable between monitoring plots and ranged from 5 – 28. Monitoring plot V3-B1 had the largest number of native species in this PCT.

Average results from the RWEA fell just below the performance criteria for the number of native species, however this result was skewed upwards by the large number of natives detected at site V3-B and four of the six monitoring sites within the RWEA failed to meet the performance criteria for this attribute, However despite not having a very diverse species assemblage some sites had a relatively dense groundcover of native species.

The recorded number of native species in this PCT has been variable over time at both reference sites and RWEA sites (**Figure 4**). The average number of native species per plot in the RWEA during 2016 was greater than previous monitoring results between 2010 and 2014. This was partially due to a spike in the number of recorded native species at site V3-B1 in 2016, with 14 additional species recorded compared to 2014.

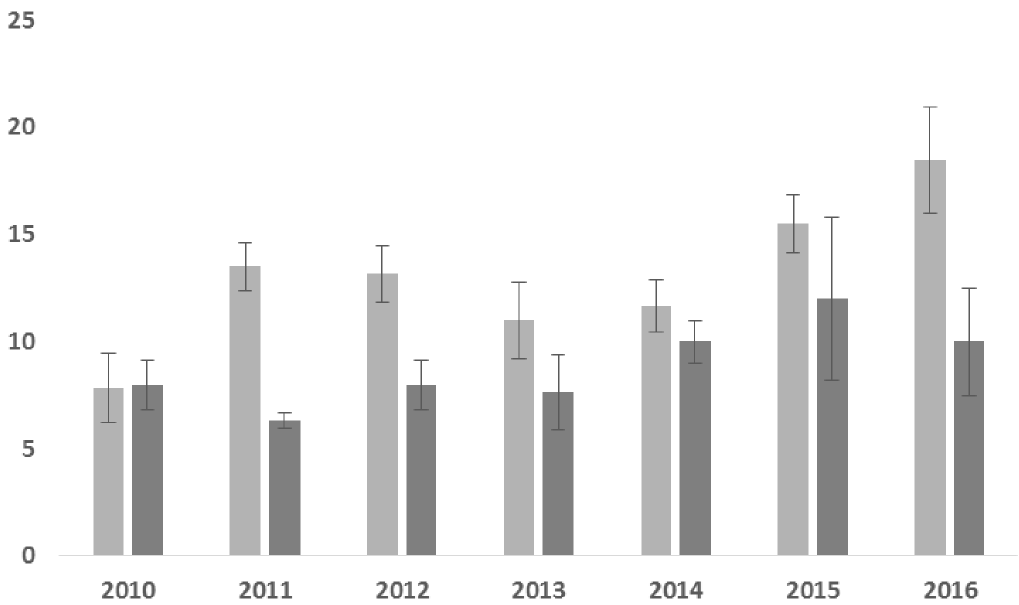

Figure 4: Average number of native species per plot in monitoring sites within riparian woodland in RWEA A (light grey) and from reference sites outside the boundary of RWEA's (dark grey). Error bars represent the standard error of the mean

Both RWEA monitoring sites and reference sites display a similar slightly positive trend, suggesting this trend may be related to either increases in species richness at both RWEA A sites, or related to the effect of different observers.

Differences between reference and RWEA sites in some years are likely due at least partially to the location of reference sites. Monitoring plot V1-A1 is located outside of RWEA areas at the confluence of South Wambo Creek and Wollombi Brook and is likely to be regularly disturbed by flood events. This monitoring plot had the smallest number of native species and groundcover was generally very sparse, consisting large areas of river sand and patches of leaf litter, beneath a dense canopy of *C. cunninghamiana*.

Table 6: Floristic results, performance criteria and OEH benchmarks for River Red Gum / River Oak riparian woodland wetland

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
River Oak / Rough-barked Apple Forest	PCT 42: River Red Gum / River Oak riparian woodland wetland in the Hunter Valley	Outside of RWEP	V1-A1	5	58.5	0	6	0	4	20.5	1	0	55
		Outside of RWEP	V1-A2	12	32	3	32	2	0	70		0	35
		A	V1-B1	16	21	9	18	4	30	36		0	0
		A	V1-B2	21	38	22	18	0	0	21		0	6
		A	V1-B3	10	43	4	42	0	14	20		0	12
River Red Gum Woodland		Outside of RWEP	V2-A1	13	2	13	18	0	10	52		0	9
		A	V2-B1	16	29.5	26.5	2	0	4	84		2	4
		A	V2-B2	20	8.5	6	8	0	36	66		0	0
Yellow Box / Blakely's Red Gum / Rough-barked Apple Forest		A	V3-B1	28	38.5	14	26	4	34	0		3	26
Average values for RWEP monitoring sites				18.5	29.75	13.6	19	1.3	19.6	45.3	1	0.83	8
Performance criteria				>20	10-50	10-50	20-60	1-5	5-30	<10	1	-	-

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NPS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Benchmark value				38	10-50	10-50	20-60	1-5	10-30	<5	1	0.1	10

2.3.2 Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area

Within WCPL owned land, this community is mostly restricted to the eastern side of Wollombi Brook primarily within RWEP area A (**Plate 3**). This PCT forms the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed Critically Endangered Ecological Community (CEEC) *Warkworth Sands Woodland of the Sydney Basin Bioregion* and is also listed under the NSW TSC Act. This PCT occurs on aeolian sand deposits and is restricted to the Warkworth area.

Plate 3: Warkworth Sands Woodland within RWEA A

Vegetation monitoring in this community indicates that it is in generally good condition, with a large number of native species and a low cover score for exotic plant species at two of the four monitoring plots (**Table 8**). On average the cover of exotic species did not meet performance criteria. However, this was due to the influence of monitoring site V5-B4 (within the railway loop) which was the worst performing monitoring site within the Warkworth Sands Woodland at WCPL in regards to exotic species cover (52%). This monitoring site has a moderately high exotic cover (~25%) of *Melinis repens* (Red Natal Grass). Exotic cover scores from biometric plots at V5-B1 and V5-B4 appear to have increased progressively over time (**Table 7**) and these areas may require additional management.

Table 7: Exotic cover scores between 2014 and 2016 from Warkworth Sands Woodland monitoring plots

Plot Name	2014	2015	2016
V5-B1	1.5	9.5	18
V5-B2	0	0	4
V5-B3	0	0	2
V5-B4	2	32	52

Despite this apparent increase in exotic cover, an additional 10 native species were recorded at V5-B4 in 2016 when compared to 2014. This was also the case at V5-2 where 10 more native species were recorded in 2016. The average number of native species within Warkworth Sands Woodland monitoring plots have appear to have remained relatively steady over time with a spike in the number recorded during the current monitoring period (**Figure 5**).

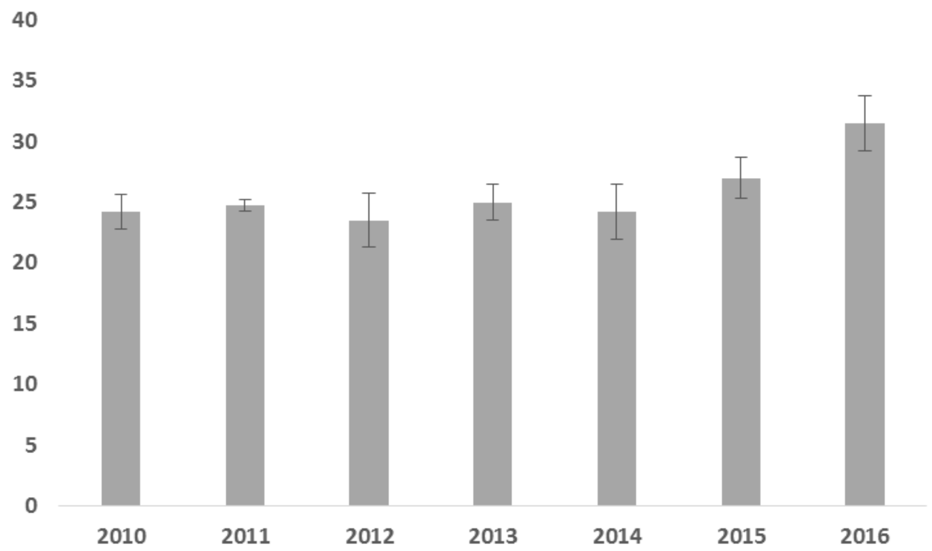

Figure 5: The average number of native species recorded within Warkworth Sands Woodland monitoring plots over time

Dieback of *Angophora floribunda* (Rough-barked Apple) was noticed in sections of this community away from monitoring plots (**Plate 4** and **5**) and was severe in some locations. However this phenomenon did not appear to be restricted to the RWEA as dieback of *A. floribunda* was also noticed along Putty Road at the time. An investigation should aim to determine the cause of this dieback within WCPL lands with additional monitoring of the issue to determine whether management actions are required and what (if anything) can be done to remedy the issue.

Plate 4: *Angophora floribunda* canopy dieback in parts of Warkworth Sands Woodland in RWEA A

Plate 5 *Angophora floribunda* canopy dieback in parts of Warkworth Sands Woodland in RWEA A

Table 8: Floristic results, performance criteria and OEH benchmarks for Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NNS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Coast Banksia / Rough-barked Apple / Blakely's Red Gum Forest	PCT 1658: Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area	A	V5-B1	26	15	5.5	44	12	12	18	1	0	15
		A	V5-B2	32	27.5	7.5	78	0	22	4		2	22
		A	V5-B3	37	10.5	16.5	38	0	4	2		0	42
		Rail Loop	V5-B4	30	26.5	2.5	2	8	16	52		0	13
Average values for RWEP and Rail Loop monitoring sites				31.3	19.9	8	40.5	5	13.5	19	1	0.5	23
Performance criteria				>20	10-40	10-50	4-20	5-30	5-35	<10	1	-	-
Benchmark values				26	13-40	10-50	4-15	5-30	5-25	0	1	0.8	20

2.3.3 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter

This community on land owned by WCPL is generally dominated by the canopy species *Eucalyptus crebra* and occasionally *Eucalyptus moluccana* (Grey Box) (**Plate 6**). A sparse mid-storey or shrub layer of *Allocasuarina luehmannii* (Bull Oak), *Bursaria spinosa* subsp. *spinosa* (Blackthorn) and *Notelaea microcarpa* var. *microcarpa* (Mock Olive), with a grassy understorey is often present. *Eucalyptus punctata* (Grey Gum) and *Melaleuca decora* also occur in patches.

Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest forms the TSC Act listed EEC C*entral Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions*. Sections of this community in good condition with a Eucalypt canopy are also likely to be the *Central Hunter Valley eucalypt forest and woodland* Critically Endangered Ecological Community (CEEC) under the EPBC Act.

This community appears to be performing well with a very low cover of exotic species and a large number of native species present at each monitoring plot (**Table 8**). Examination of biometric data reveals that little to no change in exotic cover has occurred in the majority of these monitoring plots since 2014 when biometric data was first collected. Some areas of minor mine subsidence were noticed within this PCT, particularly at lower elevations closer to the existing open-cut mine (**Section 3**, pg 54). However vegetation damage at this site was insignificant.

The average native mid-storey cover within RWEA's was slightly higher than the performance criteria due to the influence of sites V6-B1, V6-B2 and V6-B2c, which had higher mid-storey cover of *Allocasuarina luehmannii* and *Melaleuca decora* than the remaining monitoring sites.

Plate 6: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest at WCPL

Table 9 : Floristic results, performance criteria and OEH benchmarks for Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NNS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Narrow-leaf Ironbark / Grey Box / Bulloak / Honeymyrtle Forest	PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	C	V6-A1c	30	13.5	7	36	0	18	0	1	4	44
		Outside of RWEP	V6-A3	27	28.5	3	16	2	38	0		0	16
		A	V6-B1	35	26.5	18.5	16	4	12	0		2	107
		C	V6-B1c	32	12	8	38	4	16	0		1	13
		A	V6-B2	34	23.5	24.5	32	0	12	2		0	73
		C	V6-B2c	33	6.5	18	28	4	28	0		0	22
		A	V6-B3	41	21	8	30	0	12	2		1	48
		Rail Loop	V6-B4	16	31	3	24	0	4	2		0	4
Grey Gum / Narrow-leaf / Ironbark / Bulloak / Honeymyrtle Forest		C	V11-B1	28	12.5	3.5	24	8	14	4		0	63
		C	V11-B2	31	14	6.5	38	6	16	0		2	41
Average values for RWEP and Rail loop monitoring sites				31.1	17.83	10.8	29.6	2.9	14.6	1.1	1	1.1	46.2
Performance criteria				>25	10-40	5-10	15-50	5-10	5-40	<5	1	-	-
Benchmark values				41	15-40	5-10	30-50	5-10	20-40	<5	1	3	5

The average number of native species recorded in each plot within this PCT has remained similar to 2015. However the recorded number of native species increased during 2015 and 2016 from the 3 years previous (**Figure 6**). This pattern is closely followed by the reference site data, suggesting that these increases in native species richness are unlikely to be directly derived from management interventions and are possibly more related to weather patterns, with 2012 being a year of well below average rainfall, and larger than median rainfall in 2016.

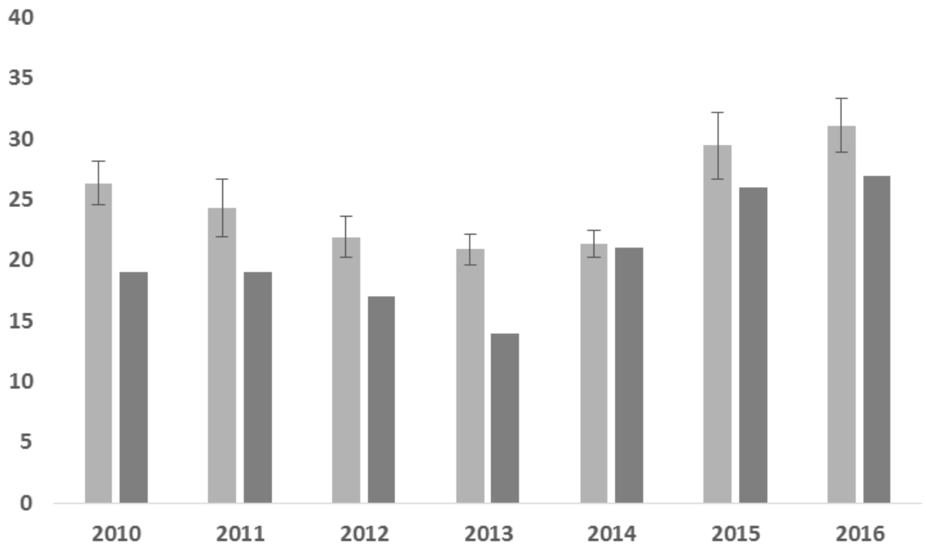

Figure 6: Average number of native species recorded in Narrow-leaved Ironbark - Bull Oak - Grey Box open forest within RWEAs (light grey) compared to reference site V6-A3 (dark grey). Error bars represent the standard error of the mean

2.3.4 Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter

Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter at Wambo is characterised by an overstorey of *Eucalyptus crebra*, *Corymbia maculata* (Spotted Gum) and *Eucalyptus moluccana* (**Plate 7**). *Eucalyptus punctata* and *Eucalyptus dawsonii* (Slaty Gum) are also occasionally present. The midstorey or shrub layer often includes *Melaleuca decora*, *Bursaria spinosa* subsp. *spinosa*, *Allocasuarina luehmannii* and *Olearia elliptica* (Sticky Daisy Bush). This community corresponds to the EEC Central Hunter Ironbark -Spotted Gum –Grey Box Forest listed under the TSC Act. Sections of this community in good condition with a Eucalypt canopy are also likely to be the Central Hunter Valley eucalypt forest and woodland CEEC, listed under the Commonwealth EPBC Act.

This PCT appears to be performing well in regards to performance criteria with large numbers of native species present at each monitoring plot despite falling just short of performance criteria (**Table 10**). Monitoring plot V10-B1 had the largest number of native species, meeting performance criteria for this attribute. Generally, few weed species are present within this PCT, with the exception of small infrequent occurrences of *Opuntia* species (Prickly Pear, Creeping Pear or Tiger Pear).

Examination of biometric data reveals that little to no change in overall exotic cover has occurred in these monitoring plots since 2014 when biometric data was first collected. The average number of native species in RWEA areas appears to decline between 2010 and 2014, before increasing again in 2015 and 2016 (**Figure 7**). Similar numbers of native species were recorded in RWEA areas in 2010 as 2016. The single reference monitoring plot appears to have remained relatively stable in regards to numbers of native species.

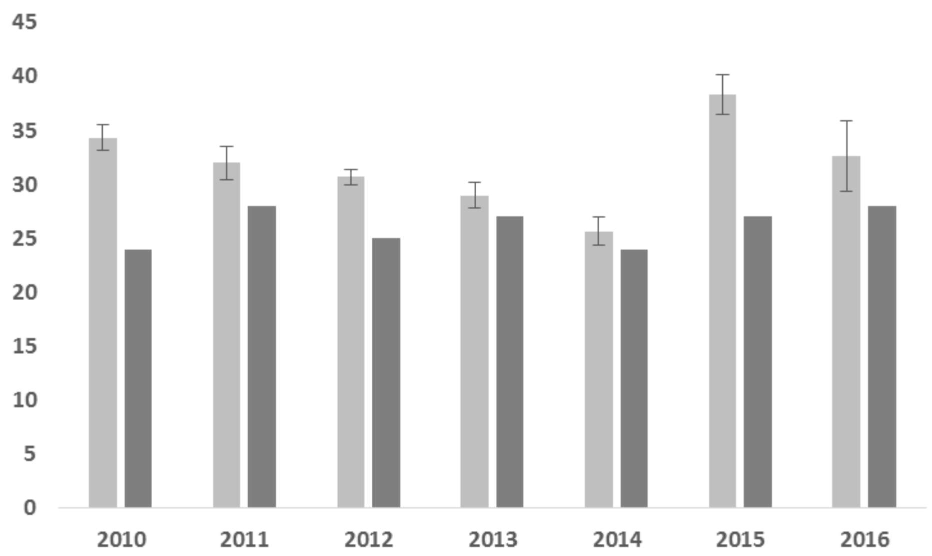

Figure 7: The average number of native species in Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland within RWEAs (light grey) compared to the recorded number at reference site V9-A1 (dark grey). Error bars represent the standard error of the mean

Plate 7: Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub – grass woodland at Wambo

Table 10: Floristic results, performance criteria and OEH benchmarks for Narrow-leaved Ironbark - Grey Box - Spotted Gum woodland at Wambo

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NNS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Spotted Gum / Narrow-leaf Ironbark/ Bulloak / Paperbark Forest	PCT1604: Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass of the central and lower Hunter	Outside of RWEP	V9-A1	28	22.5	6.5	24	0	10	0	1	1	22
		B	V9-B1	28	8.2	3.9	44	18	8	2		2	44
		B	V9-B2	31	12.5	3	42	8	8	4		0	39
		B	V10-B1	39	12.5	9.5	18	16	16	0		2	30
Average values for RWEP monitoring sites				32.7	11.1	5.5	34.7	14	10.7	1.5	1	1.25	37.7
Performance criteria				>35	15-40	5-20	30-50	5-15	5-40	< 5	1	-	-
Benchmark values				41	15-40	5-20	30-50	5-10	20-40	< 5	1	3	5

2.3.5 Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion

The canopy of Slaty Box - Grey Gum shrubby woodland is typically dominated by *Eucalyptus dawsonii* and several other species including *E. punctata*, *E. moluccana* and *E. crebra. Acacia salicina* (Cooba) and *Allocasuarina luehmannii* may form a small tree layer or be part of the upper-most canopy. The shrub layer includes species such as *Olearia elliptica*, *Acacia cultriformis* (Knife-leaved Wattle), *Canthium odoratum* (Shiny-leaved Canthium), *Notelaea microcarpa* var. *microcarpa* and *Dodonaea viscosa* subsp. *cuneata* (Wedge-leaf Hopbush). The groundcover is generally sparse to very sparse and is relatively species poor (**Plate 8**). This community is listed by the TSC Act as the EEC *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion.* Sections of this community in good condition with a Eucalypt canopy are also likely to be the *Central Hunter Valley eucalypt forest and woodland* CEEC under the Commonwealth EPBC Act.

At Wambo, the Slaty Box - Grey Gum shrubby woodland community primarily occurs on the smaller ridge tops and slopes and is patchily distributed at lower elevations. *Eucalyptus crebra* is often present and may co-dominate the canopy with *E. dawsonii*. This PCT is generally in good condition, particularly on the higher footslopes and ridgetops where historical disturbance has been minimal. A large number of native species, few weed species, sparse weed cover, and a relatively large length of logs was recorded. Occasional occurrences of the noxious weed *Opuntia* spp. were observed at low densities, similar to other woodland areas at Wambo. Very minor changes in exotic species cover values has occurred between 2014 and the present, with exotic cover remaining very low.

The monitoring sites in this community met most performance criteria. Average midstorey cover was slightly less than performance criteria and native grass cover slightly exceeded the upper limits of the performance criteria. These values are acceptable and likely reflect monitoring site selection and the overstorey being on the lower end of the performance criteria range, allowing more light to the forest floor and grass to proliferate.

The number of native species recorded in plots over time shows a similar pattern to the Narrow-leaved Ironbark - Bull Oak - Grey Box community, with a decline in native species at both RWEA and the reference site during 2012-2013 during and following a year of below median rainfall in 2012, before returning to pre-drought species numbers in 2015 and 16 (**Figure 8**).

An exceptional increase of 18 additional native species was recorded at reference site V10-A2 to the previous year, the reason behind this increase is unclear, however the additional species recorded in 2016 were mostly grasses and herbs that may have been overlooked or not present in the previous year.

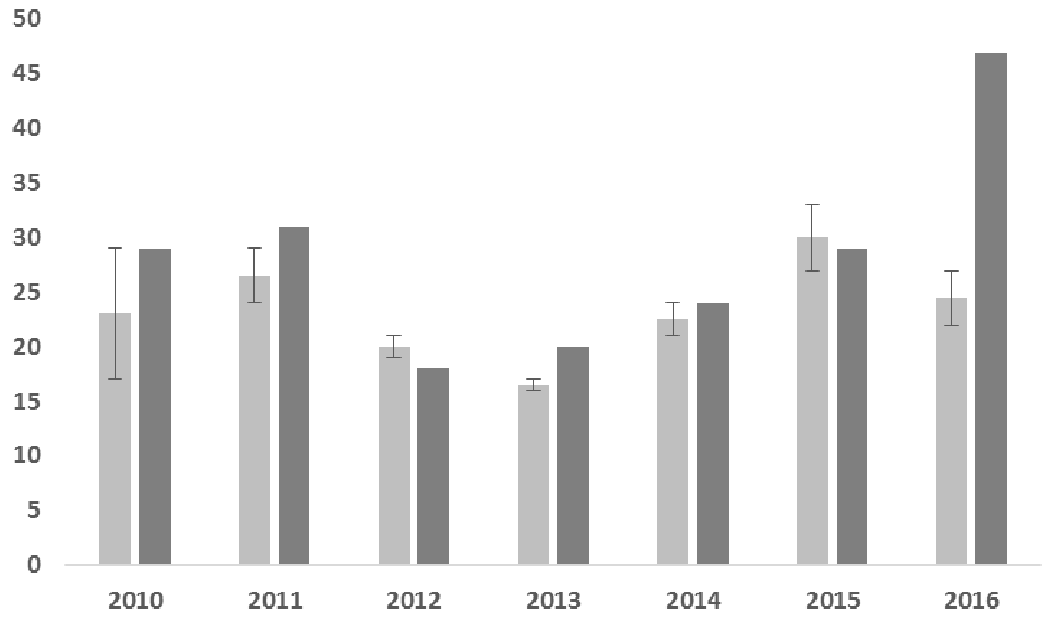

Figure 8: The mean number of native species recorded in Slaty Box shrubby woodland within RWEAs (light grey) compared to reference site V10-A2 (dark grey) Error bars represent the standard error of the mean

Plate 8: Slaty Box shrubby woodland monitoring site V10-B3 at Wambo

Table 11: Floristic results, performance criteria and OEH benchmarks for Slaty Box - Grey Gum shrubby woodland

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NNS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Slaty Gum / Narrow-leaf Ironbark / Bulloak / Paperbark Forest	1176: Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion	D	V10-A1	27	18	6	38	0	10	0	1	1	49
		Outside of RWEP area	V10-A2	47	21.5	4	34	4	0	0		0	22
		D	V10-B3	22	21	3.5	24	6	0	2		2	71
Average values for RWEP monitoring sites				24.5	19.5	4.75	31	3	5	1	1	1.5	60
Performance criteria				21	15-40	5-30	5-30	0-25	2-10	< 5	1	-	-
Benchmark values				21	19-42	6-24	5-20	0-25	2-10	< 5	1	1	30

2.3.6 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley

At Wambo this community occurs along Stony Creek and is sheltered by steep sandstone escarpments to the south and a large ridgeline to the north. This PCT is in good condition with many native species and occasional large remnant trees with hollows. One monitoring plot (V13-B1) samples this PCT. Exotic plant species cover is very low and sparse with no exotic cover recorded on the biometric transect (**Table 12**). This plot was conducted in a different location to previous years as the previous location was located on the edge of the plant community and adjacent to a clearing.

Despite not meeting performance criteria for the number of native species, the recorded value is still very high with 34 species recorded in the 20 x 20 plot and is considered acceptable. A proliferation of non-grass species such as herbs and twiners contributed to a "Native Ground Cover -Other" (NGCO) score that exceeds the performance criteria for this vegetation type. This is also considered acceptable, particularly as only one monitoring site samples this community and the variability of different patches is not entirely captured.

Plate 9: White Mahogany - Spotted Gum - Grey Myrtle forest

Table 12: Biometric scores and performance citeria for White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest at Wambo

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NNS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
White Mahogany / Rough-barked Apple Forest	PCT 1584: White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley	B	V13-B1	34	18	8.5	34	18	34	0	1	0	52
Performance criteria				>45	15-45	5-40	5-40	10-20	5-20	0	1	-	-
Benchmark values				51	22-45	5-40	5-25	10-20	5-20	<5	1	1	20

2.3.7 Brush Wilga/Native Olive Shrubland

The monitoring plots within this PCT are dominated by the shrubs *Notelaea microcarpa* var. *microcarpa*, *Geijera salicifolia* (Brush Wilga), *Olearia elliptica* and the small tree *Brachychiton populneus* (Kurrajong) (**Plate 10**). Occasional *Eucalyptus crebra* or *E. moluccana* are present. The plant community sampled by floristic monitoring may be partially a derived community, resulting from the removal of overstorey species in Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest combined with a south facing aspect. These areas are generally in good condition, with a large number of native species (average of 38 species per plot) and few exotic species.

Monitoring plot V14-A1 had the highest cover of exotic species, however this was still very low with only 4% cover of exotic species. Exotic species cover has remained consistently very low over time at these monitoring plots.

The average number of native species recorded within this PCT in RWEA areas have fluctuated in a similar fashion to other communities, with a slight dip in the number of species recorded during 2012, and 2013, 2014 before recovering with similar numbers recorded in 2015 to 2016 to earlier monitoring years (**Figure 9**). Again the reference site V14-A1 mirrors this pattern closely, suggesting that the cause of these fluctuations also affected areas outside of the RWEA and is likely to be primarily due to variance in annual rainfall.

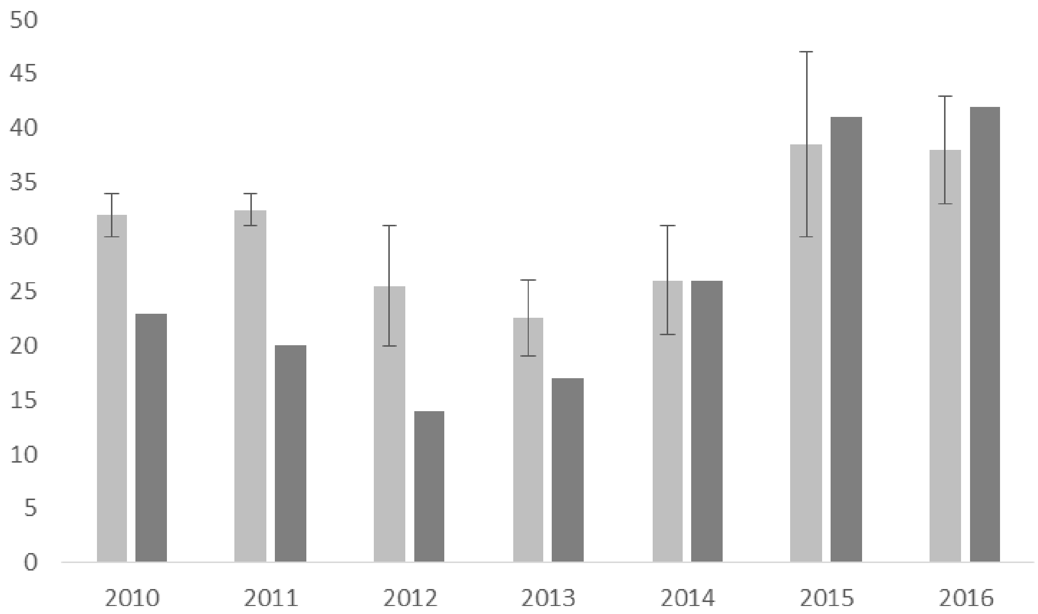

Figure 9: The mean number of native species recorded in Brush Wilga/Native Olive shrubland within RWEAs (light grey) compared to reference site V10-A2 (dark grey)

Plate 10: Brush Wilga/Native Olive Shrubland at V14-A1

Vegetation Community (Orchid Research 2003)	Plant Community Type (PCT)	RWEP Area	Plot Name	NNS	NOS (%)	NMS (%)	NGCG	NGCS	NGCO	EPC	OR	HBT	FL
Brush Wilga/Native Olive Shrubland	PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter *	Outside of RWEP	V14-A1	42	9	40.5	18	2	10	4	1	0	16
		B	V14-B1	33	6.5	38.5	40	4	14	0		0	38
		B	V14-B2	43	11.5	19.5	30	4	26	0		0	11
Average values for RWEP monitoring sites				38	9	29	35	4	20	0	1		24.5
Performance criteria				>30	5-40	5-40	30-50	5-10	10-40	<5	1	-	-
Benchmark values*				41	15-40	5-10	30-50	5-10	20-40	<5	1	3	5

* *Bench mark values for PCT 1603: Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter, however these monitoring sites sample sheltered south facing slopes with high mid-storey cover.*

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2.3.8 Woodland rehabilitation

Vegetation in woodland rehabilitation areas consisted primarily of *Eucalyptus cladocalyx* (Sugar Gum) and occasionally Spotted Gum (**Plate 11**). *Acacia saligna* (Golden Wreath Wattle) forms the dominant midstorey species in some areas. *E. cladocalyx* is native to South Australia, but has been planted widely as a windbreak tree for farms and timber production, and has also been planted on several other open-cut coal mine rehabilitation sites in the Hunter Valley. Similarly *Acacia saligna* is native to the south of Western Australia and has been widely cultivated in the past and has been used for stabilising sand dunes, road verges and open cut coal mine rehabilitation projects (RBGDT, 2015). The understorey in these areas remains very sparse, however some native species are present including *Enchylaena tomentosa* (Ruby Saltbush), *Calotis* spp. (Burr-Daisy) and several native grasses including *Cymbopogon refractus* (Barbed Wire Grass).

The area surrounding monitoring plot 6R appears to be the oldest area of woodland rehabilitation with ~ 8 m tall trees at 15 cm Diameter at Breast Height (DBH) and more than twice as many native species as the other three woodland rehabilitation areas. No particular issues with exotic weeds were identified in these areas, however small patches of *Galenia pubescens* were common in monitoring plots 6R and 8R and surrounds. Results from these woodland rehabilitation areas remain very similar to 2015 (when they were first sampled floristically). The number of native species remains generally low when compared to natural woodland sites nearby. Mid-storey and groundcover remain very sparse, with no groundcover score recorded along biometric transects for 2 of the 4 monitoring sites.

One small clump of *Lantana camara* (Lantana), a weed of national significance, was observed in the rehabilitation area of the mine. This observation is notable, as this species was not observed in natural areas surrounding the mine and has the potential to invade sheltered gully's and damp woodland sites.

Plate 11: Woodland rehabilitation at site 3R

Table 13: Biometric scores for woodland rehabilitation areas and performance criteria for older woodland rehabilitation areas

Vegetation Type	Plot Name	NPS (native to NSW)	NOS (%) (including *E.cladocalyx*)	NMS (%) (including *A.saligna*)	NGCG	NGCS	NGCO	EPC*	OR	HBT	FL
Woodland Rehabilitation	3R	6	16	2	0	0	0	0	Planted	0	0
	4R	4	22.5	0.5	0	0	0	0		0	0
	6R	15	40	3	24	0	4	6		0	25.5
	8R	7	14.5	7	6	0	0	0		0	0
Average values		8	23.3	3.1	7.5	0	1[1]	1.5	0	0	6.38[1]
Performance criteria for older woodland rehabilitation areas		> 15	15-40	5-40	5-15	5-10	5-15	<20	1	-	5

1 - recorded in one site only

2.3.9 Conservation agreement requirements and photo monitoring points

Annexure C of the Voluntary Conservation Agreements (VCAs) requires that WCPL “aim” for an exotic plant cover within the Conservation Areas that does not exceed certain exotic cover percentages. Three of the 10 monitoring plots exceed the exotic cover limits for both the 1 year and 2-5 year targets. Site A2 currently falls in-between the two targets. Exotic cover is very low at the remaining 6 sites.

Table 14: Exotic plant cover at monitoring sites in regard to VCA targets

RWEA	Site Code for VCA	Corresponding flora monitoring plot	Exotic cover limits yr 1	Exotic cover limits yrs 2-5	Exotic cover from biometric plots in 2016
Coal Terminal (Rail Loop)	CT1	V6-B4	5	5	2
Coal Terminal (Rail Loop)	CT2	V5-B4	15	15	52
A	A1	V2-B1	70	60	84
A	A2	V5-B1	20	15	18
A	A3	V1-B2	30	20	66
A	A4	V6-B1	10	5	0
B	B1	V13-B1	5	5	0
B	B2	V9-B1	5	5	2
C	C1	V11-B1	5	5	4
D	D1	V10 -B3	5	5	2

The co-ordinates provided for the photo-monitoring sites did not seem to correspond to a marked location in the field for some sites. Photos taken at the photo monitoring points and at nearby flora monitoring plots are included in Volume 2 of this report, and while they were taken in the same vegetation community, in some cases, do not appear to match with previous photo-monitoring points (from 2014) included in WCPL’s draft Biodiversity Management Plan (BMP) (2016). The majority of photographs in 2016 appear broadly similar in vegetation species and structure to those photographs taken in 2014. The canopy dieback in RWEA A (mentioned previously) is visible at site A2 and contrasts with the photo from 2014. The condition of the plant communities in these RWEAs is assessed in detail in the previous sections.

2.4 Conclusion and recommendations

The majority of remnant woodland areas are in good condition with high numbers of native species, few exotic species present and with low cover and abundance.

No overall decline in number of native species was observed, however as expected the number of native species recorded was variable over time. Fluctuations in the number of native species in reference sites generally followed a similar pattern to those in RWEAs, suggesting the cause or reason behind these fluctuations is affecting areas both in and outside of RWEAs. This is likely to be due primarily to weather conditions (**Figure 10**). Below average rainfall and very dry conditions between April and December in 2012, and record breaking temperatures over much of NSW in October 2014, combined with lower than average rainfall, may explain the decline the number of native species recorded in several plant communities between 2012 and 2014.

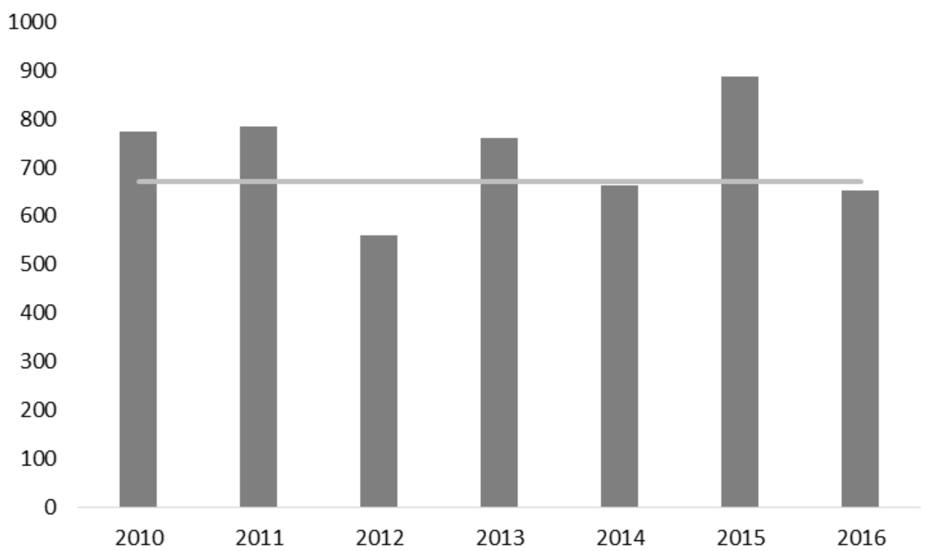


Figure 10: Total rainfall (mm) each year since 2010 (Data from both Jerry's Plains Post office (2010-2011) and Singleton STP (2012-2016)). 2016 data represents rainfall to December. The light grey line represents the long term average yearly rainfall

Angophora floribunda dieback in RWEA A is concerning as this community is listed as Critically Endangered under the EPBC Act. This issue is likely a natural phenomenon as the area in question is not currently being undermined and dieback in *A. floribunda* was also noticed elsewhere in the locality away from Wambo Colliery at the time. However it is recommended that WCPL investigate the cause of and consider monitoring these dieback patches to determine whether any management actions are required.

Overall exotic cover scores from biometric transects show little variability and to have remained consistently low during the last three years. The exception to this rule is the River Red Gum / River Oak riparian woodland wetland where recorded exotic species cover remains quite high and the number of native species generally lower than performance criteria. Exotic cover may have increased since 2014 at monitoring site V1-A2, V1-B2 and V2-B2. However caution should be used in interpreting these results as exotic species cover scores at each of these site within this PCT have been quite variable over time. The reason for this variability may be related to methodological issues, such as biometric transects conducted in a slightly different location between years (as the start and end points are not permanently marked) and possibly issues with identification of some exotic species.

Several declared weeds were observed in the riparian community (**Table 5**) that require management. A high exotic cover, dominated by of the exotic grass *Melinis repens*, was recorded at monitoring site V5-B4 (within the Warkworth Sands community within the railway loop). Exotic cover may also have increased at this location over time, however a large number of native species (30) still persist in the 20 x 20 floristic plot.

Exotic cover currently exceeds both VCA and monitoring site performance criteria in RWEA A and one of the rail loop areas. Selective management of exotic grasses and herbs such as *Melinis repens* in the rail loop and *Ehrharta erecta* (Panic Veldtgrass) as well as other exotic herbs and climbers such as *Cardiospermum grandiflorum* (Balloon Vine) in riparian areas is likely be required to meet these criteria. However reducing the cover of these weedy grasses may require spot spraying and hand weeding and may be prohibitively labour intensive and expensive, and in the case of riparian zones may be recolonised by weeds after flood events. In this scenario, targeting readily recognised and easily managed riparian weeds such as *Asparagus asparagoides* (Bridal Creeper) *Cardiospermum grandiflorum* may have the most environmental benefit.

Historically cleared areas on the Wollombi Brook floodplain have been targeted by the weed management program in 2016 presumably due to the high density of *Opuntia* species allowing large numbers of weeds to be sprayed in a short timeframe. However, a different approach is often taken in bush regeneration programs where moderate to good condition areas with weed issues are targeted for weed control prior to poor condition areas, such that areas in better condition (e.g. woodland areas or edges with low weed cover and high environmental value) are improved prior to cleared areas (generally low environmental value) with high weed cover. This approach should be considered in the management of the RWEA areas.

Woodland rehabilitation areas have not changed floristically since the previous flora monitoring in 2015. Issues mentioned in the previous monitoring report (ELA 2016a), such as the dominant species in these areas consisting of non-indigenous native species, low number of native species, and lack of groundcover at 3 of the 4 monitoring sites, are still relevant. Poor rehabilitation technique appear to have been used in these areas and initial topsoil spreading appears to have been very thin or non-existent. New areas of woodland rehabilitation should ensure the correct application of subsoil and topsoil and consider species diversity, structural diversity, local provenance as well as species performance in rehabilitation environments.

Lantana camara (Lantana), a weed of national significance, was observed in the rehabilitation area of the mine. This observation is notable, as this species was not observed in natural areas surrounding the mine and has the potential to invade sheltered gully's and damp woodland sites. It is recommended to remove this clump of *Lantana camara* as a priority.

3 Subsidence inspection

3.1 Introduction

A mine subsidence inspection was conducted while traversing RWEA areas during flora, fauna and riparian condition monitoring.

The location of subsidence cracks >10 cm width and other subsidence features encountered during monitoring fieldwork were recorded and a photograph taken. The level of disturbance to native vegetation and the condition of the surrounding vegetation was noted. Additional performance indicators for subsidence focus on changes in flora monitoring sites V6 –B1c and V11-B1 (WCPL 2016).

3.2 Results

Cracking and small pits along with water filled depressions caused by subsidence was observed within land owned by WCPL. Water filled depressions were observed to the south of the open cut at several locations. While primarily occurring in grassland, in some locations this appears to have caused the death of trees and native vegetation through waterlogging (**Table 15**).

Relatively small cracks and pits were observed within RWEA C, particularly on the periphery of this zone and the North Wambo Creek diversion area. Vegetation damage surrounding these cracks and pits within RWEA C is currently very minor and restricted in extent. In some instances subsidence cracks have exposed portions of the root systems of smaller trees such as *A. luehmannii* and *E. crebra*. Some access roads to and within RWEA C and in nearby power easements have also been affected (**Table 15**). Some of these are very recent as they were not observed during monitoring works in 2015. Deeper pits with steep sides are concerning as they potentially create a hazard for small fauna species, where they may become trapped and die. These areas should be a priority of any remediation works to be conducted.

No subsidence impacts were observed at vegetation monitoring site V6-B1c, which was observed to be in good condition and met most performance criteria for vegetation monitoring. Cracking was observed at site V11-B1 however impacts on vegetation were very minor and limited to the 10 cm wide crack itself (**Plate 12**). Subsidence impacts were noted to the east of Site V6-B2c (**Table 15**), however these did not extend into the vegetation monitoring plot.

Plate 12: Vegetation monitoring plot V11-B1 – a small subsidence crack was observed at this location, however impacts on vegetation were very minor

Table 15: Observations of mine subsidence at WCPL

Notes	Location		Photo
	X coordinate	Y coordinate	
Potential subsidence with impeded water and dead *Eucalyptus dawsonii.* Outside of RWEA in woodland between North Wambo and South Wambo Creek. This community is listed under the NSW TSC Act 1995 as the EEC *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion* and is likely to be *Central Hunter Valley eucalypt forest and woodland* CEEC under the Commonwealth EPBC Act 1999.	309798	6391809	
Subsidence damage on power-easement track ~50 cm deep, 150 cm long x 50 cm wide – on power easement south of North Wambo Creek	309839	6392496	

Notes	Location		Photo
	X coordinate	Y coordinate	
Water-filled depression from subsidence impacting on small tree (*E. crebra*) - in cleared landscape south of North Wambo Creek	311442	6391978	
20 m long depression in vegetation dominated by *A. luehmannii.* This may be an older crack that has filled with soil and debris over time. Located near flora monitoring plot V6-B2c, close to eastern boundary of RWEA C	309548	6393011	

Notes	Location		Photo
	X coordinate	Y coordinate	
1.5 m deep hole ~ 40 x 100 cm wide. Close to eastern boundary of RWEA C , near flora monitoring plot V6-B2c	309563	6393020	
Subsidence hole 1.5 m deep x 1m wide, RWEA C, near flora monitoring plot V6-B2c	309526	6392970	

Notes	Location		Photo
	X coordinate	Y coordinate	
Damage to road at entry gate to RWEA C. Varies from 10 - 50 cm wide and runs for ~ 20 m	308095	6394238	
Subsidence cracks in access road in RWEA C, ~40 cm deep	308180	6394165	

Notes	Location		Photo
	X coordinate	Y coordinate	
Subsidence crack generally 10 cm wide >30 cm deep through vegetation monitoring plot V11-B1. Crack runs for >60 m through *E. crebra* and *E. punctata* dominated vegetation. Vegetation damage surrounding this crack is very minimal.	308286	6394163	
One of several cracks on ridgeline road in RWEA B, 1 m deep x 80cm wide crack which has been enlarged through erosion. No significant damage to vegetation nearby was observed.	308877	6392276	

Notes	Location		Photo
	X coordinate	Y coordinate	
Several smaller cracks on access track on western boundary of RWEA C	3008002	6393577	

3.3 Conclusion and recommendations

A range of subsidence features were observed at WCPL. At present impacts to vegetation in RWEAs appears to be minimal, and as such, performance indicators in the draft BMP have not been exceeded. In addition, many smaller cracks and depressions are likely to self-repair over time. However, some of these features are impacting on EEC through water logging and deeper holes pose a risk to wildlife and humans. Some features on road edges may also become exacerbated by erosion. Suggestions for subsidence management in the draft BMP (WCPL 2016), including the filling of minor cracks with appropriate material, should be considered.

Outside of RWEAs subsidence depressions are creating several small wetlands and ponding in some areas, which in some circumstances, has altered existing vegetation and killed trees. Consideration should be given to whether environmental benefits from repairing these features, outweigh the disturbance caused by removal of wetland areas which are likely providing valuable habitat for a range of fauna species.

4 Landscape function analysis

4.1 Introduction

Landscape Function Analysis (LFA) is currently used to monitor the progress of the North Wambo Creek diversion, woodland rehabilitation and pasture rehabilitation towards achieving a suitable condition for their intended land use post-mining. The rehabilitation objectives for the North Wambo Creek Diversion (WCPL 2015) include:

- To establish pasture species consistent with revegetation strategy.
- Tree species established along creek lines consistent with the riparian zone.
- Creek diversion stable and will not present a greater safety hazard than surrounding land.
- Creek diversion able to shed water safely without causing excessive erosion, jeopardising landform integrity or increasing pollution of downstream watercourses.
- All watercourses subject to subsidence impacts shall be hydraulically and geomorphologically stable, with riparian vegetation established that is the same or better than prior to commencement of mining.

The completion criteria in regards to erosion control (WCPL 2015) state that no tunnel or gully erosion is to be present. Rill erosion is to be limited to <200 mm deep and/or <200 mm wide and ground cover is to be greater than 60%. Specific completion criteria for LFA are listed in **Table 17.**

Landscape organisation relates to the proportion of the transect occupied by patches - patches being landscape elements that are relatively permanent and provide stable, resource accumulating structures, such as grassy tussocks and other ground cover, leaf litter and logs. Therefore, a larger Landscape Organisation Index (LOI) number implies a more stable transect that is less prone to erosion.

The Soil Surface Assessment (SSA) results go one step further than this and contribute to an index for stability, infiltration and nutrient cycling for all patch and inter-patch types for the whole of landscape (transect).

Stability is defined as the ability of the soil to withstand erosive forces, and to reform after disturbance. The stability index is derived from data collected during the SSA's, such as crust broken-ness, surface resistance, slake tests, erosion type and severity, deposited materials, moss, algae and lichen (cryptogam) cover, rain splash protection and leaf litter cover.

Infiltration concerns the way water interacts with soil to become soil water (and becomes available for plants) or runoff water where water is lost from the system or transports materials (such as soil, nutrients and seed) away. Scores for vegetation cover, surface roughness, slake tests, litter cover, origin and decomposition, surface resistance to disturbance and soil texture contribute to the infiltration index.

Nutrient cycling is defined as how efficiently organic matter is cycled back into the soil. Scores for vegetation cover, litter cover, origin and decomposition, cryptogam cover and surface roughness contribute to nutrient cycling values.

4.2 Methods

Landscape Function Analysis (LFA) data was collected from a total of 21 monitoring sites, including eight in riparian rehabilitation areas at the North Wambo Creek Diversion, four in woodland rehabilitation areas and nine in pasture rehabilitation areas (**Figure 11**). LFA methods followed the method for Landscape organisation and SSA, as provided in Tongway and Hindley (2004). LFA data was collected between the 5 and 14 October 2016 by ELA ecologists Daniel McKenzie and Linden Birch.

Sites 28R to 25R were marked in the field with star pickets. Transect 26R and 25R (set up during 2015) were adjusted slightly during 2016 to sample the slope and avoid crossing the creek channel. LFA at site 14R was not completed during 2016. Uncertainty exists as to why this monitoring location on South Wambo Creek is included in the monitoring program.

Soil texture scores are usually collected once at the start of an LFA monitoring program and kept consistent throughout. As such soil texture scores were kept consistent with Niche (2014c).

Raw numerical values from previous years were available for Landscape organisation, Stability, Infiltration and Nutrient cycling indices. Data for pasture and woodland sites was available for the 11 monitoring periods from 2006 – 2016, while creek diversion sites were first sampled at the completion of the creek diversion construction and subsequent seeding in 2008. Trends in these values over time were examined to inform management recommendations.

Performance criteria have previously been developed from a range of scores from previous monitoring years from nearby sites with relatively undisturbed riparian habitat. A colour system was devised to highlight the performance of each LFA site and is shown below in **Table 16.**

Table 16: Colour system devised to highlight the performance of each LFA site

Green	Yellow	Orange	Red
Area is generally meeting or exceeding target values and values do not show trend of decline over time – where monitoring sites are meeting targets and values are relatively consistent, reduce monitoring to infrequent LFA when changes in landscape or management practices occur i.e. fire or grazing)	Area generally falls below target values but within 75% of targets or appears to be on a trajectory of improvement without the need for management intervention – further monitoring required	Area generally falls between 75% and 50% of target values or shows little sign of improvement over several monitoring events – further monitoring and possibly management actions required	Area falls below 50% of target and is unlikely to improve without management actions or shows trend of decline which is unlikely to improve without management actions

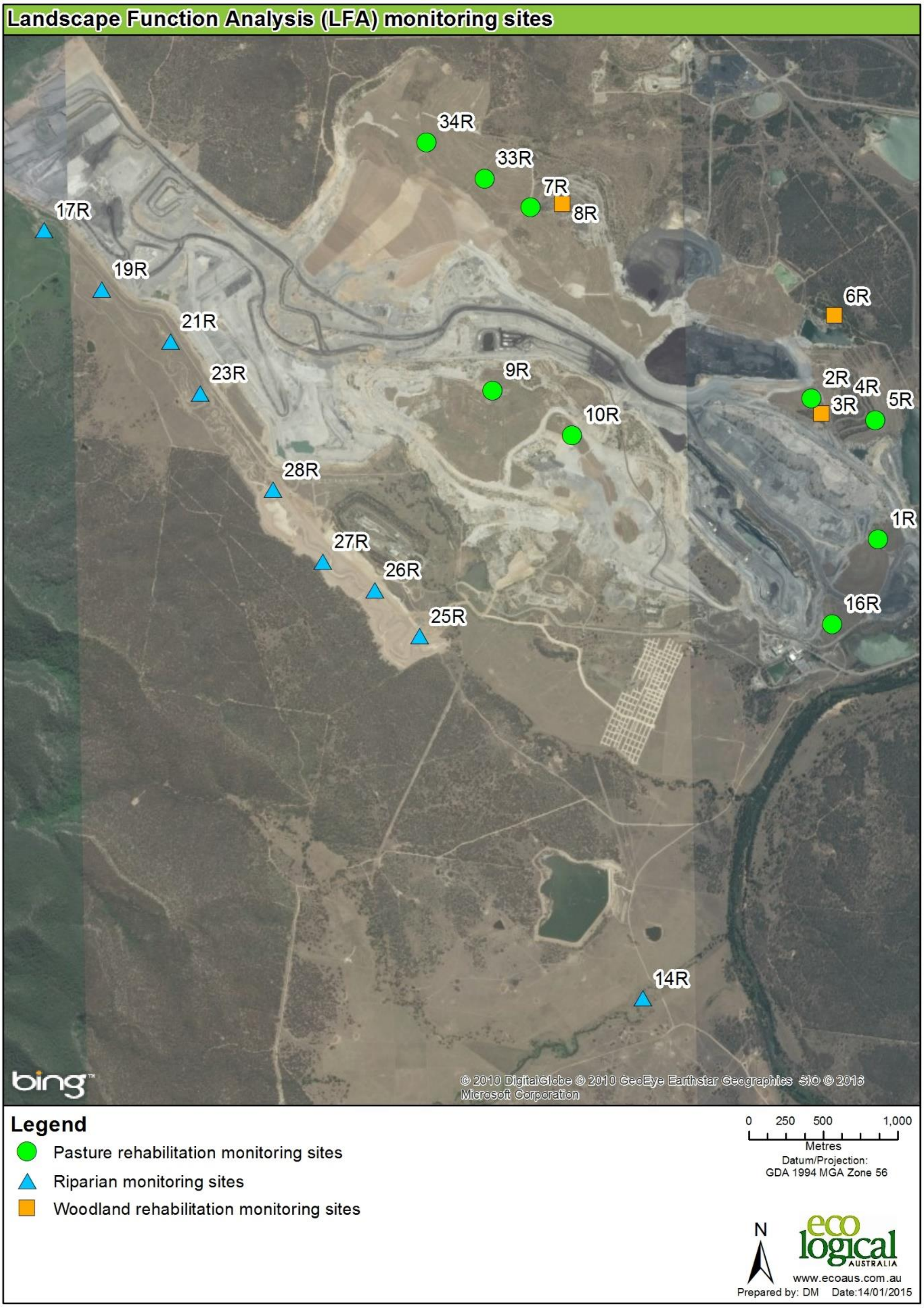


Figure 11: LFA monitoring site

4.3 Results

4.3.1 North Wambo Creek Diversion

Monitoring sites within the North Wambo Creek Diversion area are variable in condition and landscape functionality with individual monitoring sites described in **Table 18**. All monitoring sites have few native plant species and consist of predominantly low pasture, with tussocks of *Chloris gayana* (Rhodes Grass), *Galenia pubescens* and *Anagallis arvensis* (Scarlet Pimpernel) with other exotic pasture grasses and herbs. Areas of bare soil are prevalent throughout the diversion area, particularly to the south where recent ripping of soil and seeding has occurred during 2015 in an attempt to control weeds and establish cover (**Plate 13**). Some of the steeper slopes are experiencing erosion issues such as rilling (**Plate 14**:

Plate 13: North Wambo Creek diversion near site 25R

Plate 14: Soil erosion in sections of the North Wambo Creek diversion

Some natural tree and shrub regeneration was observed within the creek bed and occasionally on nearby slopes, with *Casuarina cunninghamiana*, *Acacia* spp. and *Eucalyptus* species beginning to establish. Data from the creek diversion LFA is presented in **Table 17**.

Table 17: North Wambo Creek Diversion LFA results in 2016 (Plots are organised by location - upstream to downstream)

Monitoring Plot	LOI	ST	INFI	NI	Bare Soil and Rock cover (%)
17R	0.96	65.1	36.3	26.8	4.2
19R	0.75	55.9	32.6	21.9	24.5
21R	0.76	60.3	34.8	25	24.7
23R	0.44	56.8	27.4	14.6	56.3
28R	0.55	51.9	25.5	19.2	55.5
27R	0.35	58.1	24.8	15.2	65.2
26R	0.67	59	30.2	24.7	32.8
25R	0.59	56.9	29.9	20	41.4
Average score	**0.63**	**58**	**30.18**	**20.93**	**38.08**
Target score	**>0.84**	**>62**	**>41**	**>37**	**<40%** (WCPL 2015)

Overall the creek diversion area has not yet met the established performance criteria for Landscape Function attributes and may require management actions to meet these targets in the future.

Landscape Organisation, defined as the proportion of the transect consisting of resource trapping patches such as vegetation, is variable throughout the creek diversion and scores are highest in the north (where transects are positioned on lower gradients and disturbance for the diversion appears to have been less extensive) and generally lower in the southern sites where slopes are steeper, more prone to erosion and more recent disturbance has occurred. While the average bare soil and rock cover score for all sites is meeting performance criteria, four of the eight sites have exposed bare soil and rock making up greater than 40% of the transect, indicating that these areas are not meeting the 60% groundcover required to meet the completion criteria in regard for erosion control. These areas are all downstream from site 21R.

An examination of previous LFA results reveals that landscape organisation scores appear to have either increased slightly or remained constant since the previous monitoring event in 2015. In a comparison with data collected in previous years, mean landscape organisation index were very low in 2008, reflecting the recently completed diversion area (**Plate 15**). Values for LOI then increased dramatically in 2009, likely due to cover crops of grasses establishing (**Plate 16**).

Plate 15: Construction stage of the North Wambo Creek diversion prior to completion in 2008 (Daracon, 2016)

Plate 16: The initial cover of grasses seeded on the North Wambo creek diversion following completion of construction work (Daracon, 2016)

These high LOI values remained similar until 2013, before dipping during 2014, primarily due to large drops in LOI scores at sites 19 and 21 (**Figure 12**) and may reflect a decline in the initial grass and plantings. The addition of new more recently disturbed sites in the south of the creek diversion area in 2015 slightly reduced average LOI scores during 2015 and 16. The average LFA scores in these more recently disturbed sites improved slightly (though unlikely to be statically significant) between 2015 and 2016, reflecting the re-establishment of vegetation in these monitoring sites.

Other LFA indices demonstrate a similar but less dramatic pattern, where a decline in scores occurs between 2009 and 2014. Values recorded for Stability, Infiltration and Nutrient cycling in 2014 remain similar to those in the current year (**Figure 13, Figure 14 & Figure 15**).

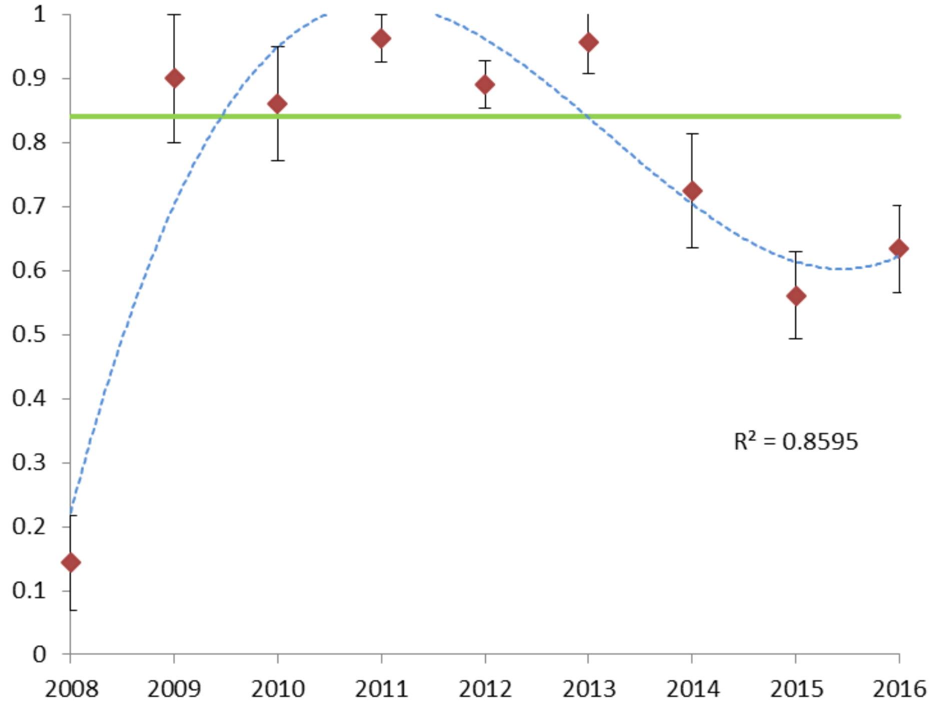


Figure 12: **Average LOI scores at sites 17r, 19r, 21r and 23r each year 2008-2014**. Average scores in 2015 and 2016 incorporate four additional sites (25r, 26R, 27R and 28r). Error bars represent standard error of the mean. Only sites 19R, 21R and 23R were sampled in 2008. The green bar represents completion criteria for LOI.

Figure 13: Average stability index values from the creek diversion sites. Values are derived from sites 17r, 19r, 21r and 23r each year since 2009-2014. Average scores in 2015 and 2016 incorporate four additional sites (25r-28r). Error bars represent standard error of the mean. Only sites 19R, 21R and 23R were sampled in 2008. The green bar represents completion criteria for the Stability Index

Figure 14 : Mean infiltration index values from the creek diversion sites. Values are derived from sites 17r, 19r, 21r and 23r each year between 2009 -2014. Average scores in 2015 and 2016 incorporate four additional sites (25r-28r). Error bars represent standard error of the mean. Only sites 19R, 21R and 23R were sampled in 2008. The green bar represents completion criteria for the Infiltration Index

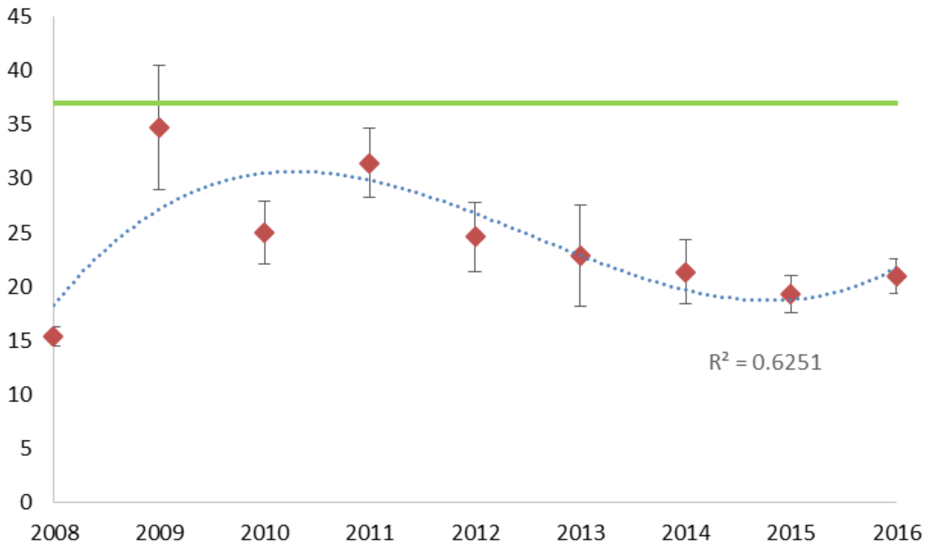


Figure 15: Mean nutrient index values from the creek diversion sites. Values are derived from sites 17r, 19r, 21r and 23r each year between 2009 -2014. Average scores in 2015 and 2016 incorporate four additional sites (25r-28r). Error bars represent standard error of the mean. Only sites 19R, 21R and 23R were sampled in 2008. The green bar represents completion criteria for the Nutrient Index

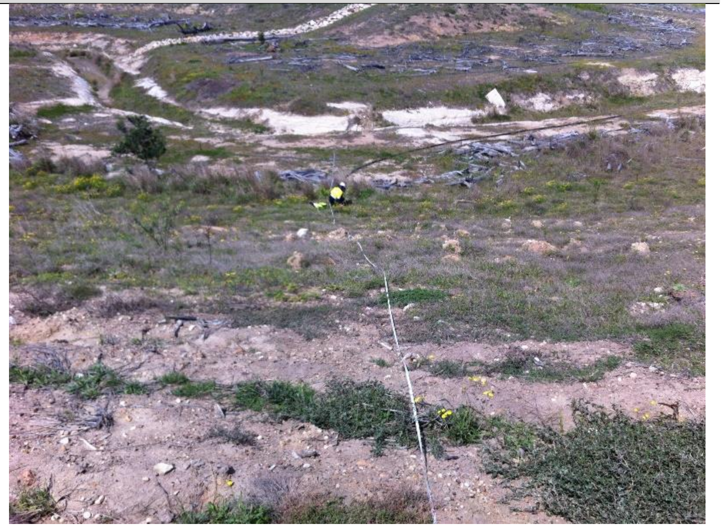
Table 18: Site description of each creek diversion transect

Transect	Notes	Photograph
17R	Transect consists of relatively flat ground covered in pasture and appears relatively stable. Exotic vegetation dominates the area with *Chloris gayana* (Rhodes Grass) and *Senecio madagascariensis* (Fireweed) common throughout. Landscape organisation index and stability index values remain larger than performance criteria, due to dense pasture cover and relatively flat ground that is less prone to erosion. Infiltration and nutrient cycling indices remain below performance criteria, however these values are larger than all other riparian sites.	

Transect	Notes	Photograph
19R	Transect relatively flat, with several small patches of bare soil throughout. *Chloris gayana* dominates the vegetation species present. A mound of soil on the western bank is covered with dense *Echium plantagineum* (Patterson's Curse - a noxious weed) and *Galenia pubescens* (Galenia). Young *Eucalyptus* and *Acacia* species are growing on creek banks downstream.	
21R	Transect relatively flat grassland, with low sparse grass and exotic herb patches dispersed by areas of bare stony soil.	

Transect	Notes	Photograph
23R	Low, primarily exotic vegetation with some extensive areas of bare soil and stony ground. The creek bank is undercut and slumping on western bank. A stand of ~ 5m tall *Casuarina cunninghamiana* and seedlings and some young Eucalypts are growing on creek banks.	
28R	Transect primarily samples the relatively steep eastern bank then crosses the creek. The eastern bank consists of a large bare patch of stony soil with *Galenia pubescens*. Rill and terracette erosion present nearby on this slope. *Cynodon dactylon* (Couch Grass) dominates the lower slopes. The creek channel has been cut into the sandstone bedrock from this point downstream, creating shallow soils in the riparian zone.	

Transect	Notes	Photograph
27R	Transect samples the relatively steep western bank of the cutting. Bare stony soil with patches of dead *Galenia pubescens* and moderate to severe erosion issues dominate this bank. Low sparse grasses and logs dominate the flat area adjacent to the creek channel.	
26R	Transect samples the relatively steep eastern bank to the edge of the creek channel. Exotic vegetation dominates the monitoring transect with some small bare soil areas.	

Transect	Notes	Photograph
25R	This slope is relatively steep with bare patches from recent (late 2015) ripping of the soil. Grasses and herbs have colonised trough areas. Large tussock grasses (*Chloris gayana*) and logs are present at the bottom of the transect near the creek channel.	

4.3.2 Woodland rehabilitation

Woodland rehabilitation areas were sampled as per previous monitoring design with four LFA monitoring locations at sites 3R, 4R, 6R and 8R.

Results are presented in **Table 19** below. The average scores for the monitoring plots generally fall just below the completion criteria, with the exception of the stability index which is currently meeting criteria. Site 6R remains the best performing site and is meeting the performance criteria for all attributes. Visually the sites appear very similar to the previous year and this is reflected in the LFA results, where 2016 results are very similar to 2015.

Over the four plots average LOI scores have remained similar over the last three monitoring events (**Figure 16**). Leaf litter remains the most common patch type and the understorey in the rehabilitated woodland communities generally remains very sparse.

Variability in LOI scores over time has been mentioned in the previous annual report (ELA 2016a) as LOI scores between 2006 and 2010 appear to be quite variable from year to year even within each site. The reasons behind this variability in recorded scores are unclear but may be related to previous field methodology.

The remaining attributes have generally remained similar to the previous year (**Figure 17, Figure 18 & Figure 19**). Scores generally display variability between years but a positive trend over time.

Plate 17: Woodland rehabilitation monitoring site 6R in 2016

Table 19: LFA scores and performance criteria for woodland rehabilitation areas

Monitoring Plot	LOI	ST	INFI	NI
3R	0.70	61.70	32.80	28.80
4R	0.76	57.50	40.60	36.90
6R	0.92	62.00	43.70	37.30
8R	0.65	55.90	36.90	30.70
Average score	0.76	59.28	38.50	33.43
Standard error	0.06	1.52	2.35	2.16
Target score	**>0.87**	**>59**	**>43**	**>36**

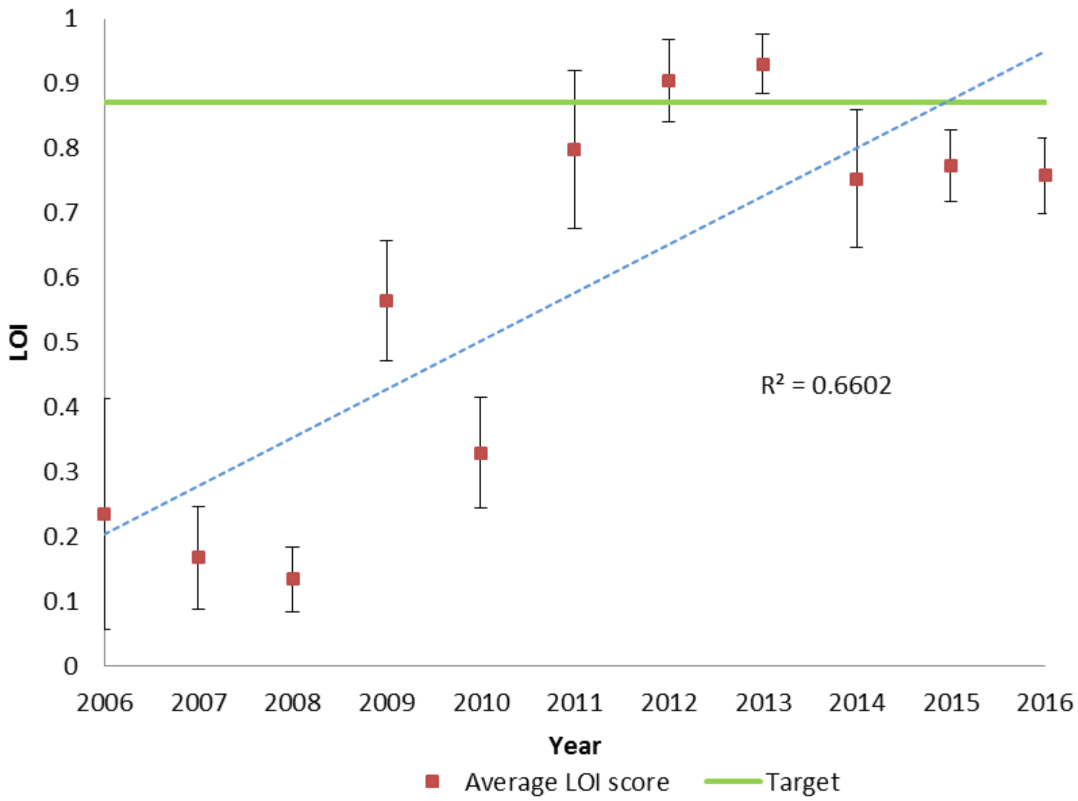


Figure 16: Average landscape organisation index scores for woodland rehabilitation 2006 - 2016

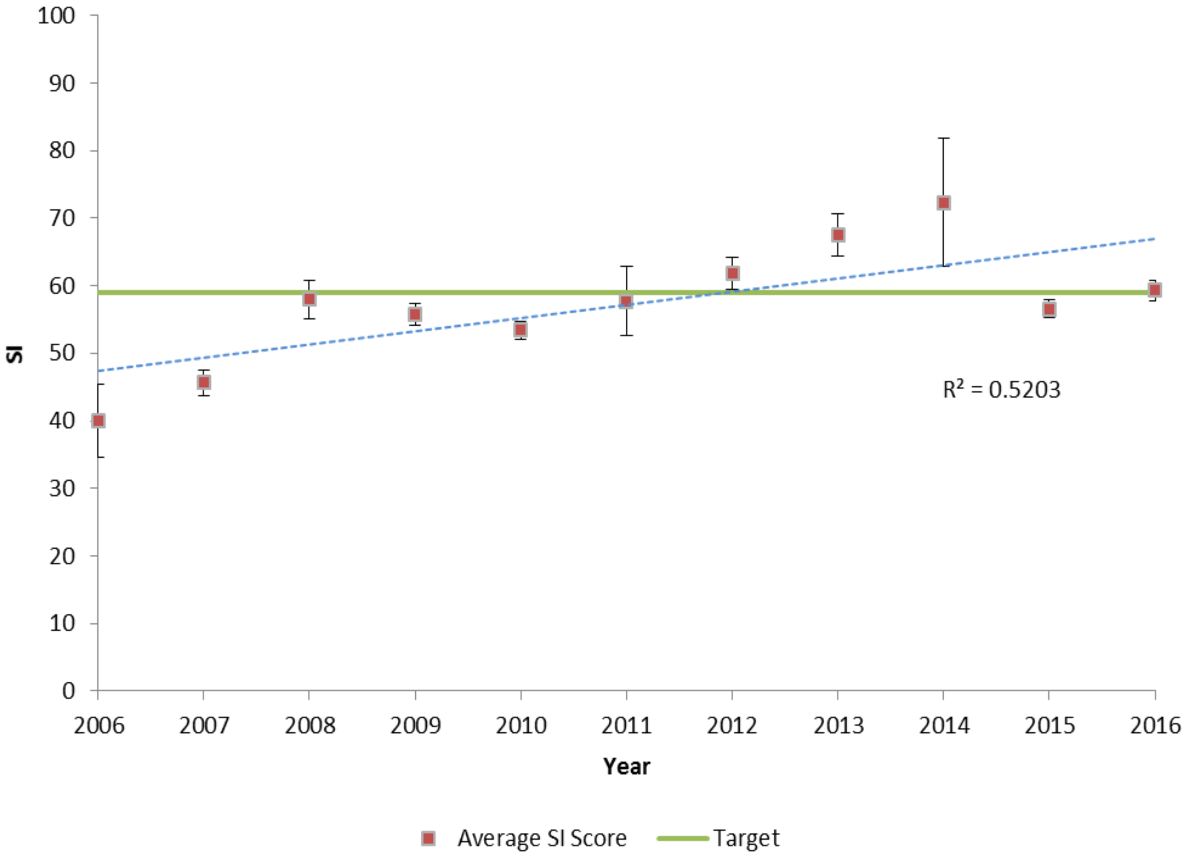


Figure 17: Average stability index scores for woodland rehabilitation 2006 - 2016

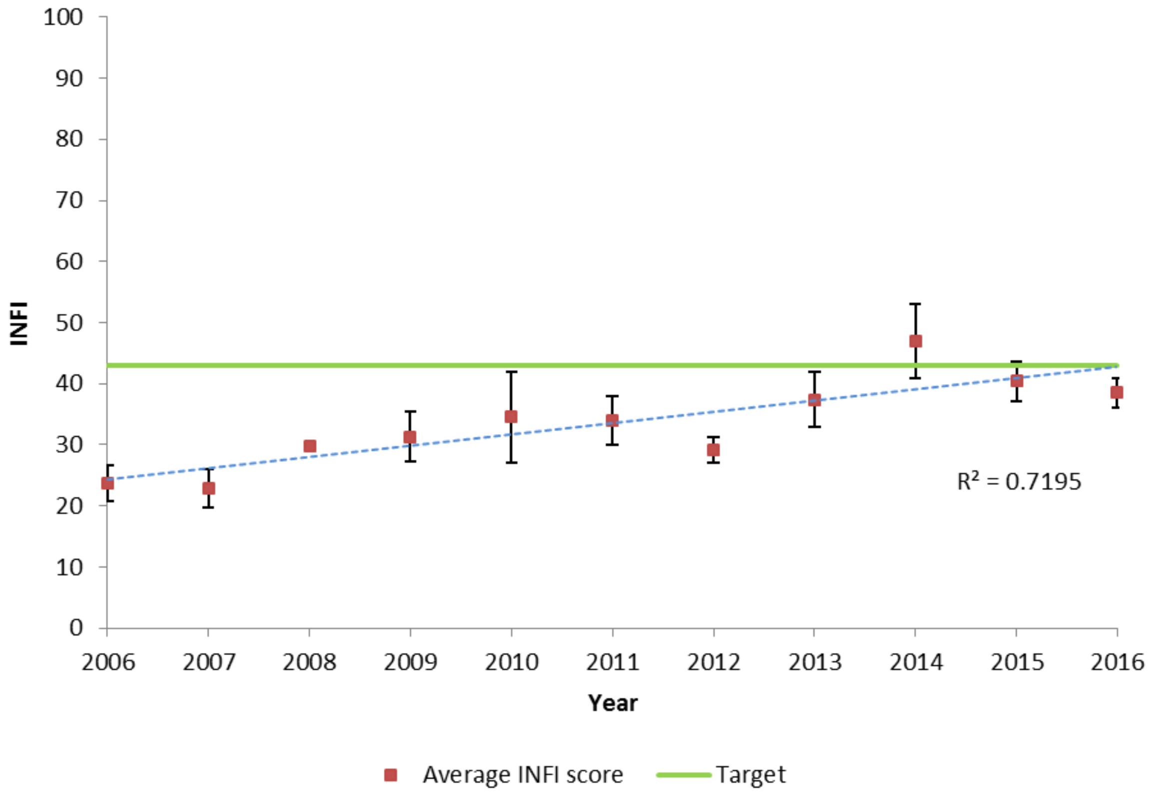


Figure 18: Average infiltration index scores for woodland rehabilitation 2006 - 2016

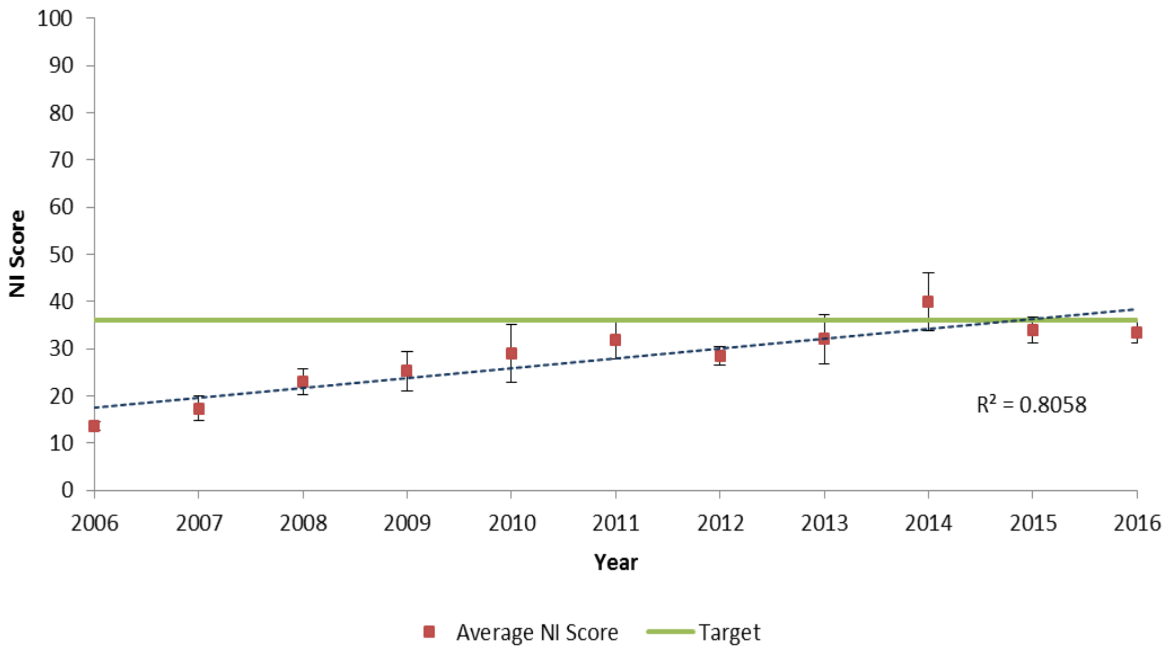


Figure 19: Average nutrient index scores for woodland rehabilitation 2006 - 2016

Table 20: Site description of each woodland rehabilitation transect

Transect	Note	Photograph
3R	A relatively flat transect through a planting of *Eucalyptus cladocalyx* (Sugar Gum). The understory is very sparse and leaf litter is the major patch type. Some bare rocky soil areas are present at the end of the transect.	

4R	This transect travels along a small ridge and slopes slightly towards the end. The transect is surrounded by plantings of *Eucalyptus cladocalyx* and *Corymbia maculata* (Spotted Gum). Understory is very sparse and again leaf litter is the major patch type	
.6R	This site is the best performing woodland rehabilitation monitoring site. A canopy of *Eucalyptus cladocalyx* is present with several native midstory species and native grasses and herbs. The weed *Galenia pubescens* also occurs in small patches. A dense cover of leaf-litter is present.	

8R	This transect is located on a lightly sloping site with plantings of *Eucalyptus cladocalyx* and *Corymbia maculata*. Leaf litter and rock are the major patch types. Several areas of bare rocky soil are present.	

4.3.3 Pasture rehabilitation

Pasture rehabilitation is currently meeting performance targets for all attributes with the exception of landscape organisation (LOI), which has a relatively high score despite not meeting the performance target. The average LOI was reduced by the influence of sites 2R and 5R, which performed the worst in terms of LOI.

Site 5R had a road being constructed through the transect in 2016, creating bare areas that affected the LOI score. Despite this change the average LOI score for pasture sites in 2016 was identical to that recorded in the previous year (0.84) and all other indices were also very similar to the previous year.

LOI scores from 2006 to 2016 show an increase in scores between 2006 and 2012 (**Figure 20**), with performance criteria achieved in the years 2009-2012. The sharp drop and then rapid increase in LOI scores during 2013-14, lead to the conclusion that 2013 values may represent an erroneous LOI score. LOI values then drop below performance criteria in 2015 and remain very similar in 2016.

Other LFA indices have consistently met performance criteria for several years. Scores for infiltration and nutrient indices appear to be improving over time (**Figure 21, Figure 22** and **Figure 23**).

Plate 18: Pasture rehabilitation area dominated by *Chloris gayana* (Rhodes Grass), near site 7R

Table 21: LFA scores and performance criteria for pasture rehabilitation areas 2016

Monitoring Plot	LOI	ST	INFI	NI
1R	0.85	65.6	44.4	36.9
2R	0.58	51	32.5	24.1
5R	0.63	61	35.80	27.8
7R	1	51.8	33.70	30.9
9R	0.8	67.2	36.40	32.3
10R	0.93	68	43.80	37.4
16R	0.98	67	49.70	44.8
33R	0.99	71.1	51.00	46.8
34R	0.78	60	39.40	34.1
Average score	0.84	62.52	40.74	35.01
Target score	0.93	61	29	25

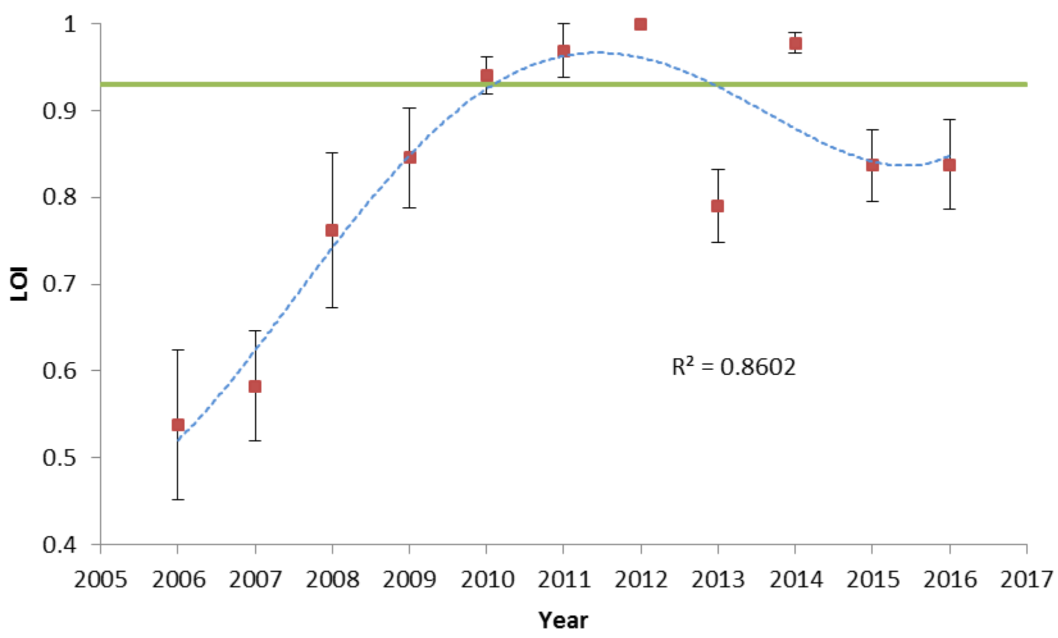


Figure 20: Average Landscape Organisation Index scores from pasture rehabilitation sites 2006-2016. Error bars represent standard error and green bar represents performance criteria.

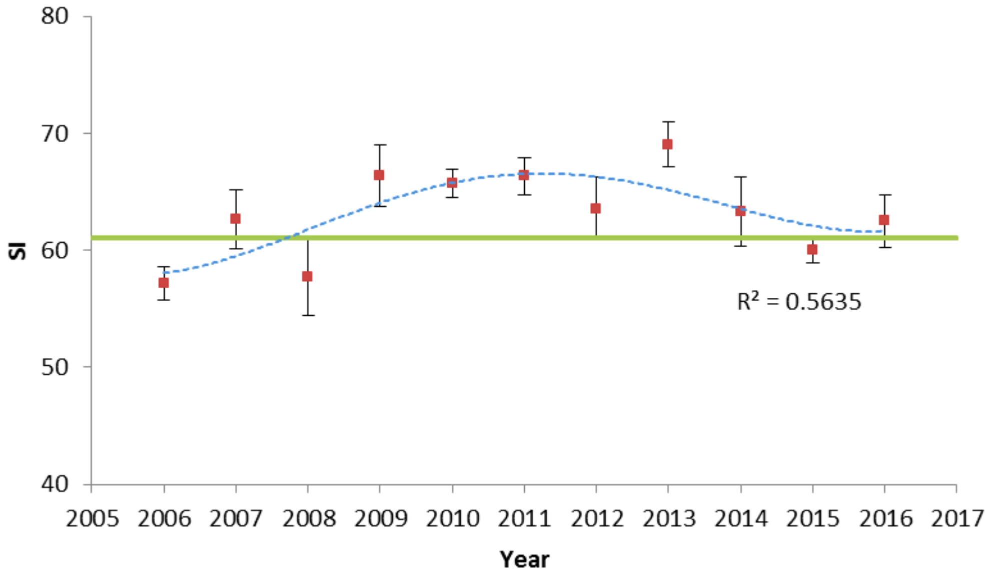


Figure 21: Average Stability Index scores from pasture rehabilitation sites 2006-2016. Error bars represent standard error and green bar represents performance criteria.

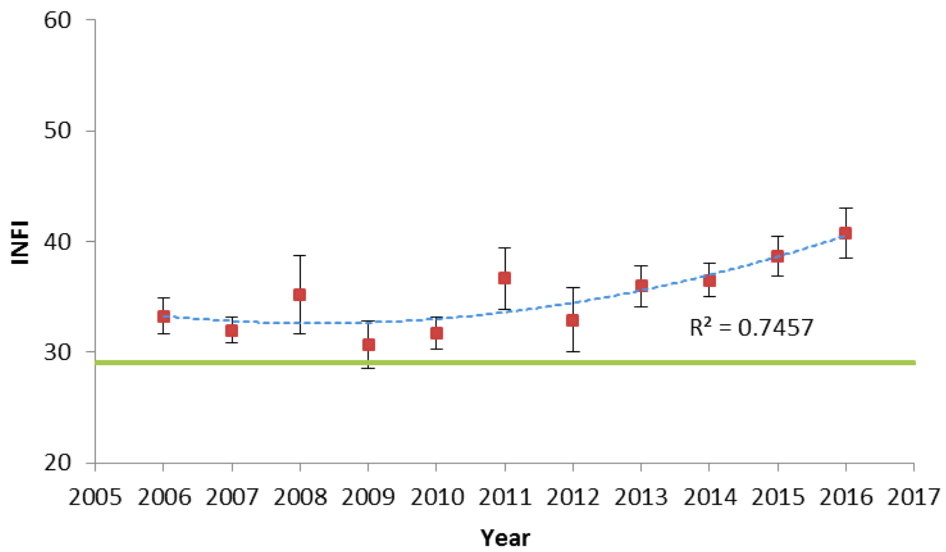


Figure 22: Average Infiltration Index scores from pasture rehabilitation sites 2006-2016. Error bars represent standard error and green bar represents performance criteria.

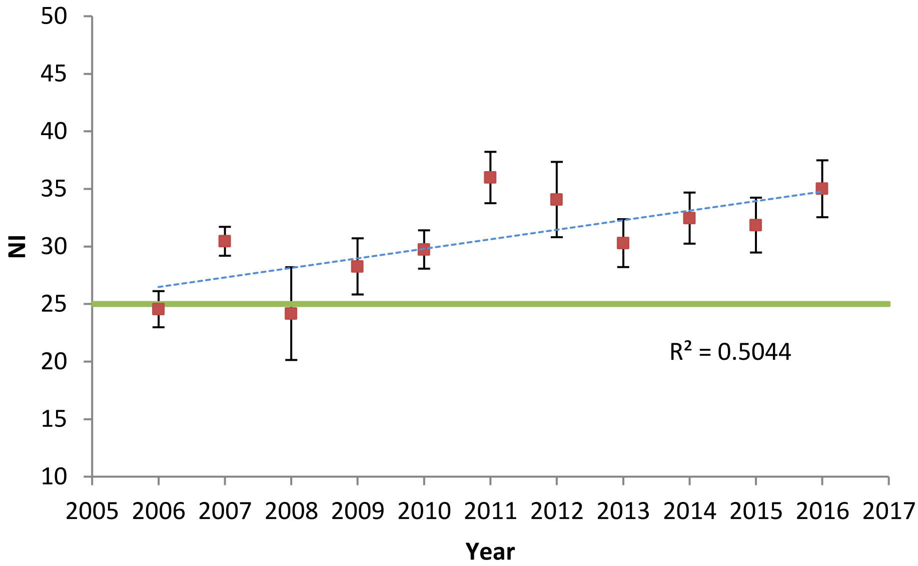


Figure 23: Average Nutrient Index scores from pasture rehabilitation sites 2006-2016. Error bars represent standard error and green bar represents performance criteria.

Table 22: Site description of each pasture rehabilitation transect

Transect	Notes	Photograph
1R	Large clumps of *Chloris gayana* are the main stabilising feature of this rehabilitation area near the coal preparation plant.	

Transect	Notes	Photograph
2R	This transect runs down a very slight slope and is composed of low grasses and herbs with several bare patches.	
5R	Construction appeared to be underway on a road through this transect, with several bare patches and disturbed ground. This transect should be relocated or removed from the pasture monitoring program.	

Transect	Notes	Photograph
7R	Transect is a mixture of grassy patches, tussocks and exotic herbs. The locally native *Acacia salicina* (Willow Wattle) is colonising rehabilitation in this area.	
9R	Clumps of *Galenia pubescens* are common around a large soil scald within this transect. Large clumps of *C. gayana* are the dominant feature for the remainder of the plot	

Transect	Notes	Photograph
10R	Transect dominated by patches of *Melilotus* sp. and *Anagallis arvensis* and runs downslope through several grassy patches towards a wet area. The transect crosses a small kangaroo track.	
16R	Transect primarily composed dense tussocks of *C. gayana* with dead grass leaf litter, low grass and patches of exotic herbs such as *Senecio madagascariensis*	

Transect	Notes	Photograph
33R	Transect primarily composed dense tussocks of *C. gayana* with dead grass leaf litter, low grass and patches of exotic herbs	

Transect	Notes	Photograph
34R	Transect primarily composed dense tussocks of *C. gayana* with dead grass leaf litter, low grass and patches of exotic herbs	

4.4 Conclusion and recommendations

4.4.1 North Wambo Creek diversion

The North Wambo Creek diversion area has not yet met completion criteria for landscape function and although no decline in average landscape function indices was recorded from the previous monitoring to the present, this area will require additional management actions to ensure that all completion criteria are met in the near future.

Most monitoring sites have few if any native groundcover species and consist of predominantly low pasture, with tussocks of *Chloris gayana* (Rhodes Grass). If the long-term goal for the diversion is to achieve a substantial native species cover, then establishment of overstorey and midstorey species should be a priority. It is understood from WCPL (2015) that weed management, the repair of erosion and re-seeding with native pasture and tree species was scheduled for 2016. It is recommended to review the rehabilitation strategy for the creek and develop a strategy to achieve the desired outcomes before continuing with these activities in 2017. The establishment of native trees and shrubs on batters and slopes of the diversion is recommended for both erosion control and creation of fauna habitat. Woodland species from the Narrow-leaved Ironbark - Bull Oak - Grey Box forest/woodland from nearby areas may be more appropriate for the majority of the creek diversion and will likely establish more readily than riparian species in these areas due to the ephemeral nature of the creek. Shallow soils adjacent to the creek channel in the south of the diversion area and the planting of riparian species with high water requirements may have contributed to the failure of tree and shrub plantings in previous years. Riparian tree species such *Casuarina cunninghamiana* could be planted in the creek bed, where natural regeneration is deemed to be insufficient or likely to occur on an insufficient timeframe.

Erosion was also noticed particularly on steeper slopes, some of which may exceed the limits set for completion criteria. Attempts to establish vegetation cover as mentioned above will assist in achieving completion criteria for erosion.

4.4.2 Woodland rehabilitation

The LFA indices examined display a trend of improvement over time, presumably largely because of leaf litter accumulation, which was the common patch type in 2016. However most LFA indices have not improved or declined slightly from 2014 to present and are currently falling below completion criteria.

Recommendations to improve LFA results are similar to those provided by the previous monitoring and those for floristic criteria, as increasing the complexity of ground cover or woody debris will improve landscape organisation scores and over time improve stability, infiltration and nutrient indices. However due to the large effort and cost involved in trying to enhance older rehabilitation areas, WCPL could instead focus on ensuring new areas of woodland rehabilitation are planned and implemented correctly.

4.4.3 Pasture rehabilitation

Pasture rehabilitation was observed to be in good condition in regards to LOI with high cover of vegetation and other resource trapping patches. Average LOI scores were very similar to the previous year and remain high despite falling slightly below performance criteria. The remaining LFA indices are meeting performance criteria with the average infiltration and nutrient indices improving since 2006.

Sites 2R, 5R and 9R remain the worst performing sites within pasture rehabilitation areas. Actions to improve poorly performing pasture sites could involve the slashing of large grass tussocks and subsequent mulching of bare areas to improve the soil profile in bare areas. A road was being constructed partially through 5R in 2016 and this site should be either relocated to a more representative location or removed from the monitoring program in future years.

5 Riparian condition assessment

5.1 Introduction

The riparian EFA monitoring program is a requirement of the 2004 development consent conditions. The objective of the monitoring program is to evaluate how the riparian environment is responding to management initiatives (such as cattle exclusion) and document any impacts arising from mine subsidence.

North Wambo Creek drains the mid and eastern sections of the North Wambo Underground Mine development area and flows south-east into Wollombi Brook, approximately 600 m south of the Mine. North Wambo Creek has been highly disturbed both by historic and present grazing activities and by the North Wambo Creek Diversion. The diversion channels the creek around the open-cut mining operation.

Stony Creek drains from Mount Wambo in a north-east direction and meanders across the western boundary of coal lease (CL) 397 near the south-western boundary of the North Wambo Underground Mine and passes in a south-easterly direction through the existing underground development area of WCPL to join South Wambo Creek. South Wambo Creek then runs east to join Wollombi Brook. Much of the riparian zone on South Wambo Creek has been disturbed by historic agricultural activities.

5.2 Methods

Field sampling for the riparian monitoring was undertaken between October 5 and 14, 2016. Due to deficiencies in the previous riparian condition scoring system, the *Rapid Appraisal of Riparian Condition* method, developed by Jansen et. al. (2005), was trialled in 2016. Using this method an overall score is obtained at each monitoring site by examining the width of riparian vegetation, proximity to large patches of native vegetation, vegetation cover, debris (leaf litter, standing dead trees and fallen logs) and other features (native canopy and understory regeneration, tussock grasses and reeds on creek banks).

Three sample sites were selected on each of the three creeks, in similar locations to previous monitoring sites. Sample site "*North Wambo 1*" and "*Stony 1*", sample riparian areas to the south of previous monitoring areas.

Methods followed Jansen et. al. (2005) with four 40 m long cross-section transects used to sample a ~500 m length of riparian zone. The location of sample sites and transects is illustrated in **Figure 24.**

The three creeks and sample sites were compared in regard to the sub-indices of habitat continuity and extent (*Habitat*), vegetation cover and structural complexity (*Cover*), dominance of natives versus exotics (*Native*), Standing dead trees, fallen logs and leaf litter (*Debris*) and other indicative features such as regeneration, presence of large native tussock grasses (e.g. *Austrostipa* spp.) and reeds (*Features*) along with the total score.

Due to changes in monitoring methodology, both in past years and the current year, a direct comparison between the current and past years cannot be made. However three previous reports (RPS 2010, Niche 2014d and ELA 2015) were reviewed and conclusions drawn from these observations and data collected.

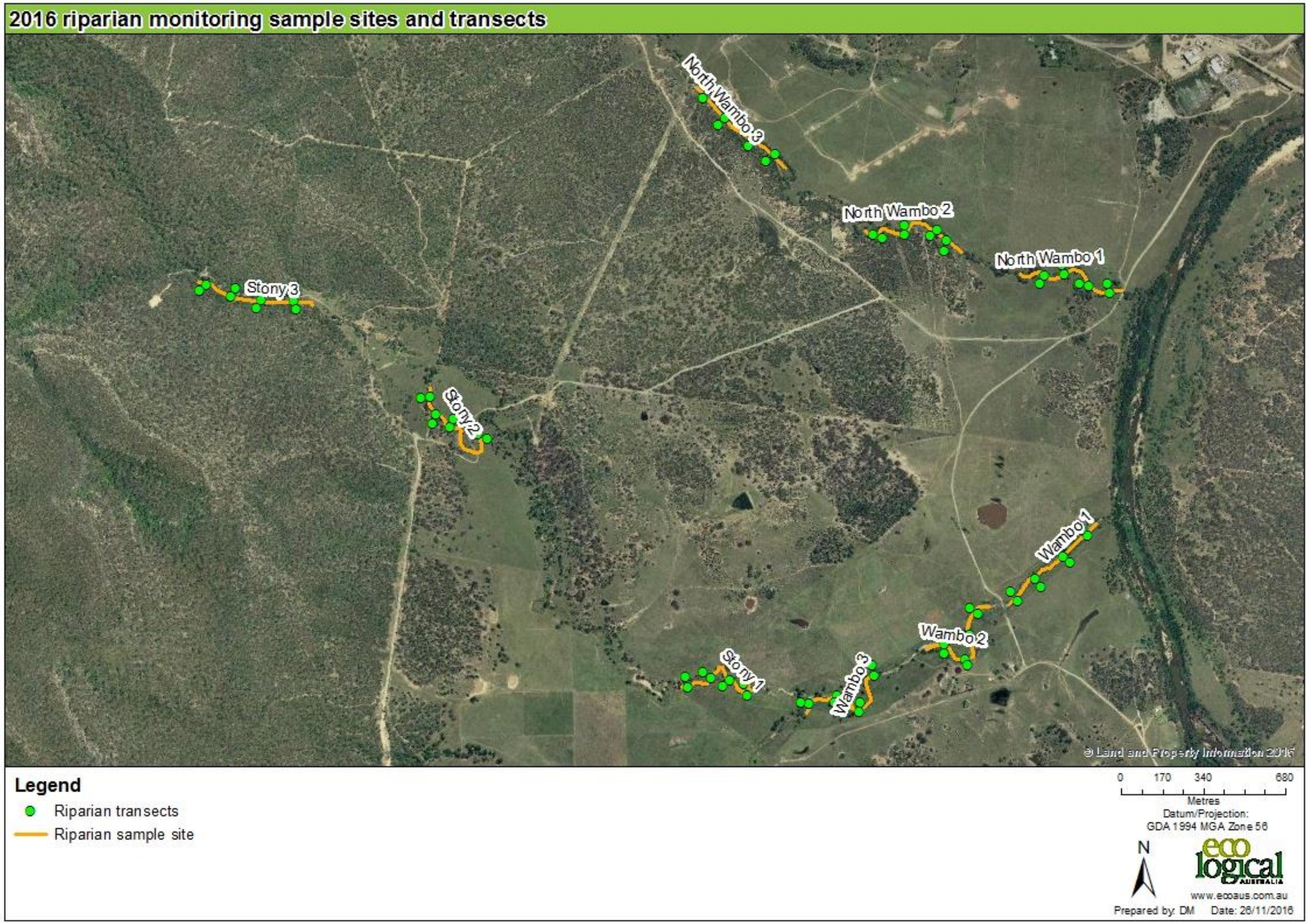


Figure 24: Location of riparian monitoring cross-sections and transects

5.3 Results

The results of the riparian condition monitoring are presented below, with raw data included in Volume 2 of this report.

Of the three creeks, South Wambo Creek had the poorest average score (18.44) and in comparison to the other creeks scored most poorly in regards to the 'Habitat' sub-index, which combines the scores for longitudinal continuity of riparian vegetation, average width of riparian vegetation and proximity to a patch of native vegetation >10ha. This low score for the "Habitat" sub-index largely reflects the generally sparse and narrow width of vegetation in the riparian zone of South Wambo Creek (**Figure 25**).

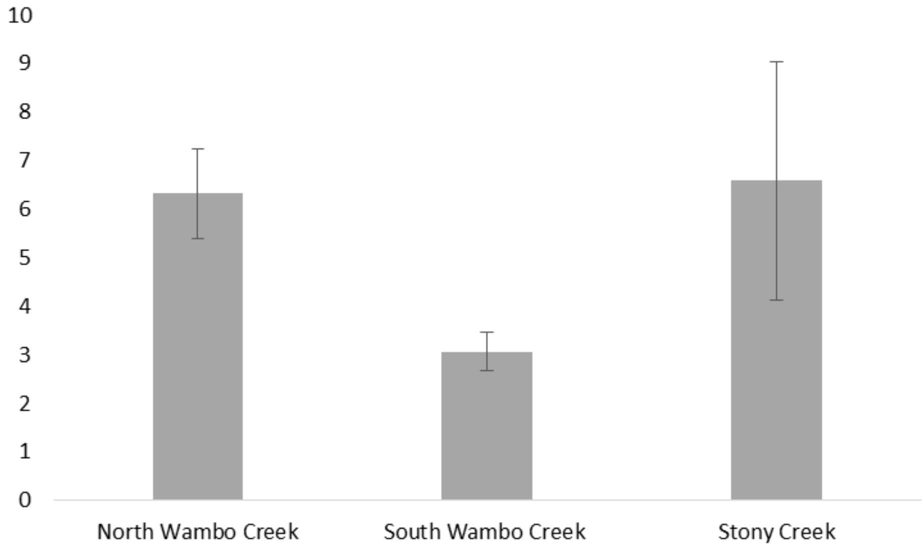


Figure 25: Average "Habitat" scores for North Wambo, South Wambo and Stony Creeks 2016

Stony Creek had the highest average score of the three creeks (25.42) and scored much more highly for "Debris" than the other creeks (**Figure 26**). However this creek also had the most variable scores over the three transects. This average score was elevated through the inclusion of sample site "Stony 3", which is located in relatively intact vegetation and received a much larger score than other sample sites. The remaining two sample sites on Stony Creek scored similarly to sample sites on North Wambo Creek.

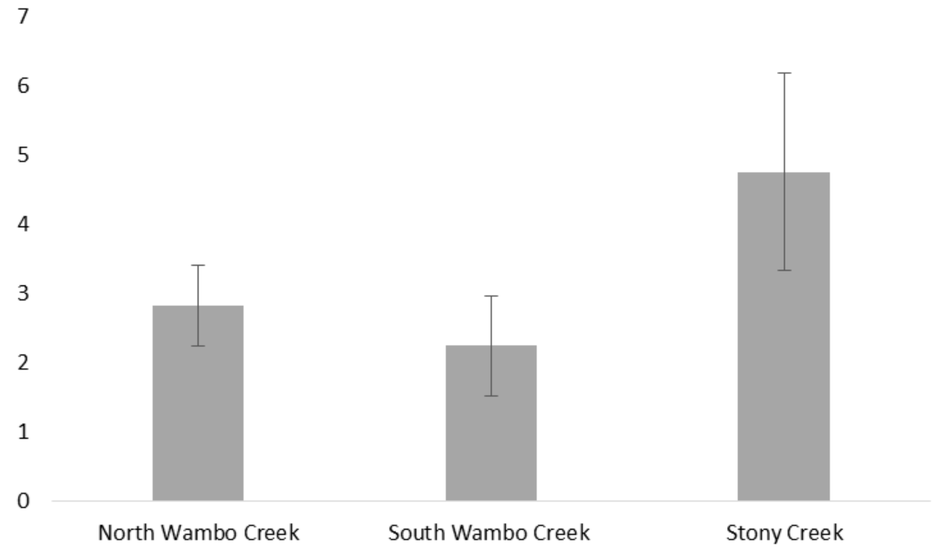


Figure 26: Average "Debris" scores for North Wambo, Wambo and Stony Creeks 2016

Surprisingly, recorded scores for cover were very similar. This may be related to the scoring system for canopy cover in the *Rapid Appraisal of Riparian Condition* method where a score of 0-3 is given for canopy and ground cover where 1-30% cover = 1 and 30-60% =2 to a maximum score of 3 for >60% cover. This criteria for canopy is likely unrealistic for the riparian environments assessed.

A direct comparison between the current and past years cannot be made due to differences in methodology and location of monitoring sites. However monitoring by ELA in 2015 (ELA 2016a) found that North Wambo Creek appeared to have improved in condition since 2009, while recorded changes in the other two creeks were relatively minor and may have been due to issues with the previous scoring methods. Niche 2014d examined changes between 2013 and 14 and concluded that limited change had occurred, with no evidence of deleterious impacts from mining activity. However some potential subsidence impacts were noticed during 2015 in the riparian zone at North Wambo Creek (ELA 2016a). No additional subsidence impacts were recorded in 2016.

South Wambo Creek was recorded as being in the poorest condition in 2015 and continues to stand out as having the lowest condition score in comparison to the other two creeks.

5.4 Conclusions and recommendations

South Wambo Creek was found to be the worst performing creek out of the three. The recommendations by Niche (2014d) to plant trees along South Wambo Creek are still applicable. Continuing to restrict cattle access to the riparian zone and plantings of trees in over-cleared riparian areas will be beneficial to this area, with broader plantings of more benefit than narrow strips along the banks. Recommended tree species to plant include the endangered Hunter Valley population of *E. camaldulensis* (River Red Gum), *E. tereticornis* (Forest Red Gum), *E. melliodora* (Yellow Box), *A. floribunda* (Rough-barked Apple) and *C. cunninghamiana* (River Oak) which occur on nearby creeks and floodplains. Tube stock or seed of all species planted should be collected locally, particular emphasis should be put on the local collection of River Red Gum as the Hunter Valley population is endangered.

Due to changes in methodology comparison with previous monitoring events is problematic. An increase in condition scores between 2015 and 2009 was previously observed for North Wambo Creek (ELA 2016a). This change in score was due to improvements in midstorey scores, reduction in weeds and less feral animal activity observed during 2015. Improvements at Stony Creek and South Wambo Creek were less obvious and have had a similar condition score recorded in 2009.

The *Rapid Appraisal of Riparian Condition* method provides a relatively simple and proven scoring system for measuring the condition of riparian zones by scoring vegetation and habitat features. Previous scoring methods had several issues which the current methodology appears to overcome. However if this method is adopted in future monitoring events, then consideration should be given to modifying the canopy cover scoring system slightly to suit the environmental conditions at WCPL. Emphasis on maintaining one scoring method for the riparian monitoring program will allow scores to be compared between over time.

6 Bird surveys and observations

6.1 Introduction

The bird monitoring program is a requirement of the current development consent conditions and has been designed to in an effort to measure the performance of the Wambo RWEP. The consent conditions (DA 305-7-2003) specify that "*Terrestrial fauna surveys should be conducted to monitor the usage of enhancement areas by vertebrate fauna. Monitoring may include fauna species diversity and abundance or, alternatively, the use of indicator species to measure the effectiveness of enhancement measures*".

Methods, results including a comparison with previous monitoring and interpretation of results in included below.

6.2 Methods

Surveys for *Lathamus discolour* (Swift Parrot) and *Anthochaera phrygia* (Regent Honeyeater) were conducted on August 30, 2016. This survey focussed on habitats with *C. maculata* as the main canopy species as this species is known to provide foraging habitat for both species (when in flower). Riparian habitats along Wollombi Brook within RWEA 'A' were also inspected as *Amyema cambagei* (She-oak Mistletoe) and riparian and floodplain habitats in general are known to be important for Regent Honeyeater.

Bird monitoring in spring was consistent with ELA (2016a) in timing of surveys and methods. During the Observers spent 10 minutes recording birds seen and heard within 50 m radius (0.8 ha) of a central point, followed by a further 10 minutes searching the balance of a 2 ha plot and recording the total numbers of birds detected (heard and seen) during a 20 minute sampling period.

Each of the 26 sites were surveyed on two separate occasions between October 5 and 14, 2016 (**Figure 27**), with one morning and one afternoon survey per site. This differs from Niche (2014b) where each site was surveyed three times over three days during the same month. Previous surveys by RPS in 2007-2012 have also varied in methodology and data collected. Thus only data from the current monitoring period and the previous year can be compared with confidence. Species lists from 2009, 2014 and 2015 were used for comparison with the current year.

The maximum count from either of the two surveys was used to determine relative abundance of each species for each site.

Figure 27: Bird monitoring locations and remnant woodland enhancement areas

6.3 Results

A diverse bird assemblage was observed at the bird monitoring locations within RWEAs and surrounding land. The 2016 monitoring observed a total of 78 bird species during formal bird surveys. This is a slightly lower species count than the previous two years when 86 species were recorded during 2015 and 94 species in 2014 during the 52 timed surveys at the 26 monitoring sites. However this species count is not likely to be significantly different from previous monitoring surveys (**Figure 28 & Figure 29**). The number of bird species detected within monitoring sites has varied over time between a low of 64 species in 2012 to 94 species detected in 2014. The additional survey effort conducted in 2013 and 2014 (Niche 2014) may explain the slightly elevated number of species recorded in these years. Variability in species richness between years are likely explained by a combination of factors such as numbers of nomadic and migratory bird species, weather, sampling methods, skill of observers and timing of surveys.

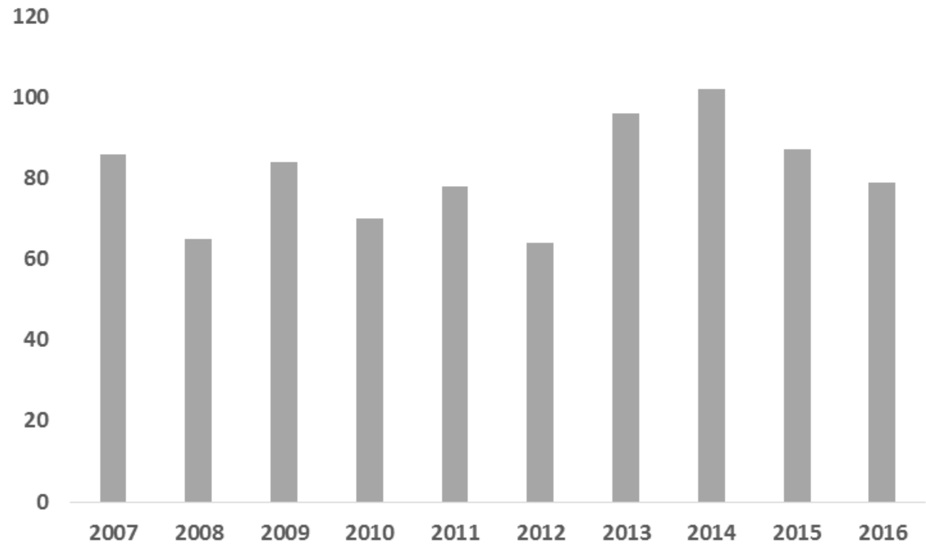


Figure 28: Number of bird species recorded at 26 monitoring plots each year between 2007 and 2016

The average number of bird species recorded per site remains very similar to the previous year (**Figure 29**). The number of species detected at each site varied between 8 (at site BP12) and 28 (at BP11) with an average of 18 species recorded per monitoring site.

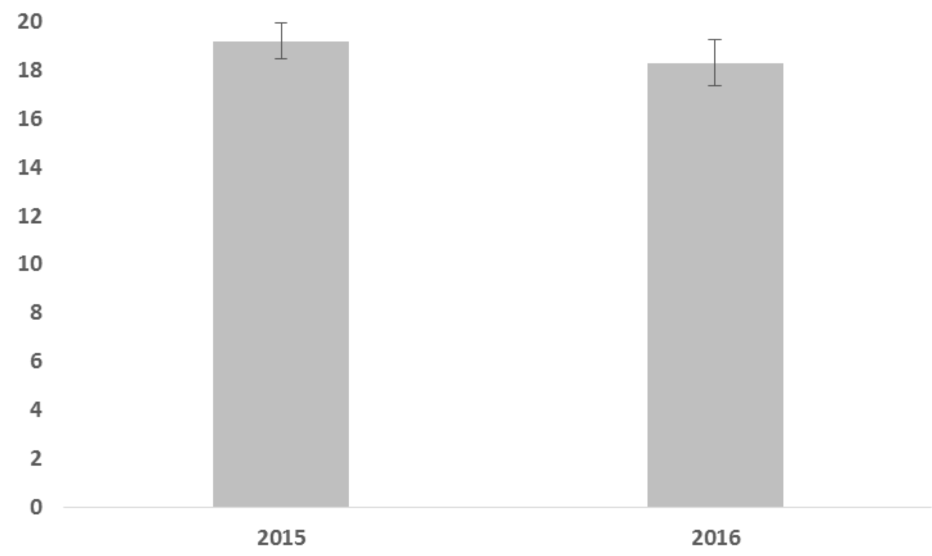


Figure 29: Average number of bird species recorded at the same 26 monitoring plots during October in 2015 and 2016. Error bars represent standard error.

The most species diverse site in 2016 was BP11, (28 species), followed by BP3 (26). BP11 is located on Stony Creek at the periphery of different 3 habitat types, while BP3 samples riparian habitat on Wollombi Brook. Species counts at these sites were also high in 2015. Site BP12, located on a woodland ridgetop has consistently been the most species poor site, with only 8 species recorded in each year during 2015 and 16 and “the lowest median count of species in 2008-2012 and the lowest total counts in 2013 and 2014” (Niche 2014b).

Bird assemblages in 2016 appear broadly similar to the previous 2 years and also 2009. *Pachycephala rufiventris* (Rufous Whistler) and *Lichenostomus chrysops* (Yellow-faced Honeyeater) were the two most widely recorded species in the last three monitoring events 2016, 2015 and 2014. Seven other species have remained in the top 20 most widely recorded species in each year 2014-2016. Ten of the twenty most widely recorded species in terms of monitoring sites in 2009 were in the top 20 most widely recorded species in 2016.

In addition two-thirds of the total species recorded in both 2015 and 2016 were recorded in both years and 70 % of the species recorded during timed surveys in 2014 were also recorded in 2016. Differences between 2014 and 2016 were mostly due to several species of waterbirds and migratory/nomadic birds and cryptic or uncommon species at WCPL. Species that were widely recorded during 2014 but were not recorded in 2016 included *Neochmia temporalis* (Red-browed Finch) (10 sites), *Taeniopygia bichenovii* (Double-barred Finch) and *Myiagra rubecula* (Leaden Flycatcher) (9 sites), *Lichenostomus fuscus* (Fuscous Honeyeater) and *Coracina tenuirostris* (Cicadabird) (7 sites). Red-browed Finch was also recorded at 10 of the 24 monitoring sites in 2009.

Six threatened species listed under the NSW TSC Act and one species listed as migratory under the Commonwealth EPBC Act were recorded during 2016 surveys (**Table 23**). The same group of threatened species were recorded in 2014 and 2015 with some exceptions. Two additional threatened species, *Petroica boodang* (Scarlet Robin) and *Grantiella picta* (Painted Honeyeater) were recorded in 2014 and 2015 respectively. *Melanodryas cucullata* (Hooded Robin), Scarlet Robin, *Calyptorhynchus lathami* (Glossy Black-Cockatoo) and *Circus assimilis* (Spotted Harrier) were all observed on a single occasion outside of designated bird surveys in 2015 but were not observed in 2016.

Table 23: Relative abundance of threatened species recorded during bird monitoring in 2015 and 2016 and the number of monitoring sites of which each threatened or migratory species was recorded 2009, 2014, 2015 and 2016

Scientific Name	Common Name	TSC Act status	EPBC Act status	Relative abundance 2015	Relative abundance 2016	No. of sites 2009	No. of sites 2014	No. of sites 2015	No. of sites 2016
Chthonicola sagittata	Speckled Warbler	V	-	16	15	11	16	7	9
Daphoenositta chrysoptera	Varied Sittella	V	-	13	10	2	13	6	2
Glossopsitta pusilla	Little Lorikeet	V	-	6	9	0	0	3	4
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-	5	3	1	0	3	2
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	2	16	1	2	1	4
Grantiella picta	Painted Honeyeater	V	V	1	0	0*****	0	1	0
Artamus cyanopterus	Dusky Woodswallow	V	-	22	3	1	5	4	1
Melanodryas cucullata	Hooded Robin	V	-	0*	0	1	0	0*****	0
Merops ornatus	Rainbow Bee-eater	-	M	7	10	3	11	5	7

***** = recorded incidentally outside of monitoring plots

Comparison of the relative abundance of threatened woodland birds and the Rainbow Bee-eater (listed as migratory) between 2015 and 2016 show that the relative abundance of Speckled Warbler, Varied Sittella, Brown Treecreeper, Little Lorikeet and Rainbow Bee-eater is similar to the previous year. Fewer Dusky Woodswallows were recorded while many more Grey-crowned Babblers were recorded at three additional monitoring locations in 2016 than 2015.

Comparison of the frequency of occurrence of these threatened and migratory species reveal that the Speckled Warbler, Varied Sittella, Dusky Woodswallow and Rainbow Bee-eater were detected at more sites in 2014 than 2009, 2015 and 2016. The frequency of occurrence of threatened species in 2016 was generally similar to 2015 with the exception of Varied Sittella (detected at 4 fewer monitoring sites), Dusky Woodswallow (detected at 3 fewer monitoring sites) and Grey-Crowned Babbler (detected at 3 additional sites.

6.4 Conclusion and recommendations

RWEA and other remnant woodland sites at WCPL continue to support a large diversity of bird species. One hundred and sixteen bird species have been recorded during timed bird surveys over the last three years, with 78 of these recorded in 2016. The total number of bird species detected each year has varied over time but those recorded in 2016 are consistent with previous years. No exotic bird species were detected within RWEP areas.

Bird assemblages in 2016 appear broadly similar to the other years examined in this analysis and review of previous results. Differences in the species recorded were observed between years. Some of these differences are due to nomadic honeyeaters, waterbirds and lorikeets or irregular migratory species such as the Cicadabird, that are present during monitoring surveys in some years but absent in others. Some of the threatened species recorded during bird surveys at WCPL, such as the Little Lorikeet and Painted Honeyeater, also fit this description and have been recorded in multiple years but are absent in others. Cryptic and uncommon species such as also contribute to differences. Both Double-barred and Red Browed Finches were absent from the current survey but were previously recorded widely in 2009, 2014 and slightly less so in 2015. The reasons behind the absence of these finches in 2016 are unclear but may be due to changes in resource availability, such as grass seed and water.

The relative abundance of sedentary threatened woodland birds such as Speckled Warbler, Varied Sittella and Brown Treecreeper appear to have remained very similar between monitoring events during spring 2015 and 2016. Additional survey effort in 2014 possibly explains the larger number of sites where Speckled Warbler and Varied Sittella were recorded in that year.

As mentioned in previous reports, the analysis of bird data in order to measure the effectiveness of woodland enhancement measures is limited by both the design of the current monitoring program, previous changes in methodology, the type of data previously collected, and limited data from previous bird monitoring. Data available for analysis for this report was limited to three previous reports by RPS (2010), Niche (2014b) and ELA (2016a). Interpretation of the data was further limited as RPS (2010) did not record relative abundance data and provided a species list only, while different survey methodology between Niche (2014) and the past two years prevented a comparison with bird community data collected in 2014. A previous flora and fauna monitoring review by ELA (2016b) has discussed these issues in detail and recommendations included in the review remain relevant. It is recommended WCPL develop a clear measurable objective for the bird monitoring program and re-design the monitoring program accordingly.

While broad comparisons and observations have been made (primarily between the last three years), longer term monitoring using consistent methods and statistical analysis to detect trends in bird distribution and abundance over time will be more meaningful than any year to year comparisons in separating trends in bird distribution and abundance from short-term fluctuations.

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REF/Job No: 16NEW - 4946

29 March 2017

Dear Harry,

Subsidence assessment

Eco Logical Australia (ELA) was engaged by Wambo Coal Pty Ltd on behalf of Peabody Energy to conduct a subsidence assessment resulting from longwall extraction from the South Bates Underground (SBU), within the broader Wambo Coal Mining Lease (WCML).

Broadly, this assessment aims to determine the extent and significance of any impacts resulting from mining subsidence to threatened and/or migratory species, populations, or ecological communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and/or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Vulnerable ecological communities (VECs) identified under the TSC Act have not been considered in this report, as under Section 5D of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), reference to threatened species, populations and ecological communities does not include a reference to any VEC.

Specifically, this assessment aims to fulfil Condition 22, 22A, Schedule 4 of DA305-7-2003 whereby subsidence performance measures must be monitored in regards to the longwall extraction of SBU. This report also considers the impacts of subsidence that may result from the longwall extraction of North Wambo Underground (NWU). The location and vegetation communities present within SBU and NWU is shown on **Figure 1**.

Data utilised within this assessment has been adapted from information presented within Chapter 3 of the *Wambo Coal Mine Flora and Fauna Monitoring Report - Volume 1* (ELA, 2016) and presents only the data captured within the SBU and NWU project boundaries. A formal parallel traverse of mined areas was not undertaken as part of this assessment.

Methods

A mine subsidence inspection was conducted opportunistically while survey teams were traversing between Remnant Woodland Enhancement Areas (RWEA) during the 2016 flora, fauna and riparian condition monitoring. Observations were made within RWEA monitoring sites, as well as during traverses between sites.

Ponding observed through interpretation of recent aerial imagery has also been included in this assessment.

The location of subsidence cracks >10 cm width and other subsidence features encountered opportunistically during monitoring fieldwork were recorded and a photograph taken. The level of disturbance and condition of surrounding vegetation was also noted.

Photographs and descriptions of the subsidence impacts observed are shown in Table 15 of the 2016 annual monitoring report (ELA, 2016).

Results

Cracking and small pits along with water filled depressions caused by subsidence was observed within land owned by WCPL. Within SBU, minor cracking of the surface was observed in several locations. No ponding was observed in SBU. Within NWU, no cracks were observed, however an area of grassland appeared to have sunken and was accumulating surface water, and review of recent aerial imagery confirmed that water did not accumulate there previously.

An assessment of the subsidence impacts against threatened species and ecological communities is described within the table below:

Monitoring Components	Subsidence Impact Performance Measure	Assessment of Subsidence Impact Performance Measure within SBU and NWU
Warkworth Sands Woodland Community (Endangered)	*Minor cracking and ponding of the land surface or other impact.* *Negligible environmental consequences.*	Warkworth Sands Woodland does not occur within SBU or NWU. No impacts or environmental consequences to this community were observed.
White Box, Yellow Box, Blakely's Red Gum Woodland/ Grassy White Box Woodland Community		White Box, Yellow Box, Blakely's Red Gum Woodland/ Grassy White Box Woodland does not occur within SBU or NWU. No impacts or environmental consequences to this community were observed.
Other Threatened Species, Populations or Communities	*Minor cracking and ponding of the land surface or other impact.* *Negligible environmental consequences.*	Minor cracking of the land surface was observed within the Central Hunter Box – Ironbark woodland (TSC Act Endangered, EPBC Act Critically Endangered) and other non-threatened vegetation communities within SBU. Cracking was relatively frequent where observed, however the majority of observed cracks were considered small and would have negligible impacts on native vegetation. Some cracks may act as pitfall traps for reptiles and will need to be remediated to prevent unwanted impacts. If remediated, the cracking is considered to have negligible ongoing impacts.

Conclusion and recommendations

A range of minor subsidence features were observed opportunistically within SBU and NWU. Impacts to vegetation within SBU and NWU appears to be negligible. In addition, many smaller cracks and depressions are likely to self-repair over time. Larger cracks (i.e. >100mm) should be filled with appropriate inert and weed-free material (such as gravel) to minimise injury to both humans and wildlife.

Some of the deeper cracks pose a risk to wildlife and further action such as identification of potential remediation actions is warranted. Remediation of these cracks should be undertaken with light equipment to minimise additional damage to vegetation. The long term impacts of these cracks if remediated would be considered negligible.

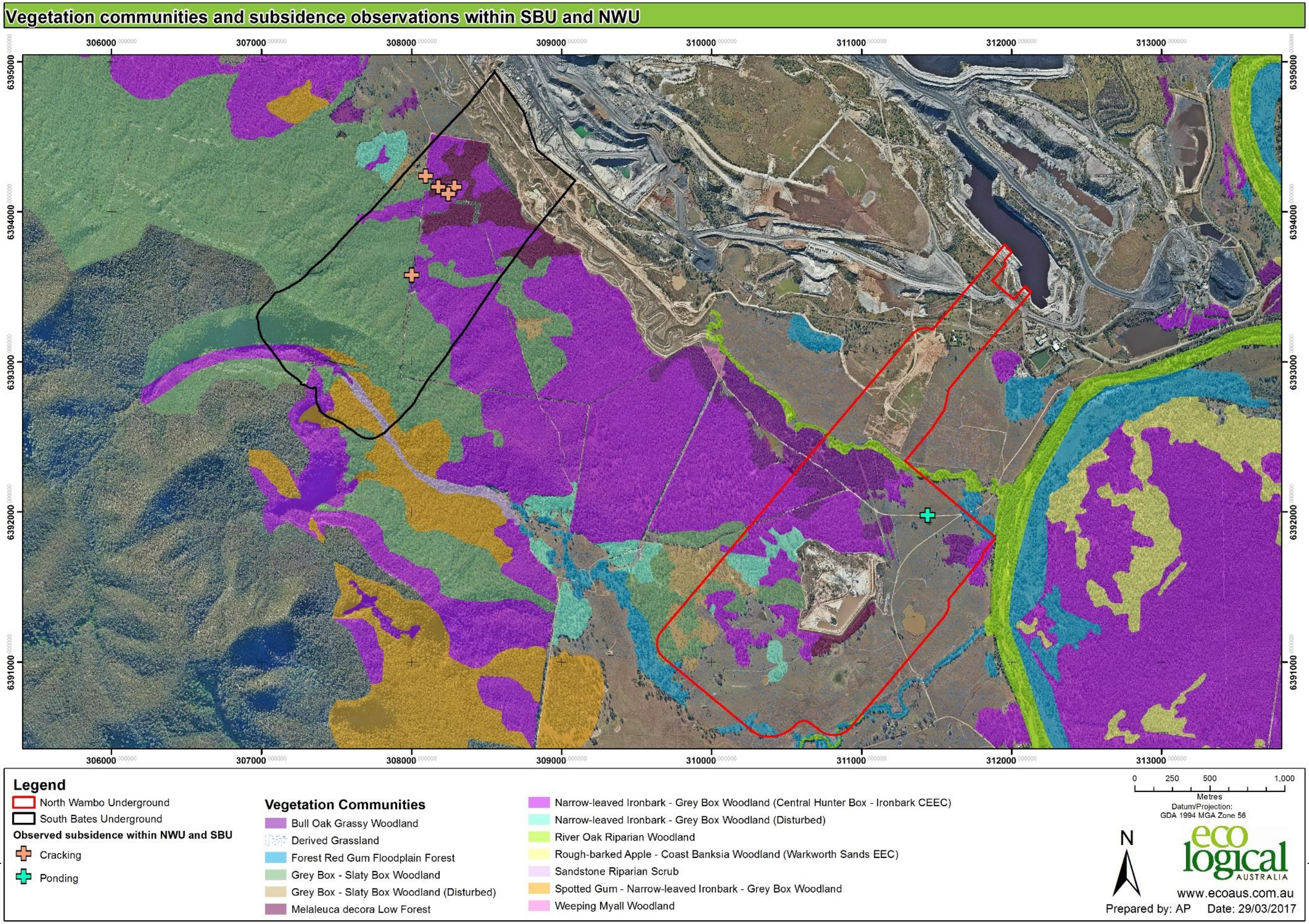
In future monitoring surveys, ELA recommends the following action be taken to monitor and respond to mining subsidence in SBU and NWU:

- Conduct a walk-through of each long-wall panel within 6 months of the completion of the panel to identify potential subsidence issues and remediation actions.
- Conduct a spatial analysis using LiDAR to determine changes in soil surface conditions post mining, or using remote sensing to identify tree health status.
- Opportunistically recording mining subsidence where observed as part of future monitoring events.
- Inspect ponding and cracks observed in 2016 and remediate as necessary.
- Mapping the extent of ponding through site inspections and aerial imagery.
- Develop a subsidence remediation plan for affected areas containing unacceptable environmental impacts.
- Mitigate unacceptable areas of ponding by managing surface water appropriately on a case by case basis.

Yours sincerely,

Alex Pursche

Senior Ecologist



Vegetation communities and subsidence observations within SBU and NWU
306000
307000
308000
309000
310000
311000
312000
313000
6395000
6394000
6393000
6392000
6391000
Legend
North Wambo Underground
South Bates Underground
Observed subsidence within NWU and SBU
Cracking
Ponding
Vegetation Communities
Bull Oak Grassy Woodland
Derived Grassland
Forest Red Gum Floodplain Forest
Grey Box - Slaty Box Woodland
Grey Box - Slaty Box Woodland (Disturbed)
Melaleuca decora Low Forest
Narrow-leaved Ironbark - Grey Box Woodland (Central Hunter Box - Ironbark CEEC)
Narrow-leaved Ironbark - Grey Box Woodland (Disturbed)
River Oak Riparian Woodland
Rough-barked Apple - Coast Banksia Woodland (Warkworth Sands EEC)
Sandstone Riparian Scrub
Spotted Gum - Narrow-leaved Ironbark - Grey Box Woodland
Weeping Myall Woodland
0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
N
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AUSTRALIA
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Prepared by: AP
Date: 29/03/2017

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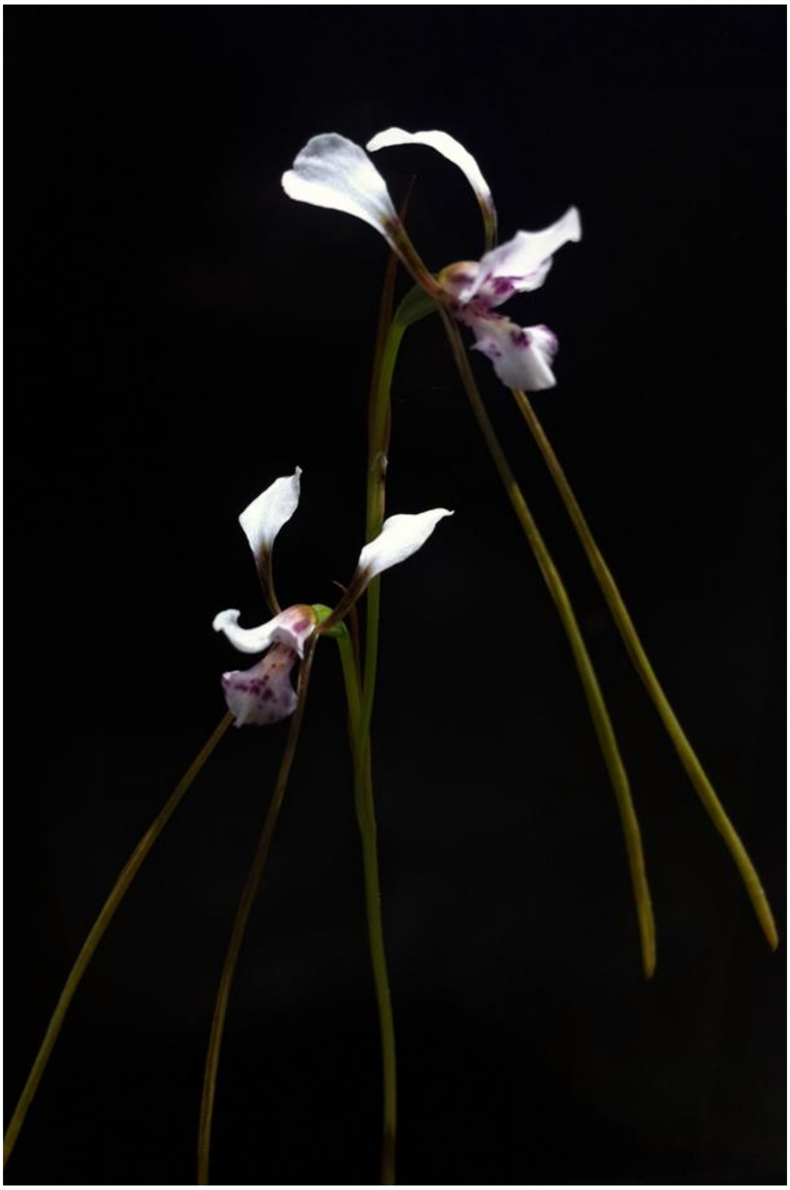
Wambo Coal Mine

Annual Flora and Fauna Monitoring Report 2016 – Volume 2

Prepared for
Wambo Coal Pty. Ltd.

10 January 2017



DOCUMENT TRACKING

Item	Detail
Project Name	Wambo Coal Mine Annual Flora and Fauna Monitoring, 2015
Project Number	15NEW - 2575
Project Manager	Daniel McKenzie (02) 4910 3403 Level 7, 19 Bolton Street, Newcastle, NSW
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Reviewed by	Martin Sullivan
Approved by	Martin Sullivan
Status	Final
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Cover photo	Clockwise from left: *Diuris alba* (White Donkey Orchid) – taken at WCPL 2016 –the vulnerable *Chthonicola sagittata* (Speckled Warbler) and *Warkworth Sands* Endangered Ecological Community. Photos by Peter Knock and Daniel McKenzie.

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Contents

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1 Introduction

This document provides raw data and photographs taken during spring 2016 monitoring at Wambo Coal Pty Ltd.

2 Floristic and fauna habitat monitoring

2.1 Monitoring data

Data collected during the 2015 floristic surveys are presented below in **Table 1.**

Several abbreviations for measured attributes are used in tables throughout the following section. An explanation of these is provided below.

- NPS – the number of native plant species within 20 x 20 plot
- NOS (%) - projected native foliage cover of canopy
- NMS (%) – projected native midstorey cover
- NGCG – native groundcover of grasses
- NGCS – native groundcover of shrubs
- NGCO – native groundcover of other plant types (sedges, herbs etc.)
- EPC – exotic plant cover
- OR – proportion of overstorey species regenerating over the whole vegetation zone
- HBT – number of hollow-bearing trees present in the 20 x 50 m vegetation plot
- FL – length of fallen logs >10 cm diameter

Table 1: Biometric plot data for remnant woodland

Orientation	Plot Name	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	L-litter	Bare ground/Rock
340°	V1-A1	5	58.5	0	6	0	4	20.5	0		55	15	17
280°	V1-A2	12	32	3	32	2	0	70	0		35	0	0
220°	V1-B1	16	21	9	18	4	30	36	0		0	22	0
180°	V1-B2	21	38	22	18	0	0	66	0		6	32	0
220°	V1-B3	10	43	4	42	0	14	20	0	1	-	-	-
120°	V2-A1	13	2	13	18	0	10	52	0		9	0	-
0°	V2-B1	16	29.5	26.5	2	0	4	84	2		4	-	-
75°	V2-B2	20	8.5	6	8	0	36	66	0		0	0	5
120°	V3-B1	28	38.5	14	26	4	34	0	3		26	-	-
0°	V5-B1	26	15	5.5	44	12	12	18	0		15	-	-
290°	V5-B2	32	27.5	7.5	78	0	22	4	2	1	22	-	-
70°	V5-B3	37	10.5	16.5	38	0	4	2	0		42	-	-
280°	V5-B4	30	26.5	2.5	2	8	16	52	0		13	-	-
230	V6-A1c	30	13.5	7	36	0	18	0	4		-	42	8
90°	V6-A3	27	28.5	3	16	2	38	0	0		16	31	0
180°	V6-B1	35	26.5	18.5	16	4	12	0	2		107	-	-
270°	V6-B1c	32	12	8	38	4	16	0	1	1	-	42	8
340°	V6-B2	34	23.5	24.5	32	0	12	2	0		73	-	-
230	V6-B2c	33	6.5	18	28	4	28	0	0		22	42	0
170°	V6-B3	41	21	8	30	0	12	2	1		48	-	-

Orientation	Plot Name	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	L-litter	Bare ground/Rock
180	V6-B4	16	31	3	24	0	4	2	0		4	-	-
45°	V11-B1	28	12.5	3.5	24	8	14	4	0		63	32	14
45°	V11-B2	31	14	6.5	38	6	16	0	2		41	40	8
340°	V9-A1	28	22.5	6.5	24	0	10	0	1		22	-	-
30°	V9-B1	28	8.2	3.9	44	18	8	2	2	1	44	42	0
0°	V9-B2	31	12.5	3	42	8	8	4	0		39	48	2
90°	V10-A1	27	18	6	38	0	10	0	1		49	34	20
180°	V10-A2	47	21.5	4	34	4	0	0	0	1	22	32	30
180°	V10-B1	39	12.5	9.5	18	16	16	0	2		30	66	0
315°	V10-B3	22	21	3.5	24	6	0	2	2		71	42	26
0°	V13-B1	34	18	8.5	34	18	34	0	0	1	52	40	0
125°	V14-A1	42	9	40.5	18	2	10	4	0		16	60	8
270°	V14-B1	33	6.5	38.5	40	4	14	0	0	1	38	38	8
90°	V14-B2	43	11.5	19.5	30	4	26	0	0		11	44	0

- = data not collected in 2016

Table 2: Biometric plot data for woodland rehabilitation areas

Orientation	Plot Name	NPS	OS	MS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	L-litter	Bare ground/Rock
As per LFA transect	3R	6	16	2	0	0	0	0	Planted	0	0	72	28
As per LFA transect	4R	4	22.5	0.5	0	0	0	0		0	0	84	16
As per LFA transect	6R	15	40	3	24	0	4	6		0	25.5	56	6
As per LFA transect	8R	7	14.5	7	6	0	0	0		0	0	66	28

Table 3: Flora species list from RWEA monitoring plots

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Abutilon sp.	Lantern Bush	N																															1		1	1
Acacia amblygona	Fan Wattle	N															1				3			3		2		1			2					
Acacia binervia	Coast Myall	N																	1						1			1	3	2		3				
Acacia decora	Western Silver Wattle	N																												3						
Acacia decurrens	Black Wattle, Green Wattle	N		4																																
Acacia falciformis	Broad-leaved Hickory	N																										1								
Acacia filicifolia	Fern-leaved Wattle	N			3	3		1		3																										
Acacia implexa	Hickory Wattle	N							1															1												
Acacia parramattensis	Parramatta Wattle	N				1			3																											
Acacia salicina	Cooba	N				1																								2					3	
Acacia sp. (bipinnate)		N								2																										
Acacia sp. (Long narrow phyllodes)		N																										1								
Acacia sp. (seedling)		N	1																																	
Acacia sp. (Unidentified 1)		N																			1															
Acacia sp.(Unidentified 2)		N																										2								
Acetosa sagittata	Rambling Dock, Turkey Rhubarb	E		2		2																														
Acetosella vulgaris	Sorrel, Sheep Sorrel	E			1			3	2		2																									
Adiantum aethiopicum	Common Maidenhair	N																															1			
Aira cupaniana	Silvery Hairgrass	E			2			2																												
Ajuga australis	Austral Bugle	N																																1		2
Allocasuarina luehmannii	Bulloak	N														1	4		3		4			3		3	2	2			2	3				
Amyema cambagei	She-oak Mistletoe	N		1																																
Amyema congener subsp. *congener*		N																																		1
Amyema gaudichaudii	Paperbark Mistletoe	N																							1		2		1							
Anagallis arvensis	Scarlet/Blue Pimpernel	E	3	2	1	2	2	1	2	2	2	2	1															1						2		

Scientific Name	Common Name	Native/Exotic	V1A1	V1A2	V1B1	V1B2	V1B3	V2A1	V2B1	V2B2	V3B1	V5B1	V5B2	V5B3	V5B4	V6A1	V6A3	V6B1	V6B1c	V6B2	V6B2c	V6B3	V6B4	V9A1	V9B1	V9B2	V10A1	V10A2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A1	V14-B1	V14-B2
Angophora floribunda	Rough-barked Apple	N									1	3	4	3	4																					
Argemone ochroleuca	Mexican Poppy	E	1																																	
Aristida ramosa	Purple Wiregrass	N									2			2	2	1	2	2	1	2	1	2	3	2	1		1	3						2	1	3
Aristida sp.1	Wiregrass	N														2																1			1	
Aristida sp.(very large -1.5m)		N																						1					1							
Aristida spp.		N																												3						
Aristida vagans	Threeawn Speargrass	N									3	2	2	2	3	2	3	2	2	2	2	3			2	2	3	2	1		2	3			2	1
Arthropodium milleflorum	Vanilla Lily	N																	2		1				1			1			1					1
Asparagus asparagoides	Bridal Creeper	E			2					1																										
Asparagus sp.		E			1				1	1																										
Asperula conferta	Common Woodruff	N									2																									
Aster spp.		E					2				1		1																							
Asteraceae sp. (Tiny)		N					1																													
Austrodanthonia spp.		N														1									1	2									2	
Austrostipa ramosissima	Stout Bamboo Grass	N		1		2			2							2													1				2			2
Austrostipa scabra subsp. *scabra*		N																								2			1					1	2	2
Austrostipa sp.(tussock)		N														2			3								2	2		2	1					
Austrostipa verticillata	Slender Bamboo Grass	N																																1		
Backhousia myrtifolia	Grey Myrtle	N				1																														
Bertya oleifolia		N																															1		1	
Bidens pilosa	Cobbler's Pegs	E			1					2																										
Bidens subalternans	Greater Beggar's Ticks	E				1			2																											
Bothriochloa macra	Red Grass	N																																1		
Brachychiton populneus subsp. *populneus*	Kurrajong	N		1					2								1										1							4	1	
Breynia oblongifolia	Coffee Bush	N														1								1	1	1			1			1				1
Breynia sp.		N			3																															

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Briza minor	Shivery Grass	E			1			2	2	2																										
Bromus catharticus	Prairie Grass	E	1	2			1			1																										
Brunoniella australis	Blue Trumpet	N														1	2				1			2	1	1		1	1	1				2	1	2
Bursaria spinosa	Native Blackthorn	N				1										1			2						4	3	2	3	4	1	2	3	2			2
Callitris glaucophylla	White Cypress Pine	N																										1								
Calotis cuneifolia	Purple Burr-Daisy	N																									1							1	1	
Calotis lappulacea	Yellow Burr-daisy	N															2				1							1						2	2	
Cardiospermum grandiflorum	Balloon Vine	E		3	4		1																													
Carex breviculmis		N																																1		
Carex inversa	Knob Sedge	N									1																									
Cassinia arcuata	Sifton Bush	N																													1					
Cassinia cunninghamii		N																										3								
Cassytha pubescens	Common Devil's Twine	N																															1			
Casuarina cunninghamiana	River Oak	N	5	3	4	4	4																													
Cayratia clematidea	Slender Grape	N				1																											1			1
Centaurium erythraea	Common Centaury	E					1																													
Centaurium erythraea	Common Centaury	E																																1		1
Centella asiatica	Pennywort	N		1			1				2																									
Centipeda minima	Spreading Sneezeweed	N					3				2																									
Cerastium glomeratum	Mouse-ear Chickweed	E							2																											
Cheilanthes distans	Bristly Cloak Fern	N														3			2								2	1		2				2	3	2
Cheilanthes sieberi subsp. sieberi		N			1	2		1	2	2	1			2	2			2	2	2	2	2	2	2	1	1	1	2	1	1	2		1	1		1
Cheilanthes sp.		N			1																															
Chloris gayana	Rhodes Grass	E	1																																	
Chloris ventricosa	Tall Chloris	N														2														1					2	
Choretrum candollei	White Sour Bush	N																	1									2			3					

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Chrysocephalum apiculatum	Common Everlasting, Yellow Buttons	N						2									1																			
Cirsium vulgare	Spear Thistle	E					2																													
Clematis aristata	Old Man's Beard	N																											1							
Clematis sp.		N			2																															
Commelina cyanea	Scurvey Weed	N					2																						1				1			
Commersonia fraseri	Brush Kurrajong	N																															1			
Conyza bonariensis	Flaxleaf Fleabane	E	2	1		2																														
Conyza sumatrensis	Tall fleabane	E			1	2	1				1																									
Corymbia maculata	Spotted Gum	N																						4	2	4			3				3			
Cyclospermum leptophyllum	Slender Celery	E	1					1																												
Cymbonotus lawsonianus	Bear's Ear	N																										1						2		
Cymbopogon refractus	Barbed Wire Grass	N						1		2	2				2	3	3	2	3	2	4	2		4	2	2	2	2	3	3	2	2	2		3	2
Cynodon dactylon	Common Couch	N	3	4	2			3	2	2	3		2		1								2					2					2			
Cyperus gracilis	Slender Flat-sedge	N									1		1										1													
Cyperus polystachyos		N																						1												
Cyperus spp.		N									1														1				1							
Daucus spp.		N									1											1													1	1
Daviesia genistifolia	Broom Bitter Pea	N															1																			
Desmodium brachypodum	Large Tick-trefoil	N														1			1		1					1								1		2
Desmodium rhytidophyllum		N																								1										
Desmodium varians	Slender Tick-trefoil	N														1			1						1	1		1	2	1	1		2	1		2
Dianella longifolia		N								1																			2							1
Dianella prunina		N																	2						1			1			1	2				
Dianella revoluta var. revoluta		N														1	1				2			1	1		1	1	2							
Dichelachne sp.		N								1																										
Dichondra repens	Kidney Weed	N								1	2		2					2	1	2	2	2		1			1	1			1				1	2

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Dichondra species A		N																							1				2				2	2		
Digitaria spp.		N									2					1																2			2	
Diuris alba	White Donkey Orchid	N						1																												
Dodonaea viscosa subsp. cuneata		N															1		1					1	1	2			1		3					
Echinopogon caespitosus	Bushy Hedgehog-grass	N																															1			
Echium plantagineum	Patterson's Curse	E		3																																
Ehrharta erecta	Panic Veldtgrass	E	2	3	4		1		2	3																										
Einadia hastata	Berry Saltbush	N								1																								2		
Einadia nutans		N																			1															
Einadia sp.1		N														1					1							1			1					
Einadia sp.2 (trigonos)		N																			1															
Entolasia marginata	Bordered Panic	N							2																								1			
Entolasia stricta	Wiry Panic	N																						1	1						3	3			2	
Eragrostis brownii	Brown's Lovegrass	N																							1		2				2					
Eragrostis curvula	African Lovegrass	E						1																												
Eragrostis leptostachya	Paddock Lovegrass	N														1																		1		
Eremophila debilis	Amulla	N															1				2													1		1
Eucalyptus blakelyi	Blakely's Red Gum	N									4																									
Eucalyptus camaldulensis	River Red Gum	N						3	4	4																										
Eucalyptus crebra	Narrow-leaved Ironbark	N									1					4	4	1	4		4	1	1	4	3	3	3	4	3		3	3	3			4
Eucalyptus dawsonii	Slaty Gum	N																									3			3						
Eucalyptus moluccana	Grey Box	N														1					3												3		3	
Eucalyptus punctata	Grey Gum	N																							1				3		3	3				
Euchiton involucratus	Star Cudweed	N									2															1										
Eustrephus latifolius		N																												1						
Exocarpos cupressiformis	Native Cherry	N								3															2											

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Exocarpus strictus	Cherry Ballart	N							1																											
exotic tomentose broad leaved		E			1																															
Fabaceae sp.1		N																										1								
Fabaceae sp.2		N															1																			
Facelis retusa	Annual Trampweed	E		1	1			1																				1								
Fimbristylis dichotoma	Common Fringe-sedge	N																	1																	
Gahnia aspera	Rough Saw-sedge	N														1										1	1	1	1	1				1	1	
Gahnia sp.		N																															2			
Galenia pubescens	Galenia	E		3		2			4	1																										
Galium propinquum	Maori Bedstraw	N															1																2	2		2
Geijera salicifolia var. salicifolia		N																																3	3	3
Geitonoplesium cymosum	Scrambling Lily	N																											1				1	1		1
Geranium sp.		N																															1			
Glycine clandestina		N							2	1									1		1			2	1	1	1	1				1		1	1	1
Glycine microphylla		N														1	2				2				1											
Gomphocarpus fruticosus	Narrow-leaved Cotton Bush	E					1																					1				1		1		
Goodenia hederacea	Ivy Goodenia	N																										1								
Goodenia rotundifolia		N																	1		1			1	2	2			1		2	2				
Grevillea montana		N																								2		1	1		1	1				
Grevillea robusta	Silky Oak	N			3																															
Heliotropium amplexicaule	Heliotrope	E		2	4			2	2	2																										
Hibbertia obtusifolia	Hoary guinea flower	N																										1				1				
Hibiscus heterophyllus subsp. *heterophyllus*	Native Rosella	N																															2			
Hydrocotyle bonariensis		E					3																													
Hydrocotyle verticillata	Sheild Pennywort	N				1																														
Hypericum gramineum	Small St Johns Wort	N									2																									

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Hypochoeris radicata	Catsear	E		1	2	1		2	2		1	2	2	2	2													1				1				
Isolepis inundata		N				2																														
Jacksonia scoparia		N																							1							1				
Juncus polyanthemus		N									4				1																					
Juncus sp.		N					1																					1								1
Juncus usitatus		N				2																														
Laxmannia gracilis	Slender Wire Lily	N																						2												
Lepidium africanum		E				2																														
Lepidosperma laterale		N																														3				
Leptospermum sp.		N		3	4	3				1																										
Leucopogon muticus	Blunt Beard-heath	N																														2				
Lomandra confertifolia subsp. *pallida*		N									2	3	2													2						2				
Lomandra filiformis	Wattle Matt-rush	N																										2								
Lomandra filiformis subsp. *coriacea*		N																							1							1				
Lomandra filiformis subsp. *filiformis*		N															1				2						1			2						
Lomandra longifolia	Spiny-headed Mat-rush	N		1	1		4																										2			
Lomandra multiflora	Many-flowered Mat-rush	N															1				1					1	1	1			1	1				
Lomandra multiflora subsp. *multiflora*	Many-flowered Mat-rush	N									2		1	1	2								1													
Lomandra sp.1		N																																	1	
Lomandra sp.2		N																										1								
Lomandra sp.3		N																																1		
Lomandra sp.4		N																								2										
Lomandra sp.5		N																	1																	
Lycium ferocissimum	African Boxthorn	E		3		2																														
Macrozamia flexuosa		N																	1																	
Macrozamia reducta		N																								1			1							

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Maireana microphylla	Small-leaf Bluebush	N																																1		
Malvaceae sp.		N		2																																
Maytenus silvestris		N																									1		1							1
Melaleuca decora		N																	3		3			3	4		4	3	3		3	3				
Melaleuca thymifolia		N									1																									
Melia azedarach	White Cedar	N							1																											
Melichrus urceolatus	Urn Heath	N																							1	1										
Melinis repens	Red Natal Grass	E																										1								
Microlaena stipoides var. *stipoides*	Weeping Grass	N		4	3	2	5	2	2	3																		2	2		1			3		3
Minuria leptophylla		N															2																			
Myoporum montanum	Western Boobialla	N																												1						
Notelaea longifolia	Large Mock-olive	N														1					1												1			
Notelaea microcarpa var. *microcarpa*		N				2			1	1	1	1	1	1	1	4	1	1		2	1	1				2	2		1	3		3	3	4	4	5
Oenothera stricta subsp. stricta	Common Evening Primrose	E						2																												
Olea europaea subsp. *cuspidata*		E			1					1																										
Olearia elliptica	Sticky Daisy Bush	N														2	1		4		1			1	2	3			2	2	2	3			2	4
Oplismenus aemulus		N			2	2																							2				2			1
Opuntia aurantiaca	Tiger Pear	E							2															1												
Opuntia humifusa	Creeping pear	E			1					1																										
Opuntia stricta	Prickly Pear	E							1							1			2					1	1		1	1		1	1					1
Oxalis chnoodes		N																																1		
Oxalis corniculata	Creeping Oxalis	E		2																																
Oxalis perennans		N						2			2	2		2	1	1		1		1		2			1			1	1				1	1	1	1
Oxalis radicosa		N				2			2																											
Oxalis spp.		N			1					1							1															1	1			
Pandorea pandorana	Wonga Wonga Vine	N																															1			

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Panicum simile	Two-colour Panic	N																													1					1
Paronychia brasiliana	Chilean Whitlow Wort	E																										1								1
Pavonia hastata		E							2		2																									
Pennisetum clandestinum	Kikuyu Grass	E	1																																	
Persicaria sp.		N									1																									
Persoonia linearis	Narrow-leaved Geebung	N																							1				1			1				
Petrorhagia nanteuilii		E			1	2		4	2	2																										
Phragmites australis	Common Reed	N	2	3	1		4																													
Plantago debilis		N																										2						2	2	
Plantago lanceolata	Lamb's Tongues	E	2				1	4	1	2	1		1																							
Poa annua	Summer grass	E				2																														
Polyscias sambucifolia	Elderberry Panax	N			1																															
Pomax umbellata		N																														2				
Pratia purpurascens	Whiteroot	N								1	2			2				2		1		2							2				2			
Pseudognaphalium luteoalbum	Jersey Cudweed	E	1	1	1		1																													
Psydrax oderatum		N																									1	1								
Pterostylis sp.	Greenhood	N																										1								
Pultenaea spinosa	Spiny Bush-pea	N																								2		1								
Rhagodia parabolica	Mealy Saltbush	N																																1		
Richardia humistrata		E						4		1																										
Romulea sp.		E									1																									
Rubus parvifolius	Native Raspberry	N				2																														
Rumex brownii	Swamp Dock	N	1	1			1			1																										1
Rytidosperma (Austrodanthonia) spp.		N																										1	1	1	1					
Salix spp.	Willow	E	3																																	
Schoenus brevifolius		N															1		2		1			1		1										2

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Senecio madagascariensis	Fireweed	E	2	1	1	2		2	2	2	2	2			2	1	1	1	2	1	1	2	2	1		1		1		1	2	1		1	1	1
Senecio quadridentatus	Cotton Fireweed	N							1																											
Senna spp.		N																	1					2									1			
Sida corrugata		N				2										1	1																1		1	
Sida rhombifolia	Paddy's Lucerne	E	1			2																											1			
Sida sp.1		N																														1		1	2	
Sida sp.2		N								4	2																									
Sida sp.3		N			1																															
Sida sp.4)		N						1																												
Silene gallica var. gallica	French Catchfly	E	1		2			1		1																										
Small tree/shrub broad leaved		N			1																															
Solanum nigrum	Black-berry Nightshade	E	2	2		2			2																											
Solanum prinophyllum	Forest Nightshade	N																						1								1				
Solanum spp.		N																	1															1		1
Solivia sessilis	Bindii	E																										1						1		
Sonchus asper	Prickly Sowthistle	E					1																									1				
Sonchus oleraceus	Common Sowthistle	E	2	1	1	2	2			1																										
Spartothamnella juncea	Bead-bush	N														1																		2	2	2
Sporobolus creber	Western Rat's Tail Grass	N																	1					1			2		1	1	1					
Sporobolus elongatus		N																							1									1		
Stackhousia viminea	Slender Stackhousia	N															1																			
Stellaria media	Chickweed	E				2			2																									2		
Stephania japonica		N			2	2																														
Unidentified grass		N																																		1
Swainsona galegifolia	Smooth Darling Pea	N																															1	1		
Tagetes minuta	Stinky Roger	E				2			2																											

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Thistle sp. (rosette only)		E	1	1	1																										1					
Tradescantia fluminensis	Wandering Jew	E			1	2																														
Trifolium arvense	Hare's Foot Clover	E						3																												
Trifolium campestre	Hop Clover	E						2																										1		
Unidentified (Opposite leaved native)		N																	1															2		
Unidentified exotic sp. (poor specimen)		E	1																																	
Unidentified grass (exotic)		E																			1			1	1											
Unidentified grass 1		N																	1													1				
Unidentified grass 2		N																	1								1	2		1						
Unidentified grass 3		N																											2							
Unidentified grass 4		N														1																1		2	2	
Unidentified native (tiny succulent)		N																	1									1								
Unidentified native shrub (small, yellow tubular flowers)		N																														1				
Unidentified sedge sp.		N																			1			1	1											1
Unidentified shrub		N																			1															
Unidentified sp. (blue herb)		N															2																			
Unidentified sp. (exotic)		E					1																													
Unidentified spp.	Unidentified native twiner	N																						2												
Unidentified twiner		N																																1		
Verbascum virgatum	Twiggy Mullein, Green Mullein	E				2																														
Verbena bonariensis	Purpletop	E						1			1																									
Verbena rigida	Veined Verbena	E						1		2																										
Vernonia cinerea		N																			1															
Veronica plebeia	Trailing Speedwell	N						1	2																											1
Veronica sp.		N			1					1																										
Vittadinia sulcata		N																																1	1	1

Scientific Name	Common Name	Native/Exotic	V1A 1	V1A 2	V1B 1	V1B 2	V1B 3	V2A 1	V2B 1	V2B 2	V3B 1	V5B 1	V5B 2	V5B 3	V5B 4	V6A 1	V6A 3	V6B 1	V6B 1c	V6B 2	V6B 2c	V6B 3	V6B 4	V9A 1	V9B 1	V9B 2	V10A 1	V10A 2	V10-B1	V10-B3	V11-B1	V11-B2	V13-B1	V14A 1	V14-B1	V14-B2
Vulpia bromoides	Squirrel Tail Fescue	E						2																												
Vulpia myuros	Rat's Tail Fescue	E			2	2				2																										
Wahlenbergia communis	Tufted Bluebell	N									1	2			2						2					1		2								
Wahlenbergia gracilis	Sprawling or Australian Bluebell	N				2		1																1	1		1							1		1
Wahlenbergia sp.		N															2																			

Table 4: Woodland rehabilitation species list and cover scores

Scientific Name	Common Name	Native/Exotic	4R	8R	3R	6R
Acacia saligna	Golden Wreath Wattle	NLN	3	2	1	
Acacia sp.1	Wattle	N			1	1
Acacia sp.2	Wattle	N		1	1	
Allocasuarina sp.	She-oak	N			1	
Anagallis arvensis	Scarlet/Blue Pimpernel	E	1			2
Aristida ramosa	Purple Wiregrass	N		1		
Asteraceae sp.		N				1
Austrostipa ramosissima	Stout Bamboo Grass	N				3
Bothriochloa macra	Red Grass	N		1		
Bursaria spinosa	Native Blackthorn	N				1
Calotis cuneifolia	Purple Burr-Daisy	N	2			2
Calotis lappulacea	Yellow Burr-daisy	N				2
Chloris gayana	Rhodes Grass	E	1	2		
Corymbia maculata	Spotted Gum	N	2	2	1	3
Cymbopogon refractus	Barbed Wire Grass	N	1	1		1
Cynodon dactylon	Common Couch	N			1	
Desmodium sp.		N				1
Einadia hastata	Berry Saltbush	N		1	2	1
Enchylaena tomentosa	Ruby Saltbush	N	2			
Eucalyptus cladocalyx	Sugar Gum	NLN	4	4	4	4
Eucalyptus crebra	Narrow-leaved Ironbark	N		1		
Eucalyptus fibrosa	Broad-leaved Ironbark	N				2
Galenia pubescens	Galenia	E				
Heliotropium amplexicaule	Heliotrope	E				1
Plantago debilis		N				2

Scientific Name	Common Name	Native/Exotic	4R	8R	3R	6R
Senecio madagascariensis	Fireweed	E	1			
Sida rhombifolia	Paddy's Lucerne	E				1
Thistle sp.		E	2			
Unidentified creeper		N				1
Unidentified grass		N	1			2
Unidentified grass sp. (heavily browsed)		N			1	
Unidentified shrub		N				1

NLN = non-local Australian native species

2.2 Photographs of floristic monitoring plots

A photograph has been taken at the start and end of the 50 m central transect within each floristic monitoring plot.

2.2.1 River Red Gum / River Oak riparian woodland wetland in the Hunter Valley

Plate 1: V1-A1 – start

Plate 2: V1-A1 – end

Plate 3: V1-A2 – start

Plate 4: V1-A2 – end

Plate 5: V1-B1 – start

Plate 6: V1-B1 – end

Plate 7: V1-B2 – start

Plate 8: V1-B2 – end

Plate 9: V1-B3 – start

Plate 10: V1-B3 – end

Plate 11: V2-A1 – start

Plate 12: V2-A1 – end

Plate 14: V2-B1 – start

Plate 13: V2-B1 – end

Plate 15: V2-B2 – start

Plate 16: V2-B2 – end

Plate 17: V3-B1 – start

Plate 18: V3-B1 – end

2.2.1 Rough-barked Apple - Narrow-leaved Ironbark - Blakely's Red Gum - Bull Oak - Coast Banksia woodland on sands of the Warkworth area

Plate 19: V5-B1 – start

Plate 20: V5-B1 – end

Plate 21: V5-B2 – start

Plate 22: V5-B2 – end

Plate 23: V5-B3 – start

Plate 24: V5-B3 – end

Plate 25: V5-B4 – start

Plate 26: V5-B4 – end

2.2.2 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter

Plate 27: V6-A1c – start

Plate 28: V6-A1c - end

Plate 29: V6-A3 – start

Plate 30: V6-A3 – end

Plate 31: V6-B1 – start

Plate 32: V6-B1 – end

Plate 33: V6-B1c – start

Plate 34: V6-B1c – end

Plate 36: V6-B2 – start

Plate 35: V6-B2 – end

Plate 37: V6-B2c – start

Plate 38: V6-B2c - end

Plate 39: V6-B3 – start

Plate 40: V6-B3 – end

Plate 41: V6-B4 – start

Plate 42: V6-B4 – end

Plate 43: V11–B1 – start

Plate 44: V11-B1 – end

Plate 45: V11-B2 – start

Plate 46: V11-B2 – end

2.2.3 Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter

Plate 47: V9-A1 – start

Plate 48: V9-A1 – end

Plate 49: V9-B1 – start

Plate 50: V9-B1 – end

Plate 51: V9-B2 – start

Plate 52: V9-B2 – end

Plate 53: V10-B1 – start

Plate 54: V10-B1 – end

2.2.4 Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin Bioregion

Plate 55: V10-A1 – start

Plate 56: V10-A1 – end

Plate 57: V10-A2 – start

Plate 58: V10-A2 – end

Plate 59: V10-B3 – start

Plate 60: V10-B3 – end

2.2.5 White Mahogany - Spotted Gum - Grey Myrtle semi-mesic shrubby open forest of the central and lower Hunter Valley

Plate 61: V13-B1 – start

Plate 62: V13-B1 – end

2.2.6 Brush Wilga/Native Olive Shrubland

Plate 63: V14-A1 – start

Plate 64: V14-A1 – end

Plate 65: V14-B1 – start

Plate 66: V14B1 – en

2.3 Photo-monitoring points

Plate 67: A1 – facing south

Plate 68: A2 – facing south

Plate 69: A3 – facing north

Plate 70: A4 – facing north

Plate 71: B1 – facing south-west

Plate 72: B2 – facing west

Plate 73: C1 - facing north-east

Plate 74:C2 –facing east

Plate 75: D1 – facing south-west

Plate 76:CT1-facing north

Plate 77:CT2 - facing west

3 Landscape function analysis –site photos

3.1 North Wambo Creek diversion and riparian areas

Plate 78: 17R

Plate 79: 19R

Plate 80: 21R

Plate 81: 23R

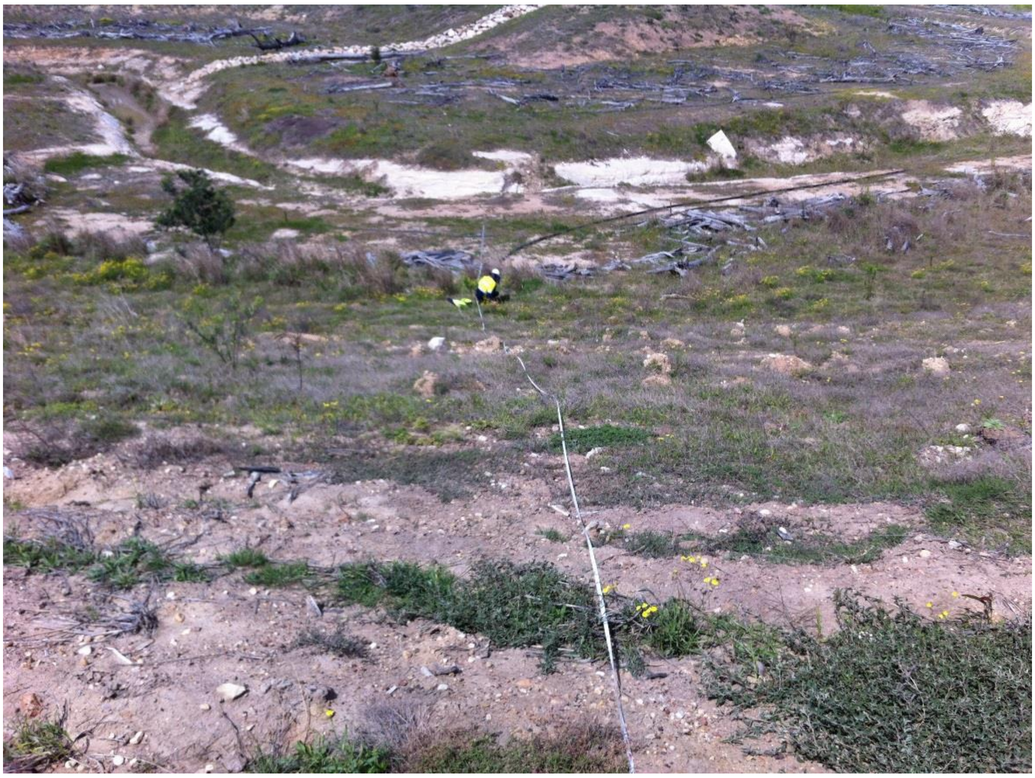

Plate 82: 25R

Plate 83: 27R

Plate 84: 28R

3.2 Woodland rehabilitation areas

Plate 85: 3R

Plate 86: 4R

Plate 87: 6R

Plate 88: 8R

3.3 Pasture rehabilitation areas

Plate 89: 1R

Plate 90: 2R

Plate 91: 5R

Plate 92: 7R

Plate 93: 9R

Plate 94: 10R

Plate 95: 16R

Plate 96: 33R

Plate 97: 34R

4 Riparian condition assessment

4.1 Riparian condition data

Site	Habitat	Cover	Natives	Debris	Features	Total
Maximum Score	11	12	9	10	8	50
North Wambo 1	4.54	8.00	2.25	2.25	1.75	18.79
North Wambo 2	6.81	8.00	3.50	2.25	1.5	22.06
North Wambo 3	7.60	6.50	3.50	4.00	3.5	25.10
Wambo 1	2.29	6.00	2.75	1.00	2.67	14.71
Wambo 2	3.63	7.75	3.50	2.25	2.75	19.88
Wambo 3	3.26	8.00	3.50	3.50	2.50	20.76
Stony Creek 1	2.50	7.50	2.50	4.00	2.00	18.50
Stony Creek 2	6.25	8.00	4.00	2.75	1.75	22.75
Stony Creek 3	11.00	7.50	4.50	7.50	4.50	35

5 Bird monitoring

5.1 Bird monitoring data

Table 5: Species and maximum count of birds, heard and observed over two site visits; morning and afternoon during October 2016

Scientific Name	Common Name	Monitoring site and maximum count from the two bird surveys																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total	No. sites
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	6	0	0	0	17	4
Acanthiza lineata	Striated Thornbill	0	0	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	6	4	0	0	0	18	4
Acanthiza nana	Yellow Thornbill	5	0	5	8	0	3	0	0	0	0	0	0	0	0	5	2	8	5	2	0	0	1	0	4	0	0	48	11
Acanthiza pusilla	Brown Thornbill	0	0	0	0	0	0	0	1	0	4	1	0	2	1	0	2	0	3	1	3	5	0	0	0	0	0	23	10
Acanthiza reguloides	Buff-rumped Thornbill	0	0	0	0	5	10	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	0	0	21	4
Acanthorhynchus tenuirostris	Eastern Spinebill	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
Acrocephalus australis	Australian Reed-Warbler	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	3	3
Alisterus scapularis	Australian King-Parrot	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Aquila audax	Wedge-tailed Eagle	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1	5	4
Artamus cyanopterus	**Dusky Woodswallow**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1

Scientific Name	Common Name	Monitoring site and maximum count from the two bird surveys																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total	No. sites
Cacatua galerita	Sulphur-crested Cockatoo	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	1	0	0	7	4
Cacatua sanguinea	Little Corella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2	2
Cacomantis flabelliformis	Fan-tailed Cuckoo	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	3
Cacomantis variolosus	Brush Cuckoo	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	2
Chalcites lucidus	Shining Bronze-Cuckoo	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	5	5
Chthonicola sagittata	**Speckled Warbler**	0	0	0	2	1	2	0	0	0	0	0	2	0	0	1	3	0	0	1	0	0	1	2	0	0	0	15	9
Climacteris picumnus	Brown Treecreeper	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2
Colluricincla harmonica	Grey Shrike-thrush	0	0	2	0	0	0	3	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0	1	0	2	1	14	10
Coracina novaehollandiae	Black-faced Cuckoo-shrike	0	0	2	0	0	2	0	0	0	0	0	0	1	0	1	0	0	2	0	0	0	0	0	0	0	0	8	5
Corcorax melanorhamphos	White-winged Chough	0	0	4	5	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	4	0	0	28	7
Cormobates leucophaea	White-throated Treecreeper	0	0	0	0	1	1	0	2	2	0	0	0	0	2	0	1	1	0	0	1	1	0	0	0	0	0	12	9

Scientific Name	Common Name	Monitoring site and maximum count from the two bird surveys																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total	No. sites
Corvus coronoides	Australian Raven	3	1	1	1	1	0	2	0	1	0	0	0	0	0	0	0	0	2	1	0	0	1	3	2	0	0	19	12
Cracticus nigrogularis	Pied Butcherbird	0	1	0	0	0	1	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	5
Cracticus tibicen	Australian Magpie	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1	0	2	0	1	0	0	1	0	2	1	0	18	16
Cracticus torquatus	Grey Butcherbird	0	1	0	1	0	1	1	1	2	1	1	0	1	1	2	0	0	0	1	0	0	0	2	1	1	0	18	15
Dacelo novaeguineae	Laughing Kookaburra	1	0	2	0	1	0	0	0	0	0	2	0	0	3	0	0	0	1	0	1	0	0	0	0	0	0	11	7
Daphoenositta chrysoptera	**Varied Sittella**	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	10	2
Dicaeum hirundinaceum	Mistletoebird	0	2	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	2	9	7
Egretta novaehollandiae	White-faced Heron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
Eolophus roseicapillus	Galah	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2
Eopsaltria australis	Eastern Yellow Robin	0	1	0	1	1	1	3	0	0	1	1	1	1	1	1	0	0	1	1	2	0	1	0	0	1	1	20	17
Eudynamys orientalis	Eastern Koel	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	2
Eurystomus orientalis	Dollarbird	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Geopelia humeralis	Bar-shouldered Dove	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	6	3
Geopelia striata	Peaceful Dove	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	2

Scientific Name	Common Name	Monitoring site and maximum count from the two bird surveys																										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total	No. sites
Gerygone albogularis	White-throated Gerygone	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	0	0	1	0	0	10	10
Glossopsitta concinna	Musk Lorikeet	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	11	2
Glossopsitta pusilla	**Little Lorikeet**	0	0	0	0	0	0	2	2	0	0	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	9	4
Leucosarcia picata	Wonga Pigeon	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Lichenostomus chrysops	Yellow-faced Honeyeater	4	1	3	2	3	2	0	0	3	4	4	4	2	1	1	3	3	5	1	5	4	2	1	4	1	0	63	23
Lichenostomus leucotis	White-eared Honeyeater	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4	3
Lichenostomus melanops	Yellow-tufted Honeyeater	0	0	0	0	0	0	3	2	8	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	17	7
Lichenostomus penicillatus	White-plumed Honeyeater	0	0	0	0	0	0	10	0	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	4	21	4
Malurus cyaneus	Superb Fairy-wren	12	0	11	0	0	1	1	1	0	1	4	0	5	0	0	1	7	10	3	4	2	3	2	3	1	0	72	18
Malurus lamberti	Variegated Fairy-wren	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	5	2
Manorina melanocephala	Noisy Miner	1	0	0	4	0	2	0	2	0	0	0	0	0	0	10	0	2	0	0	0	0	0	0	2	0	1	24	8

Scientific Name	Common Name	Monitoring site and maximum count from the two bird surveys																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total	No. sites
Manorina melanophrys	Bell Miner	0	0	0	0	0	0	0	15	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	2
Melithreptus brevirostris	Brown-headed Honeyeater	0	0	0	0	0	0	0	0	0	2	2	0	1	0	0	0	0	0	0	0	2	1	0	2	0	0	10	6
Melithreptus lunatus	White-naped honeyeater	0	0	0	0	0	0	1	1	0	0	2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	6	5
Menura novaehollandiae	Superb Lyrebird	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Merops ornatus	Rainbow Bee-eater	1	0	2	0	0	1	0	0	0	0	2	0	0	0	0	0	1	2	0	0	0	0	0	0	0	1	10	7
Microeca fascinans	Jacky Winter	0	0	0	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3
Ocyphaps lophotes	Crested Pigeon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2	2
Oriolus sagittatus	Olive-backed Oriole	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	5
Pachycephala pectoralis	Golden Whistler	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	6	4
Pachycephala rufiventris	Rufous Whistler	3	1	2	2	2	1	6	2	4	1	1	1	0	2	4	2	3	1	1	2	2	1	1	0	2	1	48	24
Pardalotus punctatus	Spotted Pardalote	3	0	4	1	2	0	0	0	0	0	2	1	0	0	1	0	2	0	1	0	0	0	0	0	0	0	17	9
Pardalotus striatus	Striated Pardalote	3	0	1	0	0	0	3	0	0	0	0	0	0	2	0	3	0	2	0	0	1	0	0	1	0	0	16	8

Scientific Name	Common Name	Monitoring site and maximum count from the two bird surveys																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total	No. sites
Petrochelidon nigricans	Tree Martin	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	2
Phalacrocorax carbo	Great Cormorant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1
Phaps chalcoptera	Common Bronzewing	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Philemon corniculatus	Noisy Friarbird	2	1	1	0	8	1	2	1	4	1	1	0	1	2	1	2	0	0	0	2	3	0	0	0	0	1	34	17
Platycercus eximius	Eastern Rosella	1	0	2	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4
Plectorhyncha lanceolata	Striped Honeyeater	2	0	0	0	1	0	0	0	0	1	1	0	3	0	3	0	2	2	0	0	0	0	3	0	0	2	20	10
Pomatostomus temporalis	Grey-crowned Babbler	0	0	0	0	0	4	4	0	0	0	2	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	16	4
Psephotus haematonotus	Red-rumped Parrot	6	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2
Psophodes olivaceus	Eastern Whipbird	0	0	0	0	0	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	4
Ptilonorhynchus violaceus	Satin Bowerbird	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Rhipidura albiscapa	Grey Fantail	0	0	1	1	0	1	0	0	0	2	1	0	0	3	0	1	2	2	0	0	0	0	0	0	0	0	14	9
Rhipidura leucophrys	Willie Wagtail	3	0	2	0	0	0	1	2	2	0	1	0	0	0	0	0	1	2	0	0	0	0	0	2	0	1	17	10
Scythrops novaehollandiae	Channel-billed Cuckoo	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1

Scientific Name	Common Name	Monitoring site and maximum count from the two bird surveys																										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total	No. sites
Sericornis frontalis	White-browed Scrubwren	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	6	3
Smicrornis brevirostris	Weebill	0	5	0	4	3	1	0	0	0	2	0	1	1	3	3	3	1	1	5	1	3	4	4	4	0	0	49	18
Strepera graculina	Pied Currawong	0	1	2	0	0	0	0	1	0	1	2	0	0	0	0	0	0	2	0	0	1	0	0	1	1	1	13	10
Trichoglossus moluccanus	Rainbow Lorikeet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	15	1
Vanellus miles	Masked Lapwing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
Zosterops lateralis	Silvereye	15	10	15	5	5	0	0	0	5	3	4	4	1	0	20	4	10	20	10	3	4	6	5	5	10	0	164	21
Number of species per site		21	14	26	19	21	21	23	22	16	21	28	8	16	17	22	14	24	22	15	13	16	15	16	21	11	14		

*Species in bold listed as Vulnerable under the NSW TSC Act 1995

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APPENDIX E – ANNUAL ENVIRONMENTAL REPORTING 2016 AQUATIC ECOSYSTEM MONITORING

Annual Environmental Reporting 2016

Aquatic Ecosystem Monitoring

Prepared for Peabody Energy - Wambo Coal Pty Ltd

October 2016

Document control

Project no.:	3190
Project client:	Wambo Coal Pty Limited PMB1 Singleton NSW
Project office:	Newcastle
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Project Director:	Frank Lemckert
Project Manager:	Matthew Russell
Authors:	Matthew Russell
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Author	Revision number	Internal review	Date issued	Signature
Matthew Russell	D1	David Cumming	1/10/2016	

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Cover photograph: South Wambo Creek

1. Executive summary

Context

The report documents findings for the flora and habitat complexity monitoring requirements in accordance with DA 305-7-2003, Schedule 4, conditions 44, 48a and 48b managed in accordance with the sites approved Flora and Fauna Management Plan.

Aims

The aim of the aquatic monitoring program is to assess river health of drainages occurring within the North Wambo Underground Mine Lease Area, open cut operations and associated infrastructure. The drainages include North Wambo Creek, South Wambo Creek, Waterfall Creek and Wollombi Brook.

Results/Conclusion

The results showed that upper South Wambo Creek had good stream health (Band A) with macroinvertebrate communities similar to modelled reference sites and good riparian vegetation and aquatic habitat. Waterfall Creek (Band C) and sites within the North Wambo Creek stream alignment (Band D) exhibited poor stream health with macroinvertebrate communities differing from modelled reference communities and had limited aquatic habitat and riparian vegetation. However there were some signs of growth of riparian vegetation and macrophytes with in the stream realignment. Sediment deposition into a dry tributary of Waterfall Creek from a dam failure earlier in the year does not appear to have impacted macroinvertebrate communities downstream in Waterfall Creek itself. Other sites in Wollombi Brook, North Wambo Creek, and South Wambo Creek showed some impairment (Band B) and in general, had riparian vegetation and aquatic habitat in moderate condition. Comparison to previous survey data found no significant temporal trends attributable current catchment management. Ephemeral streams (North Wambo, South Wambo and Waterfall creeks) are particularly susceptible to variations in water availability, which in turn affect the availability of aquatic habitat and lead to changes to water quality associated with a drying system. These changes ultimately result in variation in aquatic faunal communities.

Recommendations

The following recommendations are provided for the consideration of future management activity:

- Establish artificial habitat (e.g. log jam) to create in stream habitat through pool retention in Stage 3 of the North Wambo Creek Diversion
- Continue riparian revegetation, and bank stabilisation.
- Continue wider riparian management involving the revegetation of the North Wambo riparian zone using industry standard techniques and guidelines, and restriction of cattle movement in the riparian zone and waterway.

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2. Glossary and abbreviations

AEMR	Annual Environment Monitoring Report
ANZECC	Australian and New Zealand Environment and Conservation Council
Anthropogenic	Caused or produced by humans
Aquatic macroinvertebrates	Animals that have no backbone, are visible with the naked eye and spend all or part of their life in water
AUSRIVAS	Australian Rivers Assessment system
BOA	Biodiversity Offset Area
CMA	Catchment management area
Discharge	A release of water from a particular source.
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
Ecology	The study of the relationship between living things and the environment.
EMP010	Wambo Coal Environmental Management System: Flora and Fauna Management Plan (Wambo Coal 2010)
Ephemeral	Existing for a shot amount of time
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally).
Oviposition	To lay eggs
Pollution	A technical term (Source: Gooderham J and Tsyrlin E 2002). SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic sources. Environmental stress may result in poor water quality occurring naturally in waterways such as those conditions found in ephemeral streams. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are natural condition.
Riparian	Relating to the banks of a natural waterway.
SIGNAL	Stream Invertebrate Grade Number Average Level
Stress	response to a stressor such as an environmental condition or a stimulus

3. Introduction

3.1 Background

The report documents findings for the flora and habitat complexity monitoring requirements in accordance with DA 305-7-2003, Schedule 4, conditions 44, 48a and 48b managed in accordance with the sites approved Flora and Fauna Management Plan. The plan requires:

"Freshwater macro-invertebrate monitoring, including an assessment of SIGNAL A values and water quality."

The aquatic monitoring program for Wambo Coal commenced in spring 2013 is required to be conducted every five years in spring. The last round of aquatic monitoring was completed in spring 2014. The program is based on AUSRIVAS (Australian River Assessment System), a prediction system used to assess the biological health of Australian rivers. These models predict the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stress, such as pollution or habitat degradation, to which the fauna collected at a site can be compared. AUSRIVAS produces a biological assessment that can be used to indicate the overall ecological health of the site. The drainages monitored include ephemeral streams North Wambo Creek, South Wambo Creek, Waterfall Creek and perennial stream Wollombi Brook.

3.2 Aim

The aim of the aquatic monitoring program is to assess river health of drainages occurring within the North Wambo Underground Mine Lease Area, open cut operations, and associated infrastructure. The aims of the monitoring program are to:

- Assess aquatic habitat.
- Assess water quality against ANZECC and Hunter Salinity Trading Scheme trigger values.
- Assess the macroinvertebrate community condition using the AUSRIVAS model and indices.
- Discuss the results in context to the various land management practices and the environment.
- Specifically examine the condition of aquatic environs within the North Wambo Creek diversion.
- Suggest management actions designed to improve the condition of aquatic environment.

4. Methods

4.1 Weather

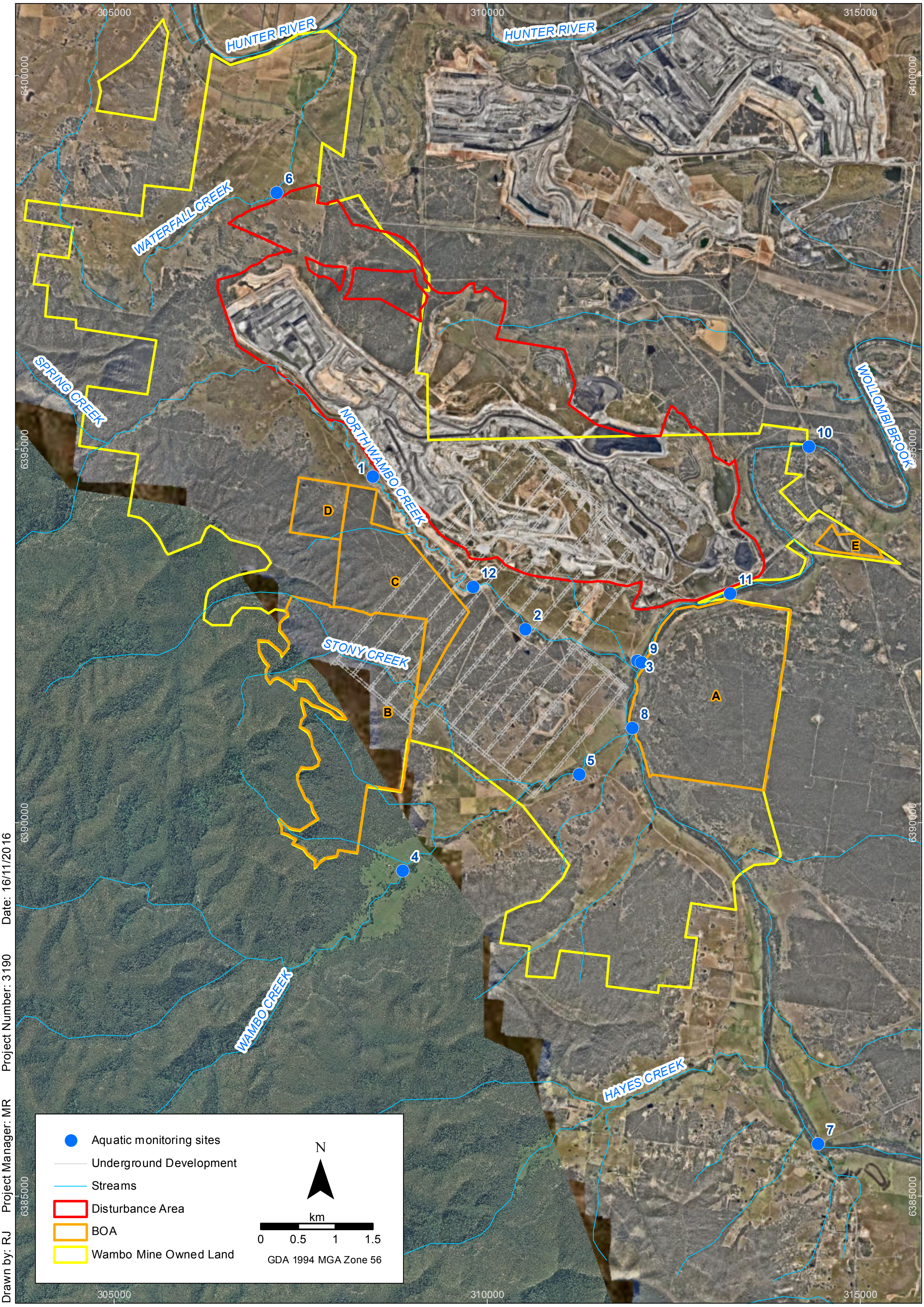
Rainfall data was taken from the nearby Bulga/South Wambo rain gauge (BOM 2016) to characterise the antecedent rainfall prior to sampling and compared to long term averages.

4.2 Location of sampling sites

The location of monitoring sites are shown in Figure 1. Four sites were located in pool habitats on North Wambo Creek, one site on Waterfall Creek, two sites on South Wambo Creek, and five sites on Wollombi Brook (Table 1, Figure 1). Effort was made to ensure site independence and appropriate representation of habitat types observed within the catchment. The locations selected were constrained by access and water availability.

Table 1 Location of sampling sites

Site number	Stream	Location	Easting	Northing
1	North Wambo	Stage 2 North Wambo	308470	6394637
2	North Wambo	Below diversion at subsidence pool	310513	6392590
3	North Wambo	At pool before confluence with Wollombi Brook	312008	6392169
4	South Wambo	Upstream Wambo site	308206	6389177
5	South Wambo	At gauge	311227	6390652
6	Waterfall Creek	Downstream pool	307175	6398438
7	Wollombi Brook	At Bulga bridge	314433	6385703
8	Wollombi Brook	At South Wambo confluence	311939	6391268
9	Wollombi Brook	At North Wambo confluence	312063	6392151
10	Wollombi Brook	Downstream bridge on Golden Highway	314308	6395036
11	Wollombi Brook	At discharge point	313248	6393066
12	North Wambo	Stage 3 diversion	309808	6393160



Location of monitoring sites

Wambo Coal 2016 aquatic monitoring

niche Environment and Heritage

FIGURE 1

Imagery: (c) Nearmap 2015-03-06; Wambo Coal 2012

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4.3 Field methods

The field methods were consistent with standardised techniques in field sampling as prescribed by AUSRIVAS (Turak et al. 2000). This included a visual assessment, water quality monitoring and sampling of macroinvertebrates. The AUSRIVAS methods of sampling both pools and riffles were modified as no suitable in-stream riffle features were present.

4.3.1 Aquatic habitat

A visual assessment of aquatic habitat was conducted using the AUSRIVAS (Australian River Assessment System) proforma. The survey is a rapid visual assessment to describe the habitat based on the following parameters:

- Geomorphology
- Channel diversity
- Bank stability
- Riparian vegetation and adjacent land use
- Water quality
- Macrophytes
- Local impacts and land use practices.

4.3.2 Water quality

Surface water quality was measured in situ using a Yeokal 611 water quality probe at each site. The following variables were recorded:

- Temperature (°C)
- Conductivity (µS/cm)
- pH
- Oxidation – Reduction Potential (ORP) (mV)
- Dissolved Oxygen (DO)(% saturation and mg/L)
- Turbidity (NTU).

Alkalinity (mg CaCa3/L) was measured with a standard titration kit. Water quality data were compared with the ANZECC (2000) default trigger values to physical and chemical stressors for protection of slightly disturbed lowland aquatic ecosystems in south-eastern Australia and Hunter Salinity Trading Scheme trigger values.

4.3.3 Macroinvertebrates

Samples were collected from pool edges for a length of 10 metres either as a continuous line or in disconnected segments. Sampling in segments was often undertaken to ensure the sampling of sub-habitats such as macrophyte beds, bank overhangs, submerged branches and root mats. Segmented sampling was also employed where pool length was short and it was logistically difficult to sample in a continuous line (e.g. in-stream logs). A 250 µm dip net was drawn through the water with short sweeps towards the bank to dislodge benthic fauna while scraping submerged rocks and debris, sides of the stream bank and the bed substrate (Plate 1). Further sweeps in the water column targeted the suspended fauna.

Each sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps, pipettes and or paint brushes. Each tray was picked for a minimum period of forty minutes, after which they were picked at ten minute intervals for either a total of one hour or until no new specimens had been found. Care was taken to collect cryptic and fast moving animals in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% ethanol.

The chemical and physical variables required for running the AUSRIVAS predictive model were recorded. These included alkalinity, modal depth and width of the river, percentage bedrock, boulder or cobble and latitude and longitude. Distance from source, altitude, land-slope and rainfall were also calculated.

Plate 1 AUSRIVAS sampling method

Laboratory methods-invertebrate identification

Macroinvertebrate samples were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Keys used include:

- Dean, J., Rosalind, M., St Clair, M. and Cartwright, D. (2004). Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera). Cooperative Research Centre for Freshwater Ecology.
- Gooderham, J. and Tsyrlin, E. (2002). The Waterbug Book: A guide to the Freshwater Macroinvertebrates of Temperate Australia, CSIRO Publishing.
- Hawking, J. and Theischinger, G. (1999). A guide to the identification of larvae of Australian families and to the identification of ecology of larvae from NSW. Cooperative Research Centre for Freshwater Ecology.
- Madden, C. (2010). Key to genera of Australian Chironomidae. Museum Victoria Science Reports 12, 1-31.
- Madden, C. (2011). Draft identification key to families of Diptera larvae of Australian inland waters. La Trobe University.
- Smith, B. (1996). Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters. Murray Darling Freshwater Research Centre.
- Website - http://www.mdfrc.org.au/bugguide/.

4.4 Data analysis

Samples collected using AUSRIVAS protocol were analysed using the predictive spring model for NSW pool edge habitats. For this program the following indices were generated to aid the interpretation of stream health.

OE50

The Observed to Expected ratio is the ratio of the number of invertebrate families observed at a site (NTC50) to the number of families expected (NTE50) at that site. Only macroinvertebrate families with a greater than 50% predicted probability of occurrences are used by the model. OE50 provides a measure of biological impairment at the test site. Bands derived from the OE50 indicate the level of impairment of the assemblage. The OE50 ratios are divided into bands representing different condition levels. AUSRIVAS definition of band classification is shown in Table 2.

Table 2 AUSRIVAS band interpretation

Band	Interpretation
Band X	Represents a more biologically diverse community than reference
Band A	Is considered similar to reference condition
Band B	Represents sites significantly impaired.
Band C	Represents sites in a severely impaired condition.
Band D	Represents sites that are extremely impaired

Note: Band classification is from AUSRIVAS; for more information see (http://ausrivas.ewater.com.au/).

SIGNAL: (Stream Invertebrate Grade Number Average Level) scores

The revised SIGNAL2 biotic index developed by Chessman (2003) was also used to determine the "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their response to a range of environmental conditions (Table taxa found, based largely on their response to a range of environmental conditions (Table 3). The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site.

Table 4 provides a broad guide for interpreting the health of the site according to the SIGNAL 2 score of the site.

Table 3 SIGNAL Grade and the Level of Pollution Tolerance

SIGNAL Grade	Pollution Tolerance
10-8	Indicates a greater sensitivity to pollution
7-5	Indicates a sensitivity to pollution
4-3	Indicates a tolerance to pollution
2-1	Indicates a greater tolerance to pollution

Table 4 Guide to interpreting the SIGNAL 2 scores

SIGNAL 2 Score	Habitat quality
Greater than 6	Healthy habitat
Between 5 and 6	Mild pollution
Between 4 and 5	Moderate pollution

Less than 4	Severe pollution

(Source: Gooderham J and Tsyrlin E 2002)

*Note that SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic pollution. Environmental stress may result in poor water quality occurring naturally in waterways. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are natural condition.

4.4.4 Fish

Fish collected by dip net sampling techniques as part of the macroinvertebrate sampling were separated from the sample *in situ* and recorded. To further sample the fish assemblage, five concertina type baitfish traps (Plate 2) were set for a minimum of half an hour at each site. The fish were identified and counted and returned to the water. Fish and macroinvertebrate sampling was conducted under Section 37 *Fisheries Management Act 1994*- scientific collection permit number P13/0008-1.1

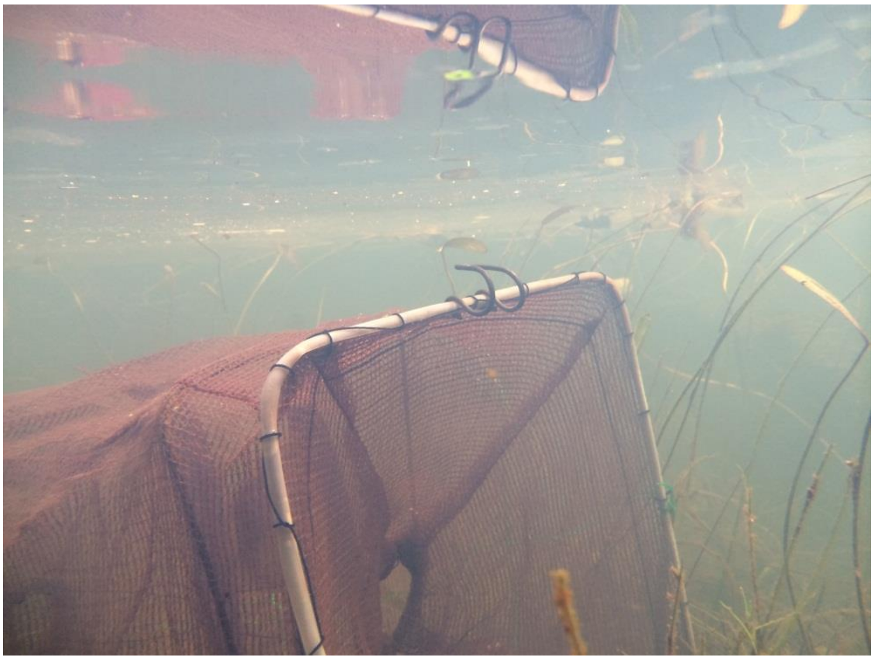

Plate 2 Concertina baitfish trap

5. Results

5.1 Weather Conditions

The survey was conducted during September 2016. The weather was mild with light winds. There was above average antecedent rainfall in June and July however below average monthly rainfall in the month leading up to sampling. There were no significant high rainfall events in the months prior to sampling (Figure 2), however 61 mm of daily rain was recorded on the 6/01/2016 (BOM 2016).

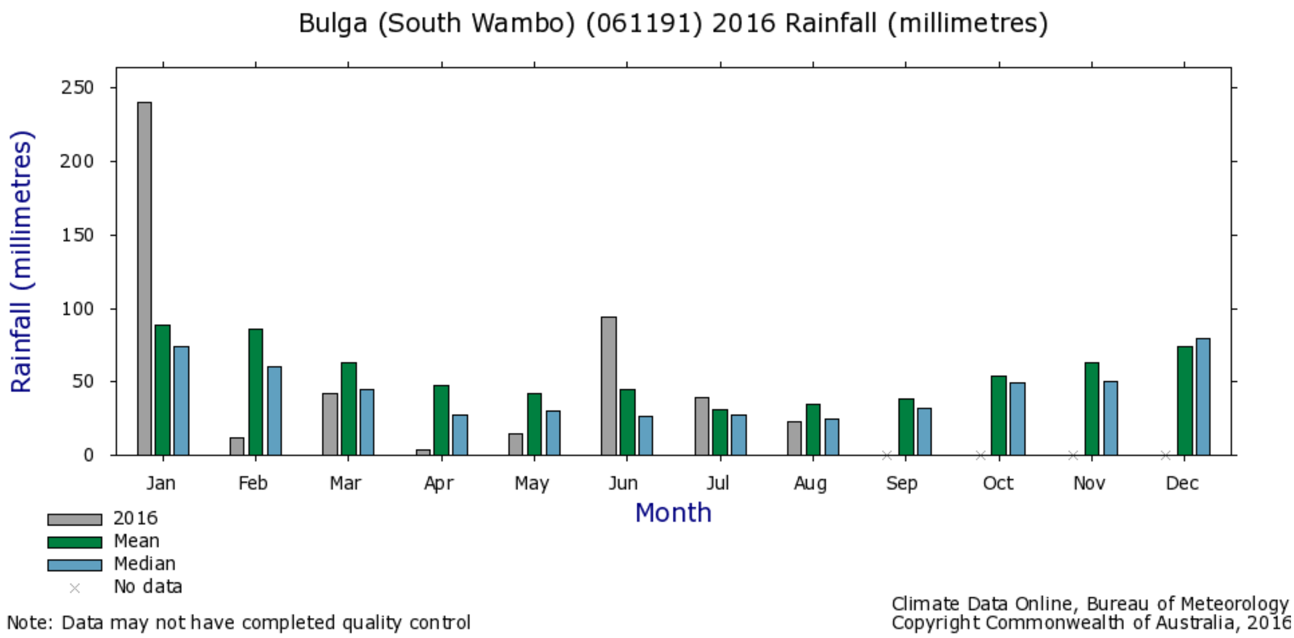

Figure 2 Mean, median, total monthly rainfall (2016)

5.2 Aquatic habitat

5.2.1 Site 1 North Wambo - Stage 2

North Wambo Creek stage 1 diversion shows signs of natural tree/shrub recruitment Plate 3 (i.e. *Casuarina cunninghamiana, Eucalyptus punctate* and *Acacia implexa*). Exotic plant cover consistent with the original rehabilitation treatment persists within this riparian environment (i.e. *Chloris gayana*) with no strong evidence indicating the development of a native groundcover stratum.

Plate 3 Site 1 North Wambo - Stage 2 (308470E 6394637N)

Shallow turbid pools were present at the location however there was no flow observed. Native emergent macrophtyes Umbrella Sedge (*Cyperus eragrostis*) and *Juncus sp.* were present at the site. The substrate consisted of fine silt and there was no shading of the stream.

5.2.2 Site 2 North Wambo below diversion

The condition of the riparian environment at site 2 was fair with visual evidence of moderate disturbance. Disturbance sources include the upstream Stage 2 and 3 diversion, subsidence and the presence of weeds.

The riparian tree canopy was dominated by River Sheoak (*C. cunninghamiana*) with Native Olive (*Notolaea microphylla*) forming a dominant midstorey strata, while Couch (*Cynodon dactylon*) was the dominant native groundcover species (Plate 4).

Plate 4 Site 2 North Wambo below diversion (310513E 6392590N)

The stream habitat consisted of a pool (0-1m deep), with 5 m modal width, and the benthos consisted of fine mud and silt. There was no visible flow and a fine green algal scum was present on the water surface. The vegetation provided low shading of the stream.

5.2.3 Site 3 North Wambo – pool near Wollombi confluence.

The riparian zone was in fair condition with only moderate disturbance. The riparian canopy was dominated by River Sheoak. Lemon scented Myrtle (*Leptospermum polygalifolia*), Wattle (*Acacia parramattensis*) dominate the midstorey stratum. Couch and Marsh Club-rush (*Bolboschoenus fluviatilis*) are also present as well as exotic species such as Willow (*Salix sp*.) and various pasture weeds.

Plate 5 Site 3 North Wambo – pool near Wollombi confluence (312008E 6392169N)

The site includes a circular pool on the Wollombi Brook flood plain with a mode (10-15m wide) and depth (>1m deep), as well as bedrock dominated creek section flowing in to this pool. Benthos was dominated by silt and clay and the occasion with bedrock and isolated pebbles prominent in the upstream section of this site (Plate 5). Common Rush (*Phragmities australis*) occurs along the pool edge. There was no visible flow at the time of sampling. The canopy provided moderate shading of the river.

5.2.4 Site 4 South Wambo upstream site

Riparian vegetation was in moderate condition, showing moderate disturbance. There was evidence of cattle crazing in the riparian zone and bank slumping. The canopy was dominated by River Sheoak and midstorey by Sandpaper Fig (*Ficus coronata*), Red Ash (*Alphitonia excela*), White Cedar (*Melia azedarach*), Snake Vine (*Stephania japonica*). The groundcover stratum consisted of Weeping Grass (*Microlaena stipoides*) and Bracken Fern (*Pteridium esculentum*). The riparian vegetation provided moderate to high shading of the river (Plate 6).

Plate 6 Site 4 South Wambo creek at Max's Farm (308863E 6389360N)

The stream pools were narrow (modal width 3m) and shallow (<1m deep). Stream benthos consisted of mixture of silt, sand, gravel, pebbles and cobbles substrates. Macrophytes were present in 90% of the reach and included Common Starwort (*Callitriche stagnalis*), *Lipilaena australis* and *Juncus sp.* There was some flow visible connecting pools. Algae also covered the benthos.

5.2.5 Site 5 South Wambo Creek at gauge

A small isolated pool was the only available aquatic habitat in this section of stream. The riparian zone, as shown in Plate 7, was in poor condition showing high disturbance such as bank degradation, evidence of cattle use and the presence of weeds. The canopy was dominated by River Sheoak. There was no mid storey present and ground cover was dominated by Kikuyu (*Pennisetium clandistinum*), Couch and Bamboo Grass (*Austrostipa ramosissima*). The vegetation provided little shading of the river.

Plate 7 Site 5 South Wambo Creek at gauge (311227E 6390652N)

The pool at this site was mostly shallow (<1 depth) with 1m modal width. Stream benthos consisted of sand and silt. There were no macrophytes present at this site and no visible flow was evident at the time of sampling.

5.2.6 Site 6 Waterfall Creek

Aquatic habitat was limited at the sampling location, with few isolated pools within the site reach. The riparian zone was in poor condition showing high disturbance from cattle accessing the stream, rubbish and erosion on adjacent banks (Plate 8). The canopy consists of Narrow-leaved Ironbark (*E. crebra*), while the mid story was dominated by Cooba Wattle (*A. salicina*) and Peppercorn Tree (*Schinus areira*). The riparian zone was made up predominately of Couch, *Bothriochloa decipiens* and *Aristida vagans*; typical vegetation found in drainages of grazing systems. The riparian vegetation provided low shading of the creek. Pools present were shallow, turbid, and had a silt dominated benthos.

Plate 8 Site 6 Waterfall Creek (307175E 6398438N)

5.2.7 Site 7 Wollombi Brook at Bulga bridge

The riparian zone showed moderate disturbance (Plate 9). Canopy vegetation was dominated by River Sheoak, which was also the most abundant midstorey species. Vegetation provided no shading of the river.

The pool depth was relatively deep (>1m) and wide (modal width 10m). Benthos was homogeneous consisting entirely of sand sized particles. Macrophytes such as Common Rush and Marsh Club-rush were abundant in this reach.

Plate 9 Site 7 Wollombi Brook at Bulga bridge (314433E 6385703N)

5.2.8 Site 8 Wollombi Brook at South Wambo confluence

The riparian zone was in good condition with only little visual evidence of disturbance as shown in Plate 10. Riparian canopy was dominated by River Sheoak, while the understorey consisted of River Club-rush

(*Scirpus validus*) and Common Rush, while Couch was the dominant grass. There were few weeds present. Vegetation cover provided moderate shading to the river.

Plate 10 Site 8 Wollombi Brook at South Wambo confluence (311939E 6391268N)

The pool was relatively deep in places (>1m) and wide (modal width 12m). The benthos consisted entirely of sand sized particles.

5.2.9 Site 9 Wollombi Brook at North Wambo Creek

The riparian zone was in fair condition showing moderate disturbance (Plate 11). The canopy was dominated by River Sheoak, with the understorey consisting of Willow, Common Rush and Slender Knotweed (*Persicaria sp.*). Weeping Grass was the dominant groundcover species. Exotic weeds were present. The vegetation cover provided low -moderate shading to the river.

Plate 11 Site 9 Wollombi Brook at North Wambo Creek (312063E 6392151N)

The pool was relatively deep in places (>1m) and wide (modal width 7-10m). The benthos consisted entirely of sand sized particles.

5.2.10 Site 10 Wollombi Brook at downstream bridge (Golden Highway)

The riparian zone was in fair condition showing moderate disturbance (Plate 12). The canopy was dominated by River Sheoak, with the midstorey consisting of Willow and smaller River Sheoak. Tall groundcover species included Common Rush and Fleabane (*Conyza sp.*). Weeping Grass, Snake Vine and *Centella asiatica* characterised the groundcover stratum below 1 metre. Exotic weeds were present. Riparian vegetation cover provided low to moderate shading of the river. Common Rush was common along pool edges as was Marsh Club Rush.

Plate 12 Site 10 Wollombi Brook at downstream bridge (Golden Highway) (314308E 6395036N)

The pool was relatively deep in places (>1m) and wide (modal width 15m). River benthos consisted entirely of sand sized particles.

5.2.11 Site 11 Wollombi Brook at mine discharge

The riparian zone was in fair condition showing moderate disturbance such as the presence of weeds (Plate 13). The canopy was dominated by River Sheoak, with the midstorey consisting of Willow and smaller River Sheoak. Tall groundcover species included Common Rush and Marsh Club-rush. Hydrocotyle characterised the groundcover stratum below 1 metre. Exotic weeds were present. Vegetation cover provided a low - moderate shading to the river.

The pool was relatively deep in places (>1m) and wide (modal width 15m). The benthos consisted entirely of sand sized particles with few gravels.

Plate 13 Site 11 Wollombi Brook at mine discharge (313248E 6393066N)

5.2.12 Site 12 North Wambo Creek – Stage 3

The riparian zone was in poor condition showing high disturbance, including lack of riparian vegetation, and exhibiting some erosion and siltation (Plate 14). There was no canopy or midstorey present. Groundcover species included weeds *Galenia pubescens* and *Senecio madagascariensis*. Soil was exposed on the banks of the stream. Emergent macrophyte (*Juncus sp*.), and Umbrella Sedge were present within the stream reach. Vegetation cover provided no shading to the river. The pool was very shallow (<.5m) and narrow (modal width 1m) with benthos consisted entirely of silt with few cobbles.

Plate 14 North Wambo Creek Stage 3 (309808E 6393160N)

5.3 Water quality

Temperature ranged between 12.57 – 24 °C the highest being North Wambo Creek at Stage 3 (Site 12) (Table 5). Conductivity ranged between 233 – 888 µS/cm with North Wambo Stage 3 found to be highest. Turbidity ranged between 5.2 – 1261 NTU; ANZECC guidelines for turbidity were exceeded in all North Wambo site and Waterfall Creek. Dissolved Oxygen (DO) ranged between 51.5 -130% saturation. Most sites with the exception of Sites 2, 5, and 12 were below ANZECC guidelines for DO. Notably, Site 12 was found to be highly oxygenated with 130% saturation. The pH readings ranged between 6.49 – 9 pH ANZECC default guidelines were exceeded in North Wambo Creek (Site 2, Site 3, and Site 12), Waterfall Creek and Wollombi Brook (Site 9 and Site10). Alkalinity ranged 40-120 mg/L the highest recorded in Waterfall Creek.

Table 5 Water quality results

Site number	Temp (C°)	Conductivity(µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH	Alkalinity (mg CaCa3/L)
1	17.92	177	116	80.1	7.78	40
2	13.69	240	685	54.5	8.1	70
3	19.02	510	13.7	83.5	8.6	100
4	12.57	179	70.7	85.6	7.84	60
5	15.54	416	5.2	51.5	6.49	80
6	14.22	167	1261	92.3	9	120
7	15.23	359	33.9	98.5	7.9	40
8	13.57	349	13.5	84	8	52
9	15.65	346	14.7	83.6	8.45	60
10	15.22	351	38.1	92.4	8.3	60
11	13.49	344	16.8	89.9	7.66	50
12	24	508	392	130	9.26	60

ANZECC guidelines for lowland streams: Electrical conductivity (Hunter River salinity trading scheme*600-900 µS/cm), Turbidity (6-50 NTU), pH (6.5-8), Dissolved Oxygen (80-110%). Text in bold indicate those variables that exceed the default trigger values.

5.4 Macroinvertebrates

AUSRIVAS results for the 12 sampled sites are provided in Table 6. Raw data is provided in Annex 1.

Table 6 AUSRIVAS results

Site number	OE50 score	Band	SIGNAL	Number of taxa
1	0.10	D	2.50	4
2	0.48	C	3.44	18
3	0.75	B	3.92	13
4	0.89	A	4.10	20
5	0.58	B	4.00	17
6	0.29	C	2.67	9
7	0.46	C	4.00	8
8	0.64	B	3.67	12

9	0.56	B	4.18	11
10	0.48	C	4.33	9
11	0.68	B	3.94	16
12	0.10	D	2.33	3

Sites 4 in South Wambo Creek scored the highest AUSRIVAS Band (Site 4 Band A OE50-0.89), contained relatively high numbers of macroinvertebrate families (20), and recorded a SIGNAL2 score of 4.10. The Band A classification indicates that this site has aquatic health that is similar to reference conditions.

Sites 3, 5, 8, 9, and 11 scored in Band B (i.e. significantly impaired), had SIGNAL2 scores ranging (3.67 – 4.33) and numbers of families ranging (11-17).

Sites 2, 6, 7, and 10 scored in Band C indicating severe impairment: the site had SIGNAL2 score ranging (2.67-4.0) and had macroinvertebrate families (8 - 18). North Wambo realignment sites (in stage 2 and Stage 3) scored in Band D (extremely impaired), returned SIGNAL2 scores of 2.33 and 2.55 and consisted of depauperate macroinvertebrate communities with only 3-4 taxa.

5.5 Fish

The fish sampling results are provided in Table 7. No fish were recorded in Site 5 (South Wambo Creek). (Plate 7). Waterfall Creek (Site 6, Plate 8) and North Wambo realignment sites (Site 1 and Site 12) (Plate 3 and Plate 14), contained minimal aquatic habitat and consisted of small shallow isolated pools. No fish were observed at these sites.

Fish were recorded at all other sites; the most dominant species were Firetail Gudgeon (*Hypseleotris galii*) which was recorded at all sites where fish were observed with the exception of Site 2. Other species include Flathead Gudgeon (*Philypnodon grandiceps*) and Dwarf Flathead Gudgeon *Philypnodon macrostomus* observed in the Wollombi Brook. Introduced species *Gambusia holbrooki* were observed in low numbers at six sites, however it is expected that these are common throughout the catchment.

Table 7 Fish sampling results

Species	**Sites**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Firetail Gudgeon *Hypseleotris galii*			21		104		7	26	2	10	14	
Flathead Gudgeon *Philypnodon grandiceps*							1			1		
Dwarf Flathead Gudgeon *Philypnodon macrostomus*								1				
Mosquito Fish *Gamubusia holbrooki*		4	1		36				2	1	1	

6. Discussion

6.1 Comparison to previous monitoring

There was little change in vegetation communities at all sites since monitoring commenced in spring 2013. There was some regrowth in North Wambo Creek realignment, however no distinctive change in communities or shading of the river was apparent. An increase in the establishment of aquatic vegetation with in the stream realignment since 2013 shows some limited stream channel rehabilitation.

Water quality results were consistent with ephemeral stream physiochemical characteristics and similar to past monitoring (Niche 2013, Niche 2014). Outliers in this survey were elevated turbidity in Waterfall Creek and elevated DO at Site 12 North Wambo Creek. While high turbidity in Waterfall Creek is related to high sediment load and disturbance in this stream, the high saturation in DO in North Wambo is likely to be related to the shallow water being susceptible to rapid water temperature fluctuations.

Overall there appears to be a reduction in stream health based on AUSRIVAS indices that have decreased since the spring 2013 sampling period. In comparison to spring 2013 and spring 2014 the average O/E50 score (0.654 - 0.548- 0.50), and number of taxa (14.5-12.9 – 11.7) in 2016 of all sites decreased. However, average SIGNAL2 increased slightly since spring 2014 (3.7 - 3.34 – 3.59). Although impairment is implied by the reduction in average O/E50 score and number of taxa, this change is likely an artefact of the sampling of poor condition sites that were not sampled in 2014 due to dry conditions (Site 1 and Site 6). Furthermore, interpretation of stream health is complicated by the natural variation of habitat availability, and associated water quality of ephemeral streams; observed trends are not necessarily the result of anthropogenic activities but driven by natural wetting and drying cycles.

Table 8 AUSRIVAS Band, SIGNAL score, and Number of Taxa (spring 2016, spring 2014, spring 2013).

	Spring 2016			Spring 2014			Spring 2013		
Site number	Band	SIGNAL	Number of taxa	Band	SIGNAL	Number of taxa	Band	SIGNAL	Number of taxa
1	D	2.50	4	dry	dry	dry	D	2	5
2	C	3.44	18	B	2.94	16	B	3.3	17
3	B	3.92	13	C	3.89	9	B	4.1	13
4	A	4.10	20	A	3.11	19	A	4.5	24
5	B	4.00	17	B	3.25	16	A	4.1	28
6	C	2.67	9	dry	dry	dry	C	2	9
7	C	4.00	8	C	4.4	5	B	4.3	12
8	B	3.67	12	B	3.5	16	B	4.1	11
9	B	4.18	11	C	3.36	11	B	4.2	13
10	C	4.33	9	B	3.31	13	B	4.4	13
11	B	3.94	16	C	3	9	-	-	-
12	D	2.33	3	B	2.7	15	-	-	-
	Average O/E50: 0.5	Average SIGNAL 3.59	Average No of Taxa 11.7	Average O/E50 0.548	Average O/E50 3.34	Average No. of Taxa 12.9	Average O/E50 0.654	Average SIGNAL 3.7	Average No. Taxa 14.4

Low SIGNAL2 scores may indicate severe[1] pollution[2] of the waterway (Gooderham J and Tsyrlin E 2002); however this index is based upon the pollution tolerance of invertebrate communities, these may naturally (or pre-mining) inhabit these streams. Therefore 'pollution' to some extent is likely to be natural (e.g. the natural drying cycles and water quality changes associated with ephemeral streams) as discussed in Niche (2013, 2014) as opposed to pollution caused by a specific management action. Fish communities in general were similar to past surveys however there were no observation of Striped Gudgeon or Eels. North Wambo Creek below the stream alignment (Site 2) previously contained Firetail Gudgeon and Flathead Gudgeon (Niche 2014) however these species were not observed on this occasion. This difference more likely an artefact of sampling variation rather than any indication of shift in community composition.

6.2 North Wambo Creek

The ephemeral nature of this stream (i.e. the natural variation in flow) is the controlling factor determining the invertebrates found at this location, however sedimentation from previous land use and input from the stream diversion, is likely to exert some influence on community composition. North Wambo sites below the diversion scored in Band B and C, while within the diversion Site 1 Stage 2 and Site 12 (Stage 3) scored in Band D. Considering the catchment condition, it is reasonable to expect a stream health below reference quality (particularly within the stream diversion), with realistic long term expectations of aquatic health likely to be aligned with Band B.

The communities present particularly within the diversion consisted predominately of adult Hemiptera, Coleopterans, and Dipteran larvae. Poor stream health is expected for a recently established drainage channel, however it is encouraging that water is being retained and providing some habitat for pioneering invertebrates. It is expected that recovery of stream health will be a slow process and take a minimum of ten years to recover to a level comparable to pre- realignment condition.

Macrophyte growth appeared to have increased since previous sampling in 2014. This shows capacity for the stream to potentially support macrophyte habitat and hence development of more complex aquatic faunal communities through the provision of food, shelter, nutrients, and aquatic insect ovipositioning as the system matures. However, pool retention is required for the development of a more complex habitat. With pool retention successional changes of associated flora and fauna are likely to progress as the creek system matures following revegetation and increased aquatic habitat complexity. This will likely result in increases in numbers of macroinvertebrate families, at different stages of their lifecycle in the long term. This succession may potentially include native fish (Firetail Gudgeon) that potentially could recruit from downstream pool refugia to long standing pool habitat once habitat is suitable.

6.3 South Wambo

Upstream South Wambo Creek (Site 4) AUSRIVAS results showed similarity to reference condition, this is despite the system having obvious land use impacts (cattle grazing, agriculture). The site had comparative better riparian vegetation, macrophytes, and benthic habitat, which is thought to contribute to good stream health. Downstream at the gauge (Site 5) the site was restricted to an isolated pool with limited aquatic habitat. It appears that degradation in AUSRIVAS classification from Band A to Band B since 2013 is related to the reduction in flow and habitat availability, and not related to any specific anthropogenic

[1] 'Severe' – A technical term defined as a SIGNAL2 score below 4 (Source: Gooderham J and Tsyrlin E 2002).
[2] 'Pollution' – A technical term (Source: Gooderham J and Tsyrlin E 2002). SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic sources. Environmental stress may result in poor water quality occurring naturally in waterways such as those conditions found in ephemeral streams. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are natural condition.

disturbance, particularly as there was flow present when sampling was conducted in 2013, and no flow in the latter sampling periods. It is likely that this pool will dry completely should below average rainfall conditions occur, with further deterioration in stream health. Despite there being an isolated pool at the site, several native Firetail Gudgeon (104) were observed, indicating the ability of an isolated pool to support high trophic level of aquatic fauna.

6.4 Waterfall Creek

The site scored in Band C indicating impairment at the site, which is consistent with the obvious dry and poor channel condition of the water way.

In 2016 an upstream dam failed and sediment was deposited into a downstream dry tributary of Waterfall Creek (Plate 15). Initial investigation determined that there was no detrimental impact to the aquatic ecology as the creek is mostly dry, deposited material was non-toxic, and was stabilised within the tributary (Niche 2016). The macroinvertebrate data collected in Waterfall Creek in this survey supported this finding with results suggesting that the macroinvertebrate community and stream health is similar when it was sampled in 2013 (Table 8).


Plate 15 Waterfall Creek tributary downstream of dam showing sediment deposition, retention devices, and the lack of water in the creek.

6.5 Wollombi Brook

Wollombi Brook stream health is variable between sites and within sites through time. Overall Wollombi Brook shows signs of impairment (i.e. not close to reference condition) scoring in either Band B or Band C. These results are expected considering the historical long term agricultural land use impacts to its catchment. Wambo Coal is unlikely the source of this streams condition particularly since upstream site, Site 7, shows similar impaired AUSRIVAS scores.

7. Conclusion and Recommendations

The results showed that upper South Wambo Creek had good stream health (Band A) with macroinvertebrate communities similar to modelled reference sites and good riparian vegetation and aquatic habitat. Waterfall Creek (Band C) and sites within the North Wambo Creek stream alignment (Band D) exhibited poor stream health with macroinvertebrate communities differing from modelled reference communities, and had limited aquatic habitat and riparian vegetation. However there were some signs of growth of riparian vegetation and macrophytes with in the stream realignment. Sediment deposition in a tributary of Waterfall creek from a dam failure earlier in the year does not appear to have impacted macroinvertebrate communities in Waterfall Creek itself. Other sites in Wollombi Brook, North Wambo Creek, and South Wambo Creek showed some impairment (Band B), however in general had riparian vegetation and aquatic habitat in moderate condition. Comparison to previous survey data found no significant temporal trends attributable current catchment management. Ephemeral streams (North Wambo, South Wambo and Waterfall creeks) are particularly susceptible to variations in water availability, which in turn affect the availability of aquatic habitat and lead to changes to water quality associated with a drying system. These changes ultimately result in changed aquatic faunal communities. Ephemeral stream ecology, and its extremes need to be considered carefully when interpreting and managing the health of waterways within Wambo Coal land.

The following are recommendations to be considered for future management:

- Establish artificial habitat (e.g. log jam) to create in stream habitat in Stage 3.
- Continue riparian revegetation, and bank stabilisation;
- Continue wider riparian management involving the revegetation of the North Wambo riparian zone using industry standard techniques and guidelines, and restriction of cattle movement in the riparian zone and waterway.

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Websites

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http://www.mdfrc.org.au/bugguide/

http://www.bom.gov.au/

Annex 1 Macroinvertebrate survey results

	North Wambo Creek			South Wambo Creek		Waterfall Creek	Wollombi Brook					North Wambo Creek
Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Nematoda		2										
Sialidae		1										
Lymnaeidae		1				2					1	
Pyralidae		1		1								
Physidae			10					1			1	
Oligochaeta		1								1		2
Acarina			6	1	4			5	1	3	3	
Cladocera						10						
Atyidae		4	20	7	15		12	12	3	4	9	
Dytiscidae	2	2	4		9	7			1			
Gyrinidae			1	7	5							
Halaphilidae					1							

Hydrophilidae				5	1			1			4	
Hydraenidae											2	
Scirtidae				1					1			
Tipulidae				1								
Dixidae				1		3						
Tabanidae		1				1						
Stratiomiyidae											1	
Culicidae						1						51
Ceratopogonidae		8	2				1					1
Tanypodinae		9		2							2	
Orthocladiinae									3			
Chironominae		34	11	1			2	3	3	4	7	
Baetidae				17	2			1		4	6	
Leptophlebiidae			1	36	4						2	
Caenidae		17	7		13		1	3	2	2	5	
Veliidae				1		5						
Gelastocoridae	1											

Isostictidae		1						5	4	2		
Megapodagrionidae										1		
Gomphidae			1								1	
Hemicorduliidae				3				1			1	
Cordulephyidae				1						2	2	
Libellulidae					4							
Ecnomidae									1			
Leptoceridae		2	3	1	8		4	25	6	1	12	1

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APPENDIX F – STREAM FLOW MONITORING REPORT

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17 February 2017

Commercial-in-Confidence

Mr Steven Peart
Manager: Environmental & Community
Wambo Coal Pty Ltd.
ABN: 13 000 668 057
PMB 1
Singleton NSW 2330

Dear Steven

Report on stream flow events along North Wambo, South Wambo and Stoney Creeks for the period 1 February 2016 to 31 January 2017.

Please find contained within this report a summary of probable flow events which occurred along North Wambo, South Wambo and Stoney Creeks from and inclusive of 1 February 2016 to 31 January 2017. However some of the identified flow events commenced prior to 1 February. Where this has occurred a comment is made below the tabulated data.

Originally there were nine flow stations which comprised this flow monitoring network. In addition to the three flow stations which were installed on Stoney Creek in December 2015, a further two flow station were installed along South Wambo Creek in December 2016, see below "1.0 Flow Station Locations, Configurations and General Observations" for further information on these two new flow stations.

Theoretical flow rates were calculated from the pressure data downloaded from each station's data logger. The pressure data was converted to a stream height in metres using the following formula:-

Measured Water Level (m) = Measured Pressure (kPa) X Conversion Factor (0.101972 m/kPa)

This conversion factor was obtained from the manufacturers of the pressure transducers.

The height data was then compared to Theoretical Flow Rating Curves generated by AECOM following the stream cross section surveys undertaken in May 2013, the surveys performed during the installation of the three flow stations along Stoney Creek and one of its major tributaries in December 2015, the two new flow stations along South Wambo Creek during December 2016 and the application of Manning's Equation.

1.0 Flow Station Locations, Configurations and General Observations

1.1 Flow Monitoring Station 1

Flow Station 1 is located at the top of North Wambo Creek and contains a Campbell Scientific (CSA) CS451 SDI-12 pressure transducer connected to a CSA CR800 series data logger. Average stream height is logged on an hourly basis along with maximum and minimum stream height occurring in the hour. In conjunction with the collection of this data the station also contains a tipping bucket rain gauge which produces an hourly running total of rain fall. The total rainfall is reset every 24 hours back to zero at 9:00 am every day.

The logger has been programmed to send SMS alerts to certain mobile phone numbers, as held by Wambo Coal's Environmental Staff, should the 24 hour rainfall reach 10mm or more. Due to the unreliable nature of mobile phone service coverage this function has proven unreliable. This also was communicated to Wambo Coal's Environmental Staff, who have advised that the rain gauge and alert system were no longer required.

During May 2013 (27 May 2013), at the request of Wambo Coal, an Insitu Rugged TROLL100 absolute pressure sensor was installed at this site as a backup sensor. This sensor logs pressure internally at 15 minute intervals.

1.2 Flow Monitoring Station 2

Flow Station 2 is located downstream from Flow Station 1 approximately midway along the old North Wambo Creek diversion. This station contains a CSA CS450 SDI 12 pressure transducer connected to a CSA CR200X series data logger. Average stream height data is collected at ten minute intervals.

An Insitu Rugged BaroTROLL was installed in the data logger enclosure at this site. This BaroTROLL is utilised to compensate the pressure data collected from the Rugged TROLL100s located at Flow Stations 1 and 4 for changes in atmospheric pressure. This sensor logs the atmospheric pressure internally at 15 minute intervals.

1.3 Flow Monitoring Station 3

Flow Station 3 was originally located on North Wambo Creek between the old Wambo Underground Surface Infrastructure and the Open Cut Overburden. Due to the expansion of mining activity in the area the station was removed on 8 November 2012 and repositioned approximately midway along the new diversion of North Wambo Creek downstream of Flow Station 2. Flow Station 3 was reinstalled on 21 and 22 May 2013.

This station comprises a CSA CS451 SDI-12 pressure transducer connected to a CSA CR200X series data logger. Average stream height data is logged every 10 minutes.

1.4 Flow Monitoring Station 4

Flow Station 4 is located at the Wambo Mine Road culvert which crosses North Wambo Creek upstream of the confluence of North Wambo Creek and Wollombi Brook.

This flow station has a CSA CS451 SDI-12 pressure transducer connected to a CSA CR200X series data logger. Average stream height data is logged at 10 minute intervals.

During May 2013 (27 May 2013), at the request of Wambo Coal, an Insitu Rugged TROLL100 absolute pressure sensor was installed at this site as a backup sensor. This sensor logs pressure internally at 15 minute intervals.

1.5 Flow Monitoring Station 5

Following the destruction of Flow Station 5 during February 2013 the station was re-established on 14 December 2016 and is located approximately a further 50m downstream of where the station was originally installed, See report "*60248386_LTRRPT0216_FS_V2_Feb16"* for further detail in the destruction of this flow station.

This station comprises of an Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10 minute intervals.

Figures 1, 2 and **3** below illustrate the location of this flow station.

In conjunction with the relocation/installation a cross and long section survey was also performed. From these surveys the cease to flow point was established, a theoretical flow rate curve and a stream bed profile chart were produced. The flow curve and profile chart are available in **Appendix B**.

Figure 1 Re-Located Flow Station 5 Sensor in Respect to the Stream Bed – Looking East Across the Stream.

Figure 2 Re-Located Flow Station 5 – Looking Up Stream Past the Sensor.

Figure 3 RE-Located Flow Station 5 – Looking Downstream from the Sensor.

1.6 Flow Monitoring Station 6

Flow Station 6 is located on South Wambo Creek approximately 200 to 300 metres up stream of the washout on Wambo Mine Road.

As a result of the data collected from this being unusable as identified in report "*60248386_LTRRPT0216_FS_V2_Feb16*" the flow station was relocated a further 20 metres up stream of its original position. Date re-located 14 December 2016.

The station now comprises of an Insitu Rugged TROLL100 absolute pressure sensor which has been configured to record data at 10 minute intervals.

Figures 4, 5 and **6** below illustrate the location of this flow station.

In conjunction with the relocation/installation a cross and long section survey was also performed. From these surveys the cease to flow point was established, a theoretical flow rate curve and a stream bed profile chart were produced. The flow curve and profile chart are available in **Appendix B**.

The barometric correcting sensor (BaroLogger) used for correcting the absolute pressure readings from flow Stations 5 and 6 is located in the logger box of old Flow Station 6.

Figure 4 Re-Located Flow Station 6 Sensor in relation to the Stream Bed.

Figure 5 Re-Located Flow Station 6 – Looking Upstream from the Sensor.

Figure 6 Re-Located Flow Station 6 – Looking Downstream from the Sensor

1.7 Flow Monitoring Station 9

Flow Station 9 is located on South Wambo Creek approximately 200 to 300m upstream of the confluence of South Wambo and Stoney Creeks.

This flow station has a HSA WL2100W SDI-12 connected to a CSA CR200X Series data logger. Average stream height data is logged at 10 minute intervals.

It was observed during the April 2013 inspection and data download that a significant amount of sediment had been deposited on top of the pressure sensor during the high flow events which occurred in January and February 2013. It is estimated from looking at the gauging board where the sensor is located that approximately 500mm of sediment was deposited in the stream bed. This situation is stilled unchanged.

The data retrieved from this flow station is unusable. This was communicated to Wambo Coal's Environmental team after the May 2015 data collection and they decided not to continue with the data collection at this site.

1.8 Stoney Creek Up Flow Monitoring Station

This flow station was installed in December 2015 and is located on Stoney Creek above the proposed area to be mined. GPS co-ordinates are Easting 307607 Northing 6392828. Due to the remote location of this flow station the flow sensor is an Insitu RuggedTROLL 100 absolute pressure sensor.

This sensor logs stream height at 10 minute intervals internally. This station replaces flow station 8.

1.9 Stoney Creek Tributary Flow Station

This flow station was installed in December 2015 and is located on a major tributary of Stoney Creek above the proposed area to be mined. GPS co-ordinates are Easting 307716 Northing 6392242. Due to the remote location of this flow station the flow sensor is an Insitu RuggedTROLL 100 absolute pressure sensor.

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1.10 Stoney Creek Down Flow Station

This flow station was installed in December 2015 and is located approximately 100m further downstream of Flow Station 7 below the proposed area to be mined. GPS co-ordinates are Easting 309530 Northing 6391043. For continuity with the other two new flow stations the flow sensor at this flow station is an Insitu RuggedTROLL 100 absolute pressure sensor.

This flow station replaces Flow Station 7.

1.11 Stoney Creek Barro Correction Sensors.

The absolute pressure readings recorded by the Insitu RuggerTROLL100 sensors utilised in the Stoney Creek up and Down plus the Tributary Flow Station require correction for fluctuations in barometric pressure. To achieve this two Insitu RuggedBARRO sensors set to log barometric pressure every 10 minutes, are required due to the vertical height difference between the Stoney Creek Up and Tributary flow stations and the Stoney Creek Down Flow Station.

The barometric correction sensor for the Stoney Creek Up and Tributary Flow Stations is located on the infrastructure associated with Flow Station 8.The barometric correction sensor associated with the Stoney Creek Down Flow Station is located on the infrastructure related to Flow Station 7.

2.0 Summary of Results

Tables 1 to **5** below present a summary of probable flow events for each flow station (including the backup sensors located at flow stations 1 and 4) for the period from 1 February 2016 to 31 January 2017.

The results represent a theoretical flow and have been derived from theoretical flow rating curves.

These theoretical flow rating curves have been generated from cross and long section surveys. From the surveys a cross sectional area and the wetted perimeter for various theoretical stream heights were derived.

From these derived values the hydraulic radius was calculated for each theoretical stream height. The hydraulic radius is calculated as follows:

$Rh = A/P$

Where:-

Rh = Hydraulic Radius

A = Calculated cross section area for a give stream height

P = Calculated wetted perimeter for a given stream height

The stream slope was calculated from the long section surveys and the Manning's coefficient of rugosity was determined from the conditions observed in the stream bed and surrounding flood plain.

These values were then entered into the Manning's equation and a theoretical stream velocity was calculated. The Manning's equation is as follows:-

$V = (Rh^{2/3} \text{ X } Sw^{1/2})/n$

Where:-

Rh = Hydraulic radius for a given stream height

Sw = Stream slope derived from the long section survey

n = Manning's coefficient of rugosity

The Manning's coefficient of rugosity was sourced from AS 3778.3.3 - 2001 *"Measurement of water flow in open channels, part 3.3: Velocity - area methods – Measurement by slope – area methods".*

The theoretical velocity, derived from the Manning's equation, was then multiplied by the calculated cross sectional area for a give stream height to give a theoretical flow rate Q. The resultant theoretical flow rates were calculated for a series of stream heights and graphed to generate theoretical flow rating curves. **Appendix B** contains these theoretical flow rating curves for each Flow Station.

The data collected from each Flow Station was presented as a pressure reading in kPa. This pressure was converted to a stream height in metres using the following equation:-

Stream Height (m) = Stream Height (kPa) X 0.101972 (m/kPa)

The calculated stream height was then compared to the cease to flow point at each site. The cease to flow point was identified in conjunction with the long section surveys and represents a point in the reach/stream which the height of the stream must attain before it starts to flow.

The relative level of the cease to flow point was compared to the relative level of the sensor at each station. The difference in height between the cease to flow point and the sensor was calculated. This difference was used to screen the data collected from each station for probable flow events.

Once a flow event had been recognised at a flow station the resultant stream height was cross referenced on the theoretical flow rating curves, for that flow station, to give a theoretical stream flow rate for the identified flow event at the station.

Note: No flow events for Flow Stations 6 and 9 have been included in this report due to the unreliable nature of the data that was collected during the May 2015 data collection event. No data is available from Flow Station 5 due to its destruction during the flood flow event which occurred during February 2013.

There were no recordable flow events at the following flow stations during the period 1 February 2016 to 31 January 2017:-

- Flow Station 1 including the backup Sensor – North Wambo Creek;
- Flow Station 4 including the backup Sensor – North Wambo Creek;

There were no recordable flow events observed on Flow Stations 5 and 6 since their re-location on 14 December 2016.

All results displayed in the following tables in respect to stream flow are theoretical and should be treated as such.

Table 1 Flow Monitoring Station 2 North Wambo Creek Mid Old Diversion – Summary of Results – 1 February 2016 to 31 January 2017.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/02 06:00	7/02 21:20	3.6	0.043	0.095	0.008	0.66	0.029	2.5
2	14/03 18:10	15/03 20:40	1.1	0.046	0.172	0.011	0.98	0.106	9.2
3	17/04 14:50	19/04 07:30	1.7	0.040	0.155	0.008	0.72	0.083	7.2
1	1/05 07:20	4/05 13:50	3.3	0.044	0.092	0.008	0.71	0.027	2.3
2	4/06 22:00	13/06 18:50	8.9	0.065	0.142	0.018	1.55	0.069	6.0
3	19/06 11:50	2/07 02:50	12.6	0.073	0.207	0.023	1.95	0.141	12
4	5/07 03:20	1/08 10:30	27.3	0.067	0.170	0.019	1.66	0.102	8.9
1	12/11 04:40	16/11 17:40	4.5	0.044	0.138	0.010	0.83	0.064	5.6
2	16/12 04:00	19/12 00:10	2.8	0.055	0.121	0.013	1.15	0.048	4.2
3	24/12 17:00	27/12 11:40	2.8	0.054	0.108	0.013	1.11	0.038	3.3
4	31/12 15:10	6/01 11:20	5.8	0.062	0.167	0.016	1.37	0.099	8.5
5	20/01 13:00	21/01 02:30	0.6	0.018	0.052	0.002	0.14	0.008	0.73
6	24/01 23:00	26/01 17:20	1.8	0.033	0.093	0.005	0.46	0.028	2.4

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Table 2 Flow Monitoring Station 3 North Wambo Creek Mid New Diversion – Summary of Results – 1 February 2016 to 31 January 2017.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	4/06 23:00	5/06 01:10	0.1	0.014	0.019	0.000	0.01	0.000	0.01
2	19/06 12:30	19/06 17:20	0.2	0.048	0.076	0.005	0.42	0.013	1.1
3	14/09 21:40	14/09 22:50	0.05	0.024	0.047	0.001	0.07	0.003	0.25
4	18/09 16:00	18/09 20:00	0.2	0.050	0.116	0.009	0.80	0.043	3.7
5	22/10 06:50	22/10 08:40	0.1	0.028	0.041	0.001	0.07	0.002	0.16

Table 3 Stoney Creek Up Flow Monitoring Station, Stoney Creek E307607 N6392828 – 1 February 2016 to 31 January 2017.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/02 00:13	29/02 20:33	28.8	0.069	0.110	<0.001	<0.09	0.004	0.39
2	1/03 07:33	1/03 13:43	0.3	0.007	0.012	<0.001	<0.09	<0.001	<0.09
3	14/03 20:43	15/03 17:03	0.8	0.050	0.073	<0.001	<0.09	<0.001	<0.09

Note: Flow 1 event commenced on 23 December 2015 and was still underway when the 2015/16 data was collected from the flow station on 9 February 2016. This flow event continued for a further 20 days.

Table 4 Stoney Creek Tributary Flow Monitoring Station, Major Tributary to Stoney Creek E307716 N6392242 – 1 February 2016 to 1 January 2017.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/02 00:08	10/02 09:48	9.4	0.022	0.054	0.0003	0.03	0.004	0.38

Note: Flow 1 event commenced on 4 January 2016 and was still underway when the 2015/16 data was collected from the flow station on 9 February 2016. This flow event continued for a further day.

Table 5 Stoney Creek Down Flow Monitoring Station, Stoney Creek E309530 N6391043 – 1 February 2016 to 31 January 2017.

Flow Event No.	Start Date & Time	End Date & Time	Duration (Days)	Average Stream Height (m)	Maximum Stream Height (m)	Average Theoretical Flow Rate		Maximum Theoretical Flow Rate	
						m^3/s	ML/d	m^3/s	ML/d
1	1/02 00:07	12/03 13:27	40.6	0.080	0.162	0.056	4.86	0.305	26
2	14/03 18:57	19/03 13:07	4.8	0.039	0.113	0.004	0.30	0.111	9.55

Note: Flow 1 event commenced on 5 January 2016 and was still underway when the 2015/16 data was collected from the flow station on 11 February 2016. This flow event continued for a further 30 days.

A summary of total monthly rain fall data presented in **Table 6** below was derived from the Wambo Coal's Meteorological Station located next to the helicopter pad near the Mine Infrastructure Area.

Table 6 Monthly Total Rain Fall Data – 1 February 2016 to 31 January 2017.

Month	Wambo Coal's Meteorological Station Total Rain Fall (mm)	Number of Days Rain Fell in the Month
February – 2016	28.8	7
March – 2016	37.8	9
April – 2016	39.3	6
May – 2016	11.4	5
June – 2016	78.0	10
July – 2016	32.4	10
August – 2016	23.3	11
September – 2016	73.4	12
October – 2016	36.6	7
November – 2016	42.4	9
December – 2016	70.3	10
January – 2017	36.3	11

The daily rain fall data was used to cross reference the raw data collected from the Flow Monitoring Stations to help identify periods where a flow event may have occurred.

Appendix C contains graphical depictions on stream height and theoretical flow in conjunction with daily and cumulative rain in three month increments.

- Increment one – 1 February to 30 April 2016;
- Increment two – 1 May to 31 July 2016;
- Increment three – 1 August to 31 October 2016, and;
- Increment four – 1 November 2016 to 31 January 2017.

The results presented in the above tables should be read with the following qualifying statements in mind:-

- All flow events represent a theoretical flow and have been derived from stream height data. The stream height data was then cross referenced to theoretical flow rating curves to give a theoretical flow. These theoretical flow rating curves were generated using cross and long section surveys in conjunction with the Manning's equation. These theoretical flow rating curves were constructed by AECOM in 2013 for flow stations 1 to 4, February 2016 for the three flow stations associated with Stoney Creek and its Tributary and February 2017 for the re-located flow stations 5 and 6;
- North Wambo, South Wambo and Stoney Creeks are ephemeral and as such only flow after significant rainfall events, therefore the theoretical flow rating curves in **Appendix B** have not been calibrated/checked against actual physical measurements of flow using a current meter;
- Some flow events may have been overlooked due to, but not limited to, poor data quality, data missing, inconsistent data, sensor failure or loss, logger failure, power supply problems and changes to stream bed characteristics; and
- The three flow monitoring stations installed on Stoney Creek and its associated tributary have been positioned such as to be outside a proposed underground mine area and designed to monitor stream flow and any associated effect of underground mining on stream flow. These stations were installed by AECOM on 7 December 2016 and replace flow monitoring stations 7 and 8.

3.0 Recommendations

The following actions are recommended by AECOM to help improve the quality of the data received from the flow monitoring stations at Wambo Coal:-

- Relocate Flow Monitoring Station 9 to a location on South Wambo Creek where there is a reach/channel with suitably stable control; and
- Re-Survey the cross sections of the streams associated with Flow Stations 1, 2 and 3. These were last surveyed in 2013. Subsequent flow events would have impacted on the accuracy of the theoretical flow curves and the cease to flow point at each station.

If you have any questions or require any clarification of aspects in this report please contact us in the Singleton office.

Yours faithfully

p.p.

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encl: Appendix A - Flow Station Field Sheets and Station Data Logger Status Sheets.
Appendix B - Theoretical Flow Rating Curves.
Appendix C - Stream Height, Theoretical Flow, Daily and Cumulative Rainfall Charts.

Appendix A

Flow Station Field Sheets & Data Logger Status Sheets

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 10/5/16

Station ID: FS4 backup sensor Time: 830

Solar Panel Condition: ——

Solar Panel Output: —— (V) Solar Panel Cleand: ~~Y / N~~

Battery Voltage: —— Battery Replaced: ~~Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: —— Current Offset: —— Datum Changed: ~~Y / N~~

New Datum: —— New Offset: ——

Stream Obsevations: Dry No Flow Flow

General Site Observation: memory used 100% data overwrite on

Battery used 27%

Station ID: FS4 Time: 845

Solar Panel Condition: DIRTY

Solar Panel Output: 17.8 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.5 V Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: —— Current Offset: —— Datum Changed: ~~Y / N~~

New Datum: —— New Offset: ——

Stream Obsevations: Dry No Flow Flow

General Site Observation:

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 10/5/16

Station ID: FS3 Time: 905

Solar Panel Condition: Dirty

Solar Panel Output: 20.95 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.48 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — ~~Datum Changed: Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Station ID: FS1 Backup sensor Time: 1010

Solar Panel Condition: —

Solar Panel Output: — (V) Solar Panel ~~Cleand: Y / N~~

Battery Voltage: — Battery Repla~~ced: Y / N~~

Data Collected: ~~Y / N~~ Sensor Operating: Y / N Logger Operati~~ng: Y / N~~

Current Datum: — Current Offset: — Datum Change~~d: Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory 100% But data wrap on battery used 28%.

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 10/5/16

Station ID: FS1 Time: 1015

Solar Panel Condition: Dirty

Solar Panel Output: Fluctating (V) Solar Panel Cleand: Y / N

Battery Voltage: 14-1 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: ~~Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Station ID: FS2 Time: 1040

Solar Panel Condition: Dirty

Solar Panel Output: 22.43 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.47 Battery Replaced: Y / N

Data Collected: Y ~~N~~ Sensor Operating: Y N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: ~~Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow Pool

General Site Observation:

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 10/5/16

Station ID: FS2 Barro logger Time: 1050

Solar Panel Condition: —

Solar Panel Output: — (V) Solar Panel ~~Cleand: Y / N~~

Battery Voltage: — Battery ~~Replaced: Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — ~~Datum Changed: Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: 30% Battery used

memory 100% Full with datawrap on.

Station ID: Stoney Creek Trib Time: 1155

Solar Panel Condition: —

Solar Panel Output: — (V) Solar Panel ~~Cleand: Y / N~~

Battery Voltage: — Battery ~~Replaced: Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: ~~Y / N~~

Current Datum: — Current Offset: — ~~Datum Changed: Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: MEMORY USED 43%

Battery USED 6%.

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 10/5/16

Station ID: Stony creek up Time: 1240

Solar Panel Condition: ——

Solar Panel Output: —— (V) Solar Panel ~~Cleand: Y / N~~

Battery Voltage: —— Battery ~~Replaced: Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: —— Current Offset: —— ~~Datum Changed: Y / N~~

New Datum: —— New Offset: ——

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory used 43%.

Battery used 4%.

Station ID: Stoney creek up Barro Time: 1310

Solar Panel Condition: ——

Solar Panel Output: —— (V) Solar Panel ~~Cleand: Y / N~~

Battery Voltage: —— Battery ~~Replaced: Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: —— Current Offset: —— Datum ~~Changed: Y / N~~

New Datum: —— New Offset: ——

Stream Obsevations: Dry No Flow Flow

General Site Observation: memory 43%.

Battery 4%. used.

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 10/5/16

Station ID: Stoney creek down Time: 1340

Solar Panel Condition: —

Solar Panel Output: — (V) Solar Panel Cleand: ~~Y / N~~

Battery Voltage: — Battery Replaced: ~~Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: ~~Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: memory used 43%.

Battery used 6%.

Station ID: Stoney creek down barro Time: 1350

Solar Panel Condition: —

Solar Panel Output: — (V) Solar Panel Cleand: ~~Y / N~~

Battery Voltage: — Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: ~~Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: memory 43%.

Battery 4%.

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60248386 - Wambo Flow Station 1 CR800 Data Logger Status Summary
10/05/2016 10:20:08

Datalogger Information
Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 22.39 °C
Memory: 4194304 bytes
CPU Drive Free: 442368 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information
Current Program: CPU:WaterLevel_V2_1A_10.CR8
Start Time: 6/02/2015 08:48:14
Run Signature: 52401
Program Signature: 58453
Results for Last Program Compiled: CPU:WaterLevel_V2_1A_10.CR8 -- Compiled in SequentialMode.
Memory Free: 21644 bytes

Program Errors
Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.96
Lithium Battery: 3.42
Number of times voltage has dropped below 12V: 0
Number of times voltage has dropped below 5V: 0

60248386 - Wambo Flow Station 2 CR200 Series Data Logger Status Summary
10/05/2016 10:44:01

Datalogger Information

OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information

Current Program: WaterLevel_CSA.

Program Errors

Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 13.53

RF Information

Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 - Wambo Flow Station 3 CR200 Series Data Logger Status Summary
10/05/2016 09:11:28

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.45

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 - Wambo Flow Station 4 Cr200 Series Data Logger Status Summary
10/05/2016 08:49:43

Datalogger Information
OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA_V2a.CR2

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.51

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 01-08-16

Station ID: station 4 Backup sensor Time: 08:00

Solar Panel Condition: Dusty

Solar Panel Output: 18.00 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.76 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: memory used = 100% (data wrap on)

battery used = 29%

Station ID: station 4 Time: 08:00

Solar Panel Condition: Dusty

Solar Panel Output: 18.00 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.76 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: ı

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 01-08-16

Station ID: station 3 Time: 08:30

Solar Panel Condition: Dusty

Solar Panel Output: 19.00 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13 72 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: dead kangaroo

Station ID: Backup sensor Station 1 Time: 09:20

Solar Panel Condition: Dusty

Solar Panel Output: 13.11 (V) Solar Panel Cleand: Y / N

Battery Voltage: 14.2 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: memory used = 100% (data wrap on)

Battery used = 30%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 01-08-16

Station ID: Station 1 Time: 09:30

Solar Panel Condition: Dusty

Solar Panel Output: 13.11 (V) Solar Panel Cleand: Y / N

Battery Voltage: 14.2 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Baro logger
~~Battery~~ ~~sensor~~

Station ID: Station 2 Time: 10:00

Solar Panel Condition: Dusty

Solar Panel Output: 21.83 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.65 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: ~~Dry~~ No Flow Flow

General Site Observation: memory used = 100% (data wrap on)

Battery used 32%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 01-08-16

Station ID: station 2 Time: 10:15

Solar Panel Condition: Dusty

Solar Panel Output: 21.83 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.65 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: ~~Dry~~ No Flow Flow

General Site Observation:

Station ID: Stoney Ck Up Time: 1210

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used ~~100%~~ 62 %
Battery Used. 6 %

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 1/8/16

Station ID: Stony Ck Trib Time: 1145

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: ~~Y / N~~

Battery Voltage: NA Battery Replaced: ~~Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used 62%

Battery Used 6%

Station ID: Stony Ck Up Bund Time: 1250

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow NA

General Site Observation: Memory Used 62%

Battery Used 6%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 1/8/16

Station ID: Stony Ck Down Time: 1310

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used 62%

Battery Used 8%

Station ID: Stony Ck Down Bore Time: 1325

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow NA

General Site Observation: Memory Used 62%

Battery Used 6%

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60248386 - Wambo Flow Station 1 Cr800 Data Logger Status Summary
1/08/2016 09:44:05

Datalogger Information

Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 12.74 °C
Memory: 4194304 bytes
CPU Drive Free: 442368 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information

Current Program: CPU:WaterLevel_V2_1A_10.CR8
Start Time: 6/02/2015 08:48:14
Run Signature: 52401
Program Signature: 58453
Results for Last Program Compiled: CPU:WaterLevel_V2_1A_10.CR8 -- Compiled in SequentialMode.
Memory Free: 21644 bytes

Program Errors

Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 14.17
Lithium Battery: 3.36
Number of times voltage has dropped below 12V: 0
Number of times voltage has dropped below 5V: 0

60248386 - Wambo Flow Station 2 CR200 Series Data Logger Status Summary
1/08/2016 10:14:02

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.70

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 - Wambo Flow Station 3 Cr200 Series Data Logger Status Summary
1/08/2016 08:50:12

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.70

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 - Wambo Flow Station 4 CR200 Series Data Logger Status Summary
1/08/2016 08:28:26

Datalogger Information
OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA_V2a.CR2

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.79

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 11/11/16

Station ID: 1 BU Time: 0940

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N NA

Battery Voltage: NA Battery Replaced: Y / N NA

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation: MEMORY 100%
BATTERY 32%

Station ID: 2 Time: 1000

Solar Panel Condition: GOOD

Solar Panel Output: 20.6 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.18 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation:
BARNO - MEMORY 100%
BATTERY - 34%
DATA DOWNLOADED

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 11/11/16

Station ID: 3 Time: 0850

Solar Panel Condition: NOT VISIBLE

Solar Panel Output: 19.68 (V) Solar Panel Cleand: Y / N TOO HIGH

Battery Voltage: 13.38 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Station ID: 1 Time: 0930

Solar Panel Condition: GOOD

Solar Panel Output: REG FLASHING OK NO VOLTS (V) Solar Panel Cleand: Y / N

Battery Voltage: 14.05 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation:

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 11/11/16

Station ID: 4 Time: 0810

Solar Panel Condition:

Solar Panel Output: 19.5 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.46 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: N/A Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Station ID: 4 BV Time: 0822

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N NA

Battery Voltage: 31% USED Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: ~~Y / N~~ NA

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation: MEMORY USED 100%

BATTERY USED 31%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 11/11/16

Station ID: SC TRIB Time: 1055

Solar Panel Condition:

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N NA

Battery Voltage: NA Battery Replaced: Y / N NA

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation: MEMORY USED - 81%

BATTER USED - 10%

Station ID: SC UP Time: 1150

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N NA

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation: MEMORY 81% USED

BATTERY 8% USED

Page of Initials: MS

AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 11/11/16

Station ID: SC BARRO Time: 1235

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: ~~Y / N~~ NA

Battery Voltage: NA Battery Replaced: ~~Y / N~~ NA

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation: BATTERY - 8% used

MEMORY - 81% used

Station ID: SC DOWN Time: 1300

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N NA

Battery Voltage: NA Battery Replaced: Y / N NA

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation: MEMORY - 81% USED

BATTERY - 10% USED

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 11/15/16

Station ID: SC Down Barro Time: 1315

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N NA

Battery Voltage: NA Battery Replaced: Y / N NA

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: NA Current Offset: NA Datum Changed: Y / N

New Datum: NA New Offset: NA

Stream Obsevations: Dry No Flow Flow

General Site Observation: MEMORY - 81% used

BATTERY - 10% used

Station ID: ______ Time: ______

Solar Panel Condition: ______

Solar Panel Output: ______ (V) Solar Panel Cleand: Y / N

Battery Voltage: ______ Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: ______ Current Offset: ______ Datum Changed: Y / N

New Datum: ______ New Offset: ______

Stream Obsevations: Dry No Flow Flow

General Site Observation: ______

Page of

Initials: [illegible]

60248386 - Wambo Flow Station 1 CR800 Data Logger Status Summary
11/11/2016 09:37:53

Datalogger Information
Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 26.44 °C
Memory: 4194304 bytes
CPU Drive Free: 442368 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information
Current Program: CPU:WaterLevel_V2_1A_10.CR8
Start Time: 6/02/2015 08:48:14
Run Signature: 52401
Program Signature: 58453
Results for Last Program Compiled: CPU:WaterLevel_V2_1A_10.CR8 -- Compiled in SequentialMode.
Memory Free: 21644 bytes

Program Errors
Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.92
Lithium Battery: 3.43
Number of times voltage has dropped below 12V: 0
Number of times voltage has dropped below 5V: 0

60248386 - Wambo Flow Station 2 CR200 Series Data Logger Status Summary
11/11/2016 10:11:18

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.42

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248368 - Flow Station 3 CR200 Series Data Logger Status Summary
11/11/2016 09:10:27

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.39

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 - Wambo Flow Station 3 CF200 Series data Logger Status Summary
11/11/2016 08:22:37

Datalogger Information
OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA_V2a.CR2

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.50

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 13/2/~~16~~ 17

Station ID: SCTRIB Time: 850

Solar Panel Condition: N/A

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 100 % Data Wrap
Battery Used = 12 %

Station ID: SCUP Time: 1000

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 100% Data Wrap.
Battery Used = 11%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 13/2/17

Station ID: SC Baro Time: 1035

Solar Panel Condition: — NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 100% Data Wrap
Battery Used = 10%

Station ID: SC D Time: 1110

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 100% Data wrap.
Battery Used = 12%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 13/2/17

Station ID: SC D Boro Time: 1125

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 100% Data wrap

Batteries Used = 10%

Station ID: NF5 Time: 1155

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 12%

Battery Used = 19

Page of Initials:

AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 13/2/17

Station ID: NF6 Time: 1215

Solar Panel Condition: NA

Solar Panel Output: — (V) Solar Panel Cleand: ~~Y / N~~

Battery Voltage: — Battery Replaced: ~~Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: ~~Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 12%

Battery Used = 1%

Station ID: SWC Baro Time: 1230

Solar Panel Condition: NA

Solar Panel Output: NA (V) Solar Panel Cleand: ~~Y / N~~

Battery Voltage: NA Battery Replaced: ~~Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: ~~Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory used = 12%

battary used = 1%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 14/2/17

Station ID: 4 Time: 800

Solar Panel Condition: Dusty

Solar Panel Output: 13.93 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.20 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Station ID: 4BU Time: 825

Solar Panel Condition: —

Solar Panel Output: NA (V) Solar Panel Cleand: Y / N

Battery Voltage: NA Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 100% Dat wrap

Battery used = 33%

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AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 14/2/17

Station ID: 3 Time: 845

Solar Panel Condition: Bird Droppings

Solar Panel Output: 18.10 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.43 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Station ID: 51 Time: 930

Solar Panel Condition: Bird Droppings

Solar Panel Output: 13.83 (V) Solar Panel Cleand: Y / N

Battery Voltage: 13.46 Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: Y / N

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation:

Page of Initials:

AECOM

Quarterly Flow Station Field Sheet

Client: Wambo　　Project Number: 60248386　　Date: 14/2/17

Station ID: 1BV　　Time: 945

Solar Panel Condition: —

Solar Panel Output: — (V)　　Solar Panel Cleand: ~~Y / N~~

Battery Voltage: —　　Battery Replaced: ~~Y / N~~

Data Collected: Y / N　　Sensor Operating: Y / N　　Logger Operating: Y / N

Current Datum: —　　Current Offset: —　　Datum Changed: ~~Y / N~~

New Datum: —　　New Offset: —

Stream Obsevations: Dry　No Flow　Flow

General Site Observation: Memory Used = 100% Dirk Wrap
Battery Used = 34%.

Station ID: S2　　Time: 1010

Solar Panel Condition: Good

Solar Panel Output: 20.54 (V)　　Solar Panel Cleand: Y / N

Battery Voltage: 13.44　　Battery Replaced: Y / N

Data Collected: Y / N　　Sensor Operating: Y / N　　Logger Operating: Y / N

Current Datum: —　　Current Offset: —　　Datum Changed: ~~Y / N~~

New Datum: —　　New Offset: —

Stream Obsevations: Dry　No Flow　Flow

General Site Observation: No Loss Data since the 11/11/16
O/L — loose Battery terminals tightened.

Page of　　　　Initials: [illegible]

AECOM

Quarterly Flow Station Field Sheet

Client: Wambo Project Number: 60248386 Date: 14/2/17

Station ID: 124 Bora Time: 1025

Solar Panel Condition: N/A

Solar Panel Output: — (V) Solar Panel Cleand: ~~Y / N~~

Battery Voltage: — Battery Replaced: ~~Y / N~~

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: — Current Offset: — Datum Changed: ~~Y / N~~

New Datum: — New Offset: —

Stream Obsevations: Dry No Flow Flow

General Site Observation: Memory Used = 100% Datawrap
Battery Used = 37%

Station ID: ________ Time: ______

Solar Panel Condition: ________________

Solar Panel Output: ________ (V) Solar Panel Cleand: Y / N

Battery Voltage: ________ Battery Replaced: Y / N

Data Collected: Y / N Sensor Operating: Y / N Logger Operating: Y / N

Current Datum: ________ Current Offset: ________ Datum Changed: Y / N

New Datum: ________ New Offset: ________

Stream Obsevations: Dry No Flow Flow

General Site Observation: ________________

Page of

Initials: [illegible]

60248386 - Wambo Flow Station 1 CR800 Data Logger Status Summary 14/02/2017 09:31:22

Datalogger Information

Reported Station Name: 6722
OS Version: CR800.Std.27
OS Date: 131010
OS Signature: 6757
PakBus Address: 801
Security Settings(1): 0
Security Settings(2): 0
Security Settings(3): 0
Panel Temperature: 24.07 °C
Memory: 4194304 bytes
CPU Drive Free: 442368 bytes
USR Drive Free: 0 bytes
Watchdog Errors: 0

Program Information

Current Program: CPU:WaterLevel_V2_1A_10.CR8
Start Time: 6/02/2015 08:48:14
Run Signature: 52401
Program Signature: 58453
Results for Last Program Compiled: CPU:WaterLevel_V2_1A_10.CR8 -- Compiled in SequentialMode.
Memory Free: 21644 bytes

Program Errors

Skipped Scans: 0
Skipped Slow Scans: 0
Skipped System Scans: 0
Skipped Records in Hourly: 0
Skipped Records in Daily: 0
Skipped Records in BatteryData: 0
Variable Out of Bounds: 0

Battery Information

Battery Voltage: 13.39
Lithium Battery: 3.40
Number of times voltage has dropped below 12V: 0
Number of times voltage has dropped below 5V: 0

60248386 - Wambo Flow Station 2 CR200 Series Data Logger Status Summary 14/02/2017 10:15:00

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 2
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.47

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 - Wambo Flow Station 3 CR200 Series Data Logger Status Summary
14/02/2017 08:54:01

Datalogger Information
OS Version: v07
OS Date: 090723
PakBus Address: 3
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA.

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.41

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

60248386 - Wambo Flow Station 4 CR200 Series Data Logger Status Summary
14/02/2017 08:15:55

Datalogger Information
OS Version: CR200X.Std.01
OS Date: 100810
PakBus Address: 4
Watchdog Errors: 0

Program Information
Current Program: WaterLevel_CSA_V2a.CR2

Program Errors
Skipped Scans: 0
Variable Out of Bounds: 0

Battery Information
Battery Voltage: 13.19

RF Information
Radio Address: 0
Network Address: 0
Hop Sequence: 0
Power Mode: NO_RF
Signal Level: 0

Appendix B

Stream Theoretical Flow Rating and Profile Curves

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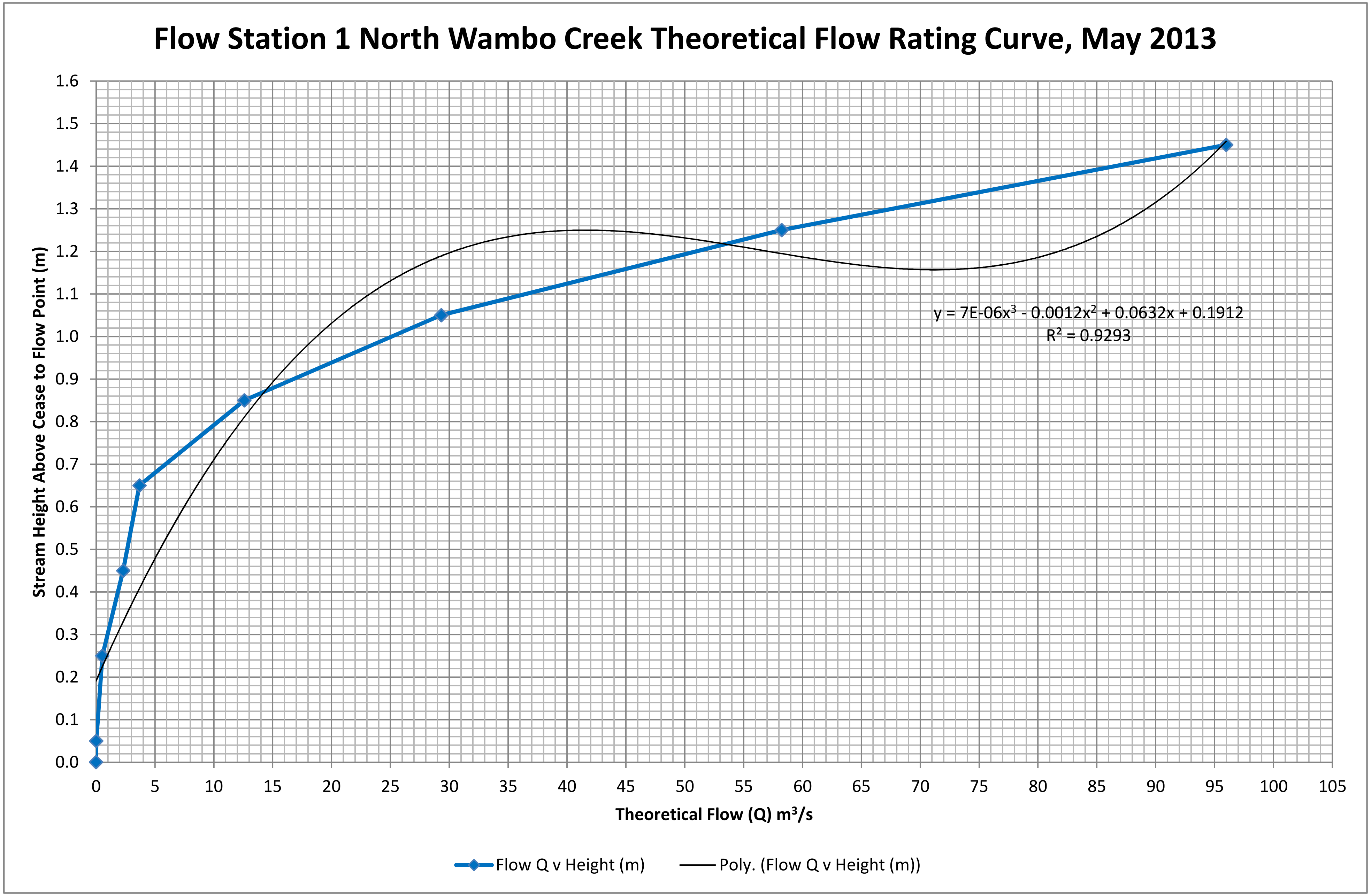
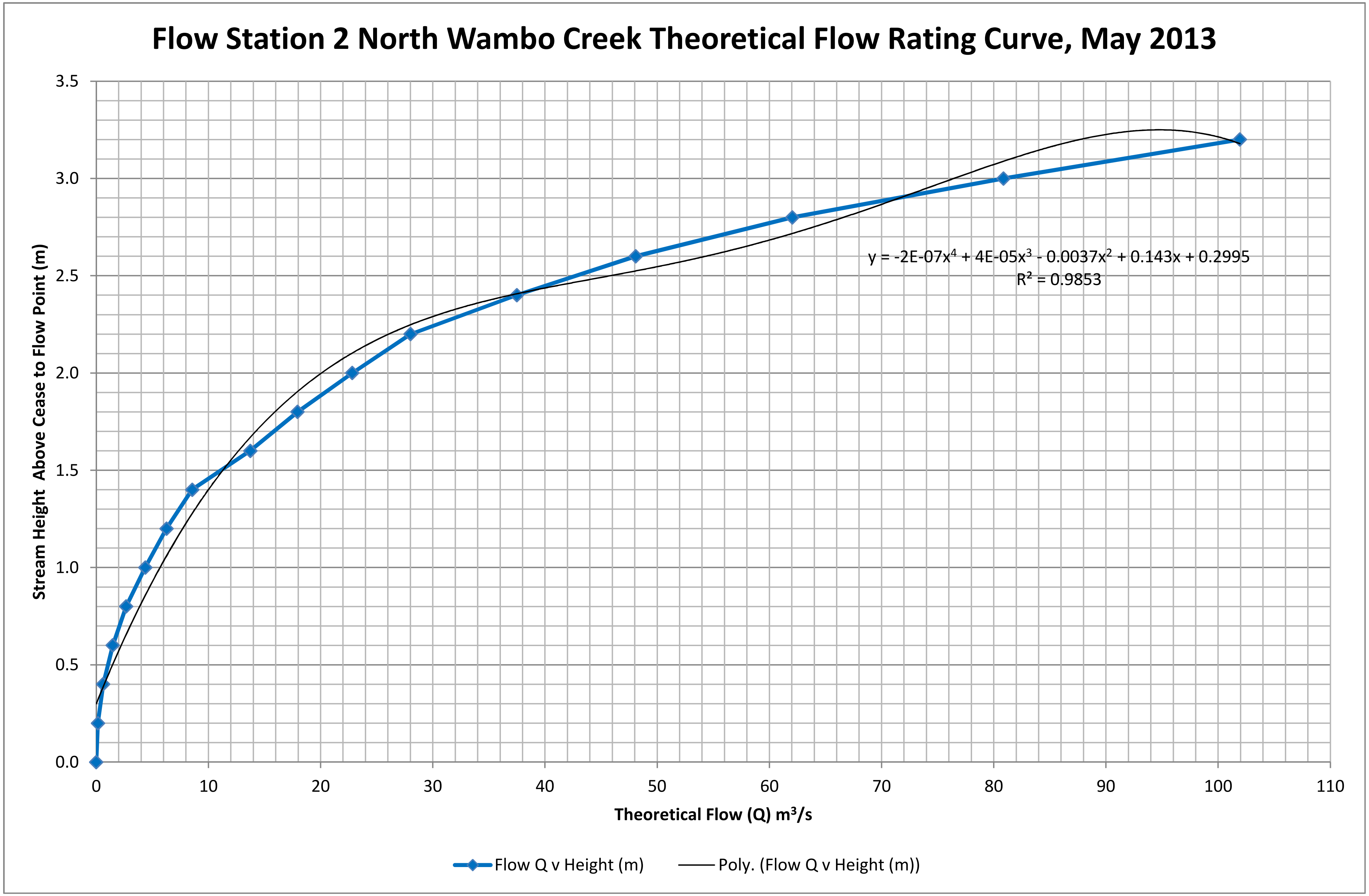
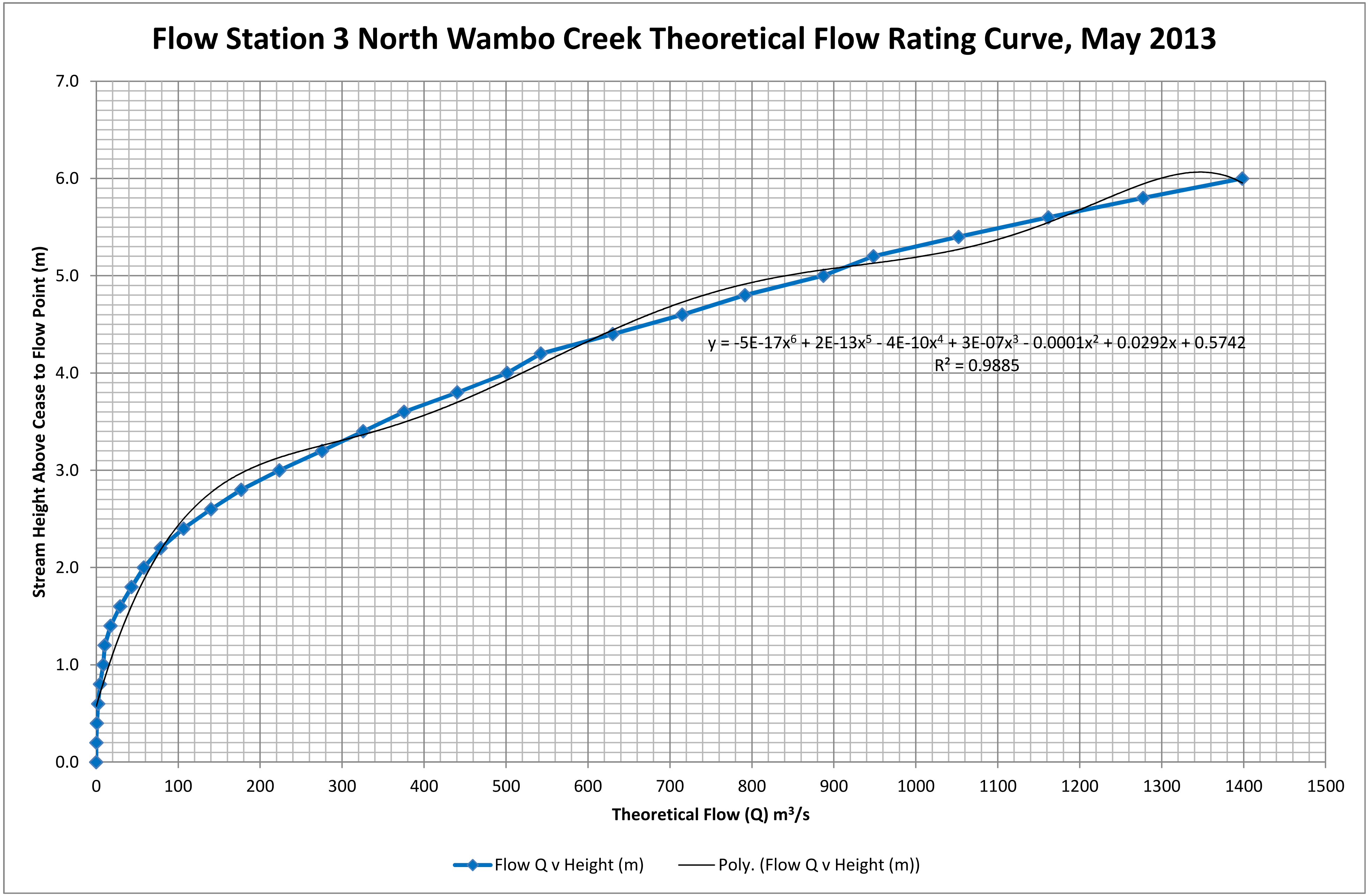


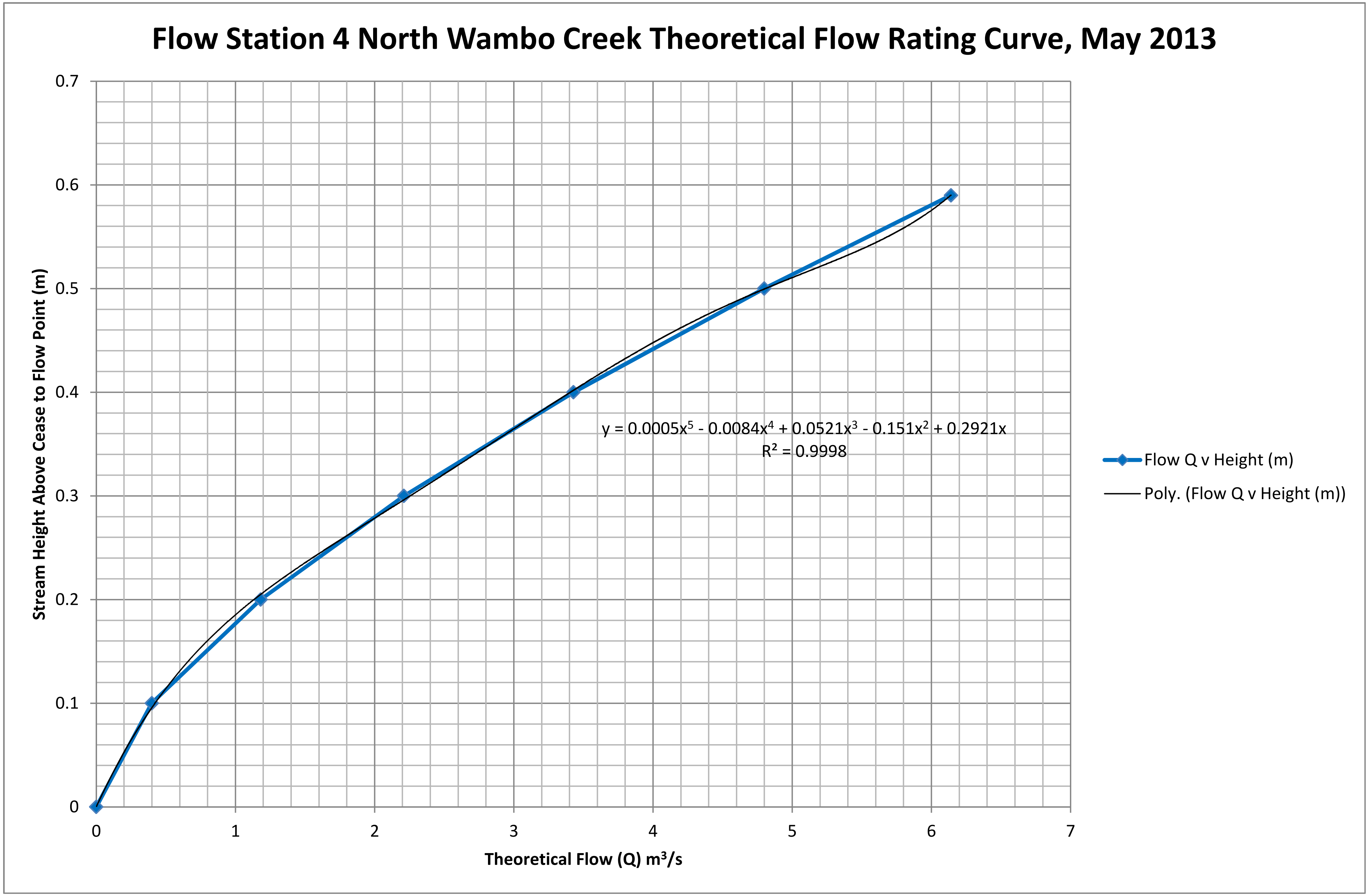
Flow Station 1 North Wambo Creek Theoretical Flow Rating Curve, May 2013
Stream Height Above Cease to Flow Point (m)
Theoretical Flow (Q) m³/s
y = 7E-06x³ - 0.0012x² + 0.0632x + 0.1912
R² = 0.9293
Flow Q v Height (m)
Poly. (Flow Q v Height (m))

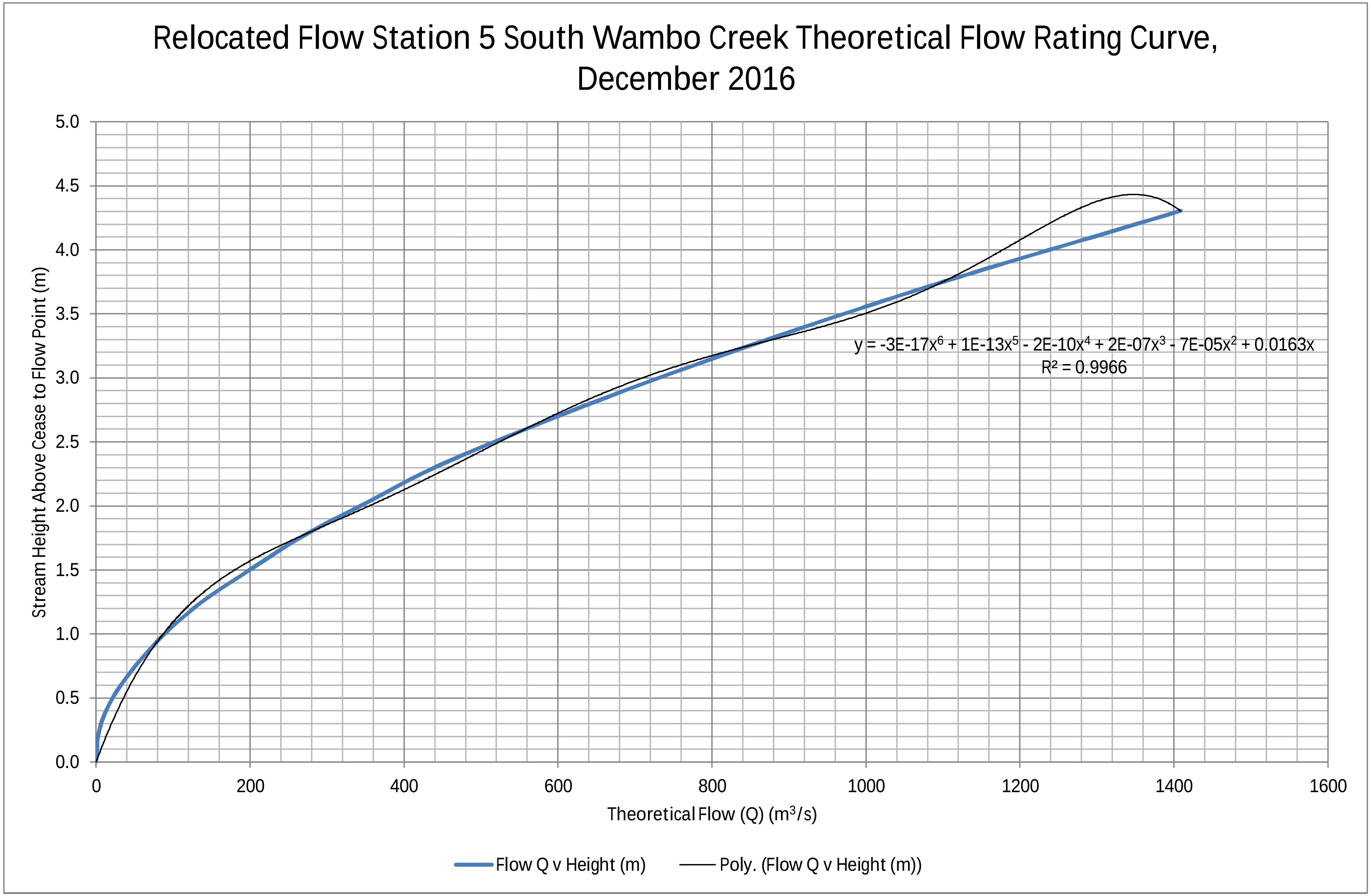


Flow Station 2 North Wambo Creek Theoretical Flow Rating Curve, May 2013
Stream Height Above Cease to Flow Point (m)
Theoretical Flow (Q) m³/s
y = -2E-07x⁴ + 4E-05x³ - 0.0037x² + 0.143x + 0.2995
R² = 0.9853
Flow Q v Height (m)
Poly. (Flow Q v Height (m))
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
80
90
100
110

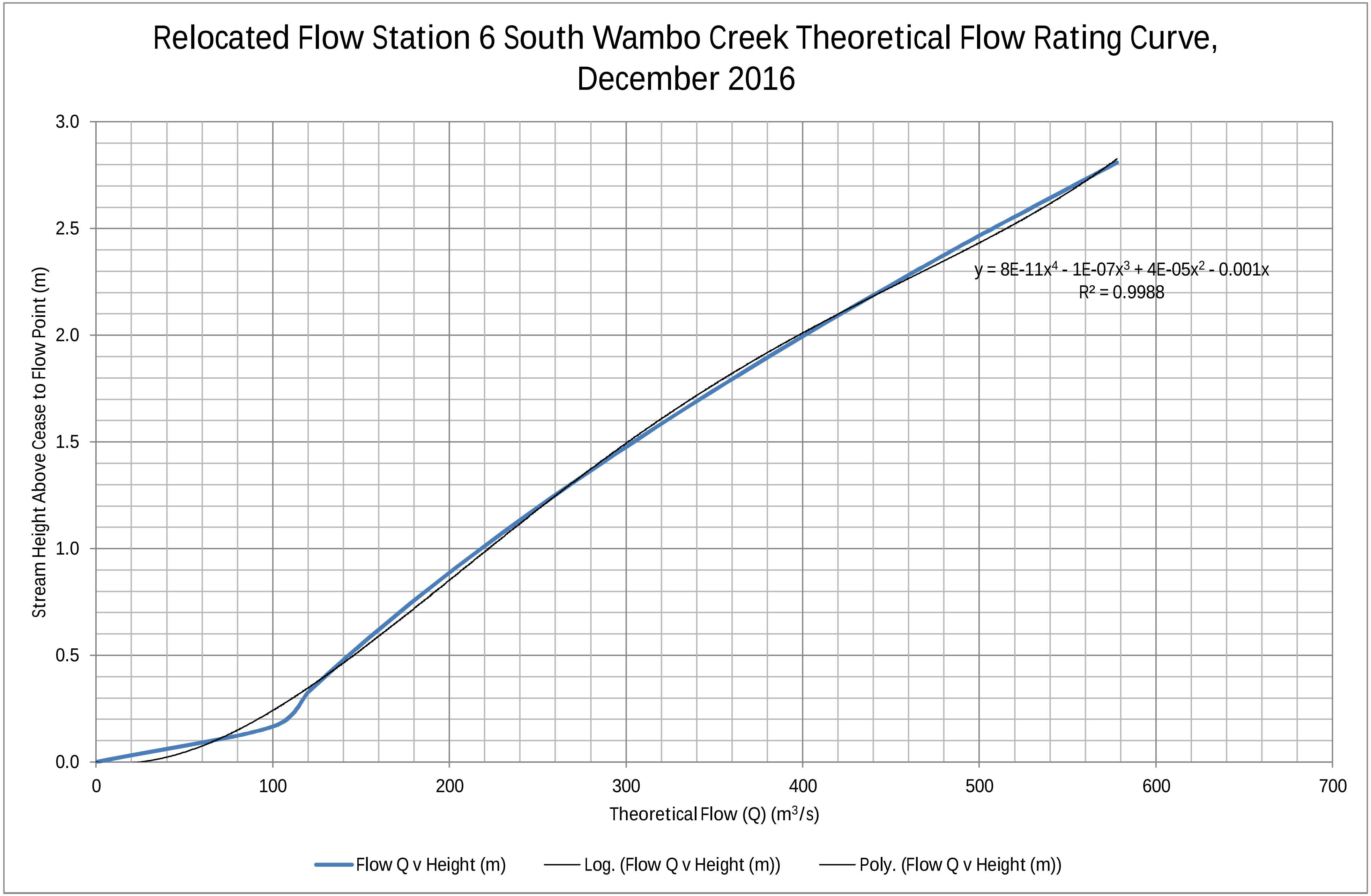


Flow Station 3 North Wambo Creek Theoretical Flow Rating Curve, May 2013
Stream Height Above Cease to Flow Point (m)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Theoretical Flow (Q) m³/s
y = -5E-17x⁶ + 2E-13x⁵ - 4E-10x⁴ + 3E-07x³ - 0.0001x² + 0.0292x + 0.5742
R² = 0.9885
Flow Q v Height (m)
Poly. (Flow Q v Height (m))

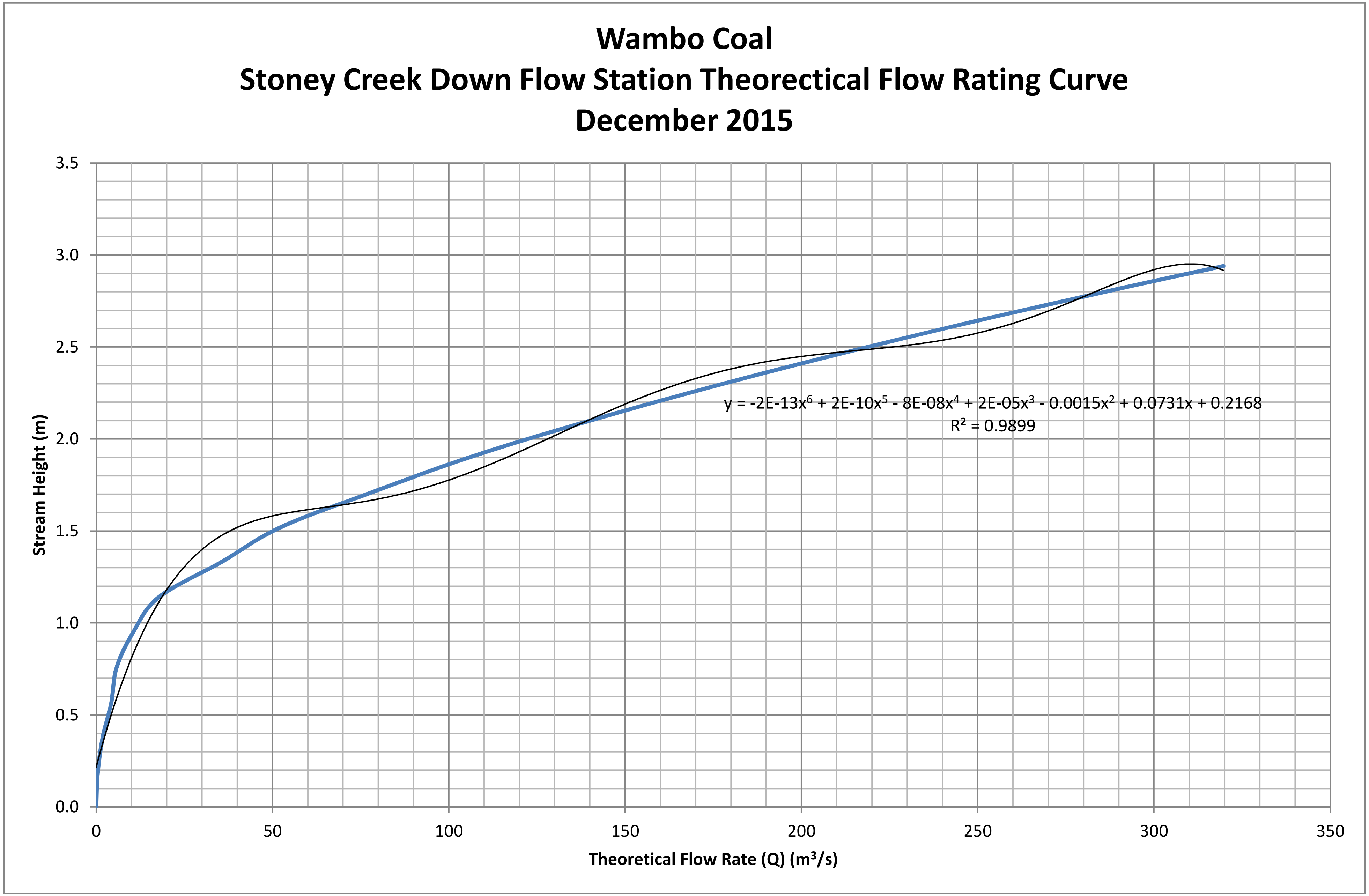

Flow Station 4 North Wambo Creek Theoretical Flow Rating Curve, May 2013
Stream Height Above Cease to Flow Point (m)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
Theoretical Flow (Q) m³/s
y = 0.0005x⁵ - 0.0084x⁴ + 0.0521x³ - 0.151x² + 0.2921x
R² = 0.9998
Flow Q v Height (m)
Poly. (Flow Q v Height (m))



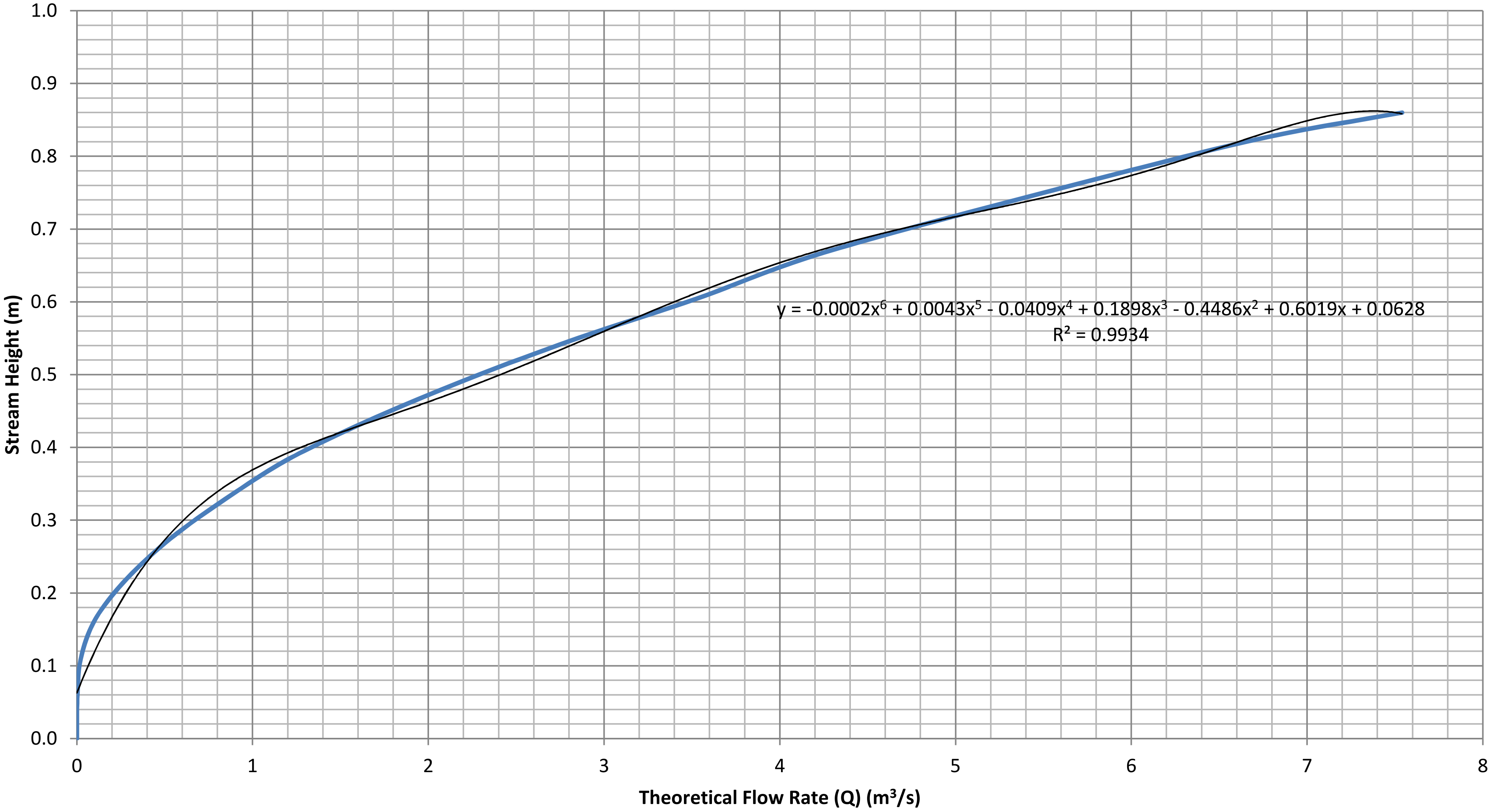
Relocated Flow Station 5 South Wambo Creek Theoretical Flow Rating Curve, December 2016
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Stream Height Above Cease to Flow Point (m)
0
200
400
600
800
1000
1200
1400
1600
Theoretical Flow (Q) (m^3/s)
$y = -3E-17x^6 + 1E-13x^5 - 2E-10x^4 + 2E-07x^3 - 7E-05x^2 + 0.0163x$
$R^2 = 0.9966$
Flow Q v Height (m)
Poly. (Flow Q v Height (m))

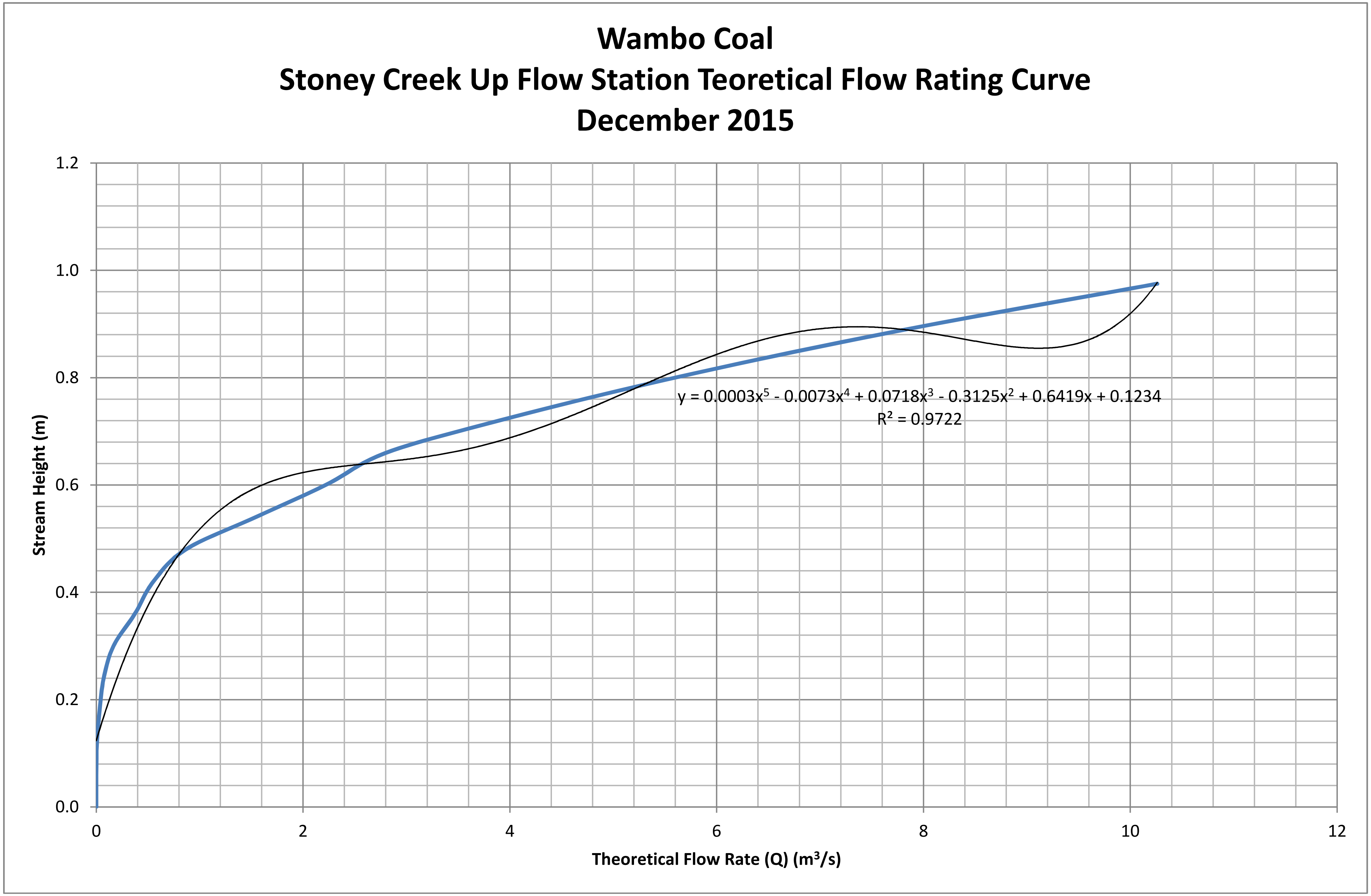


Relocated Flow Station 6 South Wambo Creek Theoretical Flow Rating Curve, December 2016
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Stream Height Above Cease to Flow Point (m)
0
100
200
300
400
500
600
700
Theoretical Flow (Q) (m^3/s)
$y = 8E-11x^4 - 1E-07x^3 + 4E-05x^2 - 0.001x$
$R^2 = 0.9988$
Flow Q v Height (m)
Log. (Flow Q v Height (m))
Poly. (Flow Q v Height (m))

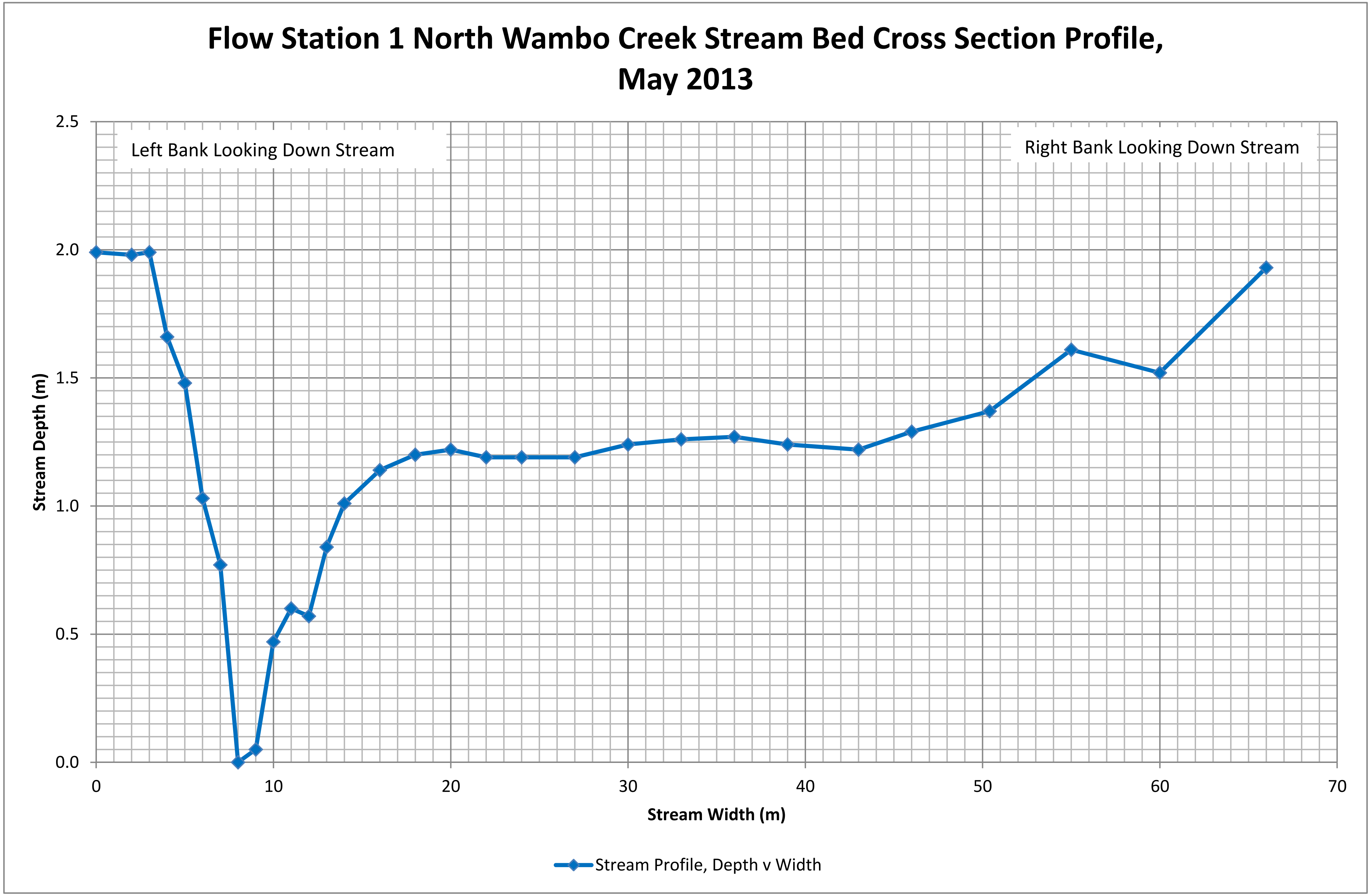

Wambo Coal
Stoney Creek Down Flow Station Theorectical Flow Rating Curve
December 2015
y = -2E-13x6 + 2E-10x5 - 8E-08x4 + 2E-05x3 - 0.0015x2 + 0.0731x + 0.2168
R² = 0.9899
Stream Height (m)
Theoretical Flow Rate (Q) (m3/s)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
50
100
150
200
250
300
350

Wambo Coal
Stoney Creek Tributary Theoretical Flow Rating Curve
December 2015

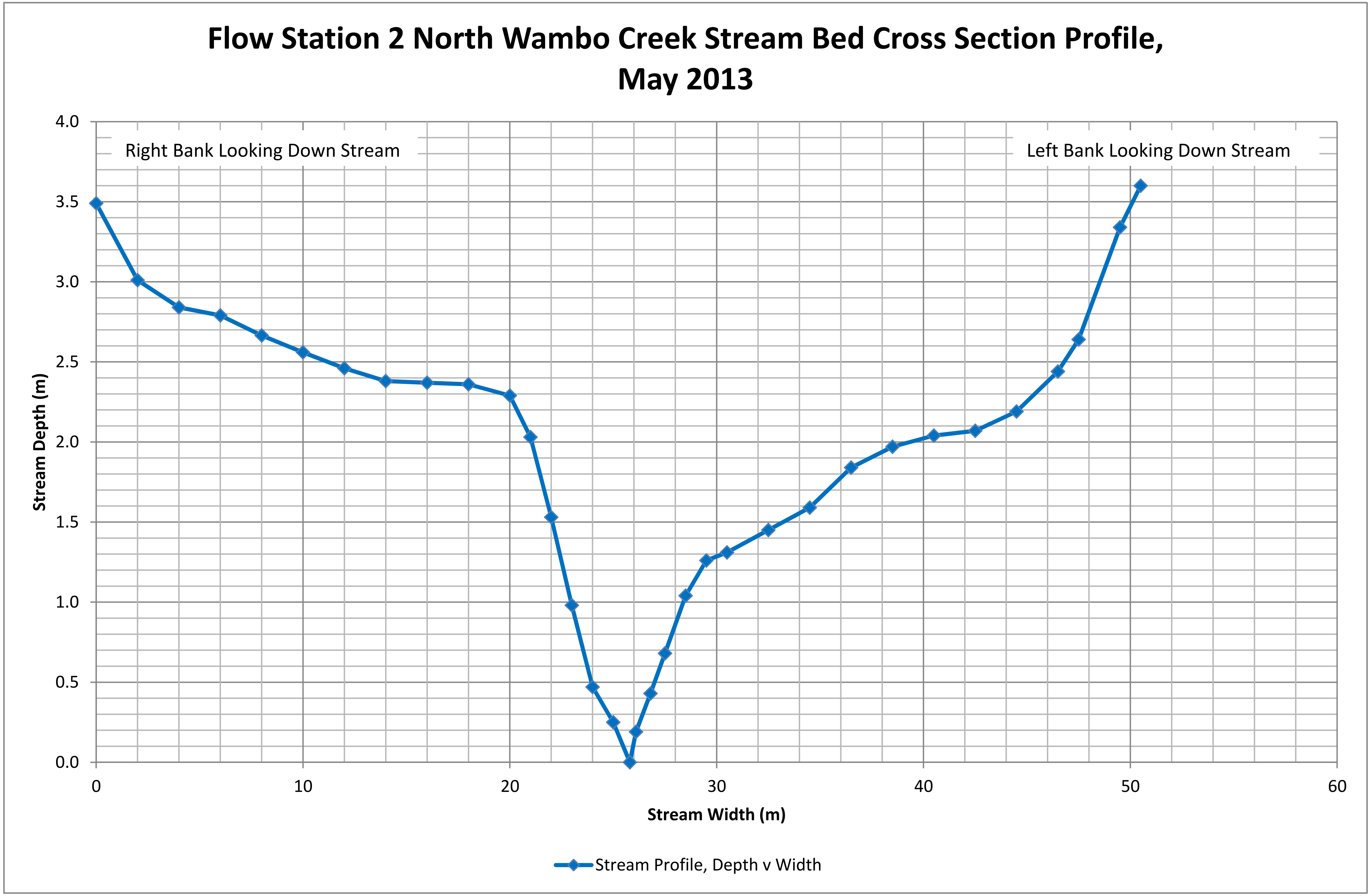




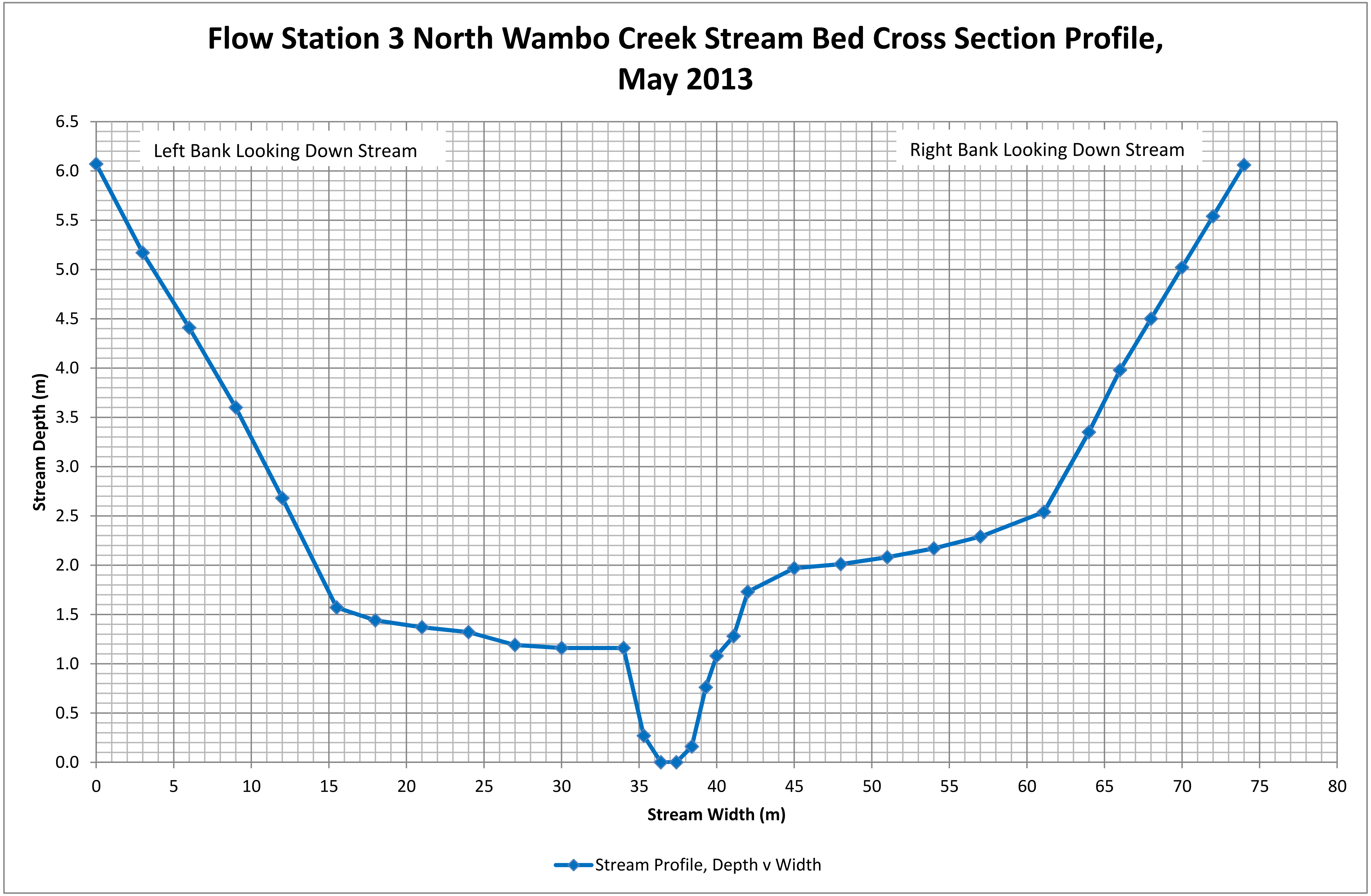
Wambo Coal
Stoney Creek Up Flow Station Teoretical Flow Rating Curve
December 2015
y = 0.0003x⁵ - 0.0073x⁴ + 0.0718x³ - 0.3125x² + 0.6419x + 0.1234
R² = 0.9722
Stream Height (m)
Theoretical Flow Rate (Q) (m³/s)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
10
12

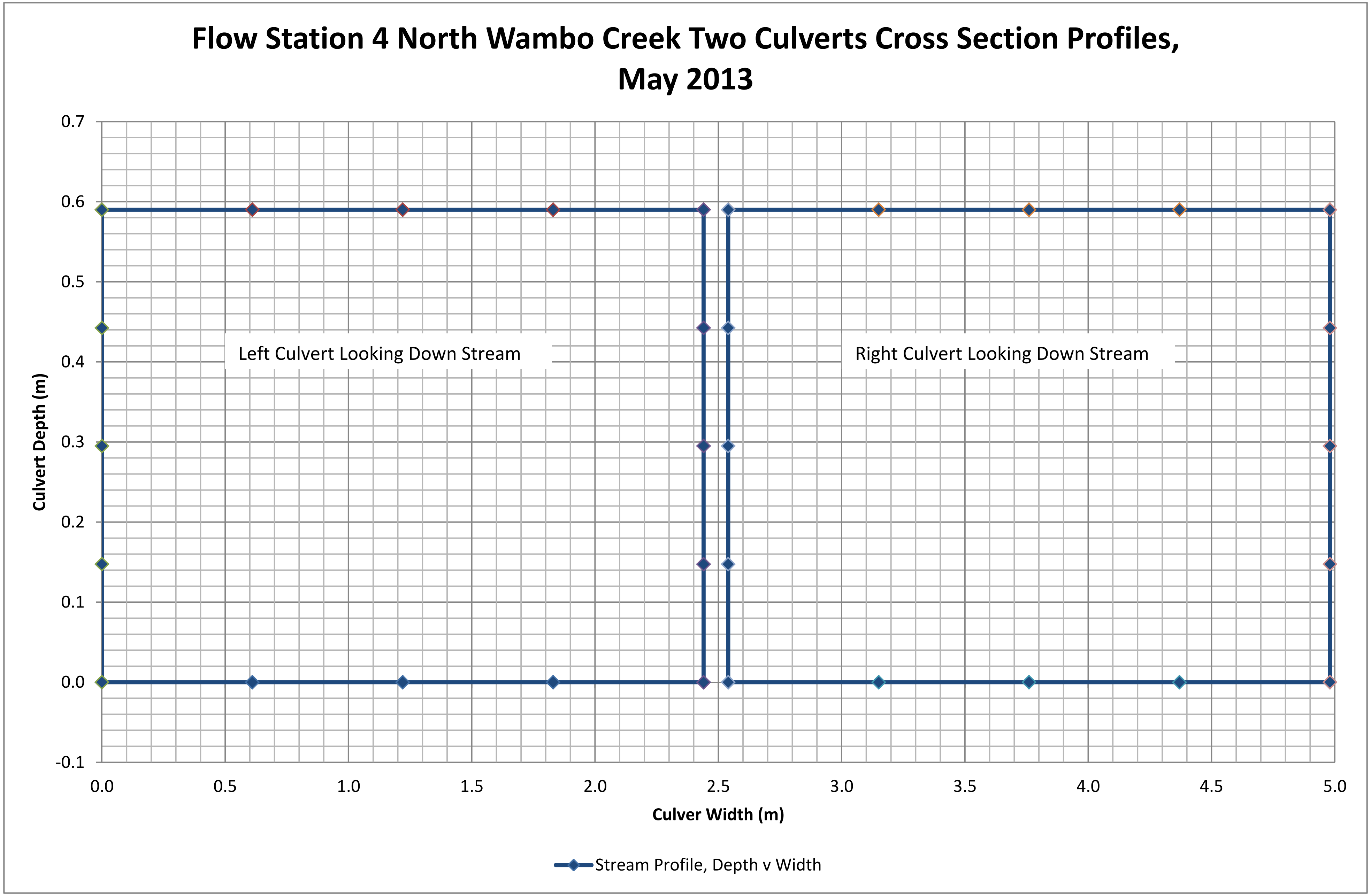


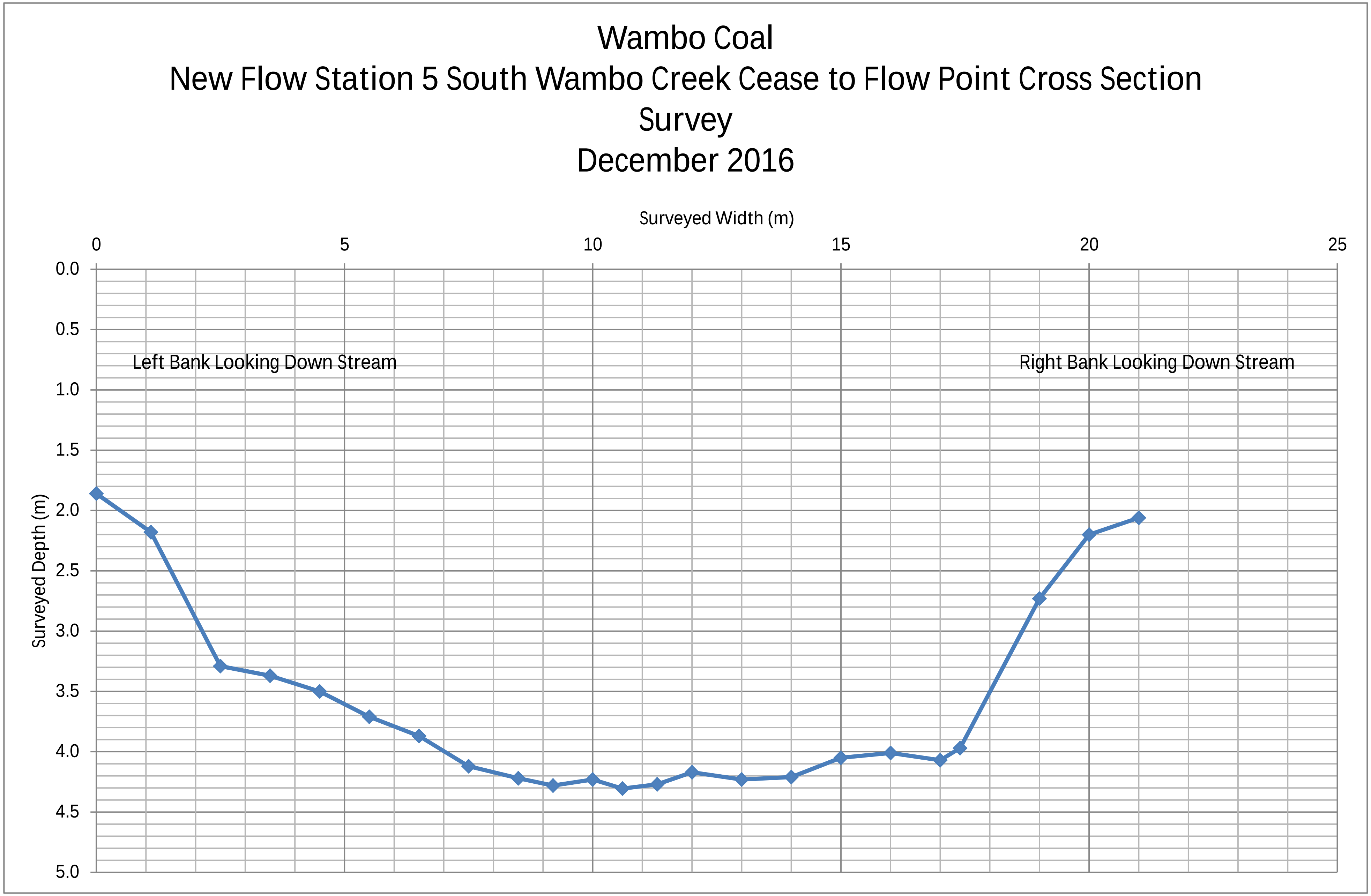
Flow Station 1 North Wambo Creek Stream Bed Cross Section Profile, May 2013
Left Bank Looking Down Stream
Right Bank Looking Down Stream
Stream Depth (m)
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
Stream Width (m)
Stream Profile, Depth v Width

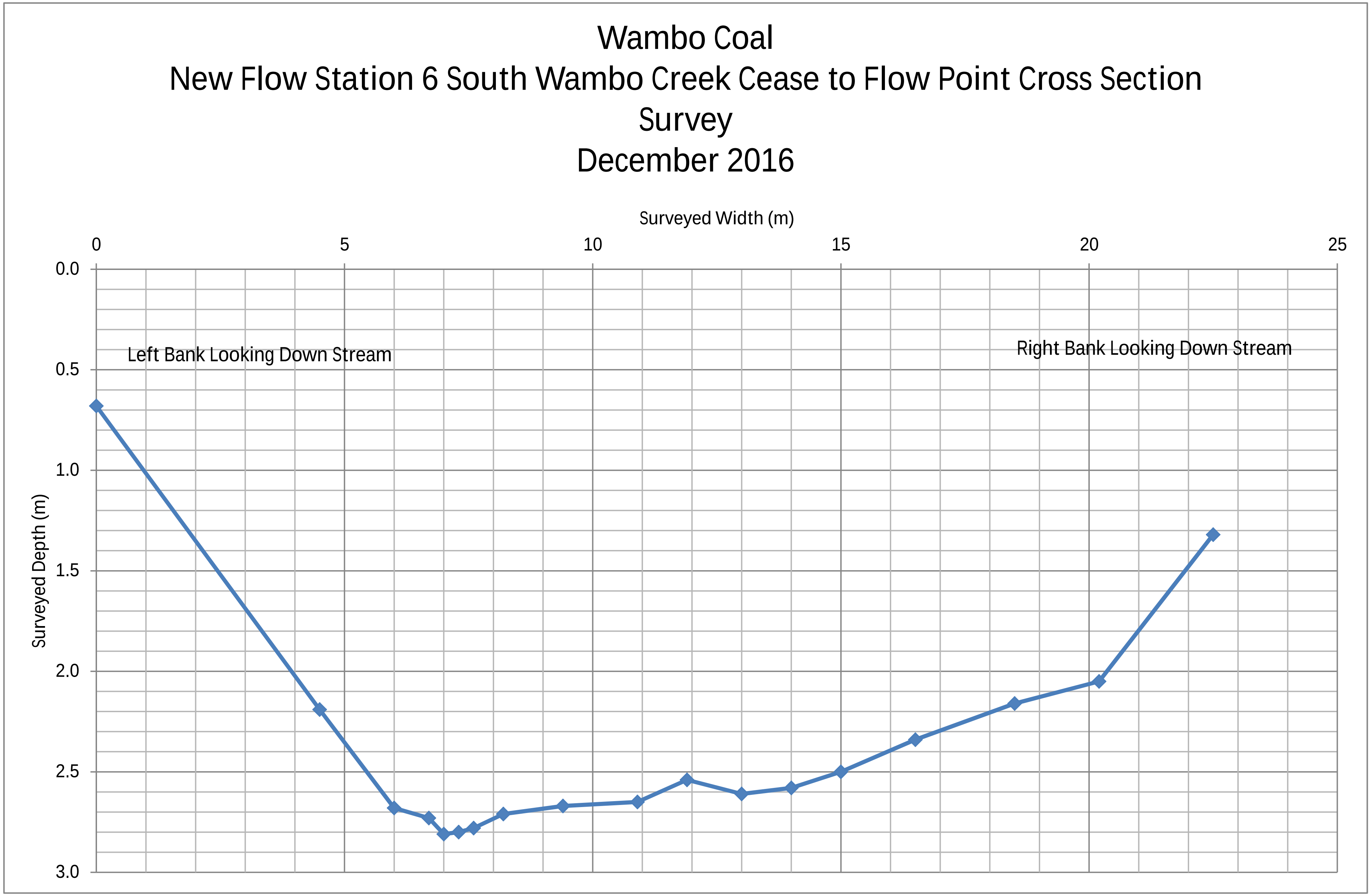


Flow Station 2 North Wambo Creek Stream Bed Cross Section Profile, May 2013
Right Bank Looking Down Stream
Left Bank Looking Down Stream
Stream Depth (m)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
Stream Width (m)
Stream Profile, Depth v Width


Flow Station 3 North Wambo Creek Stream Bed Cross Section Profile, May 2013
Left Bank Looking Down Stream
Right Bank Looking Down Stream
Stream Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
Stream Width (m)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Stream Profile, Depth v Width

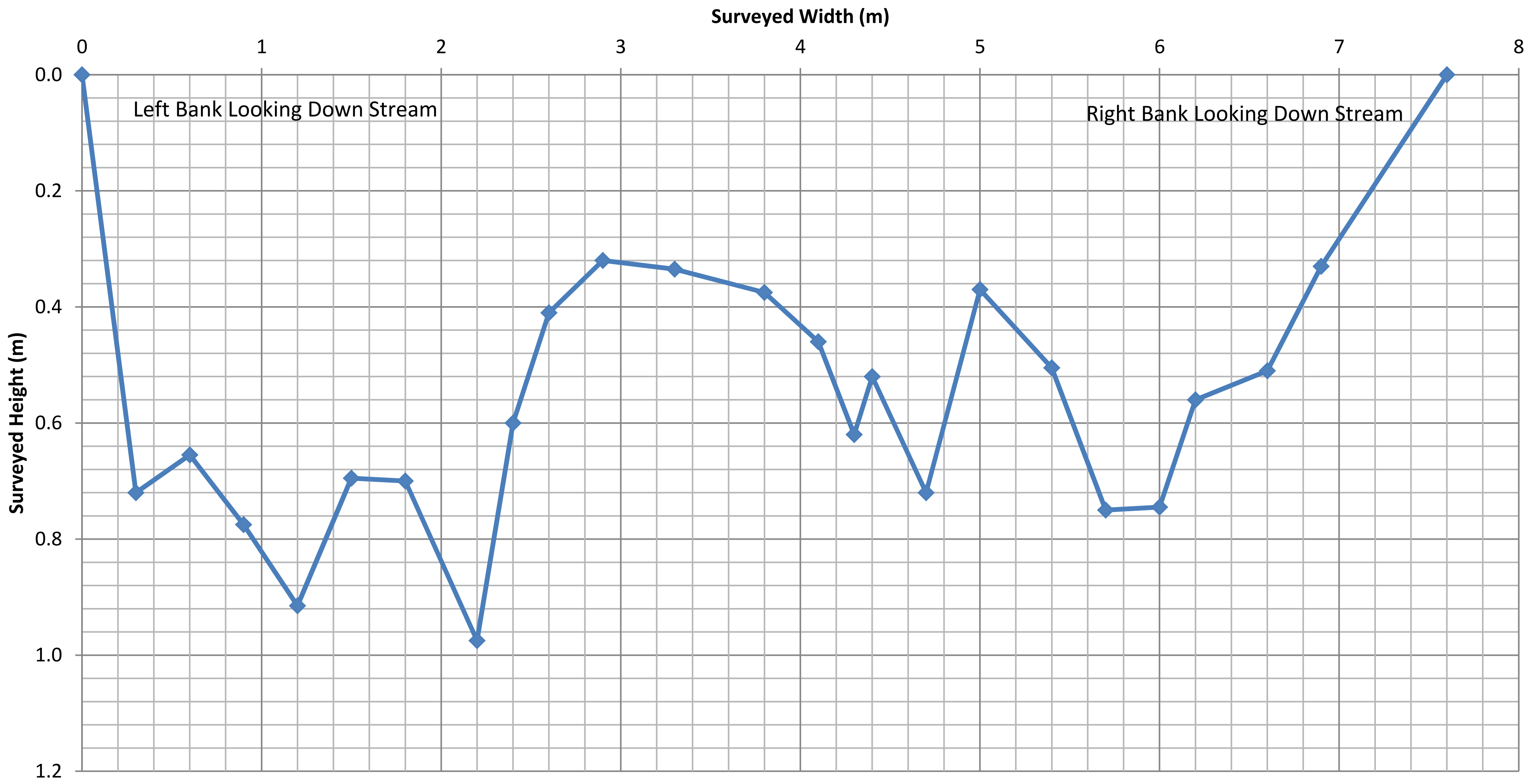

Flow Station 4 North Wambo Creek Two Culverts Cross Section Profiles, May 2013
Left Culvert Looking Down Stream
Right Culvert Looking Down Stream
Culvert Depth (m)
Culver Width (m)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Stream Profile, Depth v Width

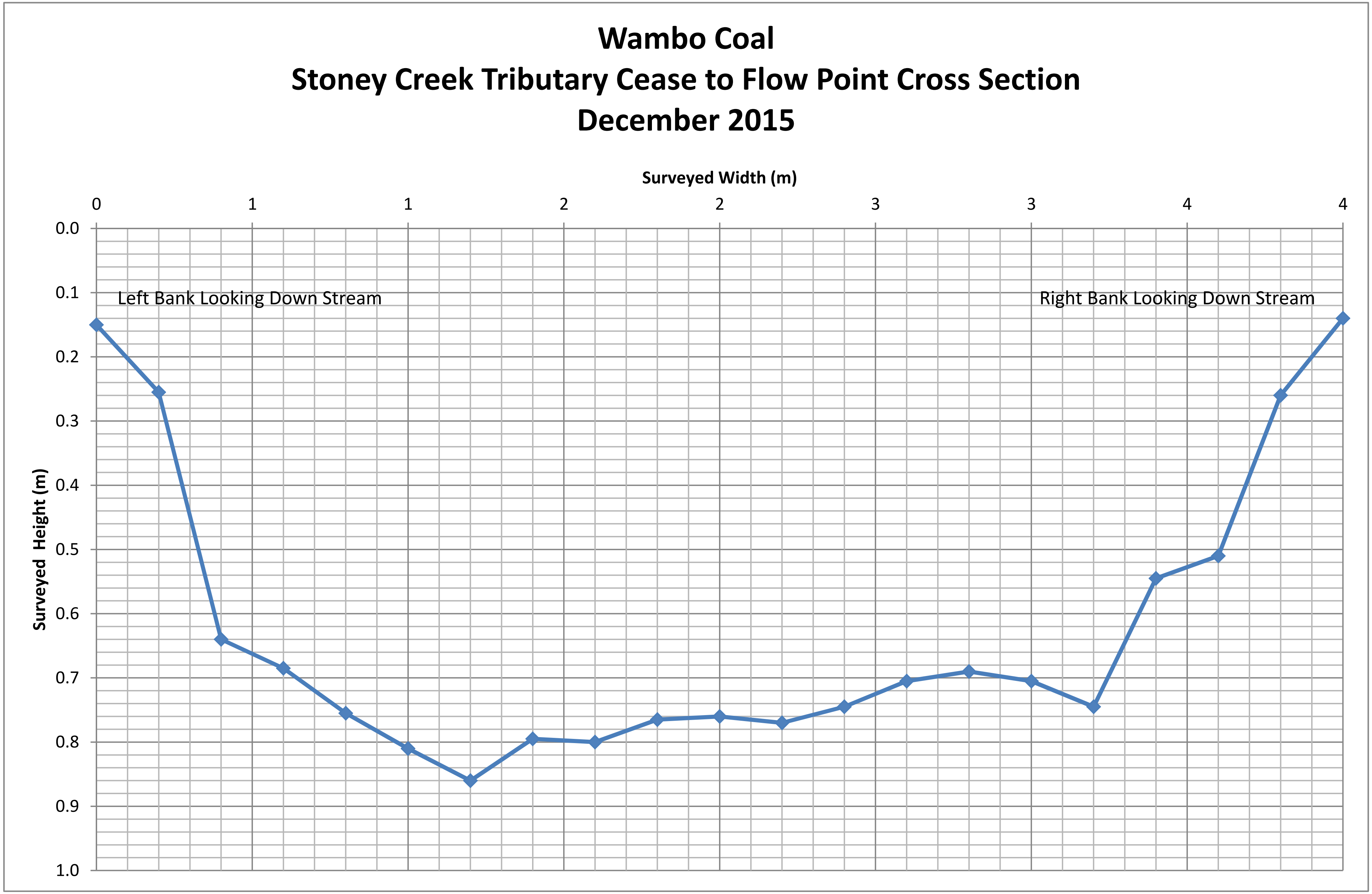

Wambo Coal
New Flow Station 5 South Wambo Creek Cease to Flow Point Cross Section
Survey
December 2016
Surveyed Width (m)
0
5
10
15
20
25
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Surveyed Depth (m)
Left Bank Looking Down Stream
Right Bank Looking Down Stream

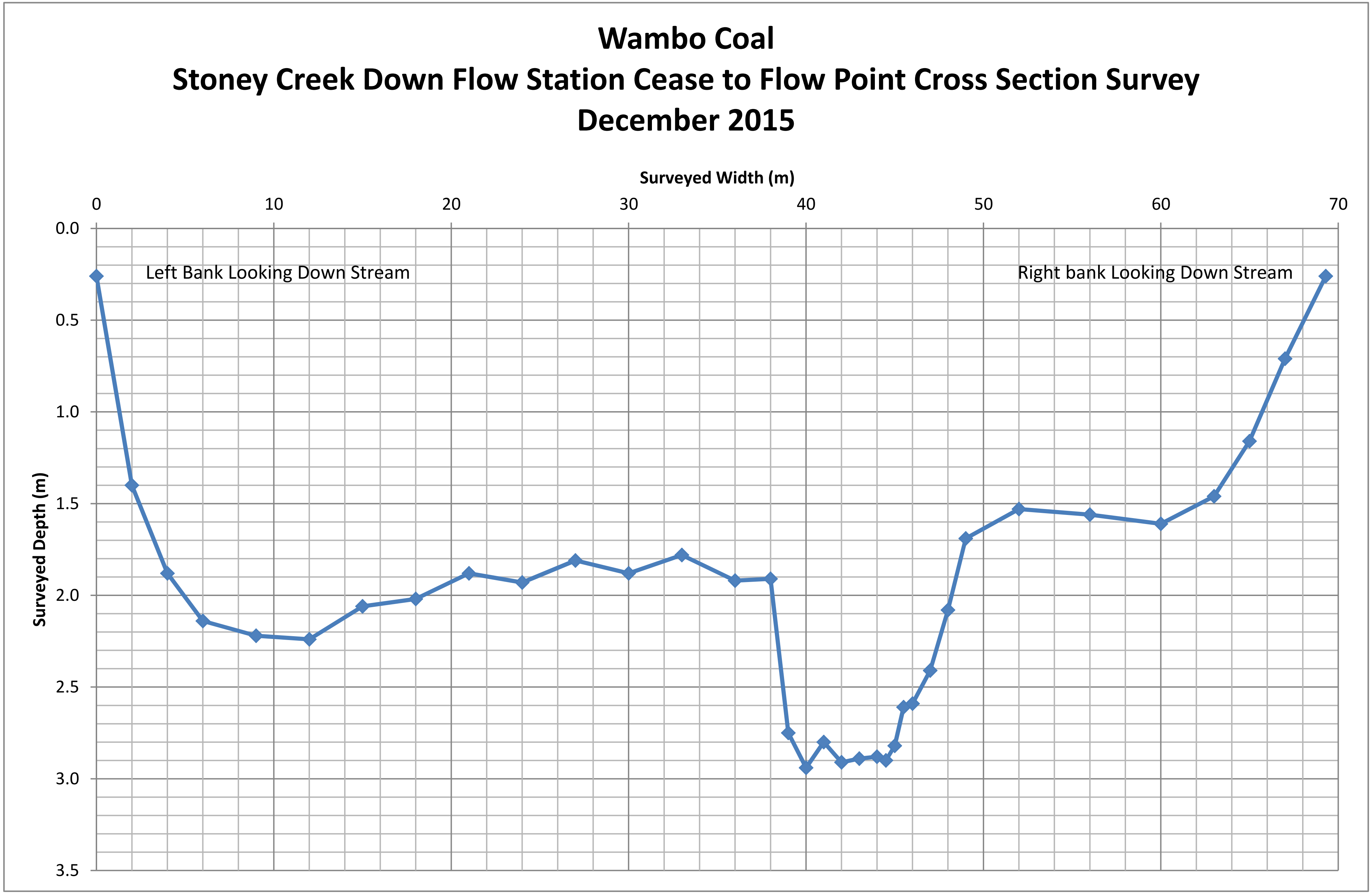


Wambo Coal
New Flow Station 6 South Wambo Creek Cease to Flow Point Cross Section
Survey
December 2016
Surveyed Width (m)
0
5
10
15
20
25
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Surveyed Depth (m)
Left Bank Looking Down Stream
Right Bank Looking Down Stream

Wambo Coal
Stoney Creek up Flow Station Cease to Flow Point Cross Section Survey
December 2015




Wambo Coal
Stoney Creek Tributary Cease to Flow Point Cross Section
December 2015
Surveyed Width (m)
0
1
1
2
2
3
3
4
4
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Surveyed Height (m)
Left Bank Looking Down Stream
Right Bank Looking Down Stream



Wambo Coal
Stoney Creek Down Flow Station Cease to Flow Point Cross Section Survey
December 2015
Surveyed Width (m)
0
10
20
30
40
50
60
70
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Surveyed Depth (m)
Left Bank Looking Down Stream
Right bank Looking Down Stream

Appendix C

Stream Height, Theoretical Flow, Daily and Cumulative Rainfall Charts

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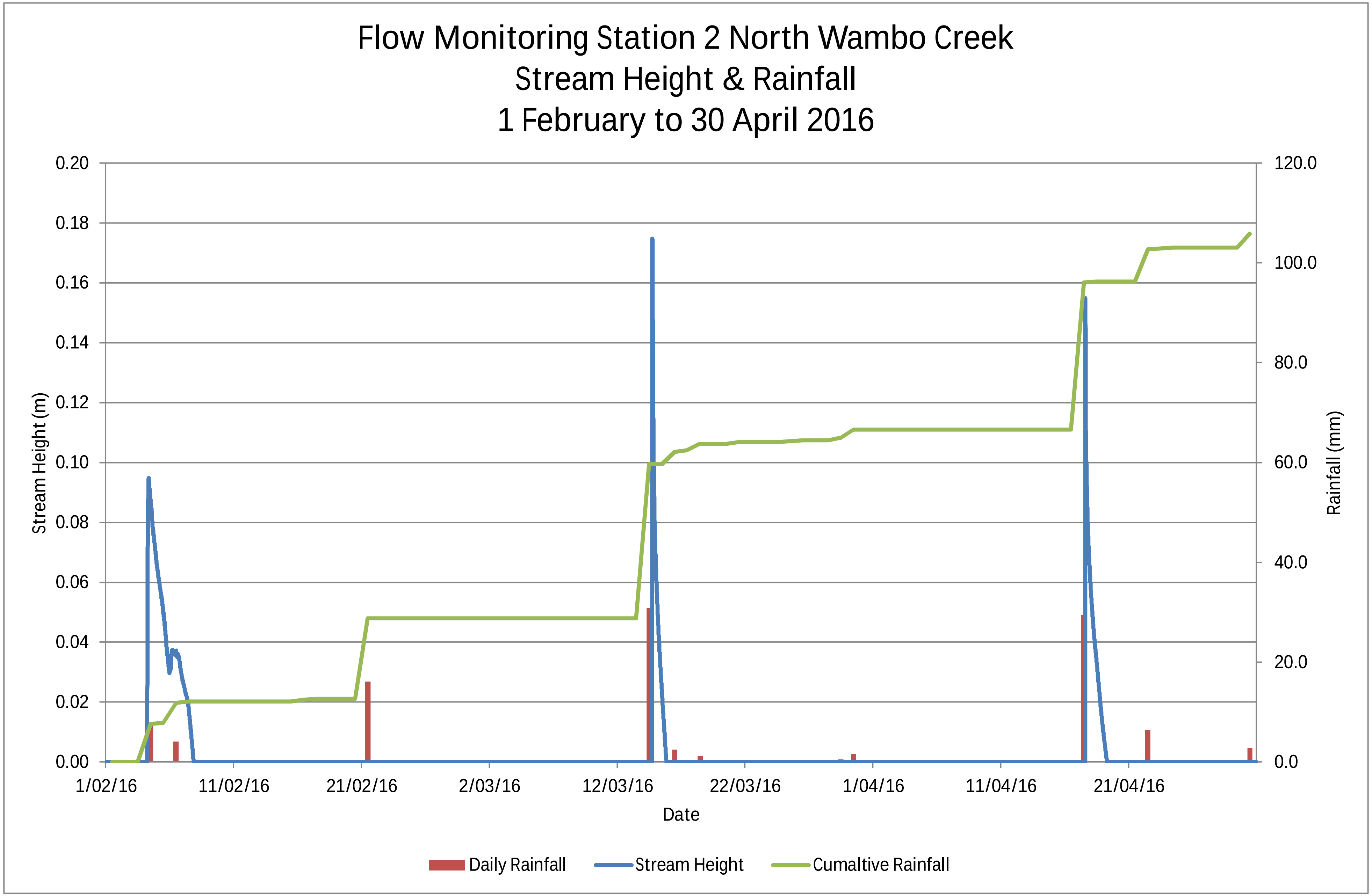
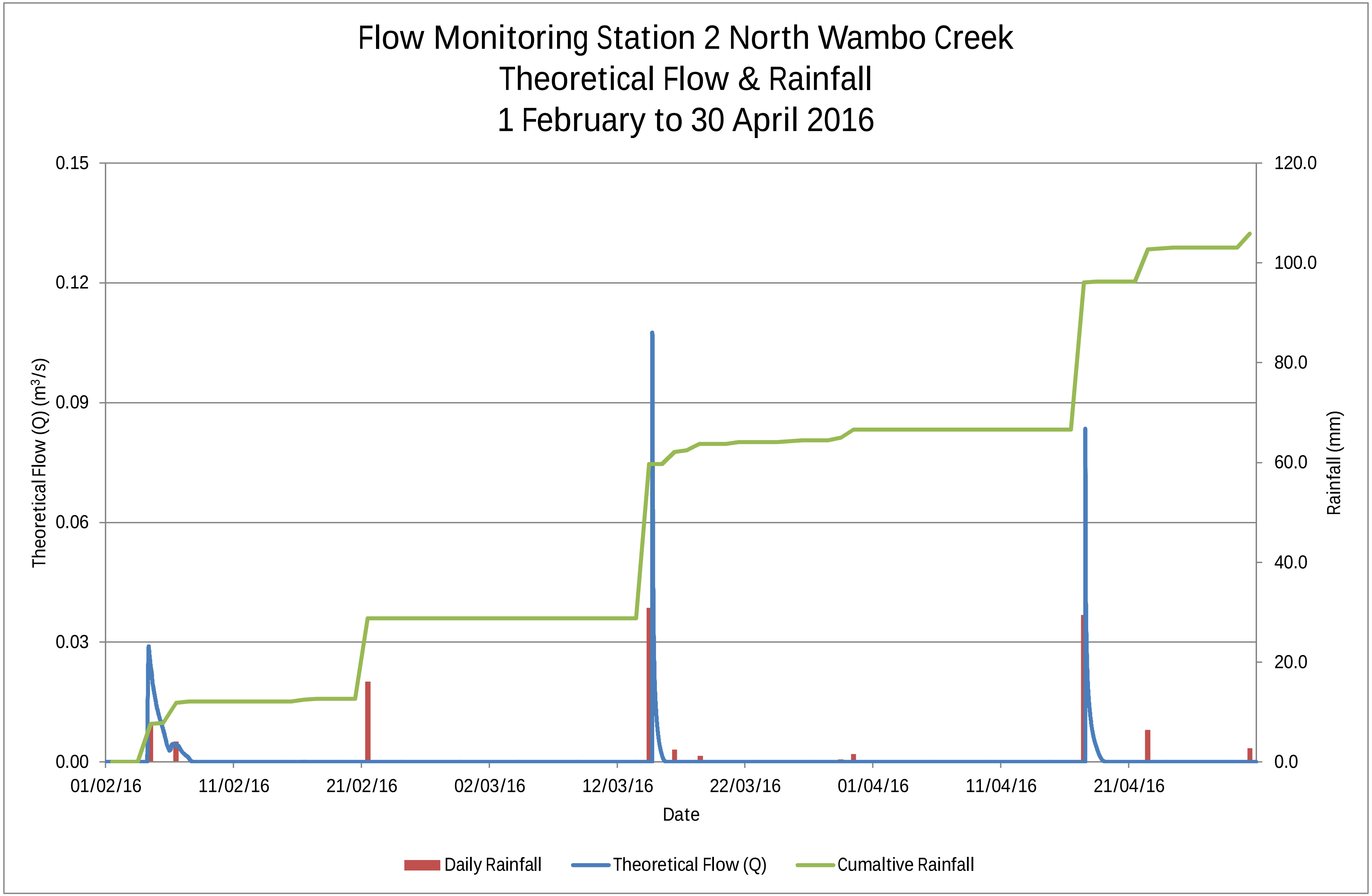
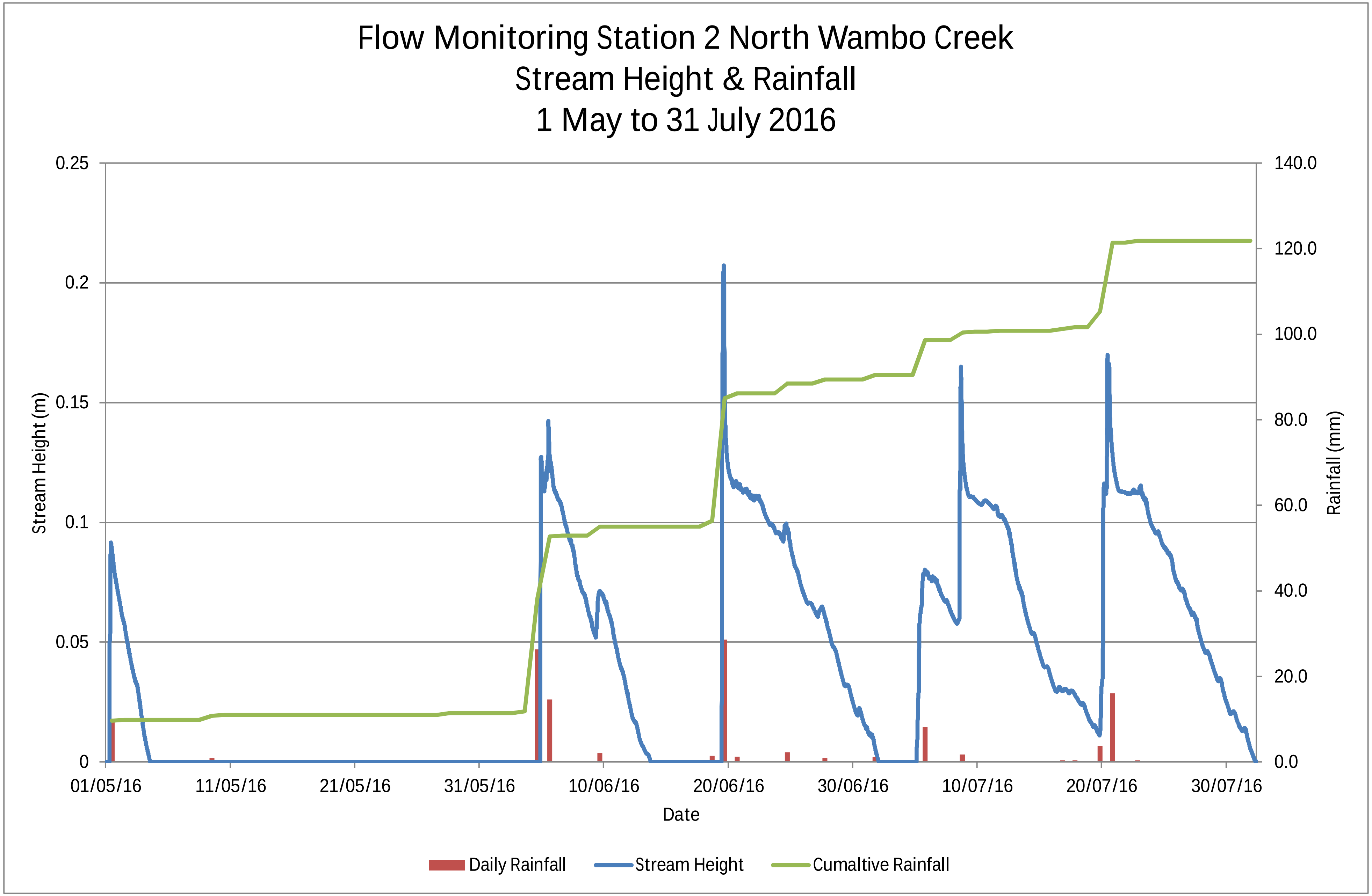


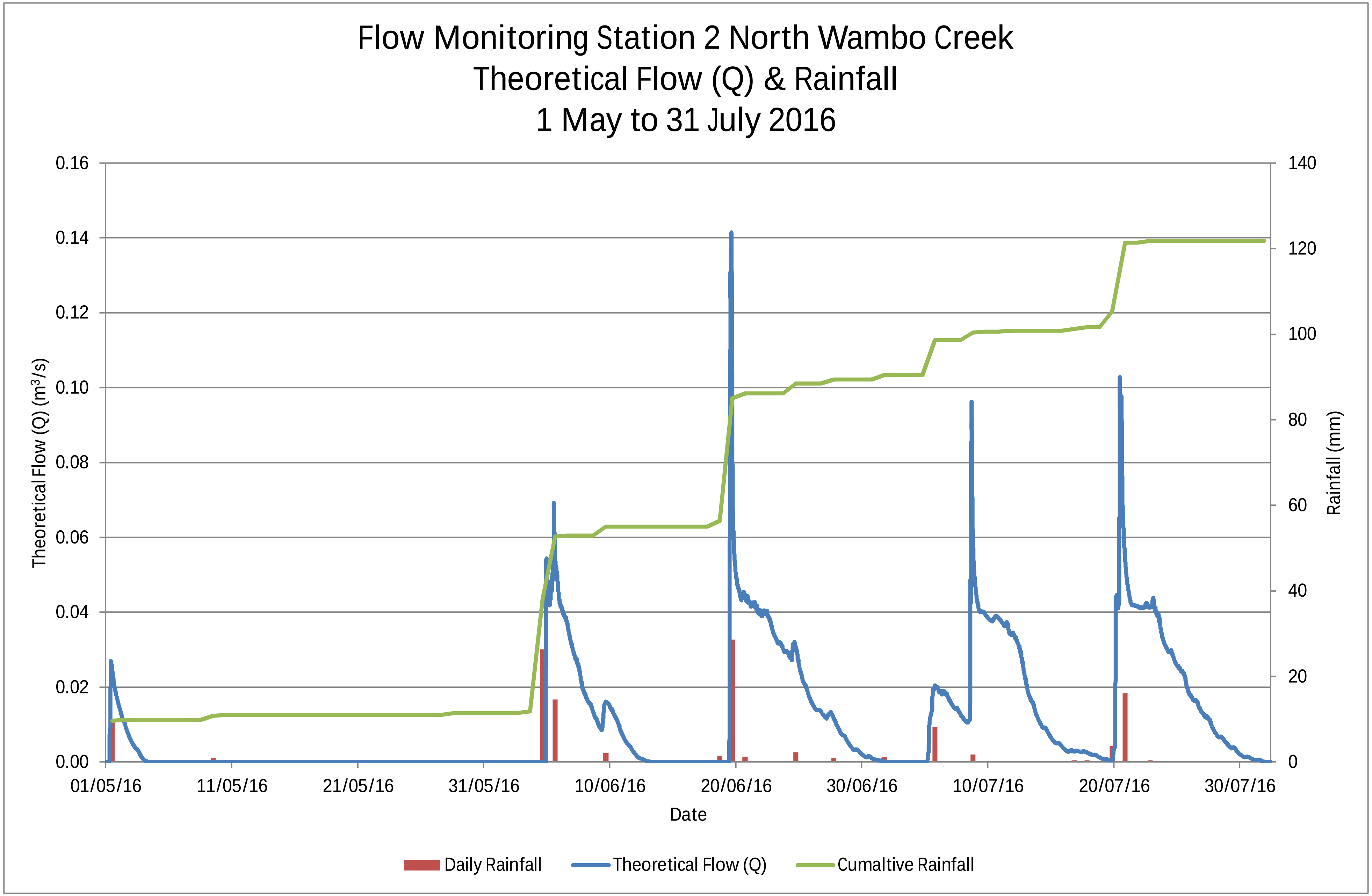
Flow Monitoring Station 2 North Wambo Creek
Stream Height & Rainfall
1 February to 30 April 2016
Stream Height (m)
Rainfall (mm)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1/02/16
11/02/16
21/02/16
2/03/16
12/03/16
22/03/16
1/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

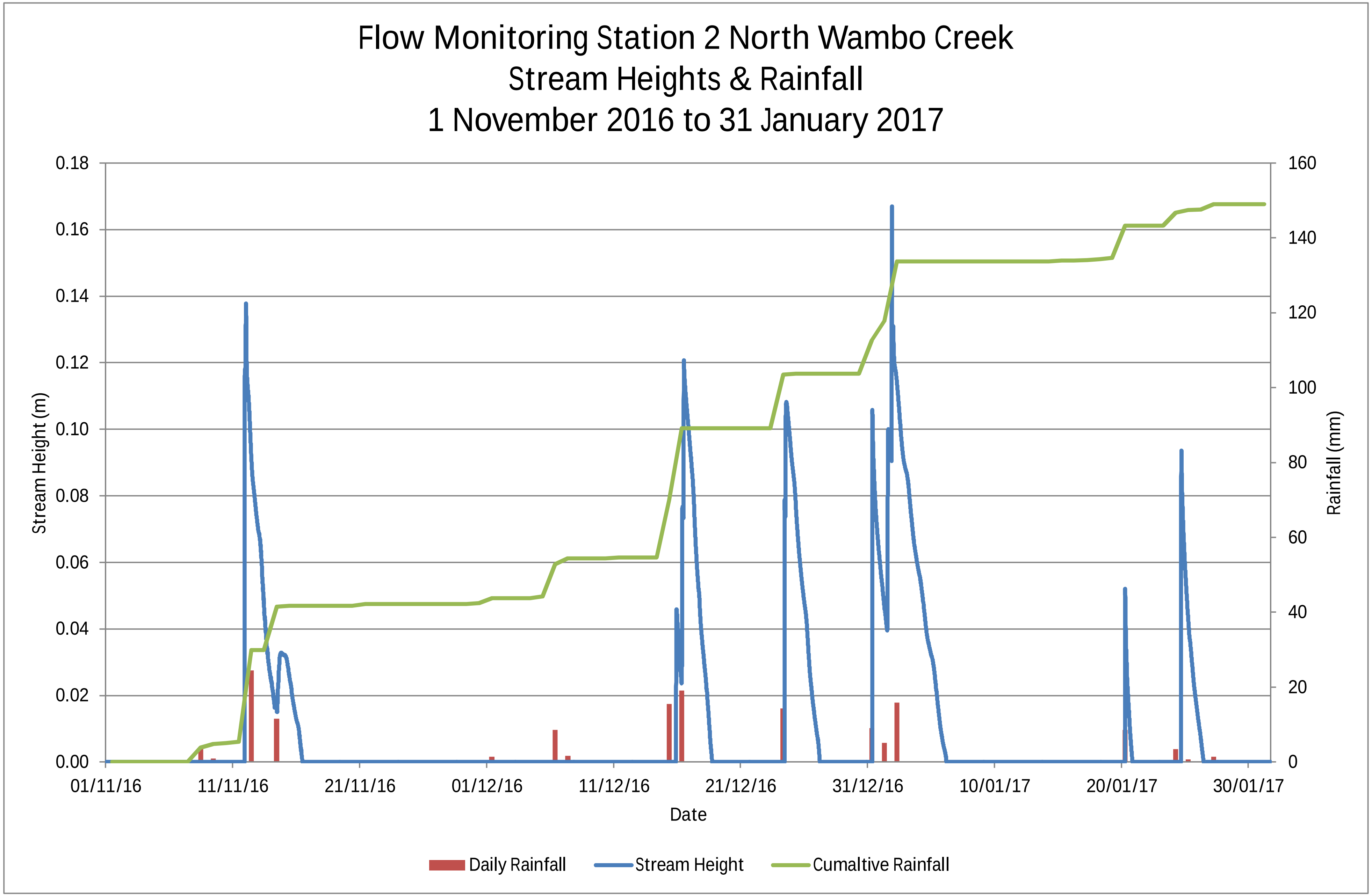


Flow Monitoring Station 2 North Wambo Creek
Theoretical Flow & Rainfall
1 February to 30 April 2016
Theoretical Flow (Q) (m³/s)
Rainfall (mm)
0.15
0.12
0.09
0.06
0.03
0.00
120.0
100.0
80.0
60.0
40.0
20.0
0.0
01/02/16
11/02/16
21/02/16
02/03/16
12/03/16
22/03/16
01/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

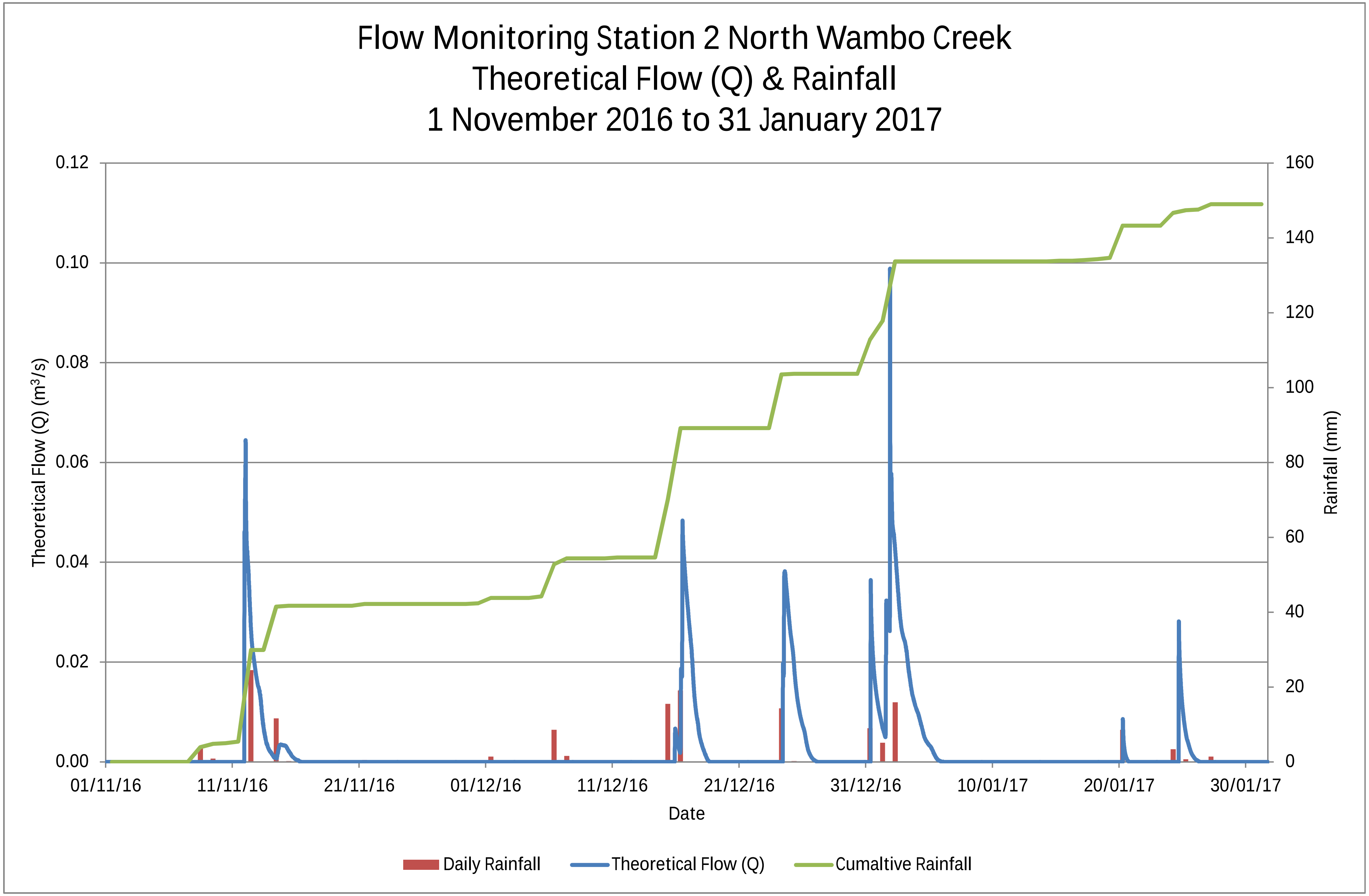


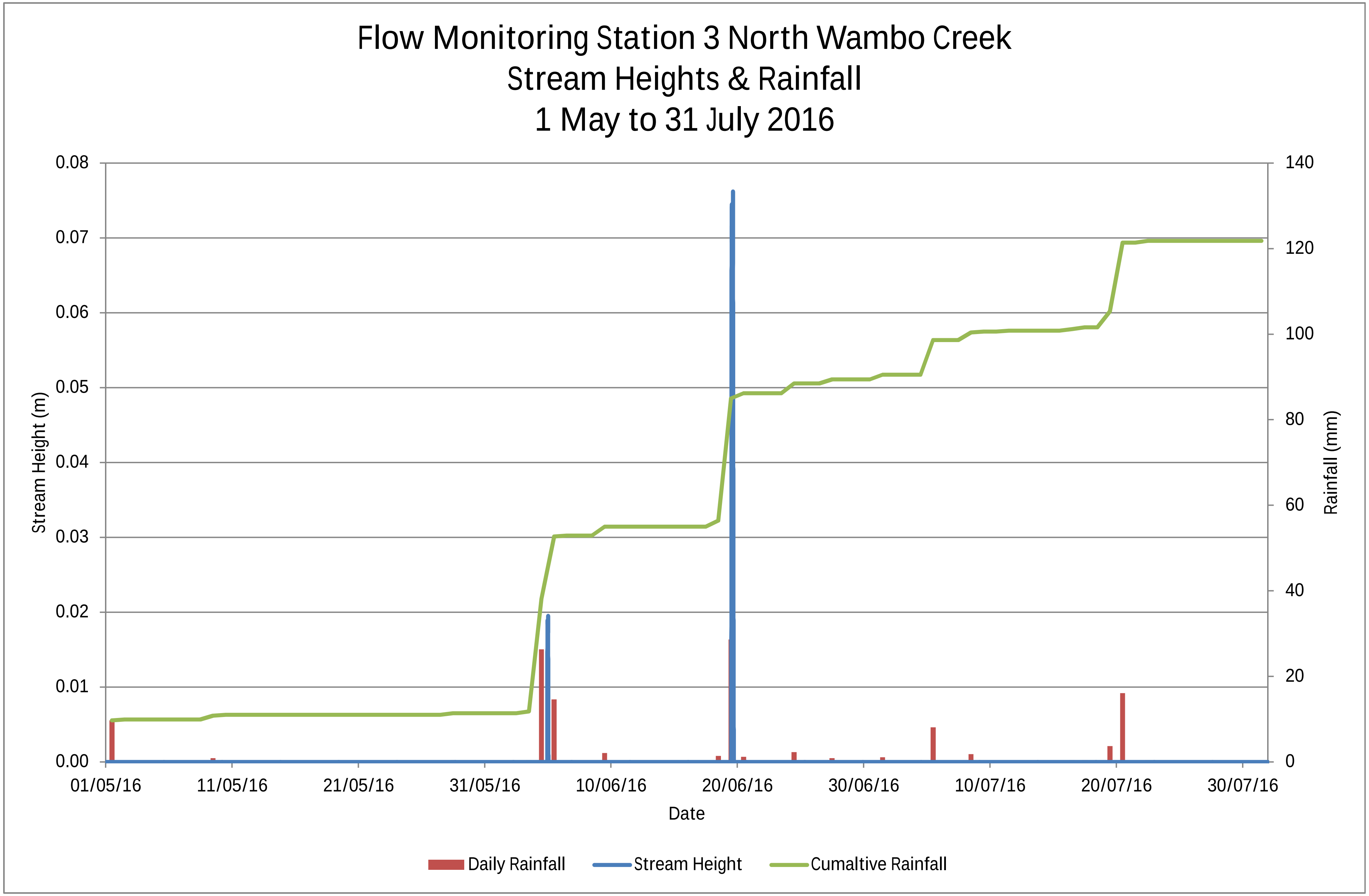
Flow Monitoring Station 2 North Wambo Creek
Stream Height & Rainfall
1 May to 31 July 2016
Stream Height (m)
0.25
0.2
0.15
0.1
0.05
0
Rainfall (mm)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
01/05/16
11/05/16
21/05/16
31/05/16
10/06/16
20/06/16
30/06/16
10/07/16
20/07/16
30/07/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

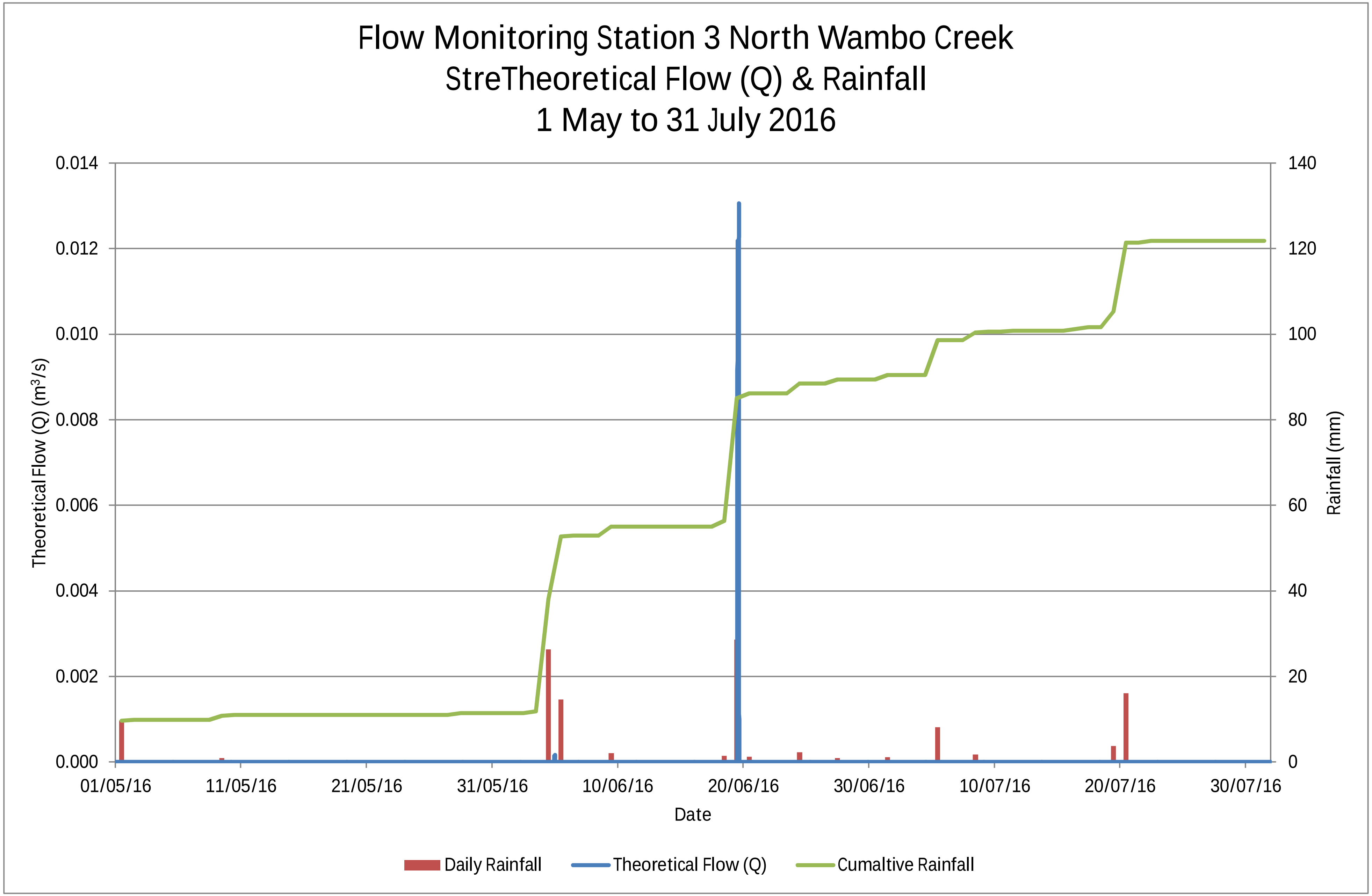

Flow Monitoring Station 2 North Wambo Creek
Theoretical Flow (Q) & Rainfall
1 May to 31 July 2016
Theoretical Flow (Q) (m³/s)
Rainfall (mm)
Date
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
140
120
100
80
60
40
20
0
01/05/16
11/05/16
21/05/16
31/05/16
10/06/16
20/06/16
30/06/16
10/07/16
20/07/16
30/07/16
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall



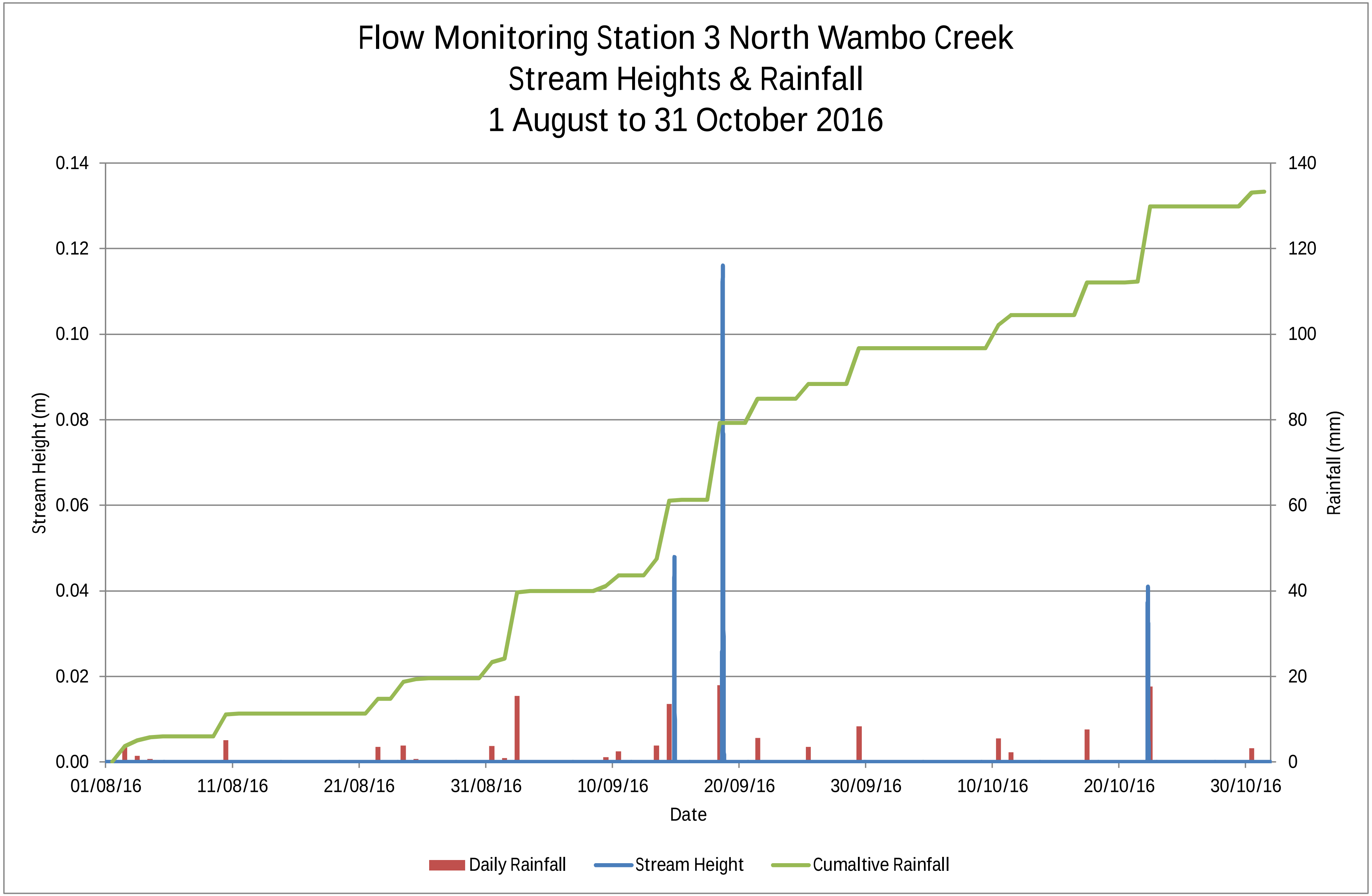
Flow Monitoring Station 2 North Wambo Creek
Stream Heights & Rainfall
1 November 2016 to 31 January 2017
Stream Height (m)
Rainfall (mm)
Date
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
160
140
120
100
80
60
40
20
0
01/11/16
11/11/16
21/11/16
01/12/16
11/12/16
21/12/16
31/12/16
10/01/17
20/01/17
30/01/17
Daily Rainfall
Stream Height
Cumaltive Rainfall


Flow Monitoring Station 2 North Wambo Creek
Theoretical Flow (Q) & Rainfall
1 November 2016 to 31 January 2017
Theoretical Flow (Q) (m³/s)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Rainfall (mm)
160
140
120
100
80
60
40
20
0
01/11/16
11/11/16
21/11/16
01/12/16
11/12/16
21/12/16
31/12/16
10/01/17
20/01/17
30/01/17
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

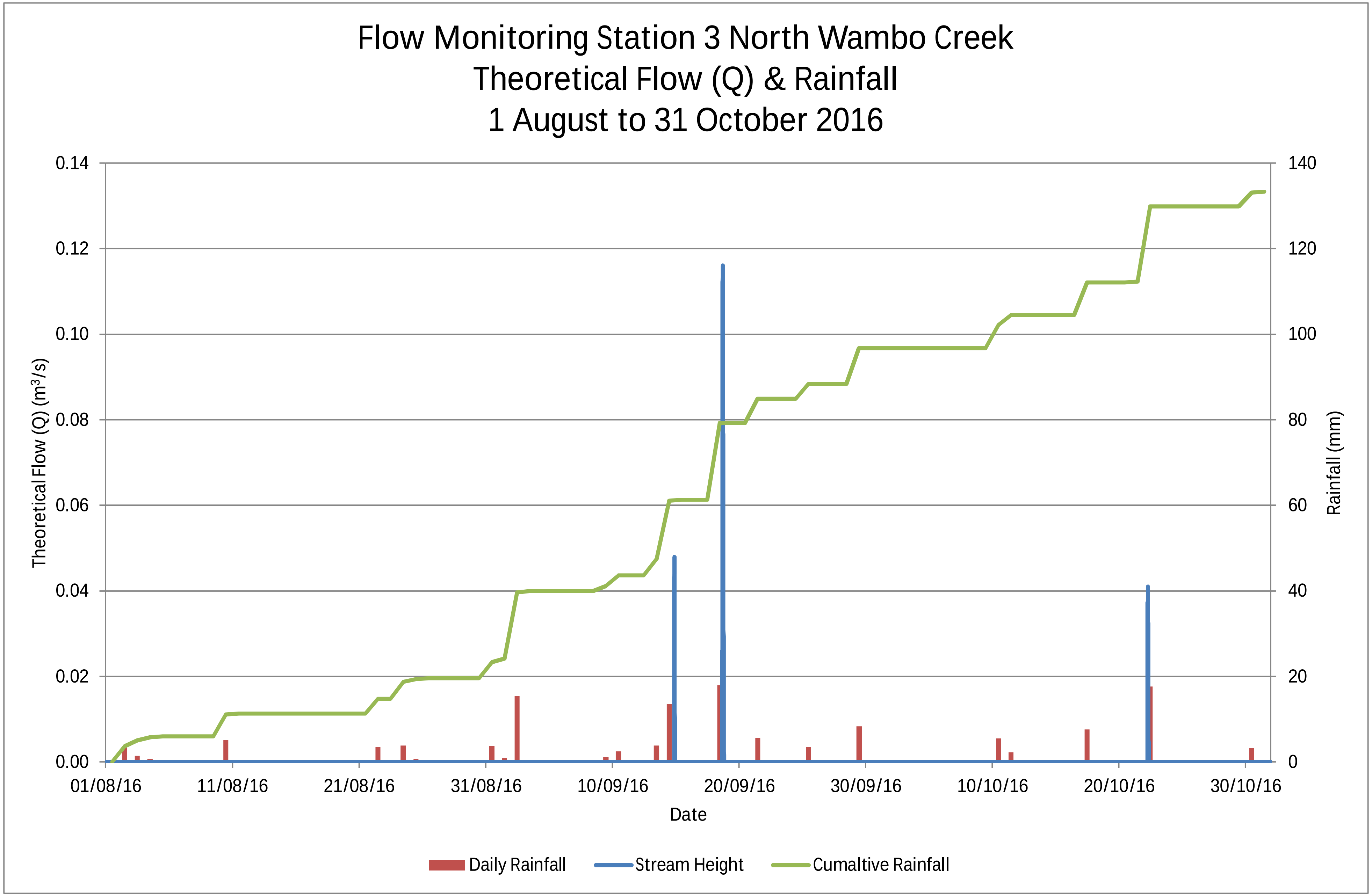

Flow Monitoring Station 3 North Wambo Creek
Stream Heights & Rainfall
1 May to 31 July 2016
Stream Height (m)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Rainfall (mm)
140
120
100
80
60
40
20
0
01/05/16
11/05/16
21/05/16
31/05/16
10/06/16
20/06/16
30/06/16
10/07/16
20/07/16
30/07/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

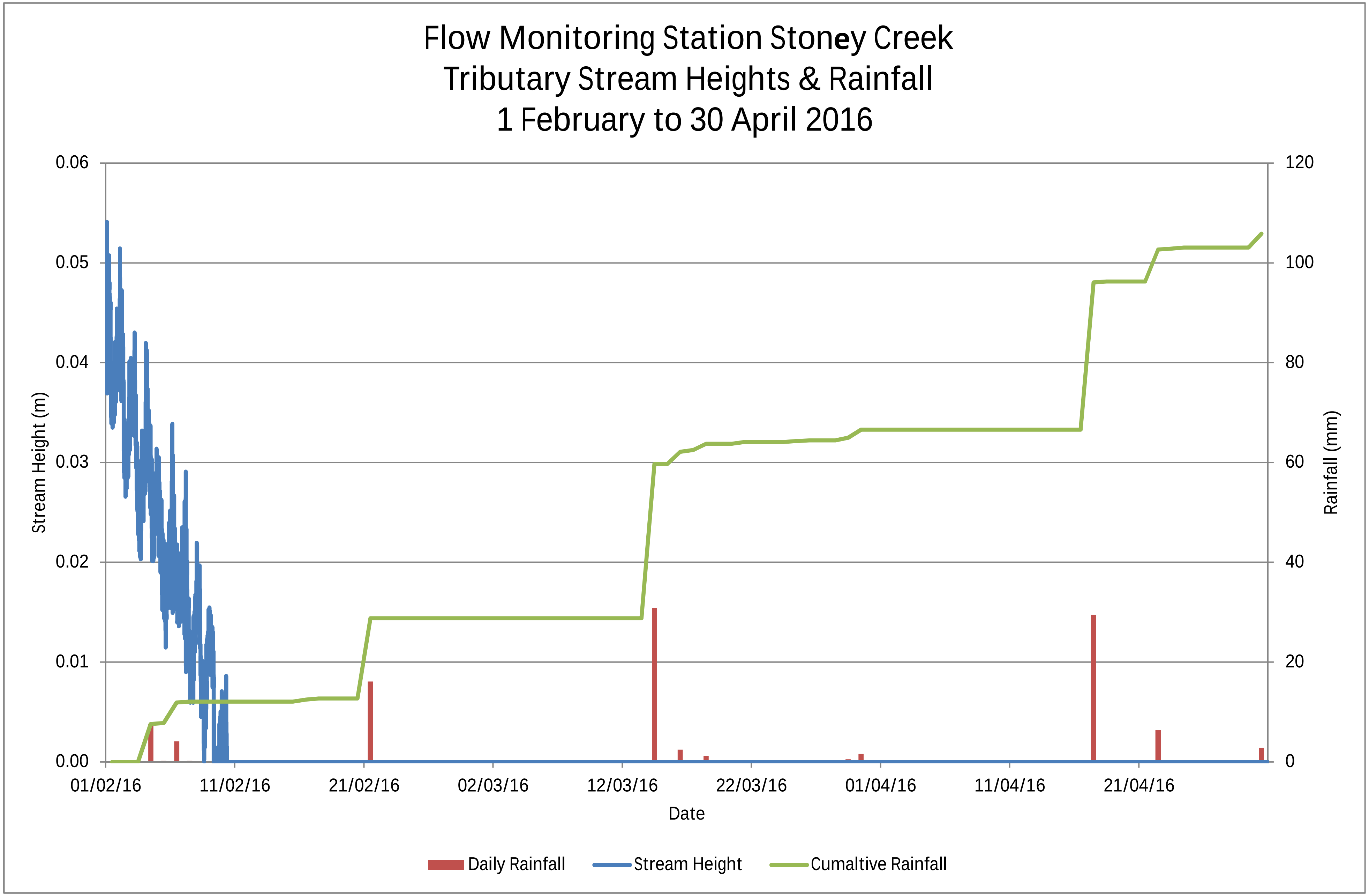


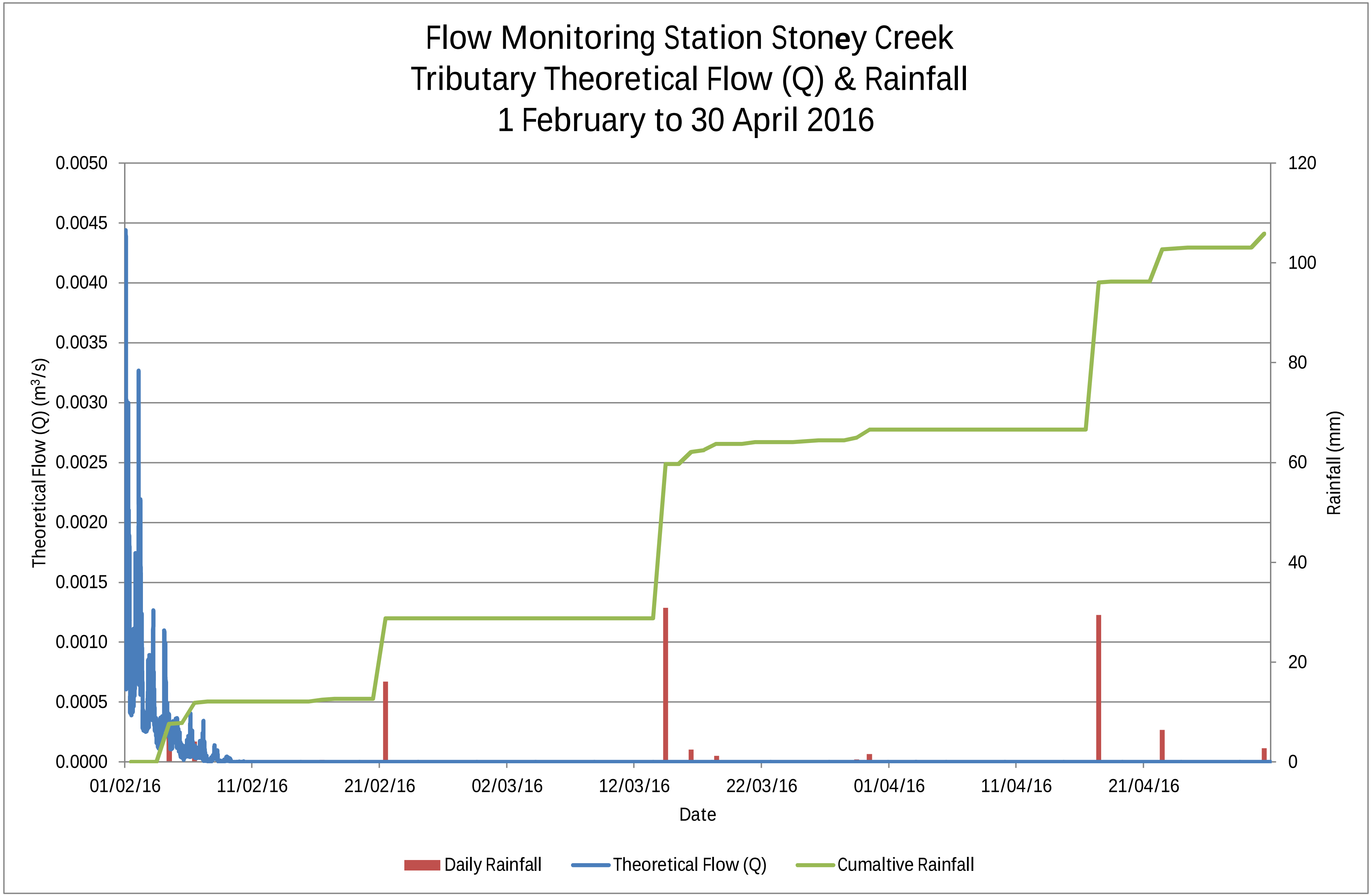
Flow Monitoring Station 3 North Wambo Creek
StreTheoretical Flow (Q) & Rainfall
1 May to 31 July 2016
Theoretical Flow (Q) (m³/s)
Rainfall (mm)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
140
120
100
80
60
40
20
0
01/05/16
11/05/16
21/05/16
31/05/16
10/06/16
20/06/16
30/06/16
10/07/16
20/07/16
30/07/16
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

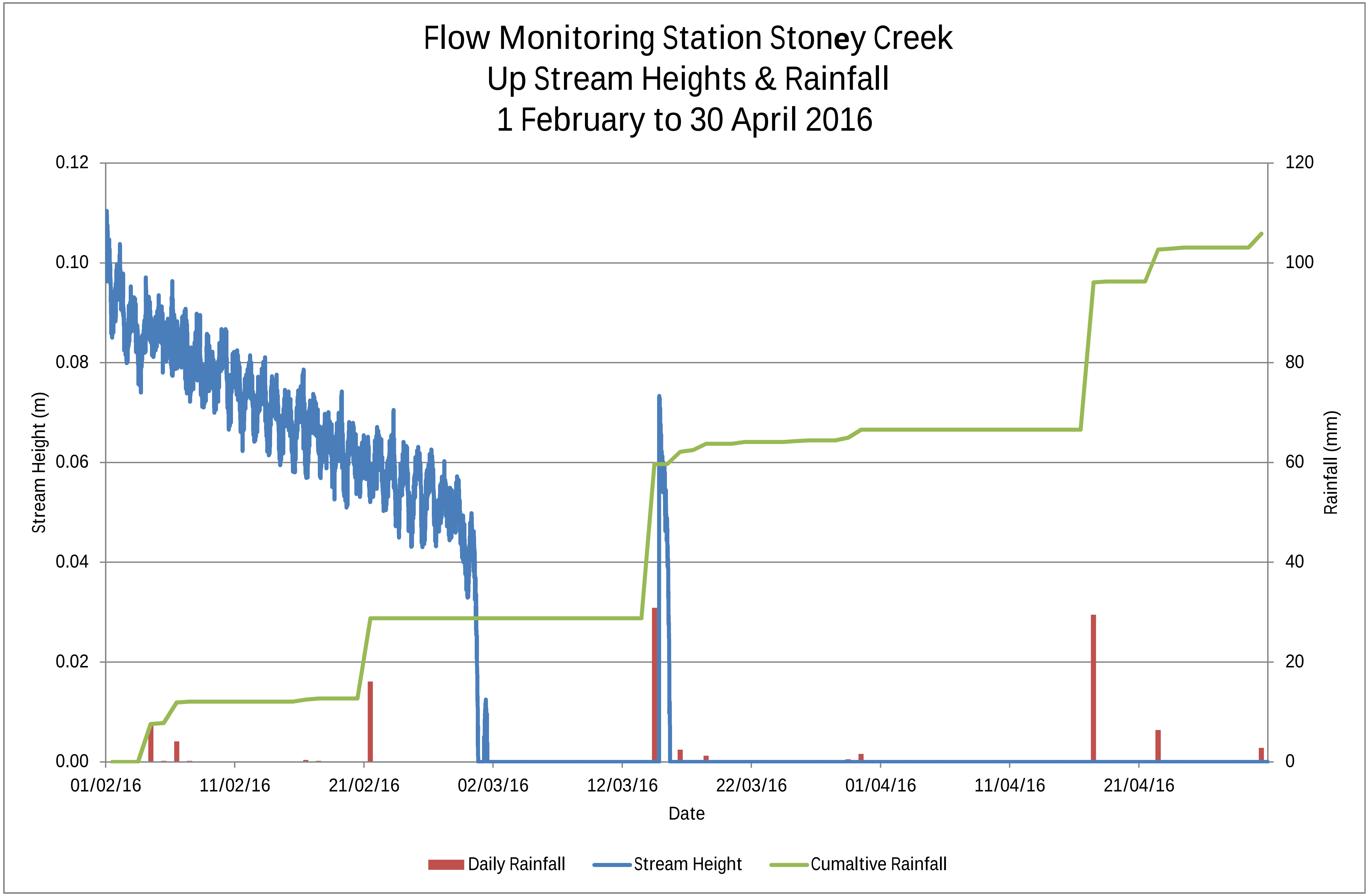


Flow Monitoring Station 3 North Wambo Creek
Stream Heights & Rainfall
1 August to 31 October 2016
Stream Height (m)
Rainfall (mm)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0
20
40
60
80
100
120
140
01/08/16
11/08/16
21/08/16
31/08/16
10/09/16
20/09/16
30/09/16
10/10/16
20/10/16
30/10/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

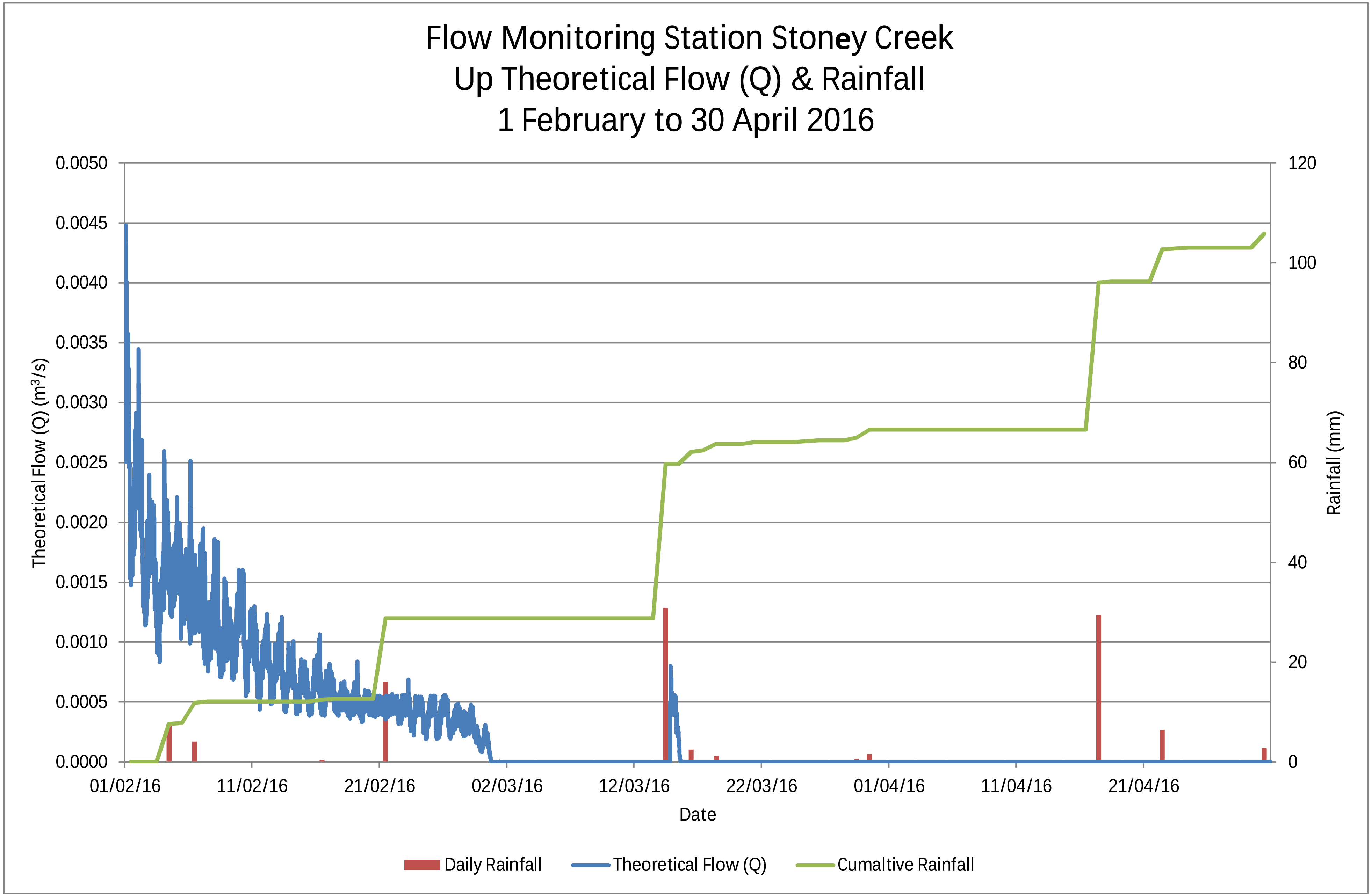

Flow Monitoring Station 3 North Wambo Creek
Theoretical Flow (Q) & Rainfall
1 August to 31 October 2016
Theoretical Flow (Q) (m³/s)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Rainfall (mm)
140
120
100
80
60
40
20
0
01/08/16
11/08/16
21/08/16
31/08/16
10/09/16
20/09/16
30/09/16
10/10/16
20/10/16
30/10/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall

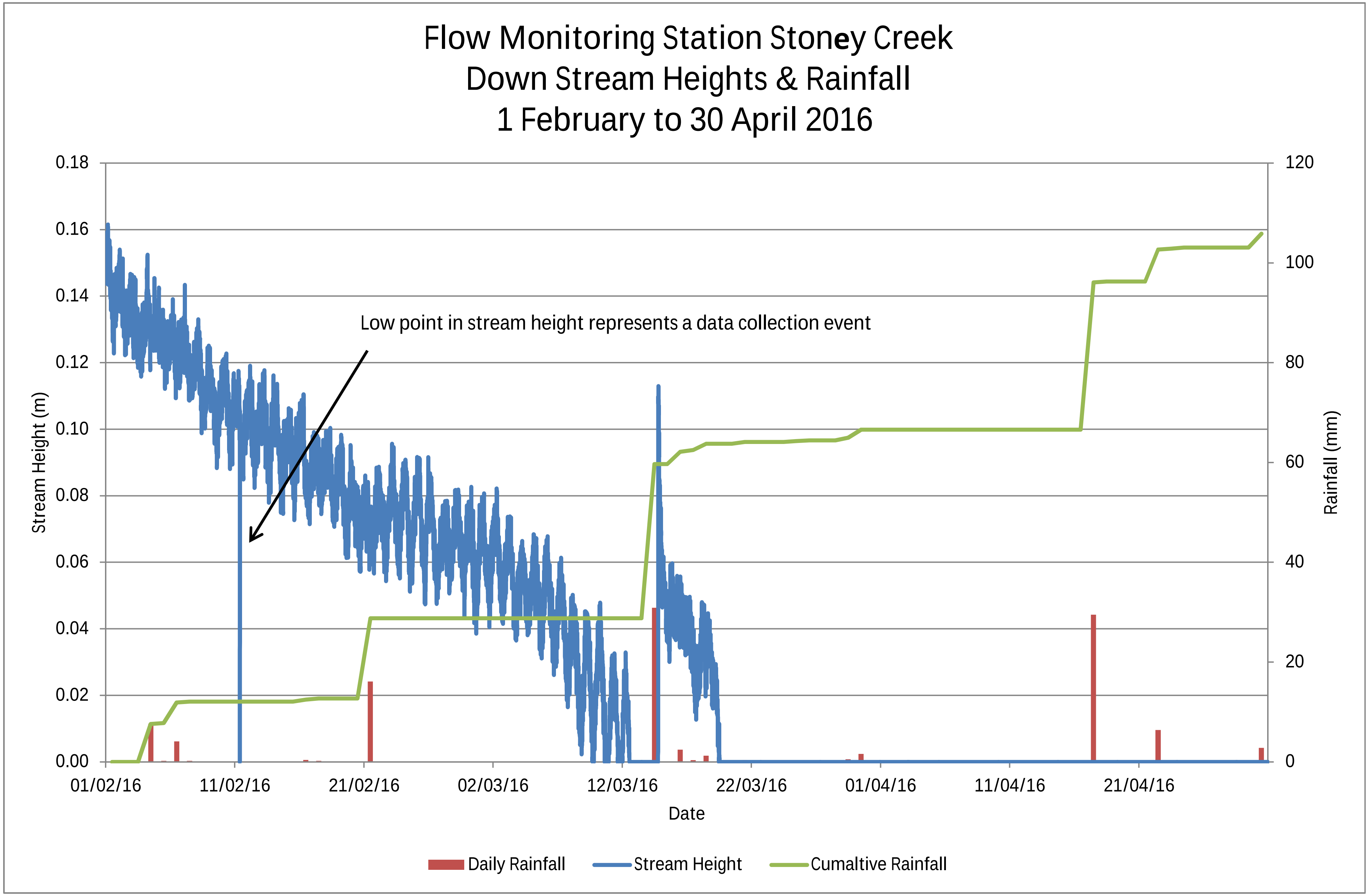

Flow Monitoring Station Stoney Creek
Tributary Stream Heights & Rainfall
1 February to 30 April 2016
Stream Height (m)
Rainfall (mm)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
120
100
80
60
40
20
0
01/02/16
11/02/16
21/02/16
02/03/16
12/03/16
22/03/16
01/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall


Flow Monitoring Station Stoney Creek
Tributary Theoretical Flow (Q) & Rainfall
1 February to 30 April 2016
Theoretical Flow (Q) (m³/s)
Rainfall (mm)
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
120
100
80
60
40
20
0
01/02/16
11/02/16
21/02/16
02/03/16
12/03/16
22/03/16
01/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

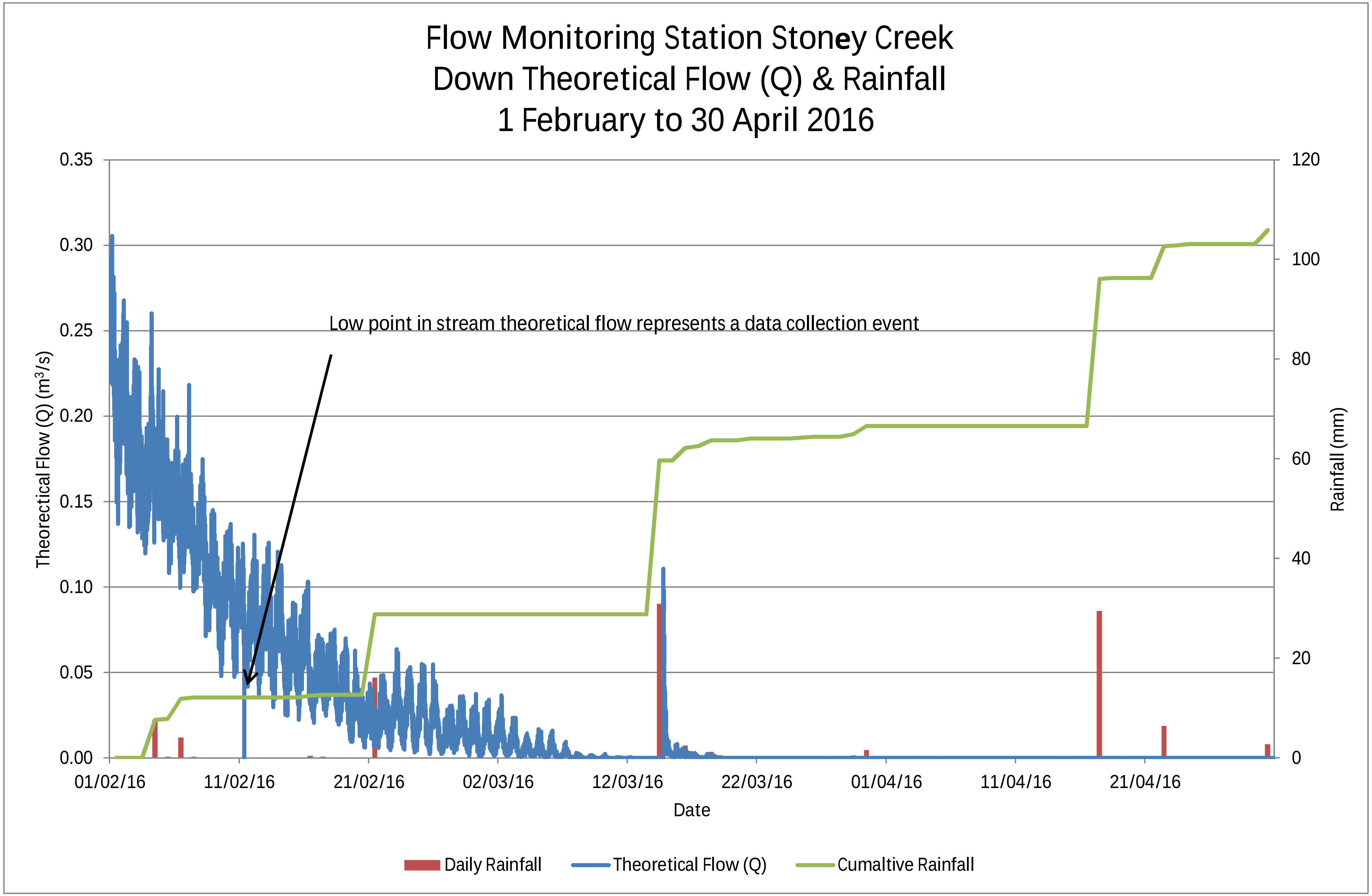


Flow Monitoring Station Stoney Creek
Up Stream Heights & Rainfall
1 February to 30 April 2016
Stream Height (m)
Rainfall (mm)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
120
100
80
60
40
20
0
01/02/16
11/02/16
21/02/16
02/03/16
12/03/16
22/03/16
01/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall


Flow Monitoring Station Stoney Creek
Up Theoretical Flow (Q) & Rainfall
1 February to 30 April 2016
Theoretical Flow (Q) (m³/s)
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Rainfall (mm)
120
100
80
60
40
20
0
01/02/16
11/02/16
21/02/16
02/03/16
12/03/16
22/03/16
01/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall



Flow Monitoring Station Stoney Creek
Down Stream Heights & Rainfall
1 February to 30 April 2016
Low point in stream height represents a data collection event
Stream Height (m)
Rainfall (mm)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
120
100
80
60
40
20
0
01/02/16
11/02/16
21/02/16
02/03/16
12/03/16
22/03/16
01/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Stream Height
Cumaltive Rainfall



Flow Monitoring Station Stoney Creek
Down Theoretical Flow (Q) & Rainfall
1 February to 30 April 2016
Low point in stream theoretical flow represents a data collection event
Theorectical Flow (Q) (m³/s)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Rainfall (mm)
120
100
80
60
40
20
0
01/02/16
11/02/16
21/02/16
02/03/16
12/03/16
22/03/16
01/04/16
11/04/16
21/04/16
Date
Daily Rainfall
Theoretical Flow (Q)
Cumaltive Rainfall

APPENDIX G – WAMBO ANNUAL REVIEW GROUNDWATER ANALYSIS

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DATE:	30 March 2017
TO:	Harry Egan Environmental Advisor
	Wambo Coal Pty Ltd Peabody Energy Australia PMB 1, Singleton NSW 2330
FROM:	Dr Noel Merrick and Adam Skorulis
RE:	Wambo Annual Review Groundwater Analysis
OUR REF:	WAM018 – Report HS2017/07

INTRODUCTION

This letter report contains the analysis and information required to address the following components of the Annual Environmental Management Review (AEMR) for the Wambo Coal Mine for the 2016 calendar year:

1 Review hydrographs for relevant groundwater monitoring bores and conduct a cause-and-effect analysis to determine whether trends are due to weather or mining.

2 Assess shallow bores for compliance with the groundwater level and water quality performance indicators (Tables 9 and 10 of the GWMP).

3 Compare groundwater monitored levels to model predictions.

Each scope item is addressed separately in the following sections.

1 ANNUAL REVIEW OF MONITORING DATA

Key data assessment results of time series groundwater level and EC data, in relation to Peabody (2015a) prescribed trigger levels for the 2016 monitoring period are outlined below. Trends from the entire period of observation have also been assessed to provide context for the 2016 monitoring period.

1.1 Key Groundwater Monitoring Sites

Bores at key sites have been selected to identify potential impacts from recent areas of longwall (NWU LW8b and SBU LW11 and LW12) and open cut mining at, and nearby, Wambo Coal Mine (WCM).

1.1.1 North Wambo Underground Impacts

Available EC and groundwater level monitoring data have been assessed at key locations P114, P116, P202, P206, P106 and P109 (**Figure 1**).

1.1.1.1 Observations and Assessment

Groundwater level at location P114 (**Figure 2**) shows a strong relationship with the long-term rainfall trend from 2003 to late 2014. Following this, the groundwater level departs from the rainfall trend and is seen to decline gradually to August 2015 before dropping rapidly to the last date of measurement in August 2016 (the October and December measurements showed the bore as 'Dry'). A minor response was recorded in February 2016 corresponding to an increase in the rainfall trend. Groundwater level has decreased by ~4 m from August 2015 to August 2016, and more than that if the ground over Longwall 10A has subsided. P114 is located over NWU Longwall 10a, which began extraction in June 2015. The rapid decline in groundwater level following the beginning of extraction is interpreted as a NWU mining impact. Groundwater EC at P114 was fresh from August 2003 to October 2011 before a sharp increase in December 2011 to brackish conditions with EC 3000-7000 µS/cm occurring until August 2015. Following this, EC has further increased with approximately 10000 µS/cm recorded from December 2015 to the last measurement in August 2016, aside from a slight freshening to 8000 µS/cm with the above average rainfall in February 2016.

At location P116 (**Figure 3**) groundwater level shows a moderate response to the long-term rainfall trend and good correlation with the HydroSimulations' interpolated Wollombi Brook stage height. The average groundwater level from late 2003 to April 2007 is seen to increase by about 1.5m to a new average from June 2007, to December 2016. This may indicate recovery from drawdown caused by the Homestead Longwall 9 mining of the Whybrow Seam that removed coal to within 10m of P116. However, it is more likely to represent a return to above average rainfall following the 'Millenium Drought' that affected much of Eastern Australia in the 2000's. This is observed with a large increase in the rainfall trend, a 3m increase in groundwater level at P116, and increases in Wollombi Brook stage height. Groundwater levels during 2016 have declined by ~1 m, with only a minor increase occurring August 2016 to October 2016. This is despite an increase in the rainfall trend and spike in Wollombi Brook stage height of a magnitude that has previously correlated with increases in groundwater level. This may indicate a mild mining effect from the extraction of North Wambo Underground Longwall 10A. EC levels at P116 indicate saline water at the start of measurement in 2003 but show a large drop between April 2007 and July 2007. Since July 2007, water has remained relatively fresh (about 1000 µS/cm). However, notable spikes in EC level are seen to occur in conjunction with declines in groundwater level (April 2010 – August 2011 and August 2014 – March 2015); the EC and groundwater level curves are almost mirror images since 2007.

P202 (**Figure 4**) groundwater level shows good correlation with HydroSimulations' interpolated Wollombi Brook stage height, and a moderate correlation with the long-term rainfall trend. An increase in average groundwater level of ~1 m is seen following a high water level in June 2007, which continues until the most recent observation in December 2016. This may indicate recovery from drawdown caused by the extraction of Homestead Longwall 9a mining of the Whybrow seam 160 m west of P202. However, it is more likely to represent a return to an above average rainfall trend (as explained in the P116 paragraph above). Groundwater EC at P202 is brackish in the early observation period and is seen to freshen with the high groundwater level in June 2007. Following this period, groundwater EC fluctuates independently from groundwater level, stream stage and long term rainfall trends at levels 3000-10500 µS/cm. High salinity periods occur from June 2008 to April 2010 and April 2014 to February 2015. The cause of the fluctuations in EC is not apparent.

P206 (**Figure 5**) groundwater levels show similar trends to those seen in P202, with an apparent increase in average water level of 1.5 m following a high water level in June 2007. This may indicate recovery from drawdown caused by the extraction of Homestead Longwall 9a in the Whybrow seam 70 m to the west of P206. Again however, it is more likely to represent a return to an above average rainfall trend (as explained in the P116 paragraph above). From June 2007 good correlation is seen between the HydroSimulations' interpolated stream stage and the long-term rainfall trend, with increases in groundwater level linked to high stream stage and rainfall events. Groundwater level is observed to decline by 2 m during 2016, despite an increase in the rainfall trend. While this may indicate a mining effect from NWU LW10A, Wollombi Brook stage height is also observed to decline at both the downstream Warkworth and upstream Bulga gauging stations during 2016 (seen in the interpolated stage height in **Figure 5**). As the Bulga station could not be affected by mining at Wambo, Wollombi Brook level is more likely to be influencing the groundwater level at P206 rather than mining. Groundwater EC at P206 is mostly stable between 2000 – 3000 µS/cm, but can be seen to decline rapidly in correlation with spikes in groundwater level associated with high river stage and rainfall events. This may indicate the infiltration of rain water into the borehole or gravel pack surrounding the bore during large storm events as seen in June 2007 and April 2015. Minor freshening's also occur at smaller spikes in groundwater level associated with rainfall and stage height.

Groundwater level in P106 shows good correlation with the long-term rainfall trend (**Figure 6**) and the interpolated stage height for Wollombi Brook. Larger fluctuations in groundwater level are observed in P106 in comparison with P114, P116, P202 and P206 (**Figures 2-5**). This is likely to be indicative of ephemeral flow in Wambo Creek, or lower specific yield in the associated alluvium. Groundwater EC at P106 is relatively fresh (less than 1000 µS/cm) and responds to the climatic influence on groundwater levels. Low groundwater levels correlate with increased EC, where a gradual decline is seen in correlation with an increasing trend in rainfall from June 2007 to December 2016, as is observed in the other bores located between North Wambo Underground mine area and the confluence of Wambo Creek and Wollombi Brook. Groundwater level responses to climatic factors such as rainfall trend and stage height during 2016 appear to be muted when compared with events of similar magnitude in earlier observations. This indicates a possible mild mining effect caused by Longwall 10A extraction and associated dewatering of overlying workings.

Time series groundwater level in P109 (**Figure 7**) is very similar in nature to P106. A strong climatic response can be observed, with larger fluctuations in groundwater levels likely indicative of ephemeral flow in Wambo Creek or lower specific yield in the associated alluvium. Groundwater EC is stable at around 600 µS/cm aside from a 6-month period April-August 2013 where EC was 1000 uS/cm. This correlates with a period of low rainfall and groundwater level. Groundwater levels during the 2016 monitoring period show a consistent climatic response to previous observations. This indicates a continued influence of ephemeral flow in Wambo Creek.

1.1.2 North Wambo Underground or Dewatering Impact at GW08 and GW09

Since April 2012, the groundwater levels in bores GW08 and GW09 have decreased by ~3 m (**Figure 8**). Available groundwater level monitoring data have been assessed for GW08 and GW09 to determine the cause of the decreased water level.

1.1.2.1 Assessment

GW08 and GW09 are located to the east of NWU. The closest NWU longwalls to GW09 are Longwall 9 (extracted mid 2014 - early 2015) and Longwall 8b (extracted late 2015 – early 2016) (**Figure 1**). The closest NWU Longwalls to GW08 are Longwalls 10 and 10A (extracted consecutively early 2015 – late 2015) (**Figure 1**). Significant drawdown in both GW08 and GW09 (**Figure 8**) begins in mid-2012, at the time when NWU Longwall 5 was being extracted (1.1 km from GW09 and 1.4 km from GW08) and Longwall 6 development headings were driven. Prior to 2012 there was a slow decline in groundwater levels probably due to the combined effects of approaching NWU mining of the Wambo Seam, the approaching Wambo open cut (and associated construction of the North Wambo Creek Diversion), and perhaps the approaching United mining far below in the Arrowfield Seam which finished in 2012. An increase in the rate of decline occurs from 2012, coincident with the commencement of dewatering of the Wambo Seam in the old workings adjacent to North Wambo Longwall 8b by means of two production bores. The water levels in these bores show only a minor response to rainfall; however, the stresses causing the declining levels are greater than the capacity of the alluvium to respond to rainfall events with GW09 going dry in late 2014. While no observation data was available for the 2015 monitoring period, observations have been made for the 2016 monitoring period from April 2016. The single water level observation at GW09 shows the bore is again dry, and a continued decline in groundwater level occurs at GW08, indicating an ongoing mining effect associated with Longwall 8b. This suggests that the earlier decline from 2013 to 2014 was not solely due to the effect of the dewatering bores.

1.1.3 Montrose open cut impact

Groundwater level data has been assessed at GW16 and GW17 and VWP N5 (**Figure 1**) to determine the potential impact of the Montrose open cut (about 300 m distant) on alluvial groundwater levels. Observations have been made at these locations since August 2010.

1.1.3.1 Long term observations

Both GW16 (**Figure 9**) and GW17 (**Figure 10**) show good correlation to the long term rainfall trend, with a period of increasing water level from the beginning of observation until mid-2012 coinciding with above average rainfall. A decrease in groundwater level of ~5 m is seen in both locations from August 2013 to February 2015 during average rainfall conditions, before increasing again by about 3 m to June 2015. The second half of 2015 shows another decrease in groundwater level of 3 m in GW16 and 2 m in GW17. Increases in groundwater level of 4 m and 5 m in GW16 and GW17 respectively, are observed in correlation with a rainfall trend increase in February 2016. At GW16 this is followed by a 5 m decrease in groundwater level to August 2016, which recovers by 2 m for October and December 2016 observations. GW17 groundwater levels following February 2016 decline by 4 m to December 2016. The EC records remain disparate – fresh at GW16 (in alluvium) and saline at GW17 (beneath alluvium).

N5 (**Figure 11**), is a multi-piezometer grouted bore with four VWPs installed at depths of 30 m (N5-4: Permian Overburden), 73 m (N5-3: Whybrow Seam), 89.5 m (N5-2: Whybrow – Wambo Seam Interburden) and 133 m (N5-1: Wambo Seam) that have been recording since July 2015. Since stabilising in October 2015, the shallowest Permian sensor (N5-4) has been recording a consistent groundwater level that shows a good correlation with the rainfall trend. A decline in groundwater level of ~10 m has been observed in the three lower sensors during the 2016 monitoring period.

1.1.3.2 Assessment

Previous reporting (HydroSimulations 2016) attributed earlier fluctuations of groundwater level at GW16 and GW17 to climate and ephemeral flows in North Wambo Creek as the main influences on groundwater level. The increasing amplitude in groundwater level response, particularly at GW16, indicates a likely mining effect from the removal of material from the adjacent open cut, given that the most recent declines are contrary to the rainfall trend. The rapid recovery that is observed following increases in the rainfall trend is likely due to ephemeral flow in North Wambo Creek and a low specific yield in its associated alluvium. Some of the drawdown may also be attributed to the extraction of South Bates Underground LW11 and LW12. However, the longwalls are over 2 km away meaning most of the observed mining effect can be attributed to the open cut.

As GW16 and GW17 are upgradient of the Montrose pit, there can be no effect on EC from the open cut operation.

The decline in groundwater level in the lower three sensors of N5 is likely due to regional depressurisation by open cut mining and NWU mining in the Wambo Seam, and the onset of SBU mining in the Whybrow Seam

1.1.4 South Bates Impact

Groundwater level data have been assessed at VWPs N2 and N3 as well as GW21 to identify the impact of the extraction of South Bates LW11 and LW12. Data at the VWPs has been recorded since July 2015 and GW21 has recorded bi-monthly data since October 2010.

1.1.4.1 Observations

N2 (**Figure 12**), located between North Wambo Underground and South Bates Underground (**Figure 1**), is a multi-piezometer grouted bore with six VWPs installed at depths of 40 m (N2-6: Permian overburden), 70 m (N2-5: Permian overburden), 100 m (N2-4: Permian overburden) and 140 m (N2-3: Whybrow Seam), 173 m (N2-2: Whybrow to Wambo Seam interburden), and 204 m (N2-1: Wambo Seam) that have been recording since July 2015. The uppermost sensor (N2-6) at 40 m depth shows a decline in groundwater level of 2 m to a near zero pressure head from the start of observation to the most recent readings. This likely represents the sensor stabilising but may also represent a response to a below average period in the rainfall trend. During the 2016 monitoring period, a 1 m increase in groundwater level is observed from January to March following a period of above average rainfall. From April 2016 to the last recorded date in October 2016, groundwater level declines to read zero pressure. Similar observations are made in the other two Permian overburden sensors at N2. The sensor at 70 m depth (N2-5) shows a stable, gently increasing groundwater level that does not appear to respond to the rainfall trend from the beginning of observation in July 2015 until March 2016. Groundwater level at this sensor is then observed to decline by 11 m until the end of the observation period in December 2016. The 100 m deep sensor (N2-4) shows a 7 m decline in groundwater level from March 2016 to the end of the observation period in December 2016. The lower sensors in the Whybrow and Wambo Seams and interburden have all recorded declines in groundwater level since the beginning of observation. The Wambo Seam sensor at 204 m depth (N2-1) and the Whybrow-Wambo Seam interburden sensor at 173 m depth (N2-2) have maintained pressure head of approximately 60 m, while the Whybrow Seam sensor at 140 m depth (N2-3) has only recorded a pressure head of ~10 m.

N3 (**Figure 13**), located above the northern edge of South Bates underground Longwall 11, is a multi-piezometer grouted bore with six VWPs installed at depths of 30 m (N3-6: Permian overburden), 55 m (N3-5: Permian overburden), 75 m (N3-4: Permian overburden), 109 m (N3-3: Whybrow Seam), 142 m (N3-2: Whybrow to Wambo Seam interburden) and 190 m (N3-1: Wambo Seam) that have been recording since July 2015. The uppermost sensor at 30 m depth (N3-6) appears to undergo a period of stabilisation from July to December 2015, after which groundwater level is consistent until February 2016. From the beginning of South Bates LW11 extraction, groundwater level declines until the sensor stops recording in May 2016. The Permian overburden sensor at 55 m depth (N3-5) shows a gradual increase from near zero pressure head at the beginning of recording to peak at a level ~10 m above the sensor in May 2016. Groundwater level then declines and remains stable at approximately 1.5 m above the sensor until the end of the monitoring period; it is the only sensor still recording. Groundwater level in the lowest overburden sensor at 75 m depth (N5-4) is reasonably stable and shows a gradual increase before declining in early April 2016 and then no longer recording after May 2016. The Whybrow Seam sensor at 109 m depth records a flat near zero pressure head before failure in May 2016. Similar to what is observed in the N2 VWP, both the Whybrow-Wambo interburden sensor and the Wambo seam sensor maintain significant pressure head (~50 m), with some activity and a minor increase in groundwater level observed prior to sensor failure in May 2016.

GW 21 (**Figure 14**) is located within 10 m of N2 (Figure 1), between North Wambo Underground Longwall 1 and South Bates Underground Longwall 13. Early observations were infrequent (only three between October 2010 and October 2013 before more regular bi-monthly monitoring was conducted), or reported the bore as dry, so it is difficult to identify any climate driven trends in groundwater level. A gradual decline in groundwater level with no response to the rainfall trend from July 2011 is seen through to December 2015 where the bore was again reported as dry. The 2016 monitoring period showed some groundwater level response to increases in the rainfall trend in both February (very minor ~10 cm) and October (~30 cm). At the end of the monitoring period groundwater level was ~20 cm above the base of the bore. Water quality has not been sampled at GW21.

1.1.4.2 Assessment

The decrease in groundwater level observed in the Permian overburden sensors at N2 indicates a mining impact caused by the extraction of South Bates Underground Longwall 11 that has continued through Longwall 12 extraction to the end of the 2016 observation period. The declining groundwater levels in the lower coal seam and interburden sensors show evidence of an early mining effect most likely caused by the extraction of North Wambo Underground longwalls.

The decline in groundwater level in Permian sensors prior to failure also shows evidence of a South Bates mining effect at N3. The sensor failure is most likely related to subsidence following the extraction of Longwall 11.

A mining effect is likely observed at GW21 resulting from North Wambo Underground longwall extraction prior to the first observation made. With the near-dry level of the bore, a mining effect caused by South Bates Underground is not able to be observed. A lack of an expected mining effect from South Bates longwall extraction has previously been suggested (HydroSimulations 2017) to be due to the mitigating effect of a fault between GW21 and South Bates Underground. However, analysis of the Permian sensors in N2 shows a clear mining effect at two levels but little effect, if any, at other levels. No further mining effect is able to be observed at GW21 due to groundwater level being so close to the base of the bore, while drawdown of approximately 10 m is observed in Permian groundwater levels very close by.

1.2 Peabody (2015) Wambo Coal Groundwater Monitoring Program - Trigger Levels

The trigger levels in **Table 1** are presented in the Peabody (2015; Table 9[1] and Table 10) Wambo Groundwater Monitoring Program as the result of statistical analysis on pre-mining baseline monitoring data. Triggers for groundwater level occur when a single bi-monthly observation exceeds or falls below the specified depth to groundwater. Triggers for EC occur when three consecutive bi-monthly observations (a 6-month period) exceed the specified trigger level. Triggers for pH occur when two consecutive bi-monthly observations (a 4-month period) exceed or fall below the specified trigger level.

Table 1 Peabody (2015) Groundwater Level and Quality Trigger Levels

Bore	Groundwater Level (mAHD) *(metres above Australian Height Datum)*		Groundwater Quality		
	Maximum (10th percentile depth)	Minimum (90th percentile depth)	EC (µS/cm)	pH min	pH max
P106	54.47	50.37	941	6.7	7.9
P109	57.84	55.74	#N/A		
P114	56.04	53.84	6141	6.5	7.8
P116	54.24	51.74	5972	6.6	7.5
P202	52.47	50.67	8172	6.7	7.7
P206	44.13	38.63	2630	7.3	8.1
P301	#N/A				
P315	90.34	85.64	552	6.0	7.4
GW02	76.70	74.00	715	6.7	7.4
GW08	#N/A				
GW09	#N/A				
GW11	76.00	73.50	592	6.8	7.5
GW12	77.38	74.38	#N/A		
GW13	57.76	57.16	4370	6.9	7.1
GW15	51.96	51.26	730	6.7	7.2
GW16	#N/A				
GW17	#N/A				
P16	50.38	49.68	10832	7	7.7
P20	50.30	49.20	10625	7	7.6

Not applicable

[1] Table 9 expresses the triggers as depth to water in metres below top of casing. For convenience of analysis, they are converted here to equivalent groundwater elevations (mAHD)

1.2.1 2016 Groundwater Level Statistics

Table 2 presents 10th and 90th percentile statistics for groundwater levels at nominated water level trigger sites for the 2016 monitoring period.

Table 2 2016 10th and 90th Percentile Groundwater Levels

Bore	Groundwater Level (mAHD) *(metres above Australian Height Datum)*		Depth to Groundwater (mBTOC) *(metres below top of casing)*	
	2016 Minimum (90th percentile depth)	2016 Maximum (10th percentile depth)	2016 Minimum (10th percentile)	2016 Maximum (90th percentile)
P106	51.7	53	8	9.3
P109	57.1	58	4.4	5.3
P114	51.4	52	9.4	10
P116	53.2	53.6	5.5	5.9
P202	52.2	52.6	7.7	8
P206	42.7	44.2	16	17.6
P301	73.5	74.5	13.7	14.7
P315	87	89.7	5.1	7.7
GW02	76.1	77	5.5	6.4
GW08	53.6	54.1	5.9	6.4
GW09*	55.1		6.9	
GW11	73.6	76.1	3.9	6.4
GW12	75.3	76.7	10.6	11.9
GW13	56.9	57.2	5.3	5.6
GW15	52	52.4	9.9	10.3
P16	49.9	50.4	7.1	7.6
P20	49.5	50.1	7.4	7.9

*Only one value recorded at GW09 during 2016 monitoring period.

1.2.2 Trigger Level Exceedances

Table 3 presents counts of trigger level exceedances for the 2016 monitoring period.

Table 3 Trigger Level exceedances in the 2016 monitoring year

Bore	Number of Trigger Level Exceedances in 2016 Observations				
	Minimum depth-to-water (10th percentile)*	Maximum depth-to-water (90th percentile)**	EC^	pH min^^	pH max^^
P106					
P109	2		#N/A		
P114		6	2		
P116					
P202	1				
P206	1				
P301	#N/A				
P315	1				
GW02	2				
GW08	#N/A				
GW09	#N/A				
GW11	1	1			
GW12		1	#N/A		
GW13		4			
GW15	5				
GW16	#N/A				
GW17	#N/A				
P16	1				
P20					

Blank cells represent no trigger exceedance, #Not applicable
*Minimum depth-to-water is equivalent to maximum groundwater level (mAHD)
**Maximum depth-to-water is equivalent to minimum groundwater level (mAHD)
^Three consecutive bi-monthly observations exceeded the specified trigger level
^^Two consecutive bi-montly observations exceed or fall below the specified trigger level

1.2.2.1 Minimum (10th Percentile) Triggers

The 10th percentile triggers allow identification of anomalously shallow depths to groundwater.

It is important to note that the baseline monitoring data used to create the trigger levels (from July 2003 until August 2007) were taken during a period of lower than average rainfall (see the Bulga rainfall residual mass plotted on the hydrographs e.g. **Figure 2**). From October 2007 to the 2016 monitoring year, a period of generally greater than average rainfall has been observed. As such, instances where trigger levels exceed the minimum (10th percentile) levels in the 2016 monitoring period should not be attributed to Wambo Coal Mine activity. A high rainfall event in January 2016 that has taken some months to recover from is consistently the cause of the trigger exceedance. In any event, a high water level is not a cause for concern unless the groundwater EC increases from evaporative processes.

1.2.2.2 Maximum (90th Percentile) Triggers

The 90th percentile triggers allow identification of anomalously deep depths to groundwater.

P114, GW11, GW12 and GW13 have exceeded the trigger level for the 90th percentile (maximum) depth to water in the 2016 monitoring year.

As stated earlier, the low groundwater levels at P114 (**Figure 2**) are a clear effect from the mining of Longwall 10A and are reasonably consistent with model predictions (Section 2.2).

GW11 (**Figure 15**) reports a groundwater level above the minimum depth-to-water trigger in February 2016 as well as a groundwater level below the maximum depth-to-water trigger in December 2016. The February 2016 exceedance correlates with the period of above average rainfall so is not considered further. The trigger in December 2016 follows a groundwater level decline of ~2.5 m since August 2016 to a level 0.2 m below the trigger. The recession occurs at a more rapid rate than previously observed, during a period of average rainfall. GW02 (**Figure 6**) is located 120 m away from GW11 and a similarly timed recession of ~1.5 m in groundwater level that does not exceed a trigger occurs. It is possible that water loss from the alluvium further downstream on Wambo Creek, associated with North Wambo Underground mine has caused the observed drawdown and the trigger exceedance at GW11. Further readings are required to clarify the unexpected response at GW11. Given a separation of 3.5 km between GW11 and SBU Longwall 12, the mining effect is unlikely to be related to SBU mining.

GW12 (**Figure 16**) (situated over Longwall 8a) exhibits an ongoing mining effect from North Wambo Underground longwall extraction, with a trigger exceedance occurring in February 2016 as the bore reported dry. A recovery of ~2.5 m is observed with the above average rainfall in early 2016 and no further trigger exceedances are observed. The mining effect is unrelated to SBU mining.

GW13 is located on the eastern side of Wollombi Brook about 3 km from NWU workings (**Figure 1**). The four trigger events at GW13 occurred from June to December 2016 and are all less than 0.2 m below the prescribed trigger level (**Figure 17**). The decline is likely to be due to the approaching Warkworth open cut rather than Wambo mining.

1.2.2.3 EC Triggers

P114 has recorded four consecutive bi-monthly EC values greater than the trigger level in the 2016 monitoring period (**Figure 2**). As was discussed further in the 2015 AEMR (HydroSimulations, 2016), it is likely that the groundwater level has now declined to the extent that it is being sourced from saline Permian overburden, opposed to the fresher source of the overlying alluvium.

1.2.2.4 pH Triggers

No triggers for pH occurred in 2016 observations.

2 OBSERVED AND MODELLED GROUNDWATER LEVELS

Hydrographs of observed groundwater levels and HydroSimulations (2017) modelled groundwater levels at key sites are presented in **Figure 18** to **Figure 29**. The following sections contain an assessment of the modelled groundwater levels where mining impacts might be observed.

2.1 Montrose Open Cut

The elevation of modelled heads at GW16 (**Figure 18**) and GW17 (**Figure 19**) is reasonably good. The variation in heads in the observed data has not been replicated as no data was available for stage height at North Wambo Creek, influential to water levels in the alluvium and shallow groundwater system. As GW17 is closer to the open cut (**Figure 1**), it is predicted to be impacted at an earlier time and to a greater extent than GW16. The model conservatively indicates the mining effect at GW17 to be larger than the impact in the observed data. The model somewhat underestimates the observed mining effect at GW16, but begins to show a decline in groundwater level toward the end of 2016.

The performance of the modelled heads at N5 (**Figure 20**) is poor, with modelled heads much higher than what is seen in the observed data. The timing of the observed drawdown due to the open cut is accurate, but the vertical hydraulic head gradients have not been reproduced. The model is overestimating drawdown in the shallower sensors indicating that vertical hydraulic conductivities may be lower than modelled.

2.2 North Wambo Underground

The performances of modelled heads have been assessed against observed data where North Wambo Underground mining activity may impact groundwater levels.

Previous reporting for P114 (HydroSimulations 2015) had underestimated the drawdown associated with North Wambo Underground Longwall 10A extraction. Following an interrogation of the groundwater model, as further explained in HydroSimulations (2017), it was found that the underestimation was only apparent due to the model's inability to represent the layering at a fine vertical scale, and that the base of P114 extends into model layer 2. The modelled heads presented for P114 (**Figure 21**) are a weighted average from layer 1 and layer 2 heads according to the degree of partial penetration. The resulting calibration is a very good representation of the observed data.

P116 (**Figure 22)** shows fairly good correlation between maximum modelled and observed heads and the declining trend with time. The climate driven variations in water level are not present due to long term averages for river stage in modelling and probably overestimated specific yield because the bore lies within the official alluvial extent but outside the limits determined by geophysics. Accordingly, it should be attributed to regolith instead of alluvium. P116 does not lie directly over NWU workings and therefore shows only minor predicted drawdown resulting from mining activity, which occurs at the same time observed groundwater level shows drawdown attributable to mining.

HydroSimulations' modelled heads at GW08 (**Figure 23**) and GW09 (**Figure 24**) have a good match with the trends seen in the observed data. Although simulated initial heads are lower than observed, the drawn down heads in 2016 are near the correct level. During the 2016 monitoring period observed groundwater level at GW08 has continued to decline while modelled heads show a milder response to the mining of Longwall 8b. At GW09, the bore has gone dry due to mining related drawdown, so it is not possible to compare the performance of observed groundwater level with that modelled for 2016. A single recovery measurement in 2016 suggests that the predicted heads are near the correct level.

The simulated groundwater levels at P106 (**Figure 25**) follow the observed declining trend and match the upper envelope of measurements, but the water level amplitudes are not reproduced due to the absence of streamflow dynamics in the model. At P109 (**Figure 26**), agreement was very good from 2003 to 2007 but the model has continued a declining trend in contrast to generally higher and more dynamic water level observations. The model does not incorporate recharge from intermittent streamflow along Wambo Creek and therefore conservatively overestimates drawdown impacts in this area.

As is seen in other alluvial bores, observed water level amplitudes at GW11 are not reproduced in the modelled data due to the absence of streamflow dynamics in the model (**Figure 27**). GW11 groundwater level is slightly overestimated but shows a good match with the upper observed values. The observed decline at the end of 2016 is matched by a lower magnitude decline in the modelled data. While this indicates a mild North Wambo Underground mining effect, further observations are needed to determine whether a lack of rainfall sufficient to generate flow in Wambo Creek is distorting the apparent observed drawdown.

GW12 was not used in model calibration due to persistent 'dry' readings during the calibration period, likely resulting from an ongoing North Wambo Underground mining effect. The modelled heads for GW12 are a weighted average from layer 1 and layer 2 heads according to the degree of partial penetration (**Figure 28**). It is difficult to determine the model performance at this location as it is likely a mining effect occurred before the beginning of observation. This is indicated by the modelled groundwater level's strong response to North Wambo Underground LW2 extraction, and subsequent LW5 extraction. The model is overestimating the observed impacts. The degree of overestimation suggests that the observations pertain to perched water conditions in the regolith.

2.3 South Bates Underground

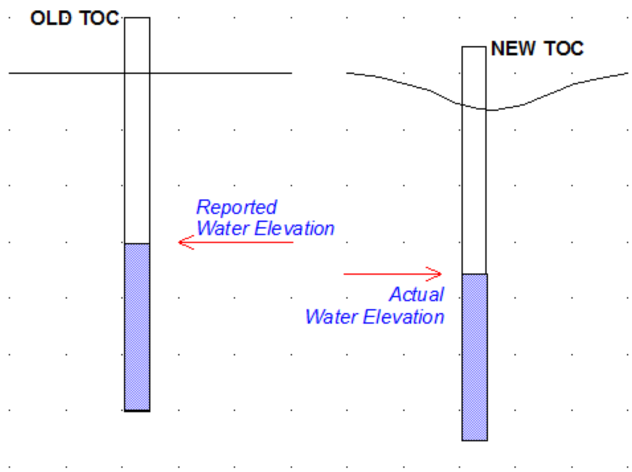
The performances of modelled heads at the GW21 standpipe bore (**Figure 29**) and N2 and N3 VWPs (**Figures 30-31**) have been assessed against observed data where South Bates mining activity may impact groundwater levels.

GW21 modelled heads show little correlation with observed groundwater levels (**Figure 29**). However, the first observation made at GW21 is after a mining effect from North Wambo Underground Longwall 1 would likely have occurred, resulting in the bore nearly going dry. This means the observed data at GW21 are not useful in assessing model performance. The model results indicate a strong mining effect caused by both North Wambo and South Bates longwall extraction. In both cases, the model is overestimating observed impacts.

Both N2 (**Figure 30**) and N3 (**Figure 31**) modelled heads face difficulty in accurately representing groundwater level in the Permian overburden sensors as three sensors are located within one model layer at each location. However, the 30 m sensor at N3 (N3-6), and the 70 m sensor at N2 (N2-5) both show an excellent match with observed data. The lower sensors in N2 overestimate groundwater level, but are accurate in indicating an ongoing mining effect from North Wambo that continues through the beginning of South Bates Underground mining. It is difficult to assess the performance of the lower sensors at N3 due to sensor failure before trends in groundwater level could be properly established.

3 RECOMMENDATIONS

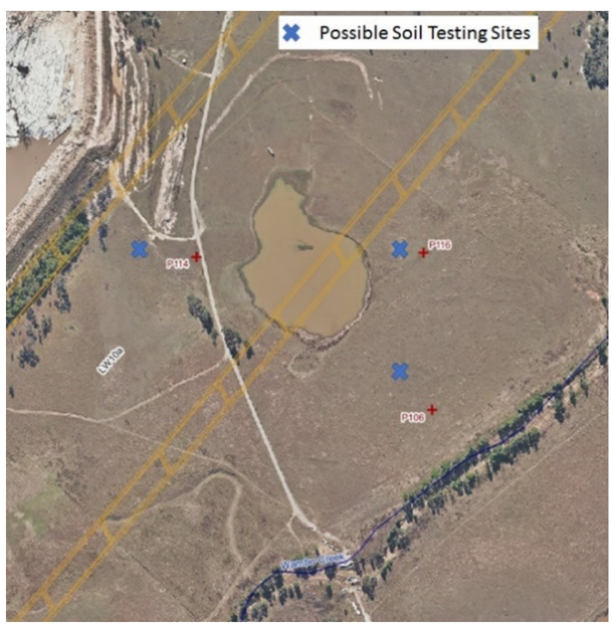
- Re-survey of the collar level at P114 to assess the amount of land subsidence caused by mining Longwall 10A. As shown in the diagram below, the reported water elevation would overestimate the actual water elevation by the amount of reduction in the collar level.



- Monthly monitoring of P114 if EC and water level triggers are exceeded at the next measurement round.

- Full chemical analysis of water from the unnamed depression to compare with the chemistry at Bore P114.

- Measurement of soil water EC and chemistry for comparison with the chemistry at Bore P114, at sites suggested in the diagram below, in order to clarify the source of salinity at P114.



4 REFERENCES

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HydroSimulations (2017) *South Bates Extension Modification Groundwater Assessment.* Report HS2016/51 for Wambo Coal Pty Ltd. February 2017

Peabody (2015) *Wambo Coal Groundwater Monitoring Program.* Document No. WA-ENV-MNP-509.1 October 2015.

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Figures

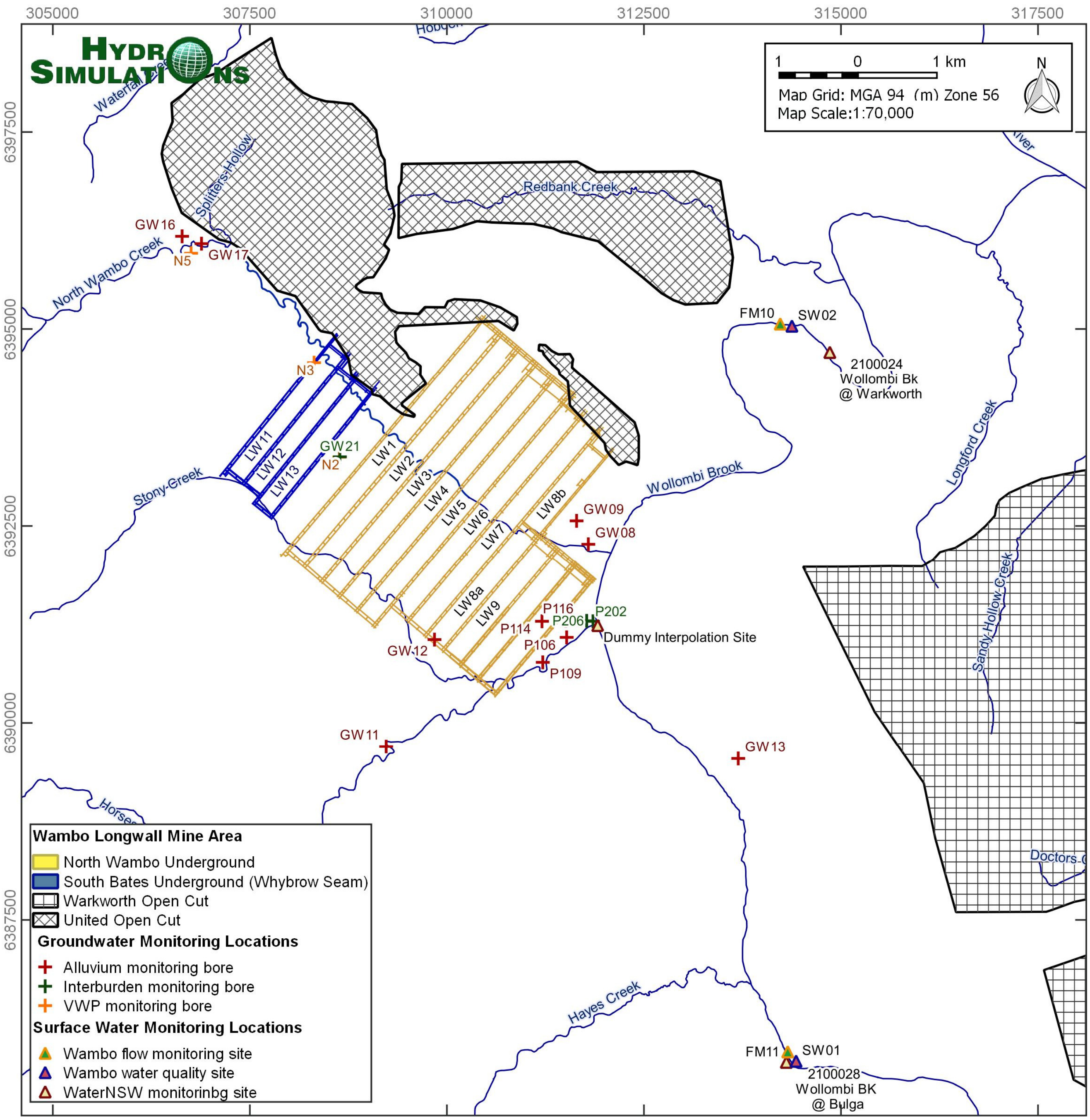

Figure 1 **Locations of bores discussed in this report**

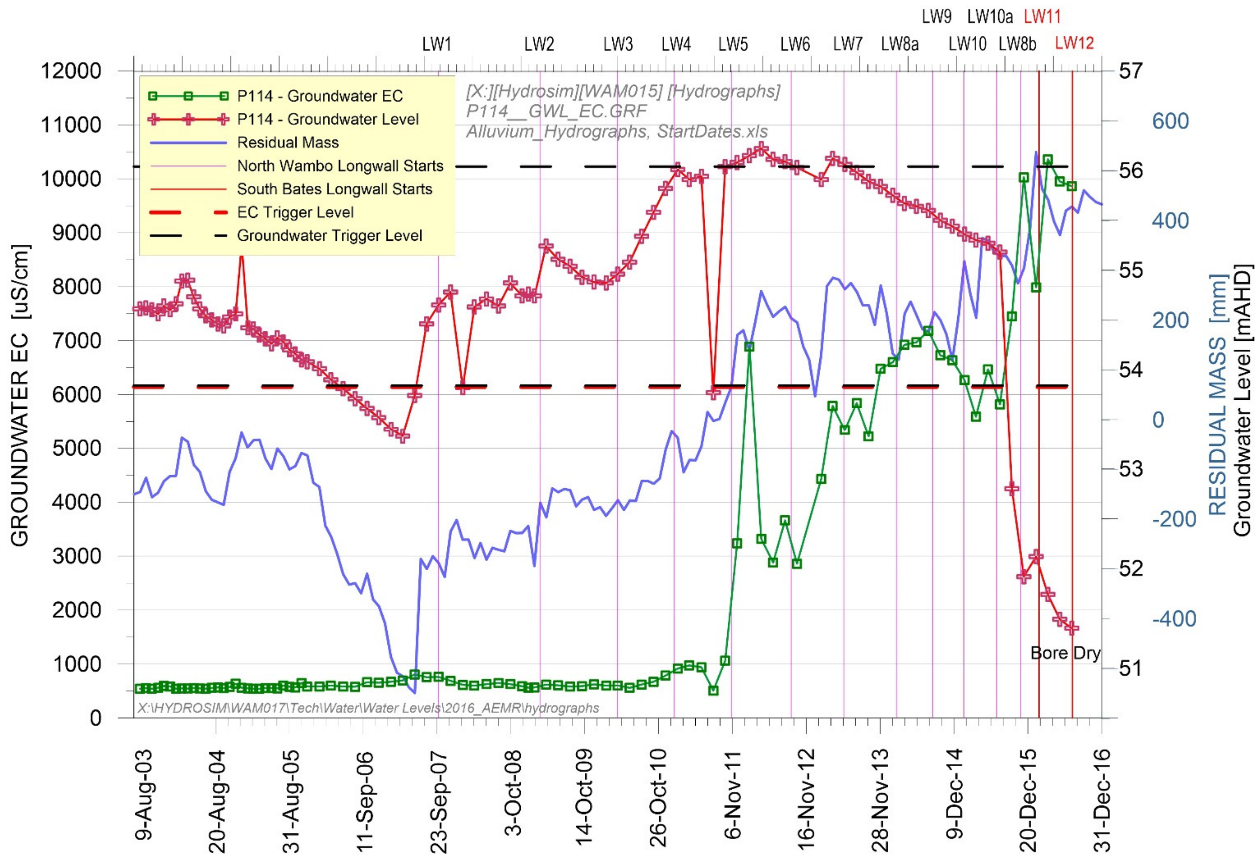

Figure 2 **P114 Groundwater Level and EC**

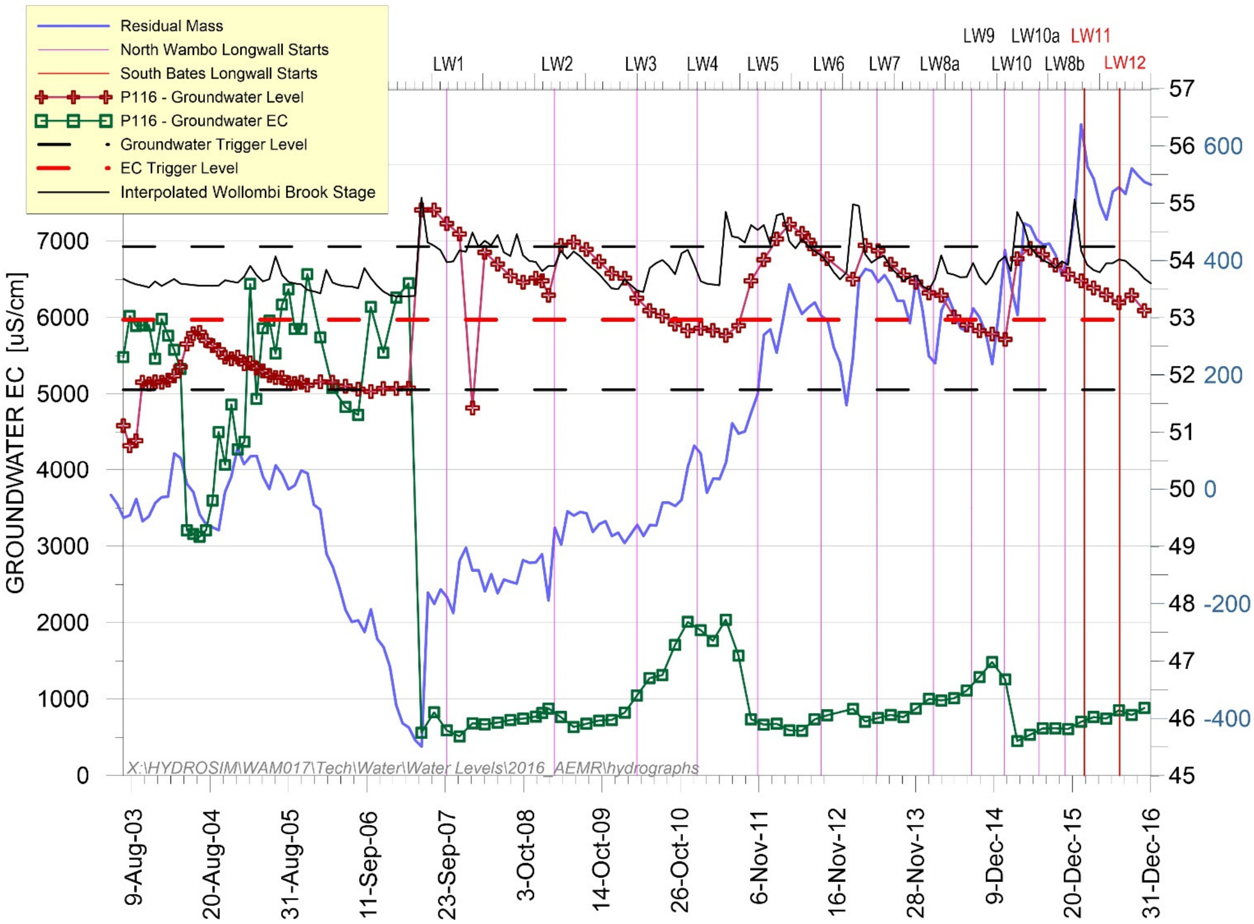

Figure 3 **P116 Groundwater Level and EC**

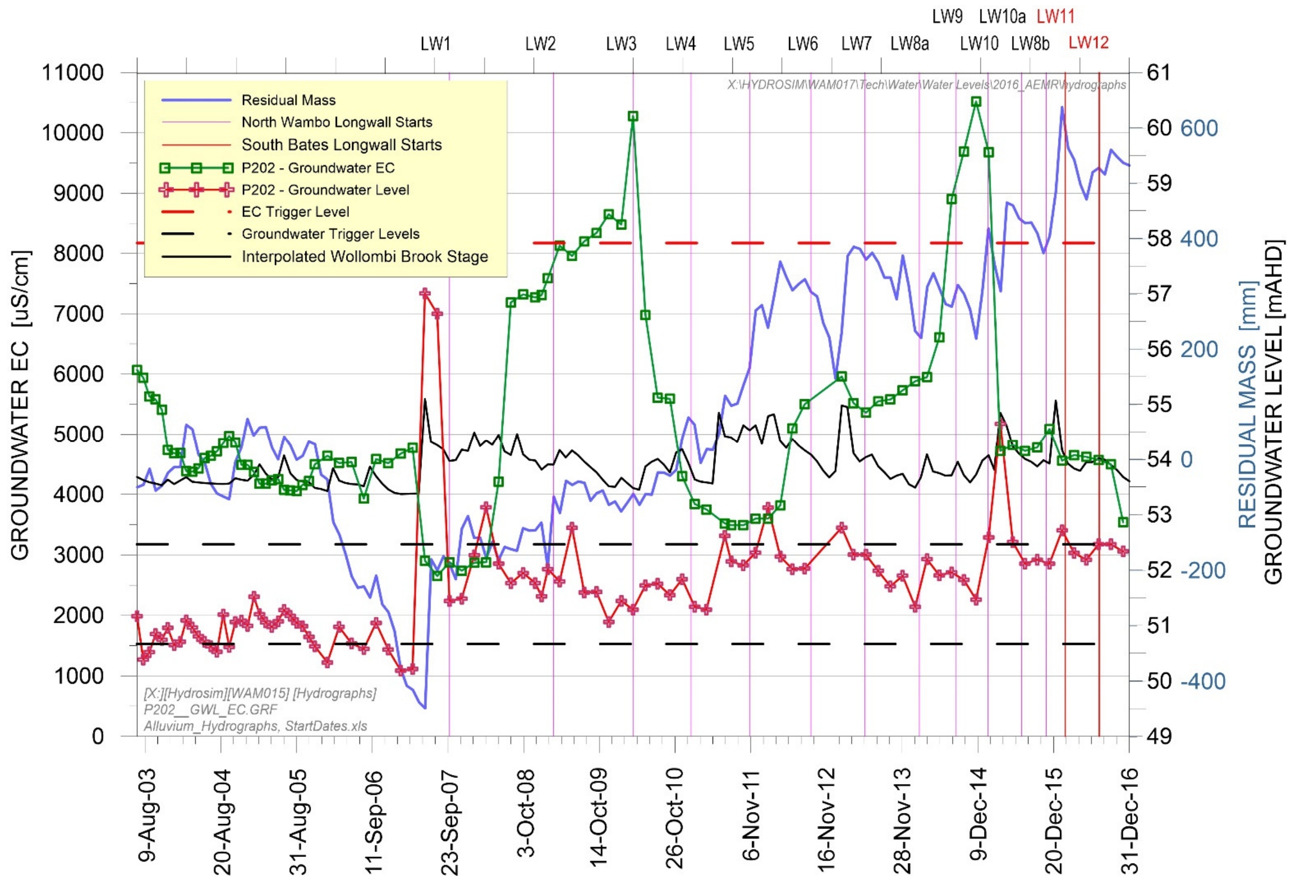

Figure 4 P202 Groundwater Level and EC

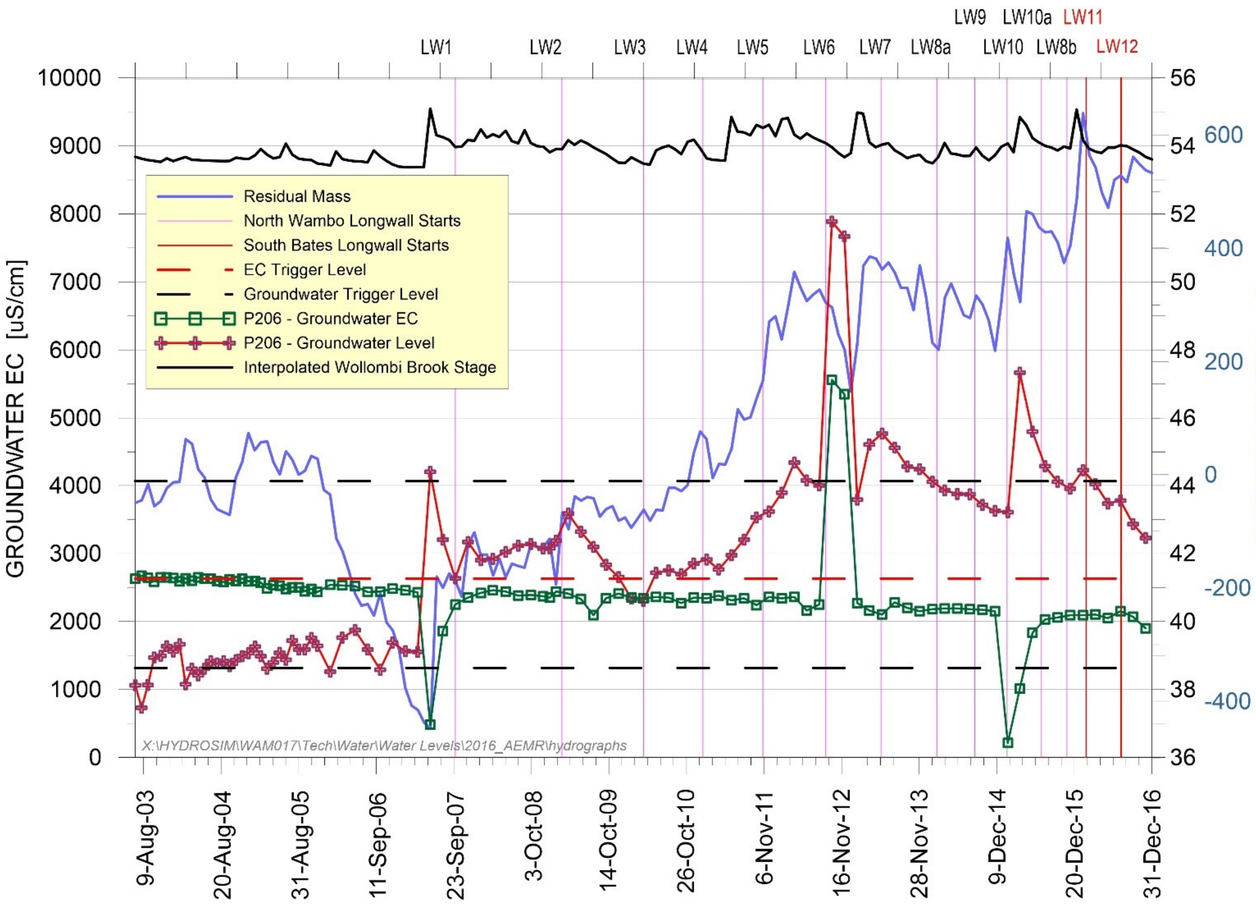

Figure 5 **P206 Groundwater Level and EC**

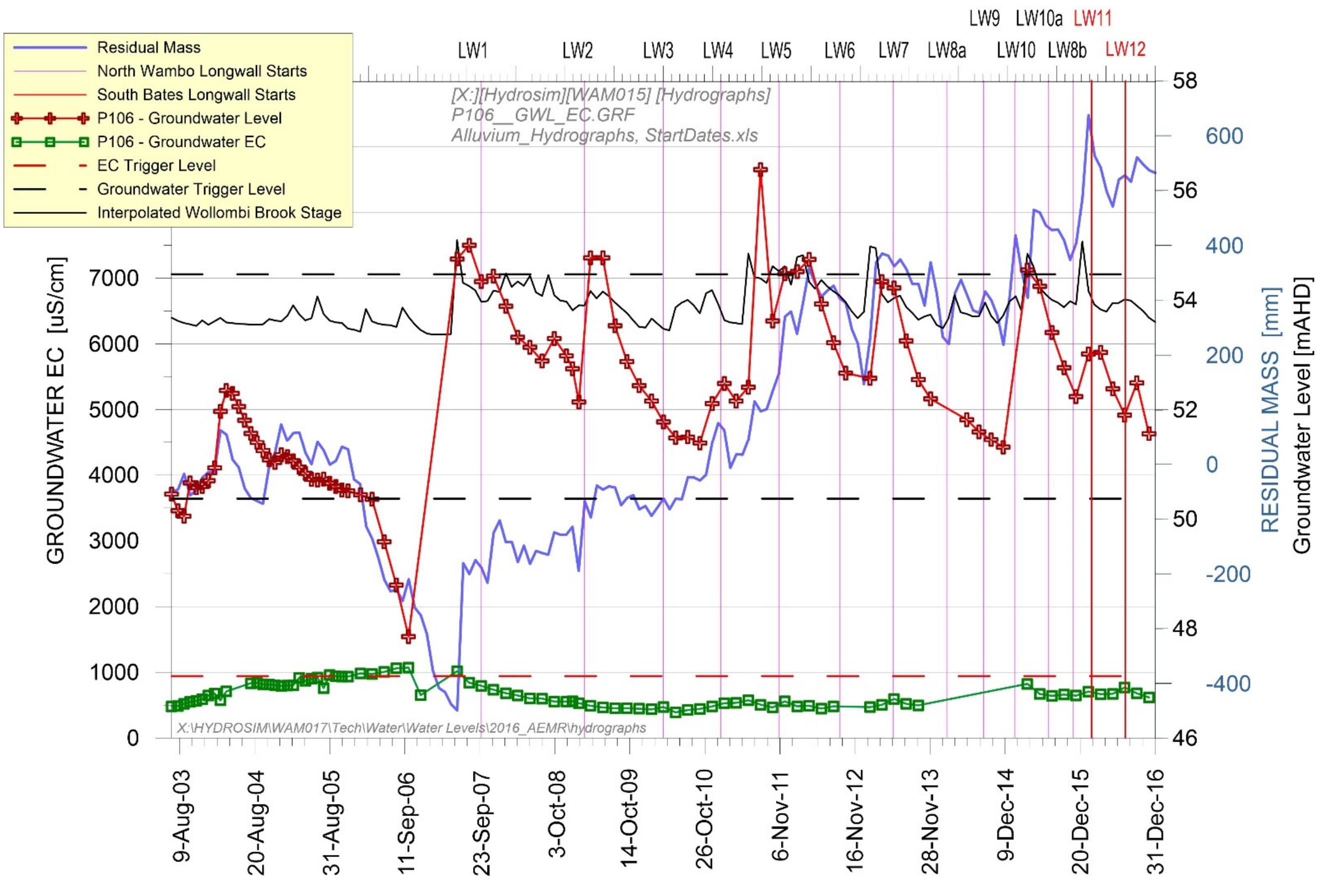

Figure 6 **P106 Groundwater Level, EC and Interpolated Wollombi Brook stage height**

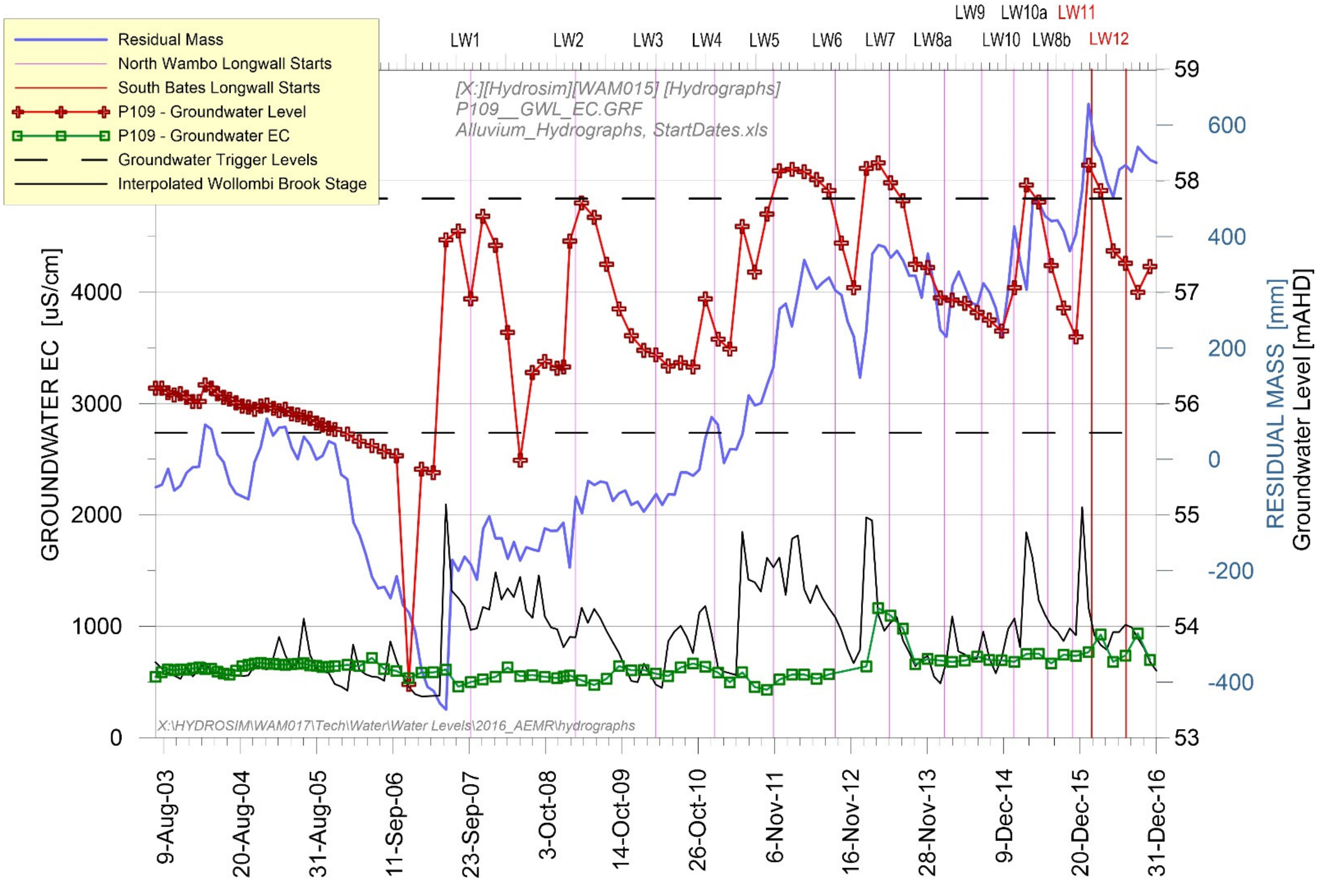

Figure 7 P109 Groundwater Level, EC and Interpolated Wollombi Brook stage height

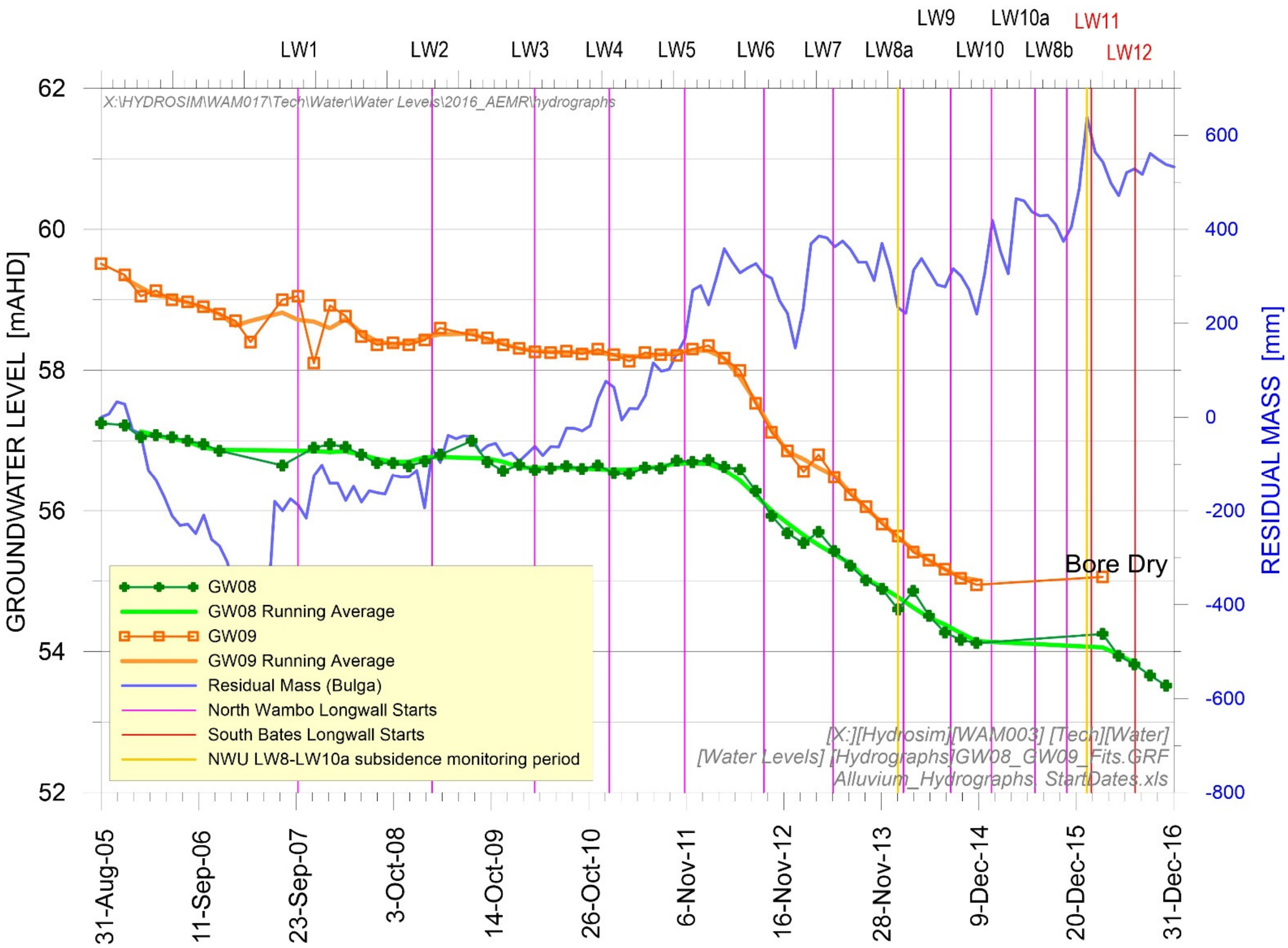

Figure 8 **GW08 and GW09 Hydrograph**

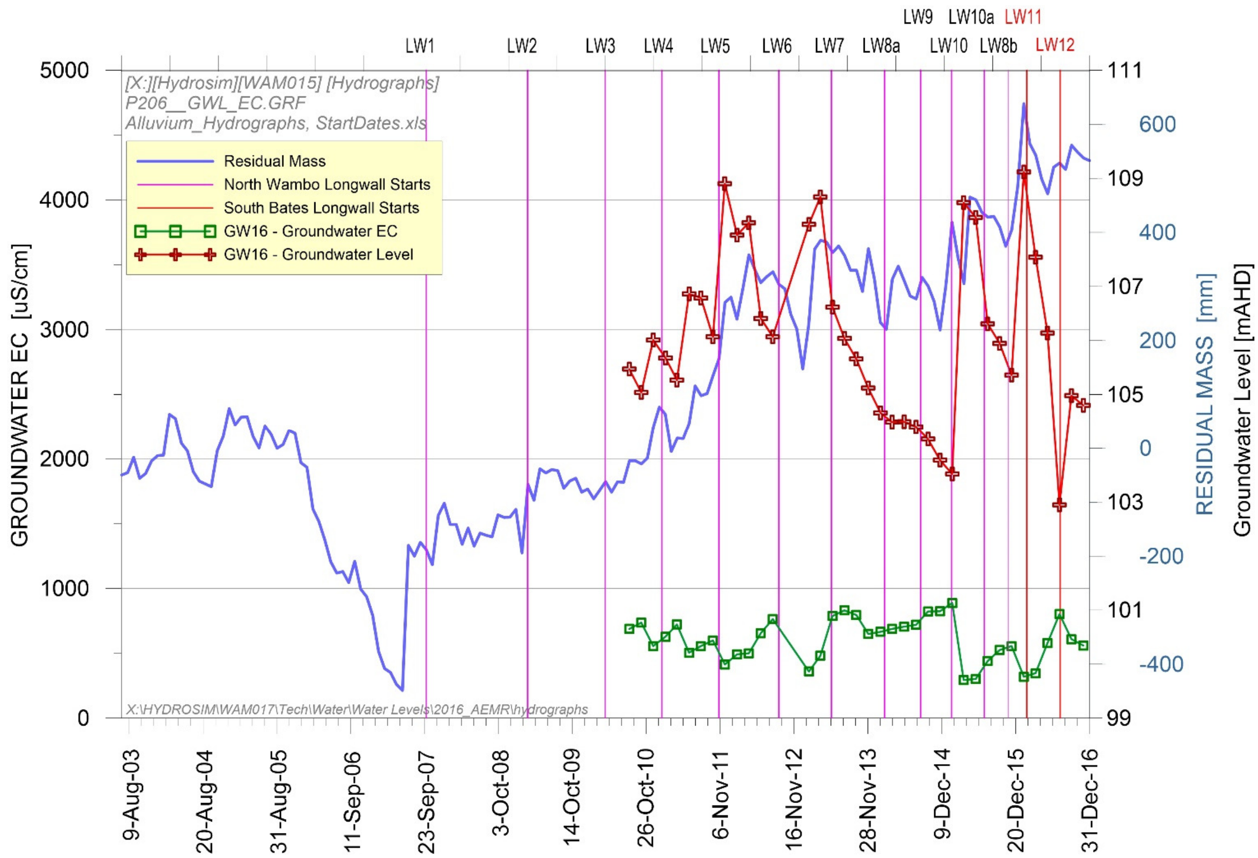

Figure 9 **GW16 groundwater level and EC**

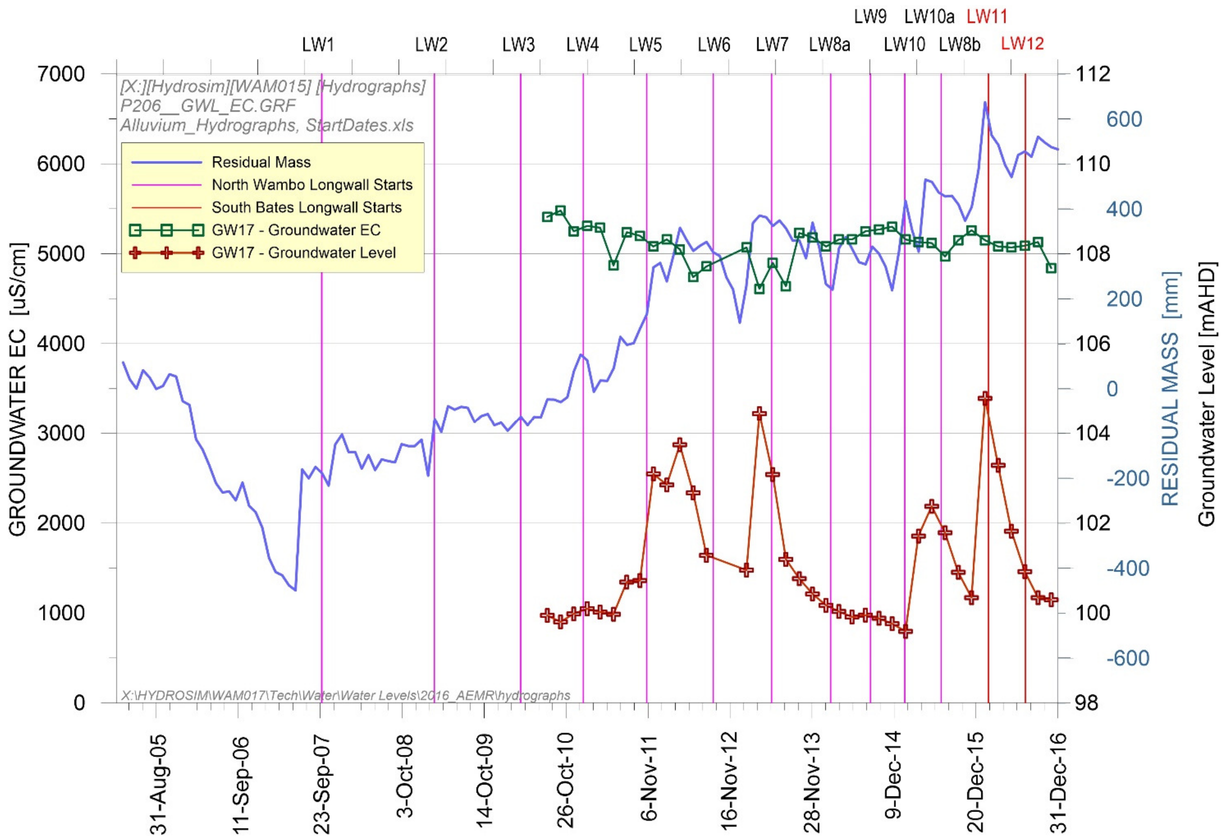

Figure 10 GW17 Groundwater Level and EC

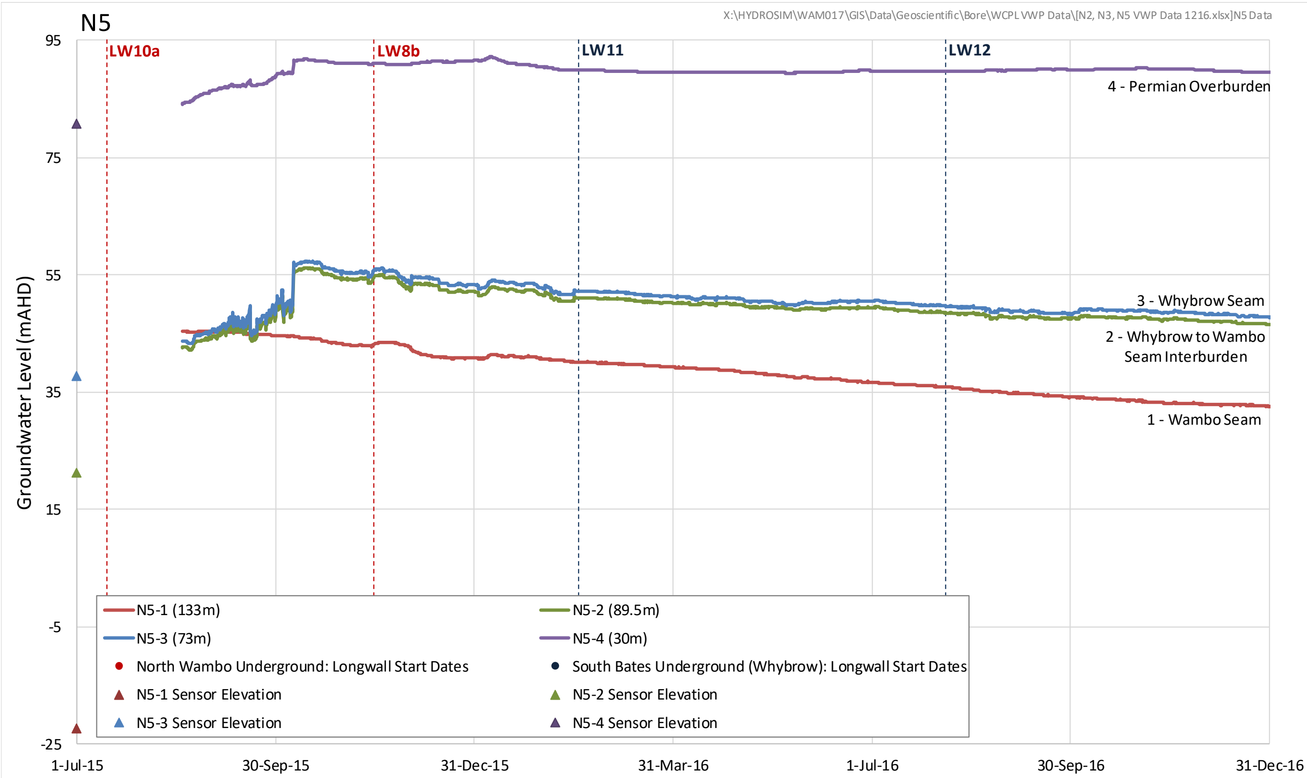

Figure 11 N5 Hydrograph

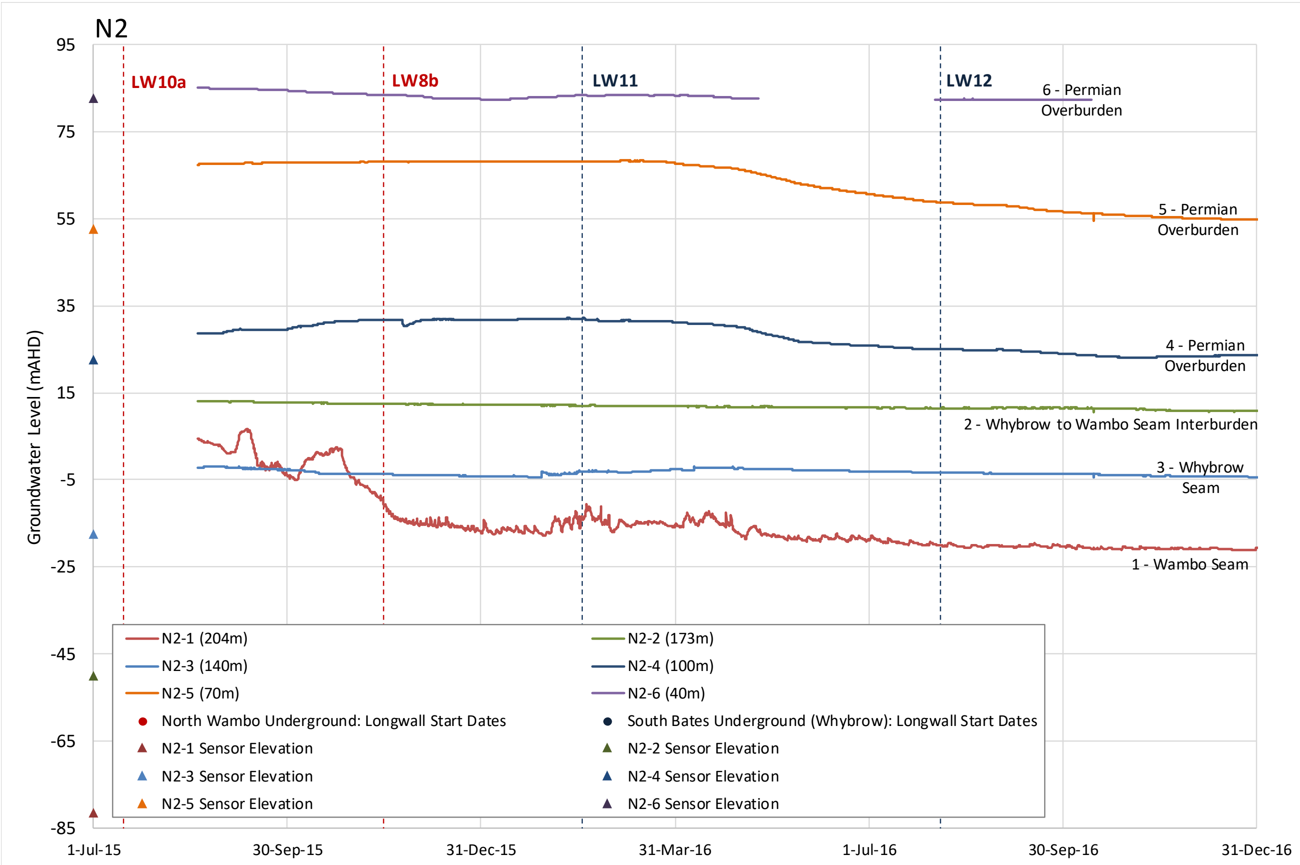

Figure 12 N2 Hydrograph

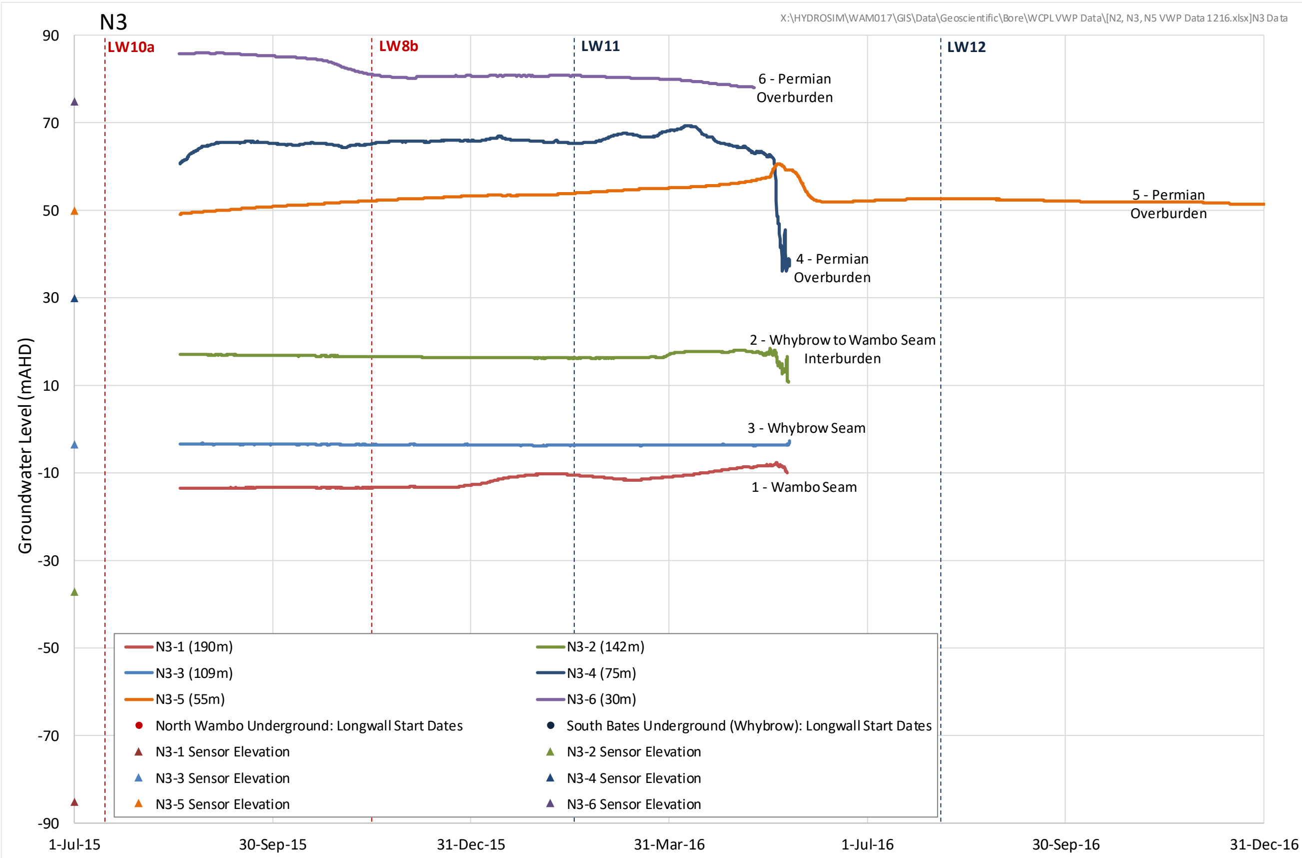

Figure 13 N3 Hydrograph

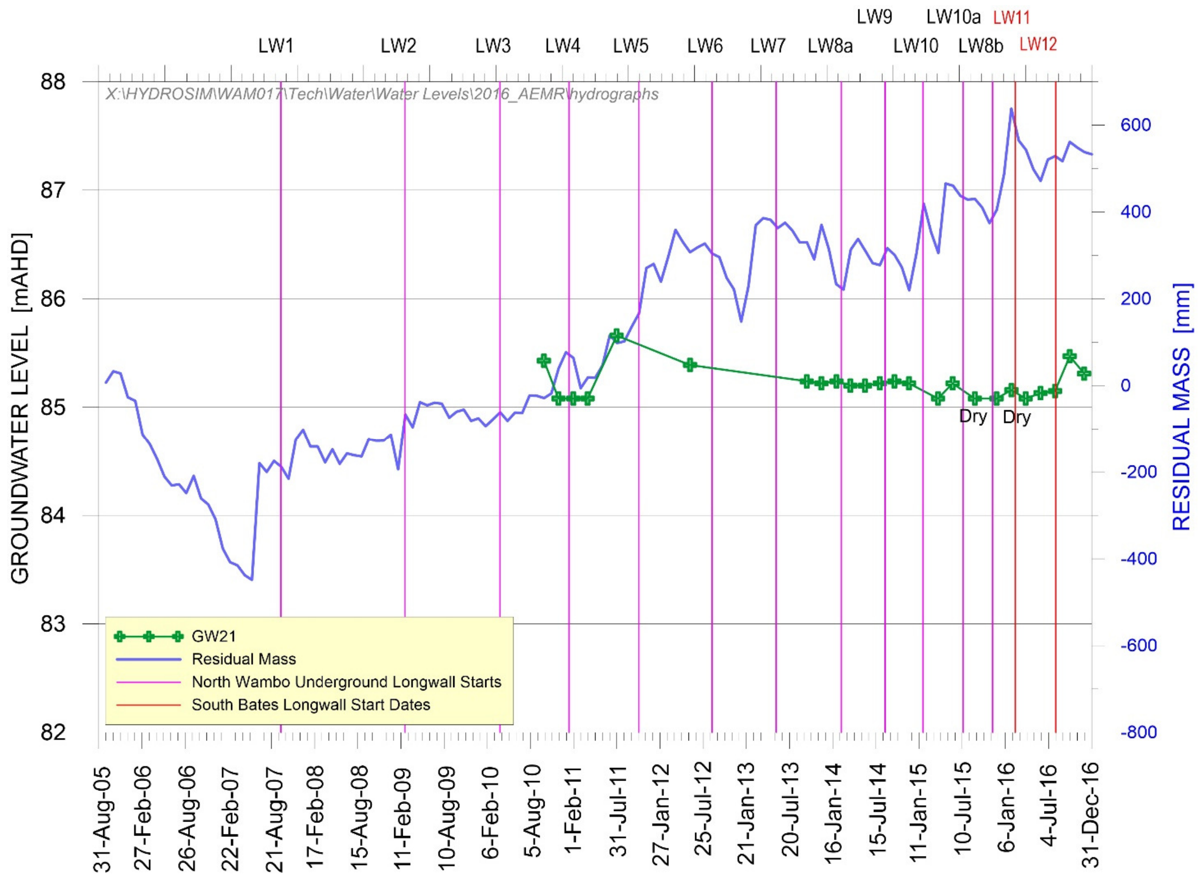

Figure 14 GW21 Groundwater Level

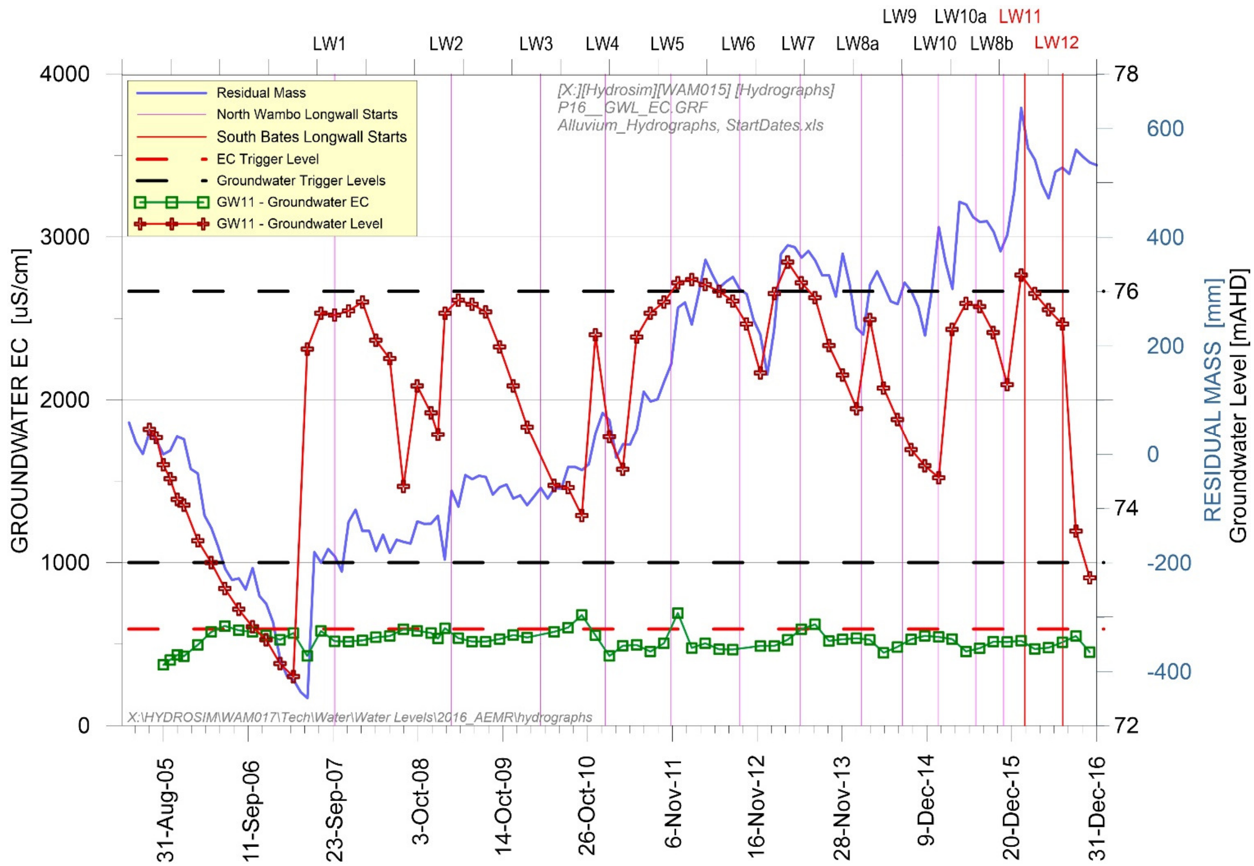

Figure 15 GW11 groundwater level and EC

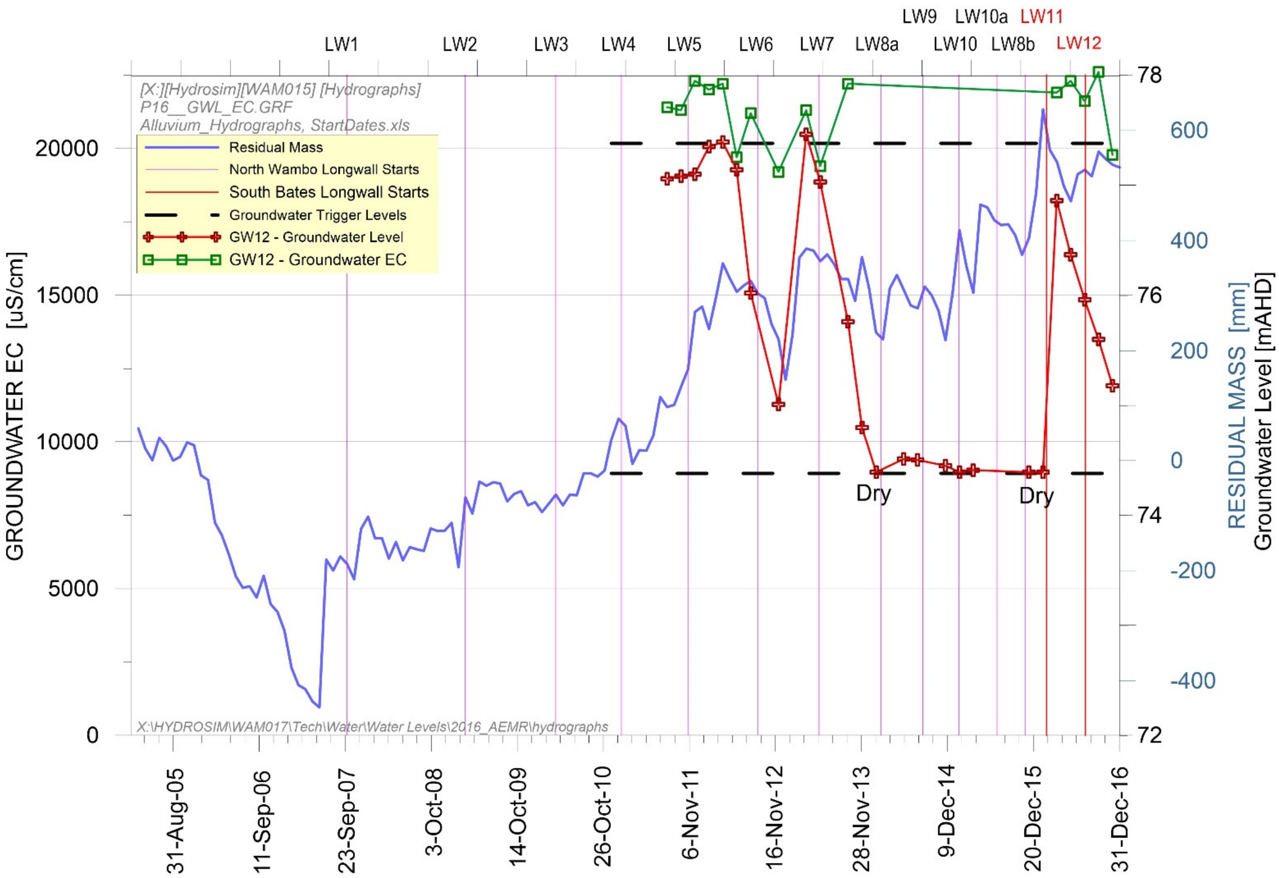

Figure 16 GW12 groundwater level and EC

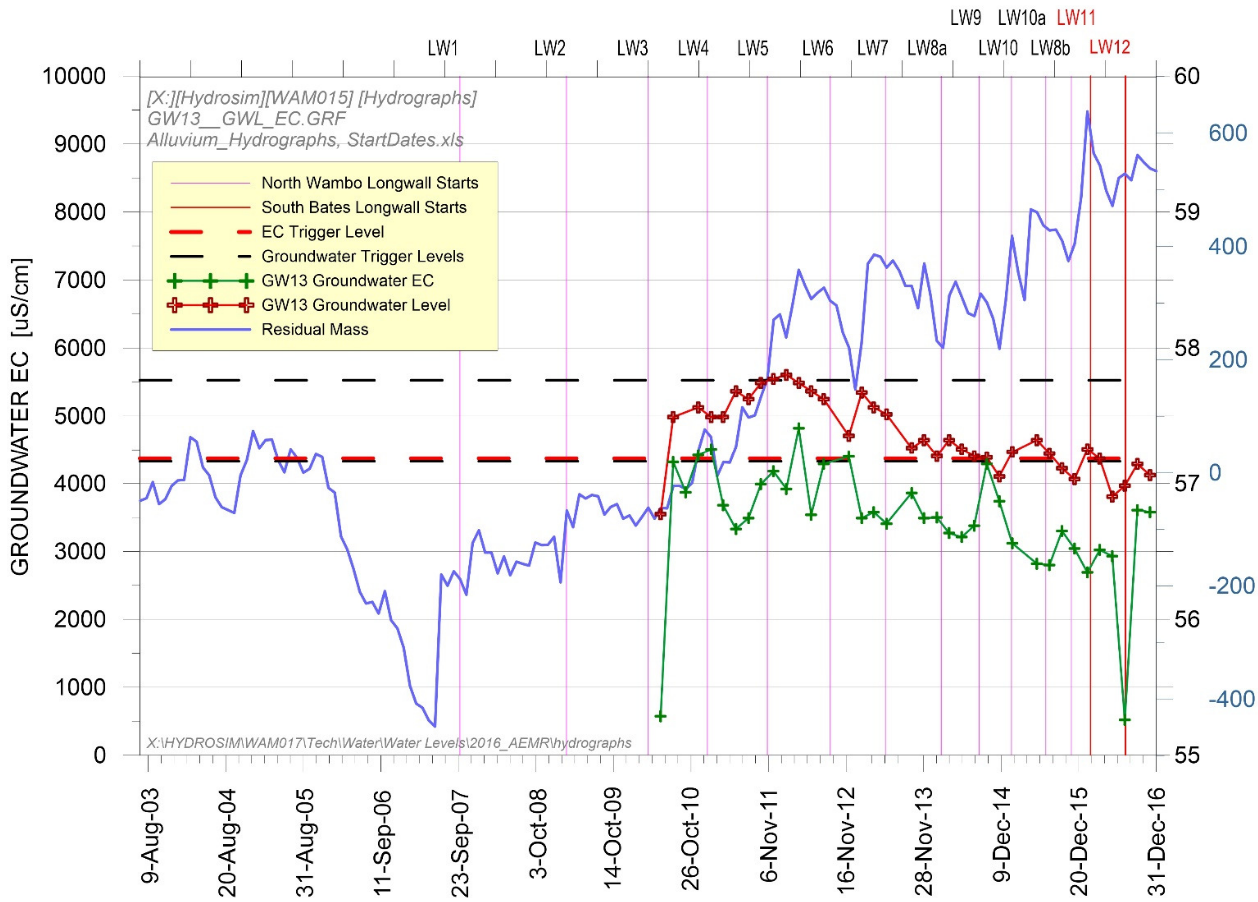

Figure 17 GW13 Groundwater Level and EC

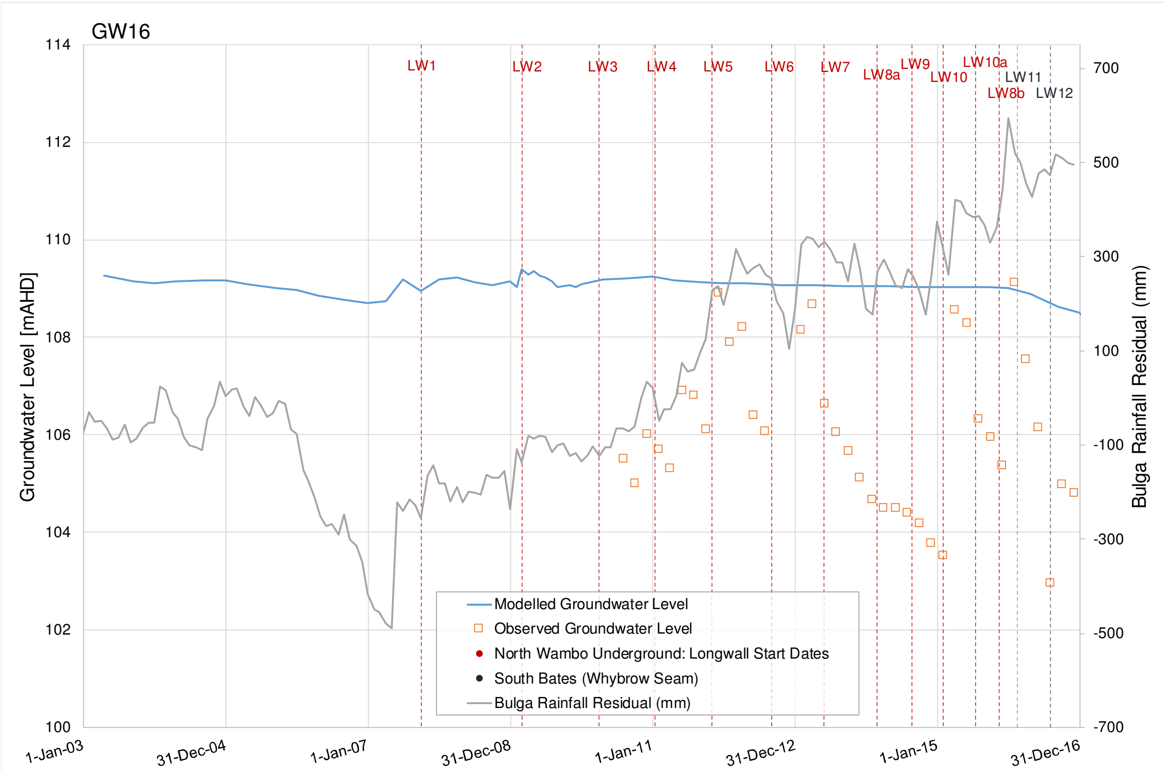

Figure 18 GW16 Calibration Hydrographs

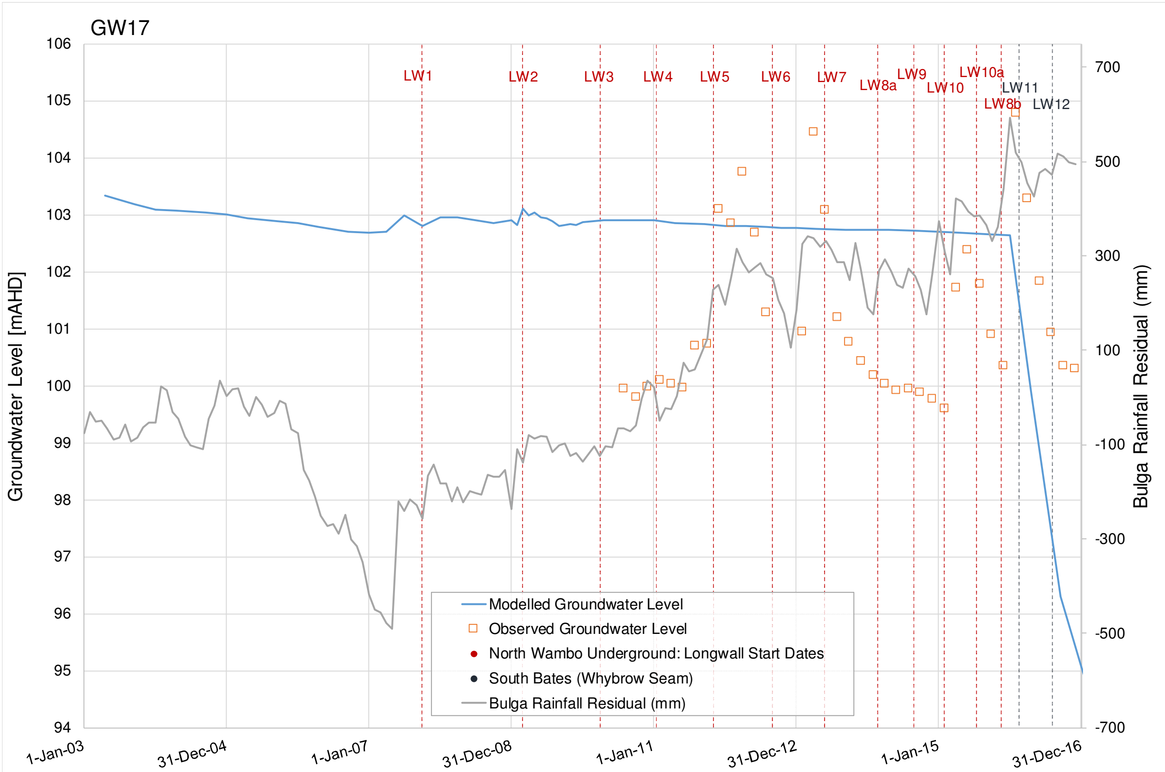

Figure 19 GW17 Calibration Hydrographs

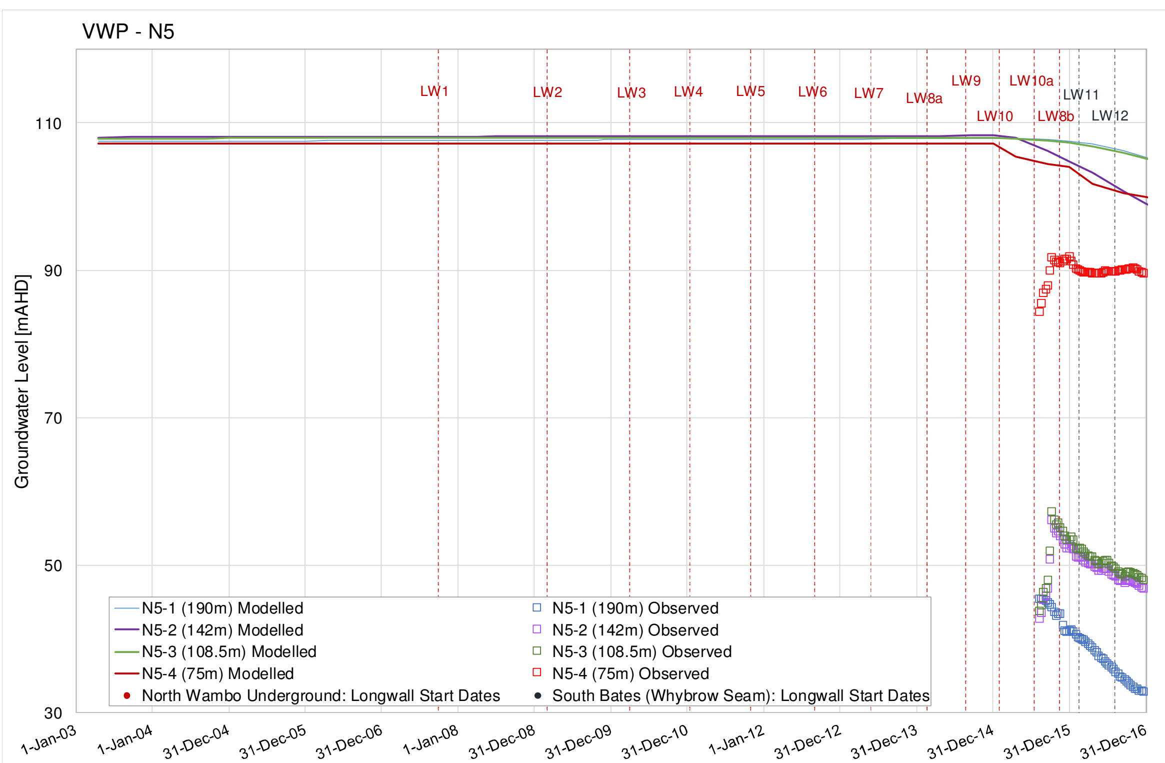

Figure 20 N5 Calibration Hydrographs

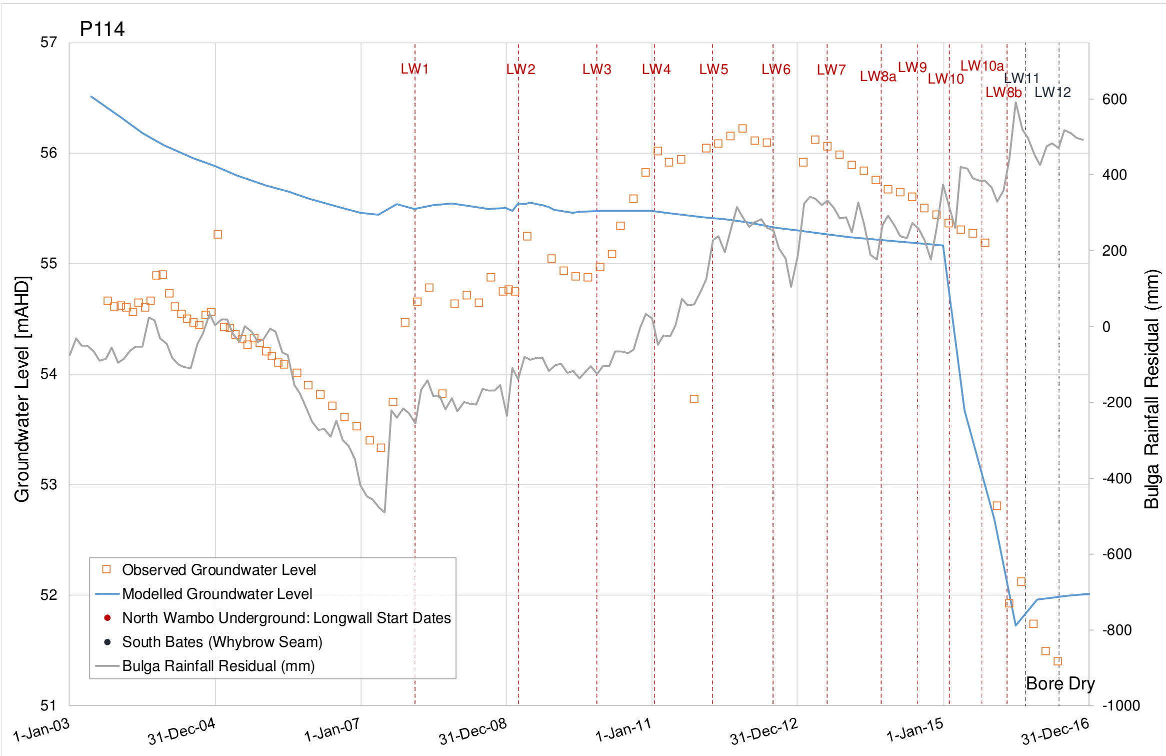

Figure 21 P114 Calibration Hydrographs

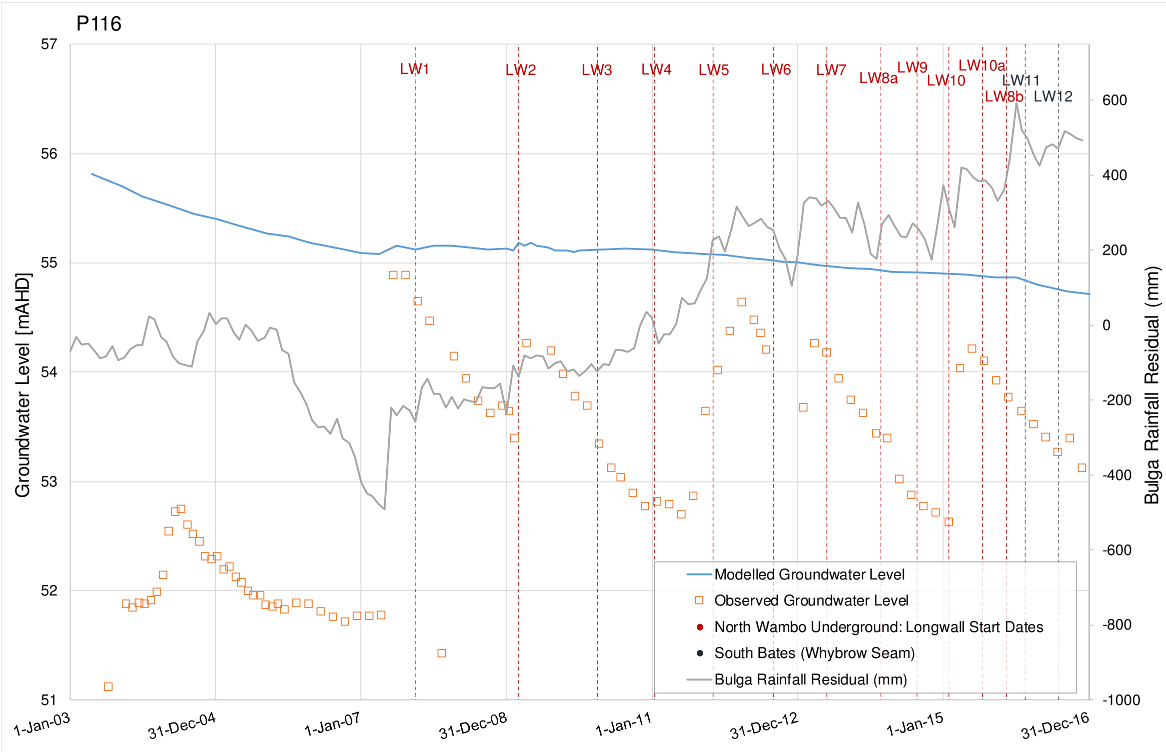

Figure 22 P116 Calibration Hydrographs

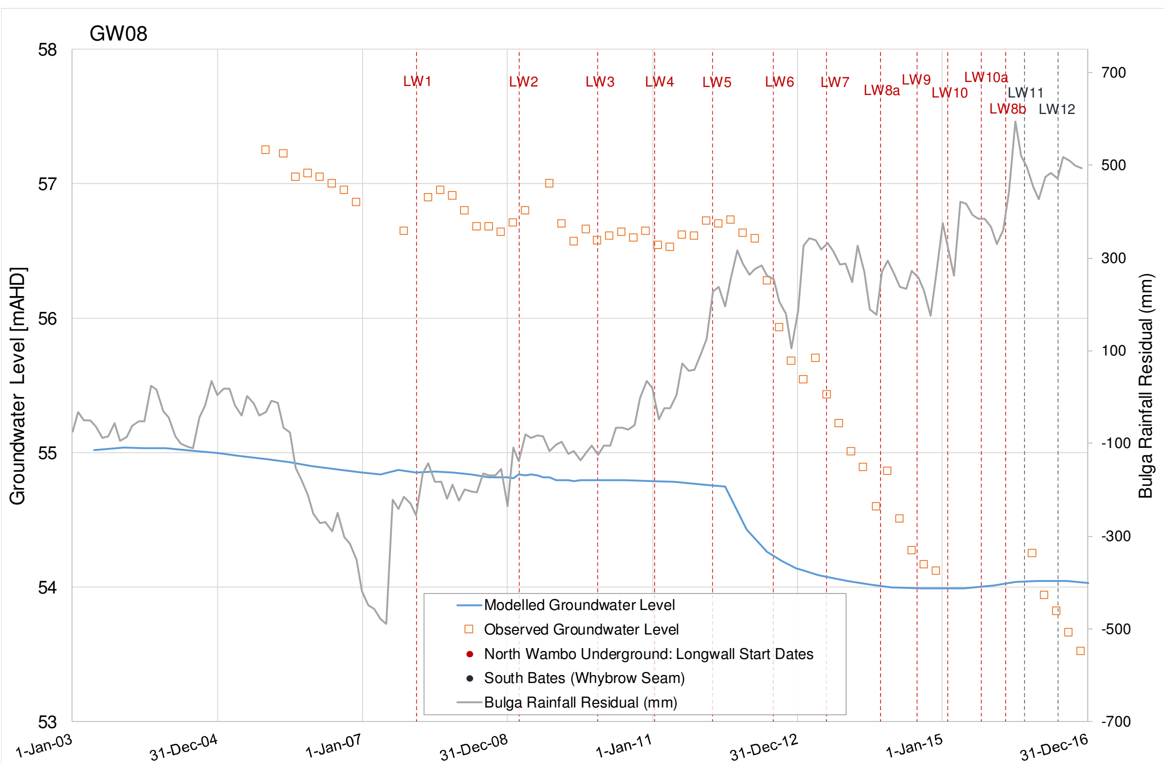

Figure 23 GW08 Calibration Hydrographs

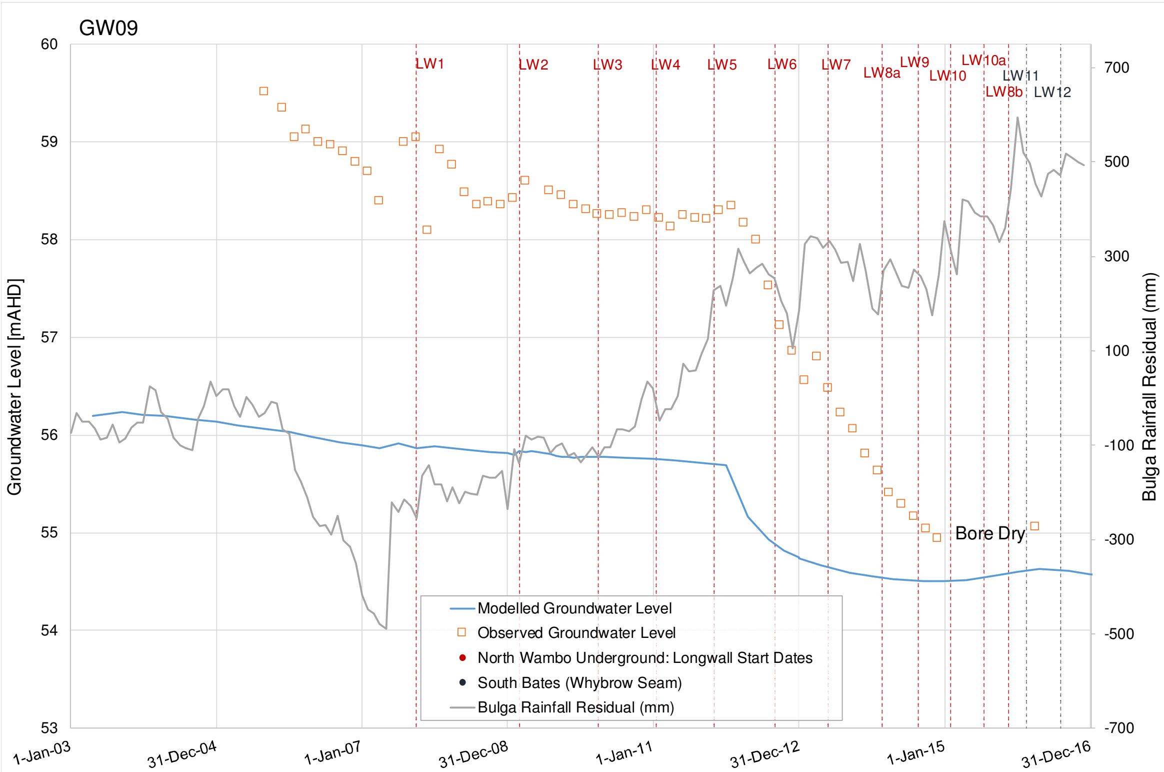

Figure 24 GW09 Calibration Hydrographs

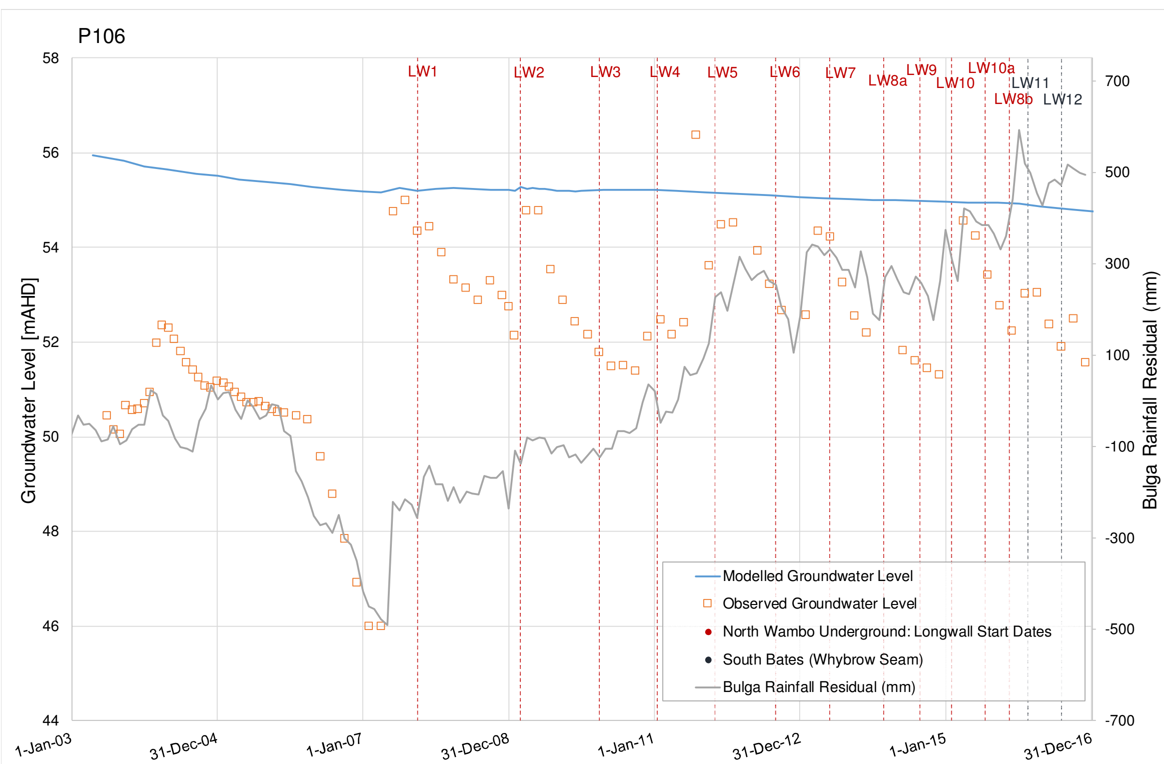

Figure 25 P106 Calibration Hydrographs

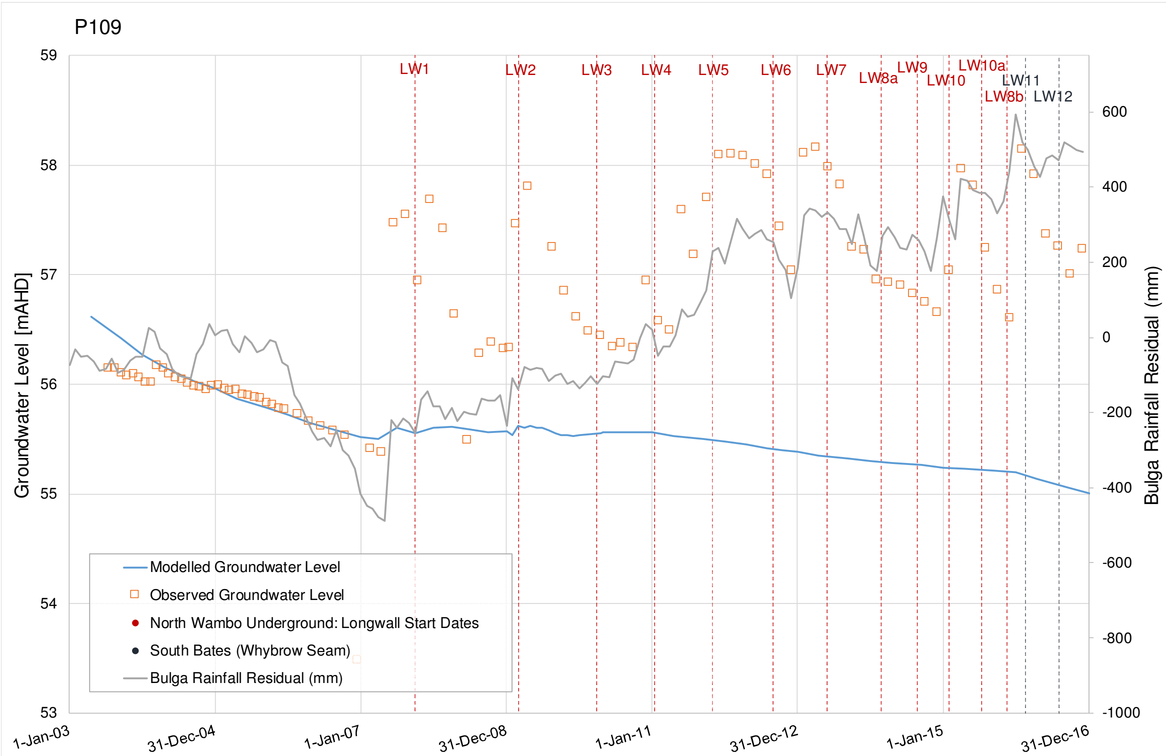

Figure 26 P109 Calibration Hydrographs

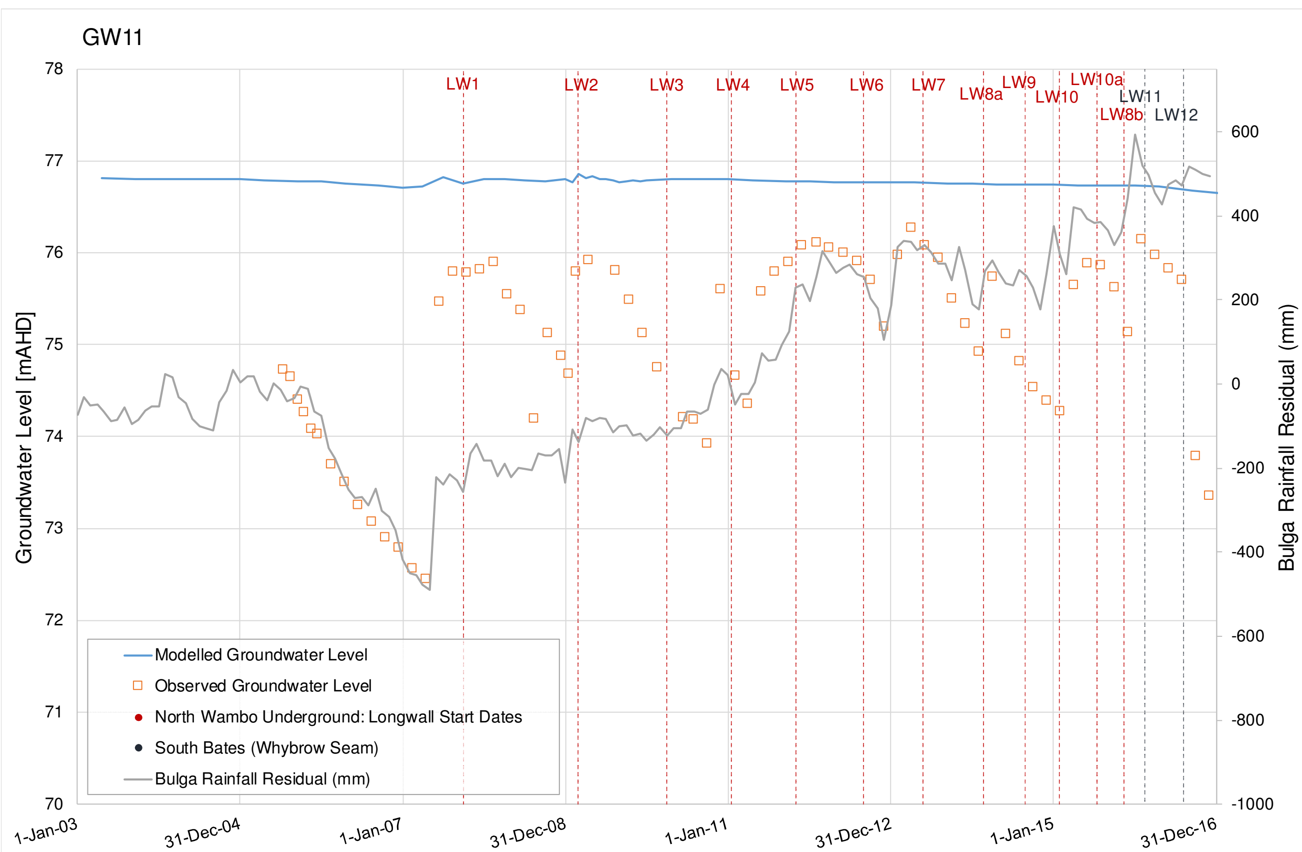

Figure 27 GW11 Calibration Hydrograph

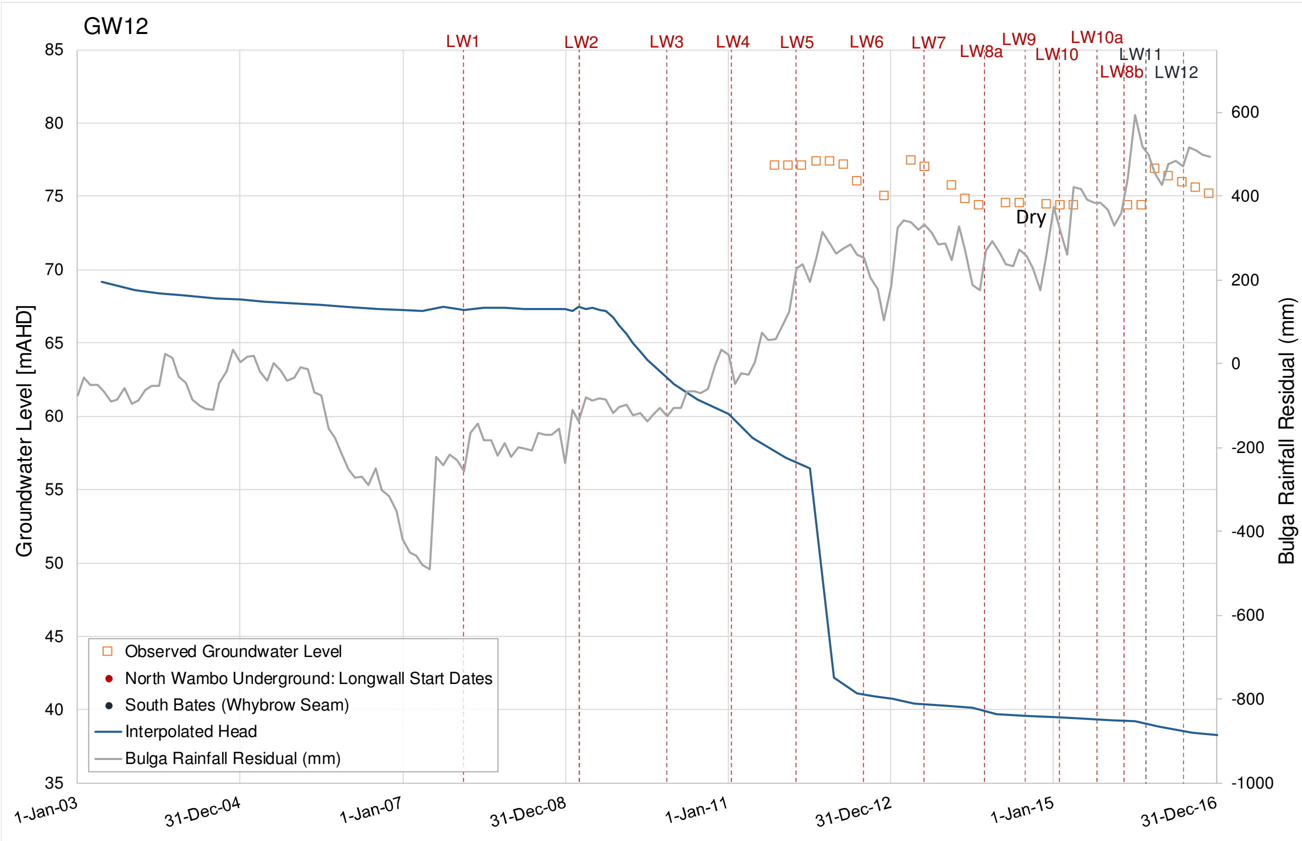

Figure 28 GW12 Modelled vs Observed groundwater level

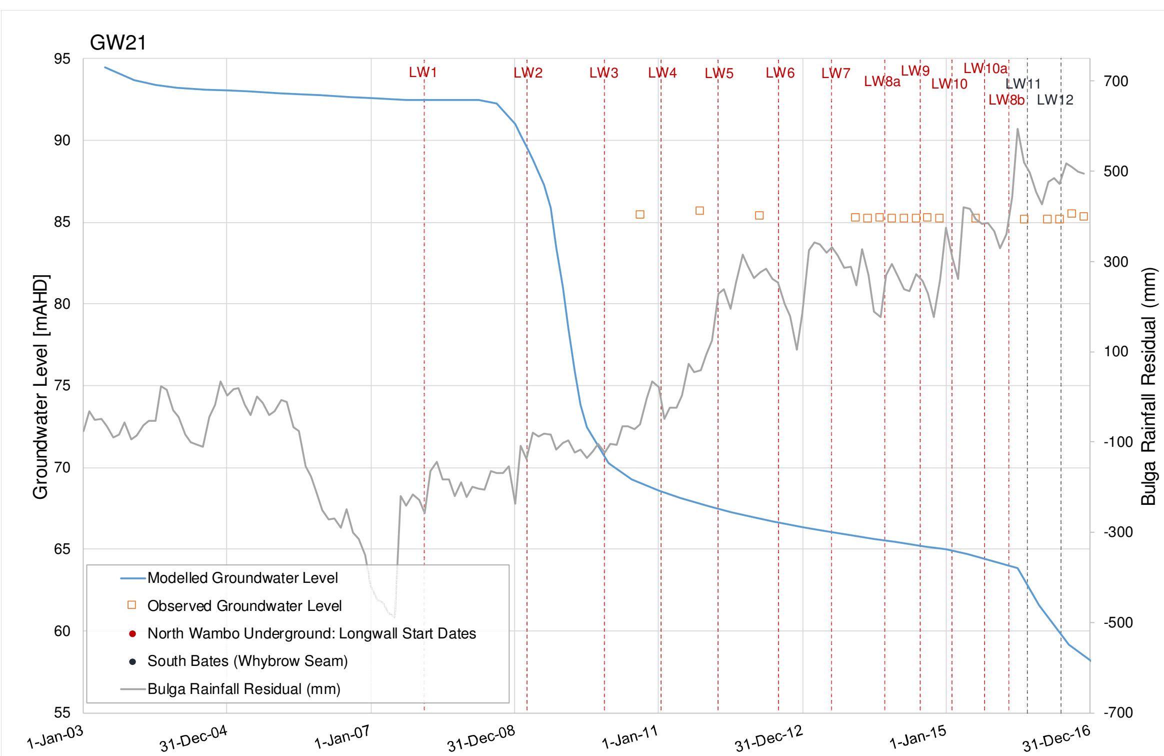

Figure 29 GW21 Calibration Hydrographs

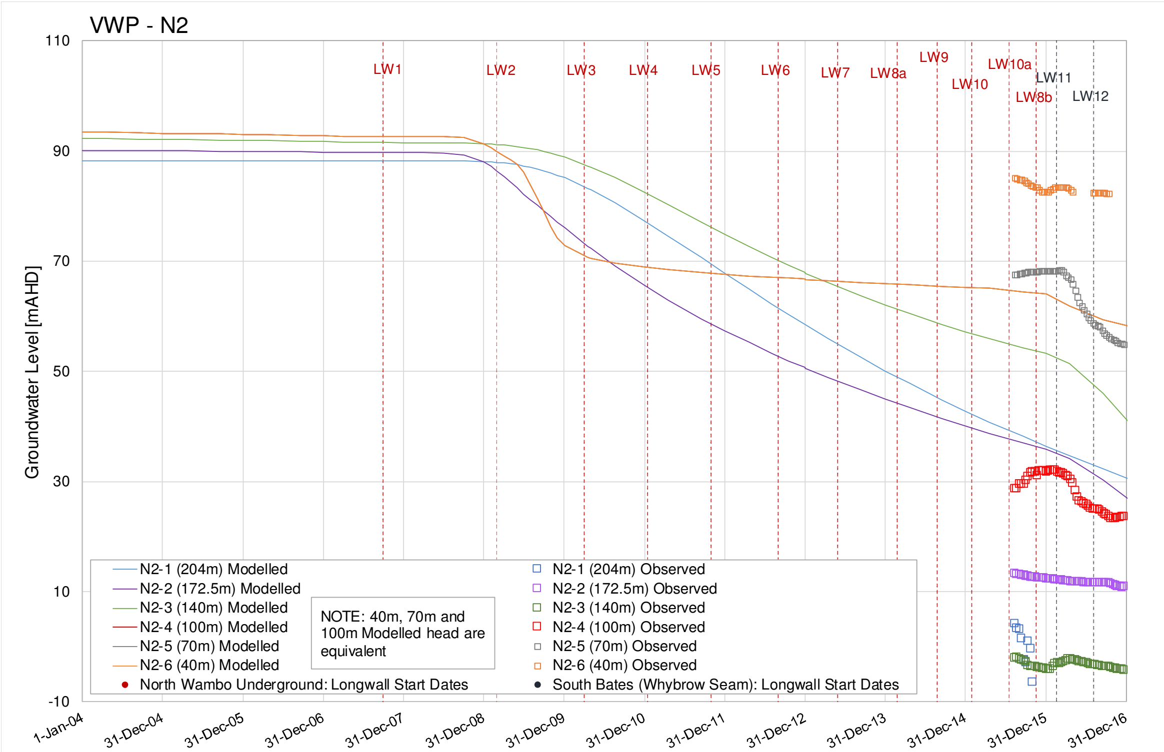

Figure 30 N2 Calibration Hydrographs

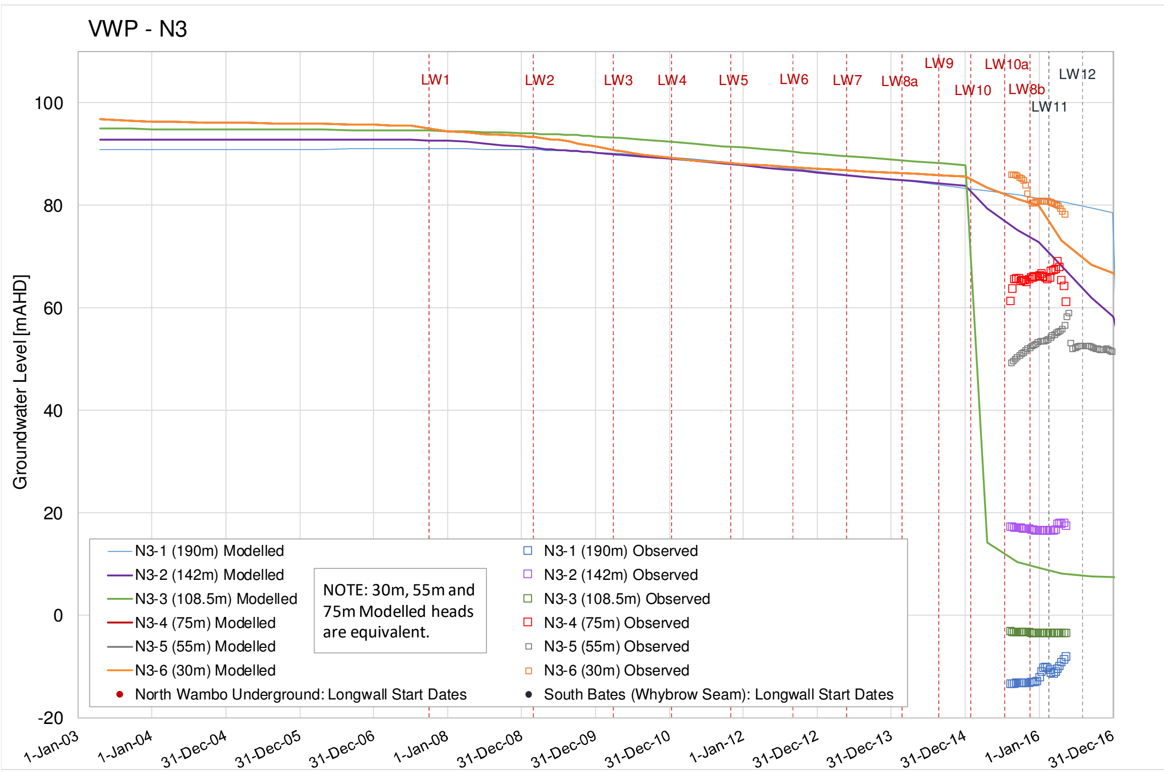

Figure 31 N3 Calibration Hydrographs

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noel.merrick@hydrosimulations.com

DATE:	29 March 2017
TO:	Harry Egan Environmental Advisor Wambo Coal Pty Ltd Peabody Energy Australia PMB 1, Singleton NSW 2330
FROM:	Adam Skorulis and Dr Noel Merrick
RE:	Compliance with subsidence performance measure in the NWU Extraction Plan (LW8-10A)
OUR REF:	HS2017/09 [Wam018]

1 INTRODUCTION

This letter report contains the analysis and information required to address compliance with the subsidence performance measure as outlined in the North Wambo Underground (NWU) Extraction Plan for Longwalls 8 to 10A. The subsidence impact performance measure is: *Negligible impact to Wollombi Brook*. Compliance has been assessed using the performance indicators in **Table 1**. The reporting period referred to in this document runs from 1 February 2014 to 31 January 2016 when Longwall 8b finished.

Table 1 Subsidence performance measure – LW8 to LW10A NWU

Feature	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Measure
Wollombi Brook	*Surface water quality in Wollombi Brook exceeds the surface water quality criteria in the SWMP.*	*Negligible impact to Wollombi Brook*
	Pumping of water from the North Wambo Underground Mine roadways requires regular pumping at rates higher than normal.	
	Groundwater levels in alluvial bores exceed the groundwater level criteria in the GWMP.	
	Groundwater quality in alluvial bores exceeds the groundwater quality criteria in the GWMP.	

2 WOLLOMBI BROOK SURFACE WATER QUALITY

The impact assessment criteria for Wollombi Brook (**Table 2**) are sourced from the most recent Surface Water Monitoring Program (SWMP) (Peabody, 2015c), and are based on the 20th and 80th percentile for the available dataset. The site assessed, SW02 (**Figure 1**), is located downstream of Wambo Coal Mine, where impacts to water quality caused by North Wambo Underground are most readily assessed.

Table 2 Surface water impact criteria

Sampling Site	Parameter	Lower Limit	Upper Limit
SW02 – Wollombi Brook	pH	7.4	8.1
	EC (µS/cm)	599	1947
	TSS (mg/L)	17 (low flow) – 308 (high flow)^	

^ Low flow conditions are based on 80th percentile of recorded concentrations and high flow criteria on maximum recorded concentrations

The data assessed for the reporting period are sourced from monthly environmental reporting conducted by Wambo Coal Mine, as well as the WaterNSW online resource that provides daily flow and electrical conductivity (EC) data.

An exceedance occurs when water quality results exceed the 80th percentile trigger values after two consecutive sampling events for Level 1 response management measures and three consecutive sampling events for Level 2 response contingency phase (Peabody, 2015d).

Throughout the reporting period there have been no exceedances of the EC upper limits at SW02 (**Figure 2**). EC was recorded by Wambo Coal Mine at below the lower limit on four occasions during the reporting period, which correlates with freshening periods observed in the daily monitoring at the WaterNSW 'Wollombi Bk @ Warkworth' site. This raises no concern as the freshening is associated with periods of an above average rainfall trend (**Figure 2**).

No exceedances of Total Suspended Solid levels (TSS) occurred for 'Low Flow' or 'High Flow' conditions during reporting period (**Figure 3**).

No exceedances of the pH level were observed during the reporting period (**Figure 3**)

3 ALLUVIAL GROUNDWATER LEVEL

Alluvial groundwater level criteria assessed for exceedances in this report are sourced from the most recent GWMP (Groundwater Monitoring Program) (Peabody, 2015b). These are based on minimum and maximum depth-to-water trigger levels derived from 10th and 90th percentiles of historical recordings.

The GWMP lists 19 bores with trigger levels, though five bores have N/A entries. The trigger values are not assessment criteria but are used to initiate investigations according to the Surface and Ground Water Response Plan (SGWRP) (Peabody, 2015d). The SGWRP provides a protocol for the investigation, notification, and mitigation of identified exceedances of these assessment criteria. To investigate potential groundwater leakage from Wollombi Brook, the Trigger Action Response Plan (TARP) in the SGWRP considers the water level responses at 10 named bores (Peabody, 2015d):

- Groundwater monitoring of standing water levels in bores P106, P109, P114, P116 within the Wambo Creek alluvium and GW13 and GW15 within the Wollombi Creek alluvium, identifies a decreasing trend, beyond natural fluctuations and predicted modelled impacts; and/or

- Groundwater monitoring of standing water levels in bores GW08 and GW09 and GW016 and GW017 within the North Wambo Creek alluvium, exceed the standing water trigger values as provided in the GWMP, beyond natural fluctuations, for more than three consecutive monitoring events.

Groundwater level at 12 alluvial bores have shown exceedances of the trigger levels during the reporting period. However, eight of these bores (P106, P109, P202, P206, P315, GW02, GW15, P16) show only exceedances of the minimum depth-to-water. Seven of these exceedances correlate with a period of above average rainfall in early 2016 and as such, do not require further investigation. The exceedance of the minimum depth-to-water at P106 occurred in 2015 following a period of above average rainfall and also does not require further investigation.

The remaining four bores (P114, P20, GW12, GW13) show exceedances of the maximum depth-to-water trigger level during the relevant reporting period. Only P114 and GW13 are included in the TARP.

P114 (**Figure 4**) shows groundwater levels that are below the maximum depth-to-water trigger level for the latter part of the monitoring period. This is a clear effect from the mining of Longwall 10A.

The first P20 groundwater level recorded during the reporting period (February 2014) is below the maximum depth-to-water trigger level (**Figure 5**). However, it is unlikely to represent a mining effect attributable to North Wambo Underground as it is about 2 km distant from Longwall 7 that was finishing at that time. The observation correlates with a period of below average rainfall that is similar to historical groundwater levels observed at P20 during other periods with a declining rainfall trend. Subsequent observations show groundwater level increase correlating with an increasing rainfall trend in June 2014, with the minimum depth-to-water trigger exceeded in April 2015 with a spike in the rainfall trend further confirming a lack of mining effect.

GW12 (**Figure 6**) exhibits an ongoing mining effect beginning at the end of North Wambo Underground Longwall 6 or start of Longwall 7 extraction that extends through the reporting period. Water levels exceeding the maximum depth-to-water occurred four times with the bore reported dry and no significant recovery or response to rainfall observed during the reporting period. However, the water level has recovered during 2016. HydroSimulations' (2014) assessment for the Longwall 10A Modification predicted drawdown of approximately 2 m in the vicinity of GW12.

GW13 (**Figure 7**) triggers occurred on three occasions during the reporting period, and although the groundwater levels are less than 20 cm below the prescribed trigger level, they accompany a general decline in groundwater level that is contrary to an increasing rainfall trend. The approaching Warkworth open cut is the likely cause, not NWU.

4 ALLUVIAL GROUNDWATER QUALITY

Alluvial groundwater quality criteria assessed for exceedances in this report are sourced from the most recent GWMP (Peabody, 2015b). The GWMP lists 15 bores with EC and pH trigger values, but three have N/A entries.

Water quality triggers for EC are based on 90th percentile values from recorded historical data at each bore. An exceedance of the 90th percentile EC value in three consecutive bi-monthly observations triggers an investigation.

At Wambo, pH is consistently between 6 and 8 at a majority of alluvial monitoring locations. 10th and 90th percentile values are used as minimum and maximum trigger values. An investigation is triggered following exceedances on two consecutive bi-monthly monitoring events.

P114 (**Figure 4**) was the only location where the EC trigger value was exceeded in three consecutive bi-monthly observations. The groundwater quality trigger was exceeded in all except two observations during the reporting period, to a total of three separate investigation triggers. An investigation conducted by HydroSimulations as part of the 2015 AEMR (HydroSimulations, 2016) found that P114 is situated partially in weathered regolith and underlying Permian overburden opposed to alluvium as was previously thought. As groundwater level has declined due to Longwall 10A extraction, the water table is now located in Permian source rock with a much higher salinity.

This exceedance of the EC trigger level at P114 by six monthly observations triggers the subsidence impact performance indicator for groundwater quality in alluvial bores as identified in the North Wambo Underground Extraction Plan for Longwalls 8 to 10A. However, the water table in P114 is no longer in alluvium and no observable impact to Wollombi Brook is apparent as a result of these exceedances.

No exceedances of pH requiring an investigation occurred during the reporting period.

5 PUMPING

During the reporting period, WCPL reported that water in the North Wambo Underground Mine roadways required regular pumping at rates that were not higher than normal. This has not been independently validated by HydroSimulations.

6 CONCLUSION

While some exceedances of trigger levels resulting from North Wambo Underground mining have been observed in the alluvial bores for both groundwater level and EC, there is no evidence of an increased pumping rate from North Wambo Underground workings, or any exceedances of surface water quality triggers observed at Wollombi Brook. A summary assessment is given in **Table 3**.

Table 3 Assessment of Subsidence performance measure – LW8 to LW10A NWU

Feature	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Measure Exceeded?	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Wollombi Brook	*Surface water quality in Wollombi Brook exceeds the surface water quality criteria in the SWMP.*	**No**	*Negligible impact to Wollombi Brook*	**No**
	Pumping of water from the North Wambo Underground Mine roadways requires regular pumping at rates higher than normal.	**No**		
	Groundwater levels in alluvial bores exceed the groundwater level criteria in the GWMP.	**Yes (at P114, P20, GW12, GW13)**		
	Groundwater quality in alluvial bores exceeds the groundwater quality criteria in the GWMP.	**Yes (at P114)**		

Exceedances of the performance indicators have been observed at:

- P114 – which can no longer be considered representative of alluvium;
- P20 – not in the TARP and unlikely to represent a mining effect attributable to North Wambo Underground;
- GW12 – not in the TARP and generally consistent with predictions; and
- GW13 – most likely affected by Warkworth Mine.

As such, compliance with the subsidence performance measure for the extraction of Longwalls 8 to 10A of North Wambo Underground is upheld. There is *negligible impact to Wollombi Brook*.

References:

HydroSimulations (2014) *North Wambo Underground Mine Longwall 10A Modification*. Report HC2014/20 for Wambo Coal Pty Ltd. September 2014.

HydroSimulations (2016) *Wambo Annual Review Groundwater Analysis*. Report HC2016/07 for Wambo Coal Pty Ltd. March 2016

NSW Office of Water
http://realtimedata.water.nsw.gov.au/water.stm?ppbm=DAILY_REPORTS&dr&3&drkd_url Accessed 20/3/2017

Peabody (2015a) *Subsidence Monitoring Program for North Wambo Underground Mine Longwalls 8 to 10A.* Document Number SWMP LW8-10a. April 2015

Peabody (2015b) *Wambo Coal Groundwater Monitoring Program.* Document No. WA-ENV-MNP-509.1. October 2015

Peabody (2015c).*Wambo Coal Surface Water Monitoring Program.* Document No. WA-ENV-MNP-509.2. October 2015

Peabody (2015d). *Wambo Coal Surface and Ground Water Response Plan.* Document No. WA-ENV-MNP-509.4. October 2015

Filepath: X:\HYDROSIM\WAM018\HS2017_9aNWU_SubsidenceCompliance.docx

Figures

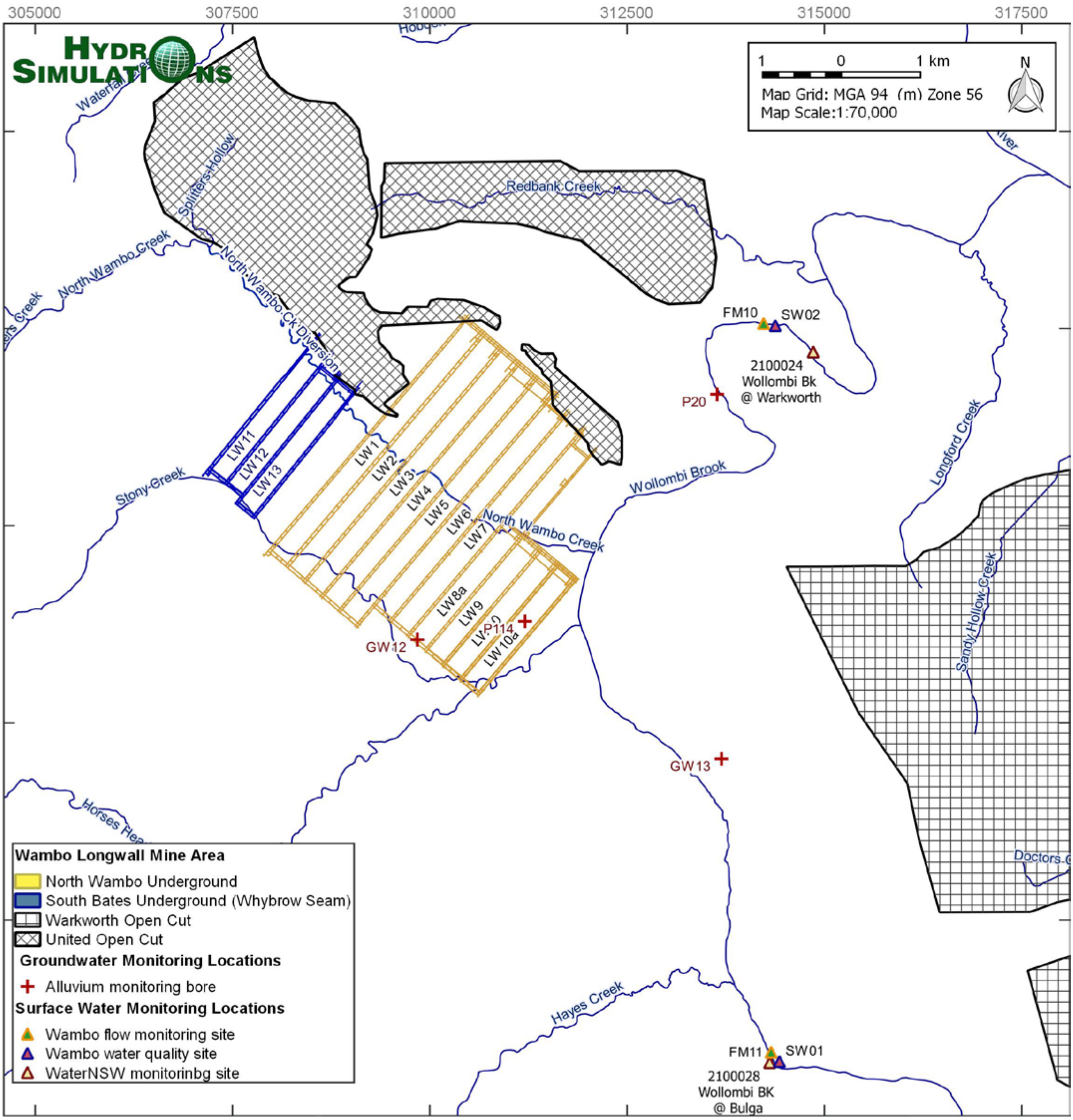

Figure 1 **Locations of bores discussed in this report.**

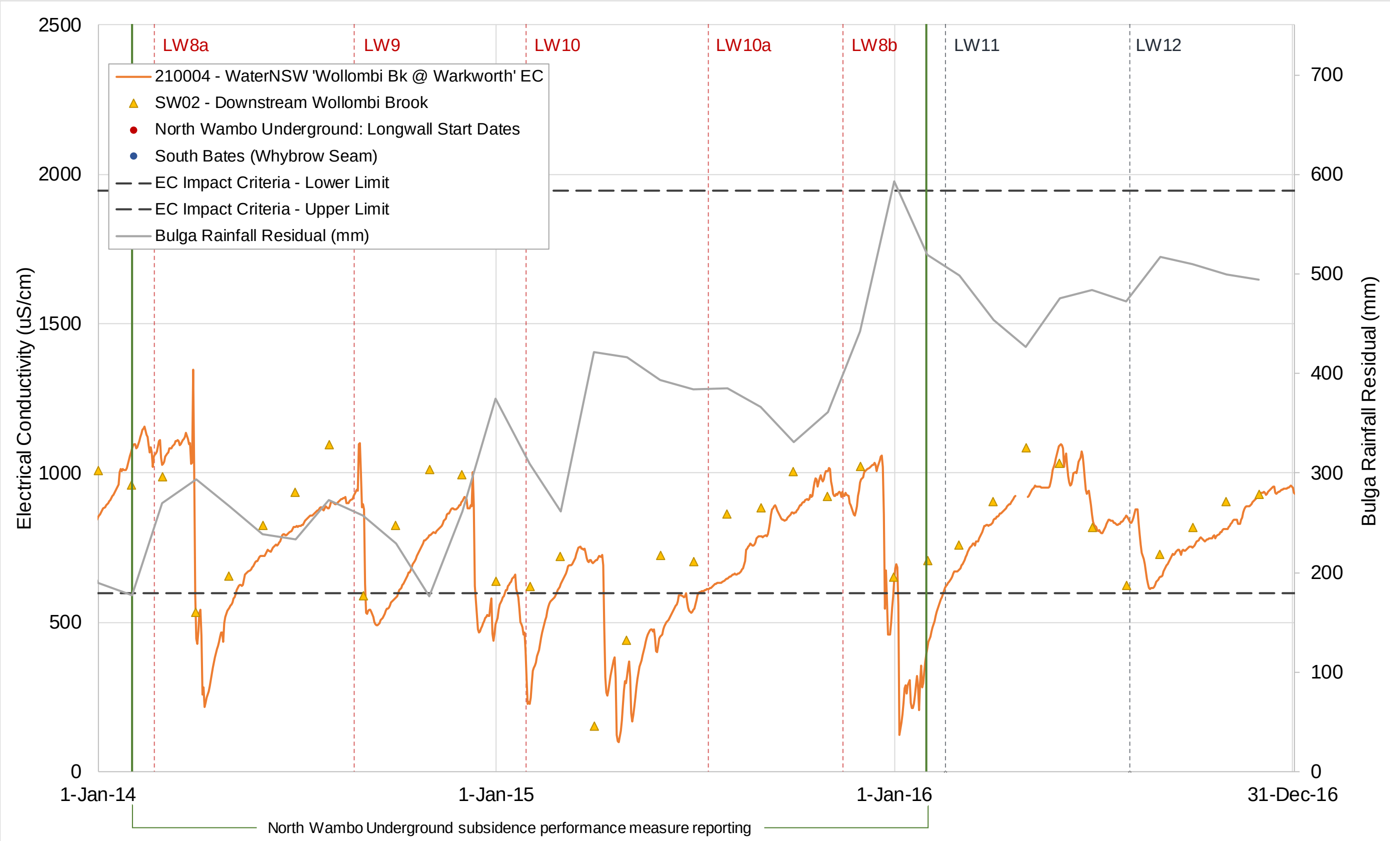

Figure 2 SW02 - EC Surface water quality trigger level

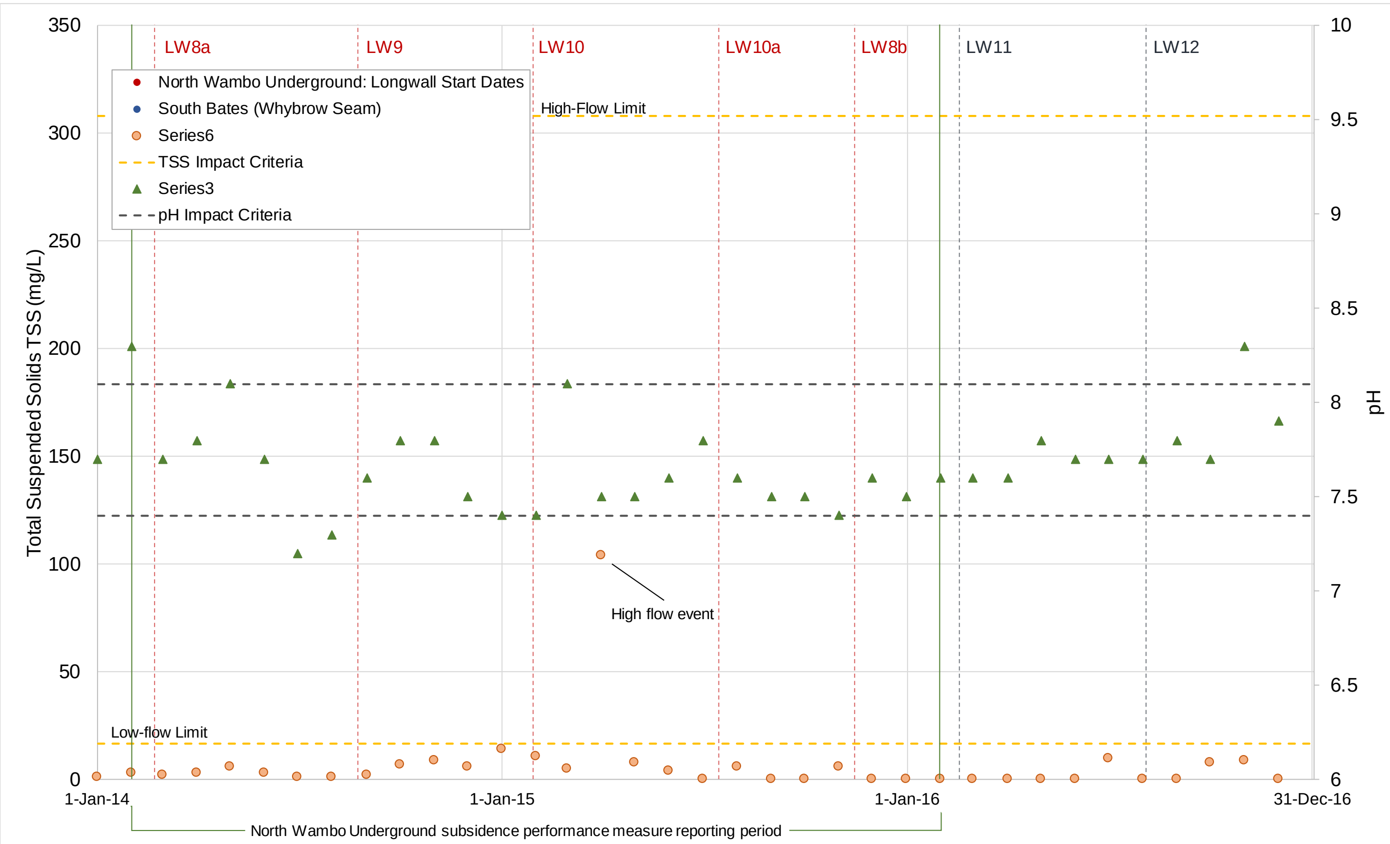

Figure 3 SW02 – pH and TSS Surface water quality trigger level

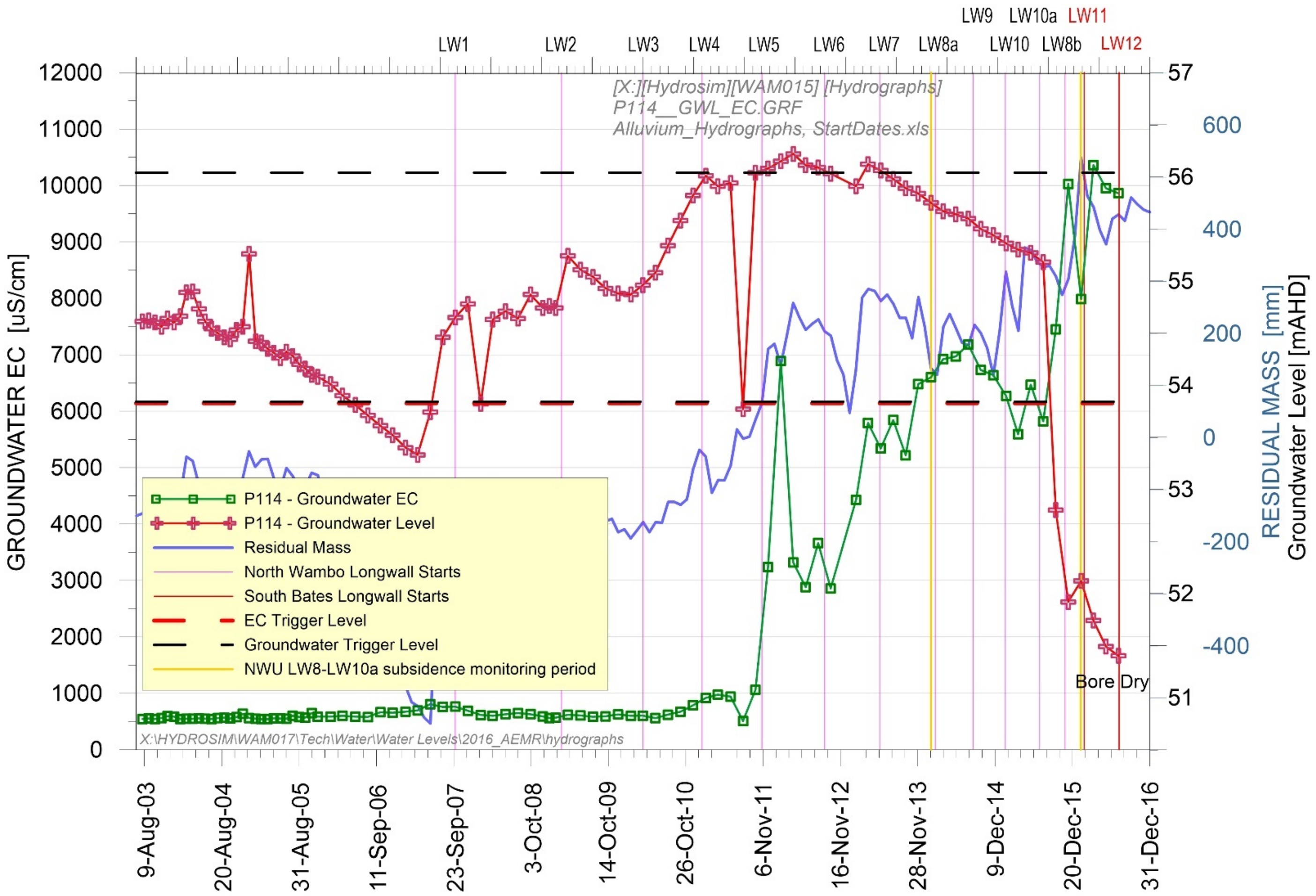

Figure 4 P114 Groundwater Level and EC

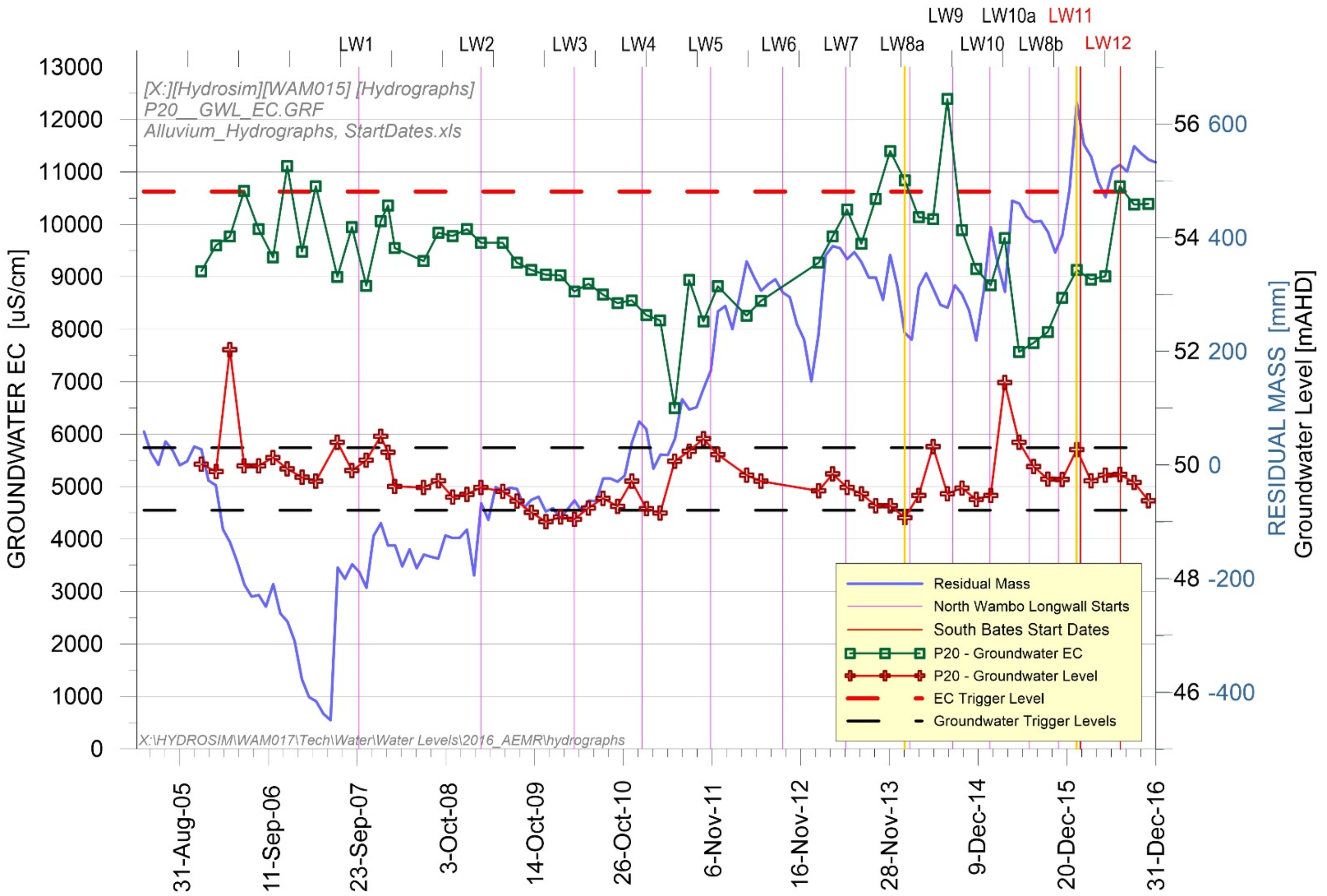

Figure 5 P20 groundwater level and EC

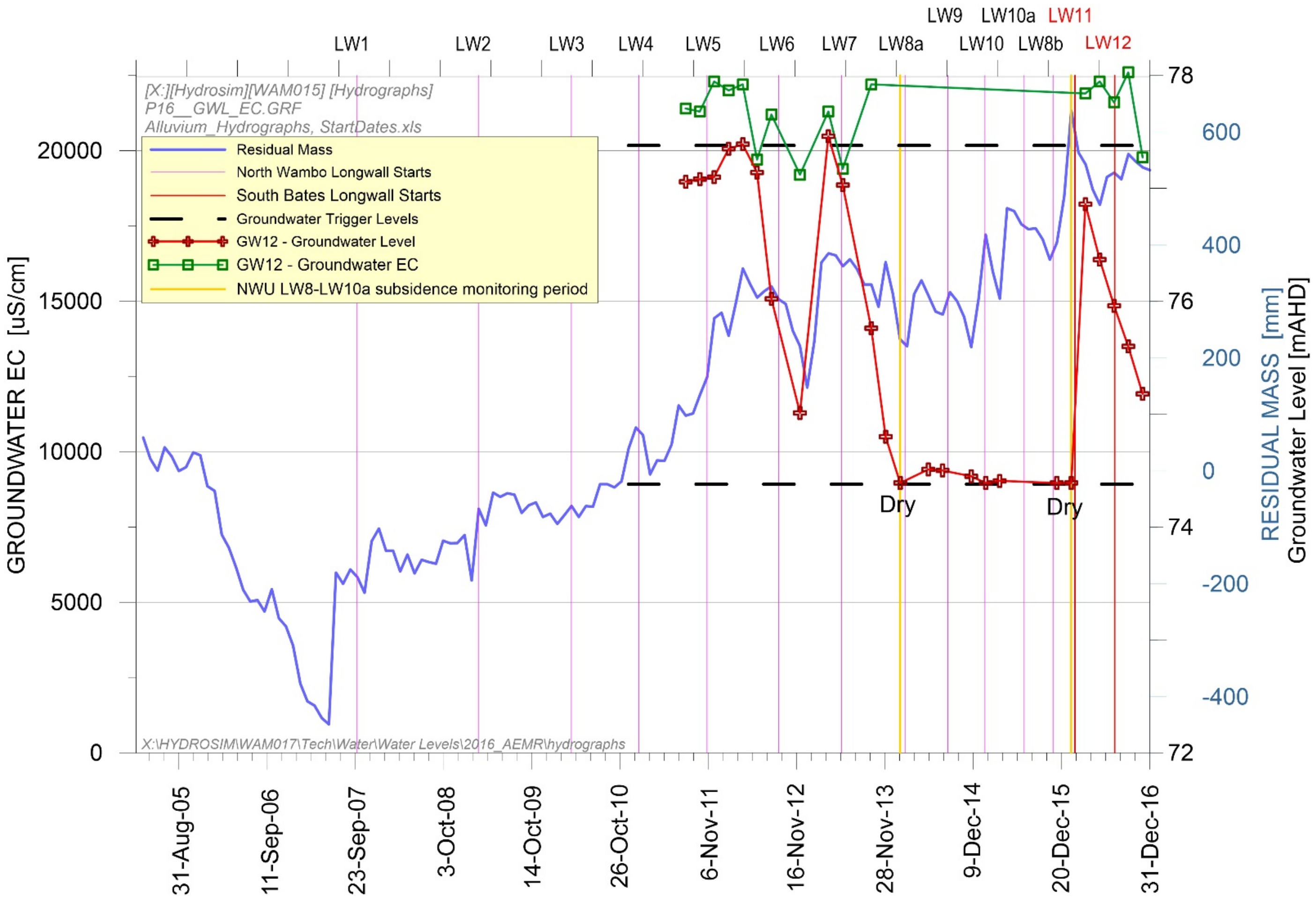

Figure 6 GW12 Groundwater Level and EC

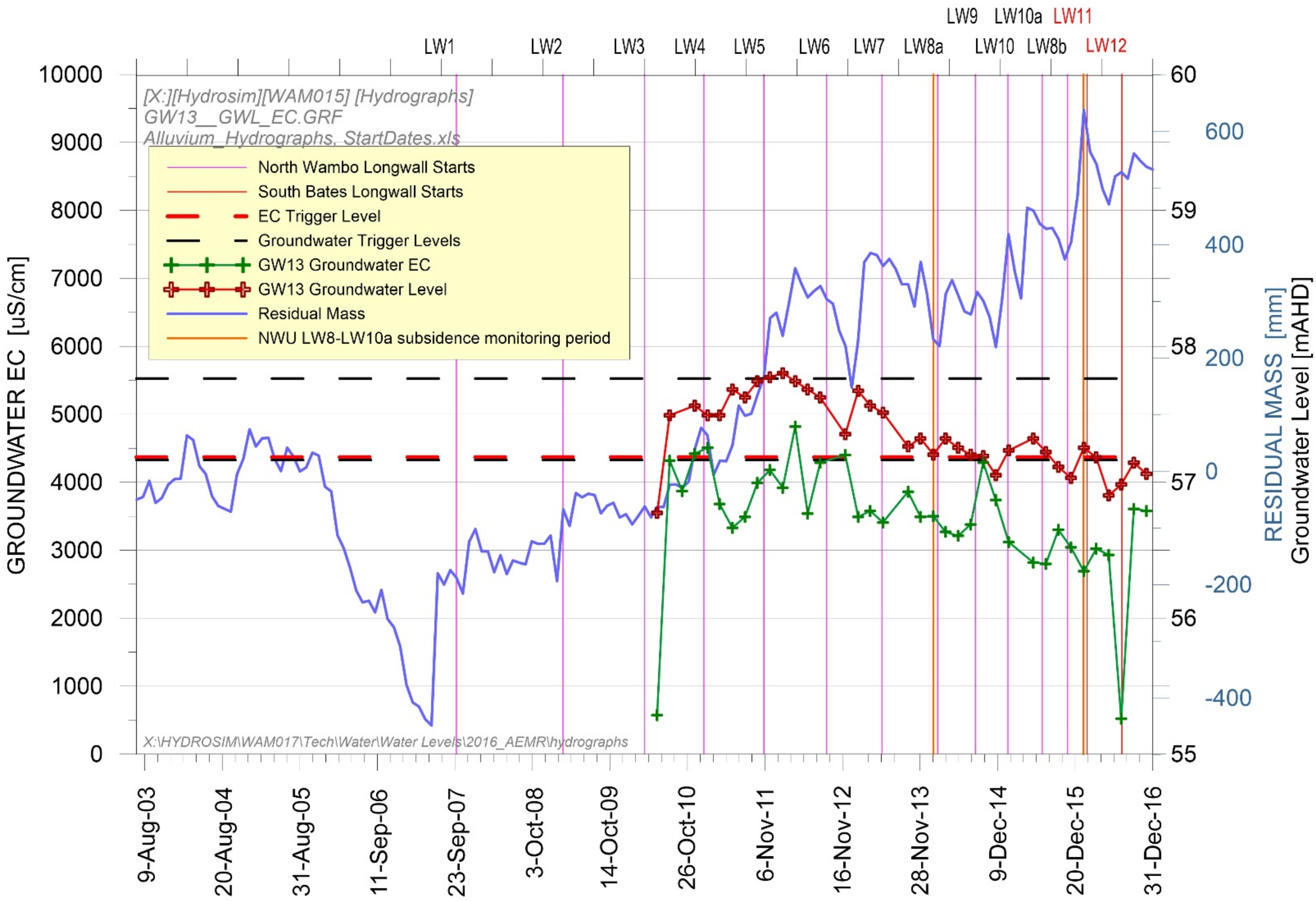

Figure 7 GW13 Groundwater Level and EC

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DATE:	29 March 2017
TO:	Harry Egan Environmental Advisor Wambo Coal Pty Ltd Peabody Energy Australia PMB 1, Singleton NSW 2330
FROM:	Adam Skorulis and Dr Noel Merrick
RE:	Compliance with subsidence performance measure in the SBU (Whybrow) Extraction Plan (LW11-13)
OUR REF:	HS2017/10 [Wam018]

1 INTRODUCTION

This letter report contains the analysis and information required to address the compliance of the subsidence performance measure as outlined in the South Bates Underground (SBU) Extraction Plan for Longwalls 11 to 13. The subsidence impact performance measure assessed is: *Negligible impact to Wollombi Brook*. Compliance has been assessed using the performance indicators in **Table 1** for the reporting period: 1 February 2016 to 31 December 2016. Longwall 11 commenced on 17 February 2016.

Table 1 Subsidence performance measure – LW11 to LW13 SBU (Whybrow)

Feature	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Measure
Wollombi Brook	*Surface water quality in Wollombi Brook exceeds the surface water quality criteria in the SWMP.*	*Negligible impact to Wollombi Brook*
	Groundwater levels in alluvial bores exceed the groundwater level criteria in the GWMP.	
	Groundwater quality in alluvial bores exceeds the groundwater quality criteria in the GWMP.	
	Zero flow is recorded at the Warkworth gauging station (FM10) and measurable flow is recorded at the Bulga gauging station (FM11).	

2 WOLLOMBI BROOK SURFACE WATER QUALITY

The impact assessment criteria for Wollombi Brook (**Table 2**) are sourced from the most recent Surface Water Monitoring Program (SWMP) (Peabody, 2015c), and are based on the 20th and 80th percentile values for the available dataset. The site assessed, SW02 (**Figure 1**), is located downstream of Wambo Coal Mine, where impacts to water quality caused by mining are most readily assessed. However, SBU mining is about 4 km from Wollombi Brook and must have considerably less effect than North Wambo Underground (NWU) mining.

Table 2 Surface water impact criteria

Sampling Site	Parameter	Lower Limit	Upper Limit
SW02 – Wollombi Brook	pH	7.4	8.1
	EC (µS/cm)	599	1947
	TSS (mg/L)	17 (low flow) – 308 (high flow)^	

^ Low flow conditions are based on 80th percentile of recorded concentrations and high flow criteria on maximum recorded concentrations

The data assessed for the reporting period is sourced from monthly environmental reporting conducted by Wambo Coal Mine, as well as the WaterNSW online resource that provides daily flow and electrical conductivity (EC) data.

An exceedance occurs when water quality results exceed the 80th percentile trigger values after two consecutive sampling events for Level 1 response management measures and three consecutive sampling events for Level 2 response contingency phase (Peabody, 2015d).

Throughout the reporting period there have been no exceedances of the EC limits at SW02 (**Figure 2**). A freshening period is observed to fall below the lower limit in the daily monitoring at the WaterNSW 'Wollombi Bk @ Warkworth' site early in the reporting period. However, this raises no concern as the freshening is associated with periods of an above average rainfall trend (**Figure 2**).

No exceedances of Total Suspended Solid levels (TSS) occurred for 'Low Flow' conditions during the 2016 monitoring period (**Figure 3**).

The pH level was observed to exceed the upper limit once during November 2016 (**Figure 3**). The final observation in December 2016 showed a return of pH to within the limits of the impact criteria.

3 ALLUVIAL GROUNDWATER LEVEL

Alluvial groundwater level criteria assessed for exceedances in this letter are sourced from the most recent GWMP (Groundwater Monitoring Program) (Peabody, 2015b). These are based on minimum and maximum depth-to-water trigger levels derived from 10th and 90th percentiles of historical recordings.

The GWMP lists 19 bores with trigger levels, though five bores have N/A entries. The trigger values are not assessment criteria but are used to initiate investigations according to the Surface and Ground Water Response Plan (SGWRP) (Peabody, 2015d). The SGWRP provides a protocol for the investigation, notification, and mitigation of identified exceedances of these assessment criteria. To investigate potential groundwater leakage from Wollombi Brook, the Trigger Action Response Plan (TARP) in the SGWRP considers the water level responses at 10 named bores (Peabody, 2015d):

- Groundwater monitoring of standing water levels in bores P106, P109, P114, P116 within the Wambo Creek alluvium and GW13 and GW15 within the Wollombi Creek alluvium, identifies a decreasing trend, beyond natural fluctuations and predicted modelled impacts; and/or

- Groundwater monitoring of standing water levels in bores GW08 and GW09 and GW016 and GW017 within the North Wambo Creek alluvium, exceed the standing water trigger values as provided in the GWMP, beyond natural fluctuations, for more than three consecutive monitoring events.

Groundwater level at 11 alluvial bores have shown exceedances of the trigger levels during the relevant reporting period. However, seven of these bores (P109, P202, P206, P315, GW02, GW15, P16) show only exceedances of the minimum depth-to-water. These exceedances correlate with a period of above average rainfall in early 2016 and as such, do not require further investigation.

The remaining four bores (P114, GW11, GW12, GW13) show exceedances of the maximum depth-to-water trigger level during the reporting period.

P114 (**Figure 4**) shows groundwater levels that are below the maximum depth-to-water trigger level for the entire reporting period before reporting as dry. This is a clear effect from the mining of Longwall 10A. The mining effect is unrelated to SBU mining.

GW11 (**Figure 5**) reports a groundwater level above the minimum depth-to-water trigger in February 2016 as well as a groundwater level below the maximum depth-to-water trigger in December 2016. The February 2016 exceedance correlates with the period of above average rainfall so is not considered further. The trigger in December 2016 follows a groundwater level decline of ~2.5 m since August 2016. The recession occurs at a more rapid rate than previously observed, during a period of average rainfall. GW02 (**Figure 6**) is located 120 m away from GW11 and a similarly timed recession of ~1.5 m in groundwater level that does not exceed a trigger occurs. It is possible that water loss from the alluvium further downstream on Wambo Creek, associated with North Wambo Underground mine has caused the observed drawdown and the trigger exceedance at GW11. Further readings are required to clarify the unexpected response at GW11. Given a separation of 3.5 km between GW11 and SBU Longwall 12, the mining effect is unlikely to be related to SBU mining.

GW12 (**Figure 7**) exhibits an ongoing mining effect from North Wambo Underground longwall extraction, with a trigger exceedance occurring in February 2016 as the bore reported dry. A recovery of ~2.5 m is observed with the above average rainfall in early 2016 and no further trigger exceedances are observed. The mining effect is unrelated to SBU mining.

GW13 (**Figure 8**) triggers occurred from June to December 2016 but are less than 20 cm below the prescribed trigger level. The approaching Warkworth open cut is the likely cause, not NWU and certainly not SBU mining.

4 ALLUVIAL GROUNDWATER QUALITY

Alluvial groundwater quality criteria assessed for exceedances in this report are sourced from the most recent GWMP (Groundwater Monitoring Program) (Peabody, 2015b). The GWMP lists 15 bores with EC and pH trigger values, but three have N/A entries.

Water quality triggers for EC are based on 90th percentile values from recorded historical data at each bore. An exceedance of the 90th percentile EC value in three consecutive bi-monthly observations triggers an investigation.

At Wambo pH is consistently between 6 and 8 at most alluvial monitoring locations. 10th and 90th percentile values are used as minimum and maximum exceedance values. An investigation is triggered following exceedances on two consecutive bi-monthly monitoring events.

No EC exceedances are observed except at P114 (**Figure 4**) where the EC value has exceeded the groundwater quality trigger in all 2016 observations. As has been discussed previously in HydroSimulations (2016a), P114 is situated partially in weathered regolith and underlying Permian overburden. As groundwater level has declined due to Longwall 10A extraction, the water table is now located in source rock with a much higher salinity.

This exceedance of the EC trigger level at P114 by four monthly observations triggers the subsidence impact performance indicator for groundwater quality in alluvial bores as identified in the South Bates Underground (Whybrow) Mine Extraction Plan for Longwalls 11 to 13. However, the water table in P114 is no longer in alluvium and no observable impact to Wollombi Brook is apparent as a result of these exceedances. The mining effect is unrelated to SBU mining.

No exceedances of pH requiring an investigation occurred during the reporting period.

5 WOLLOMBI BROOK FLOW DIFFERENTIAL

The *performance indicator* for flow at Wollombi Brook is considered exceeded if the Warkworth gauging station (FM10) records zero flow, and the Bulga gauging station (FM11) records measurable flow at the same time (**Figure 1**).

Discharge rate in ML/ day for FM10 and FM11 was downloaded by HydroSimulations from the WaterNSW website for the 'Wollombi Bk at Bulga' (station number: 210008) and 'Wollombi Bk at Warkworth' (station number: 210004), which correlate with FM11 and FM10 respectively. Wollombi Brook discharge is initially presented using a logarithmic y-axis scale (**Figure 9**) to clearly capture the relationship between gauging stations in periods of both low and high flow. It is again presented for the reporting period only, using a regular y-axis (**Figure 10**) so as not to distort the apparent differential between flow at the gauging stations between periods of low and near zero flow.

At the beginning of the reporting period, there is an excellent match between discharge at both Wollombi Brook gauging stations, in which low, and declining flow conditions generally show higher discharge volumes at the Warkworth gauging station than are recorded at the Bulga gauging station. A good example of this is observed between March and June 2016 (**Figure 10**). This is expected due the larger catchment area downstream at the Warkworth gauging station, as well as tributaries such as Wambo, Sandy, and North Wambo Creeks feeding flow. However, since the end of November 2016, zero flow has been recorded at the downstream Warkworth (FM10) gauging station, while the Bulga (FM11) gauging station has been recording measurable flow, although very low (less than 1 ML/day) (**Figure 9**).

This was preceded by a flow recession beginning mid-November, in which the downstream, Warkworth site recorded a decline in flow earlier, and at a greater rate than the Bulga site. This is a change from other observations and requires further invesitgation.

This triggers an exceedance of the subsidence *performance indicator* for flow in Wollombi Brook. A further investigation is required into whether there has been an exceedance of the *performance measure* for the SBU mine to have a 'negligible impact on Wollombi Brook'. It is difficult to directly correlate this lack of flow at the Warkworth gauging station with longwall extraction at SBU. The SBU longwalls are over 3.5 km away from Wollombi Brook which is likely to be too distant to cause any direct effect.

6 ASSESSMENT OF PERFORMANCE MEASURE AND RECOMMENDATIONS

In the event that the subsidence impact performance measure relating to water is exceeded or likely to be exceeded, the Extraction Plan for South Bates Underground (Whybrow) Longwalls 11 to 13 details a contingency plan that should be employed to more accurately assess the cause of the exceedance.

A summary assessment is given in **Table 3**.

Table 3 Subsidence performance measure – LW11 to LW13 SBU (Whybrow)

Feature	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Wollombi Brook	*Surface water quality in Wollombi Brook exceeds the surface water quality criteria in the SWMP.*	**No**	*Negligible impact to Wollombi Brook*	**No**
	Groundwater levels in alluvial bores exceed the groundwater level criteria in the GWMP.	**Yes (at P114, GW11, GW12, GW13)**		
	Groundwater quality in alluvial bores	**Yes (at P114)**		

Feature	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
	exceeds the groundwater quality criteria in the GWMP.			
	Zero flow is recorded at the Warkworth gauging station (FM10) and measurable flow is recorded at the Bulga gauging station (FM11).	**Yes**		**Requires Further Investigation**

Exceedances of the performance indicators have been observed at:

- P114 – which can no longer be considered representative of alluvium;
- GW11 – not in the TARP and 3.5 km from SBU mining;
- GW12 – not in the TARP and located above North Wambo Underground;
- GW13 – most likely affected by Warkworth Mine; and
- FM10 – zero flow at downstream gauging station.

None of the exceedances of water level or EC can be attributed to SBU mining. The absence of flow at the FM10 gauging station is unlikely to be attributable to SBU mining, given a separation of 4 km between the mine and Wollombi Brook, unless flows in North Wambo Creek have been captured.

HydroSimulations recommends that further investigations are conducted by a specialist hydrologist to determine if there has been an exceedance of the subsidence performance measure of *negligible impact to Wollombi Brook*.

References

HydroSimulations (2016a) *Wambo Annual Review Groundwater Analysis*. Report HC2016/07 for Wambo Coal Pty Ltd. March 2016

HydroSimulations (2016b) *South Wambo Underground Mine Modification - Groundwater Assessment*. Report HC2016/01 for Wambo Coal Pty Ltd. March 2016

WaterNSW *http://realtimedata.water.nsw.gov.au/water.stm?ppbm=DAILY_REPORTS&dr&3&drkd_url* Accessed 20/3/2017

Peabody (2015a) *Subsidence Monitoring Program for North Wambo Underground Mine Longwalls 8 to 10A.* Document Number SWMP LW8-10a. April 2015

Peabody (2015b) *Wambo Coal Groundwater Monitoring Program.* Document No. WA-ENV-MNP-509.1. October 2015

Peabody (2015c).*Wambo Coal Surface Water Monitoring Program.* Document No. WA-ENV-MNP-509.2. October 2015

Peabody (2015d).*Wambo Coal Surface and Ground Water Response Plan.* Document No. WA-ENV-MNP-509.4. October 2015

Filepath: X:\HYDROSIM\WAM018\HS2017_9aNWU_SubsidenceCompliance.docx

Figures

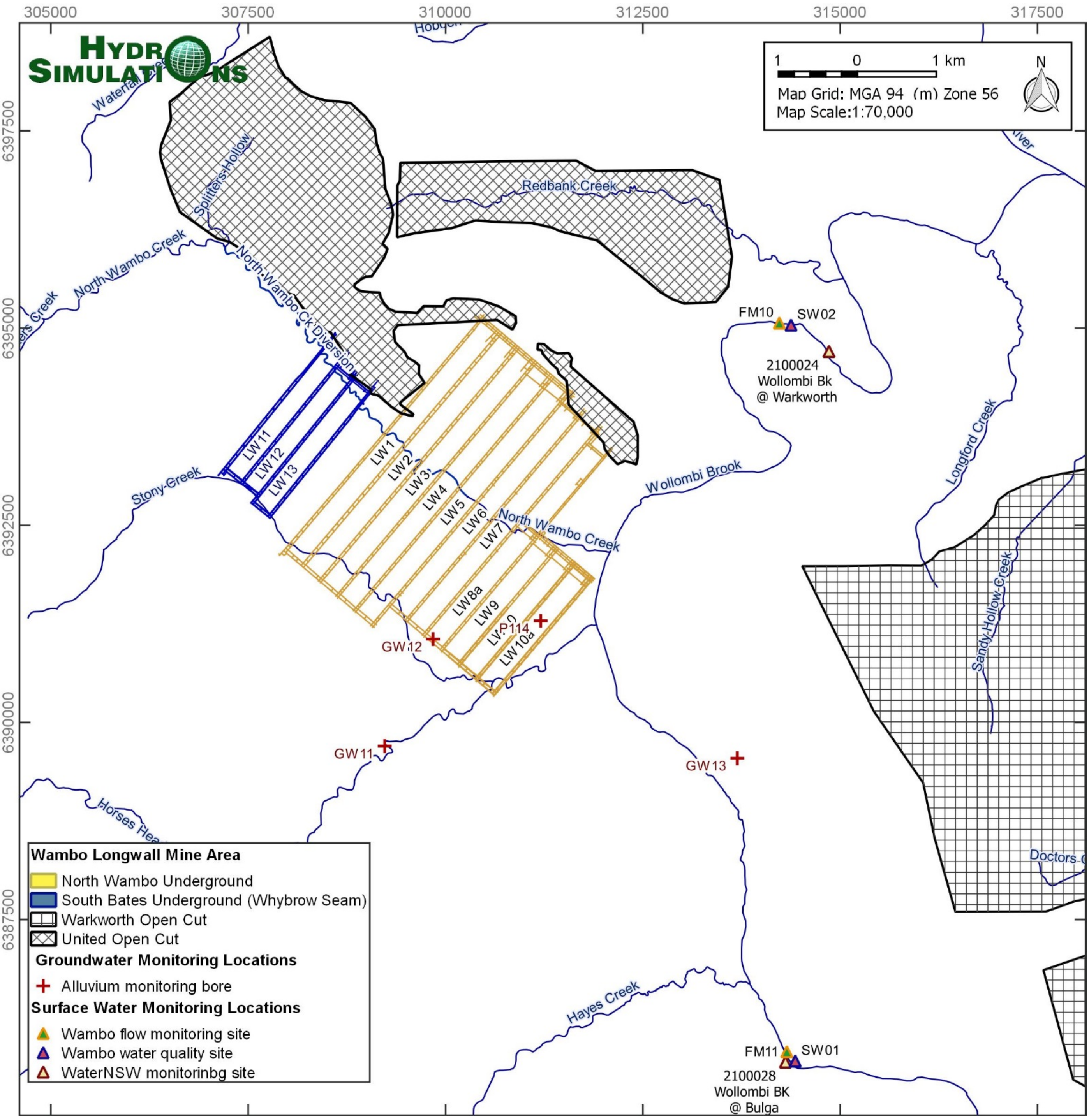

Figure 1 **Locations of groundwater and surface water sites discussed in this report.**

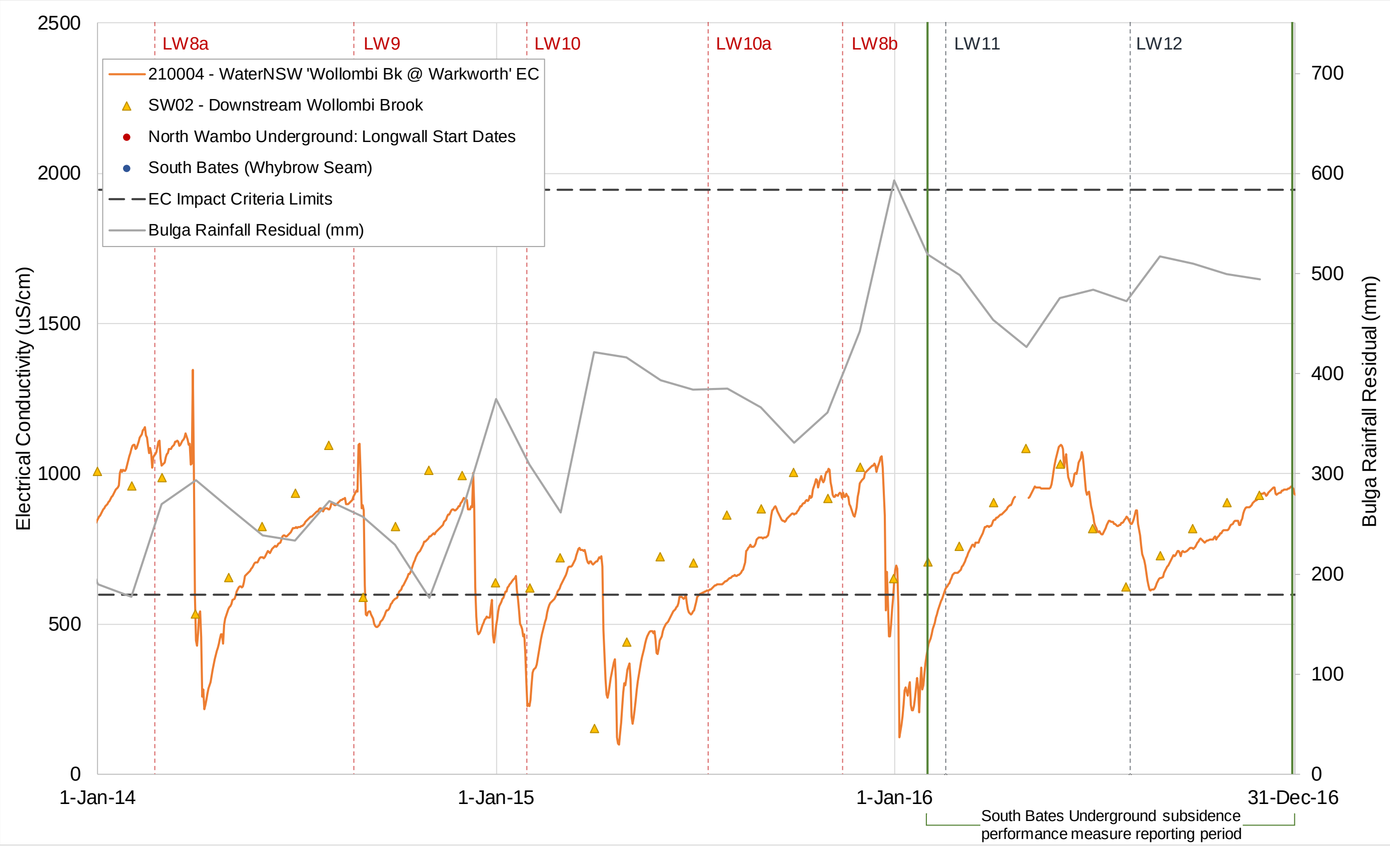

Figure 2 SW02 - EC Surface water quality trigger level

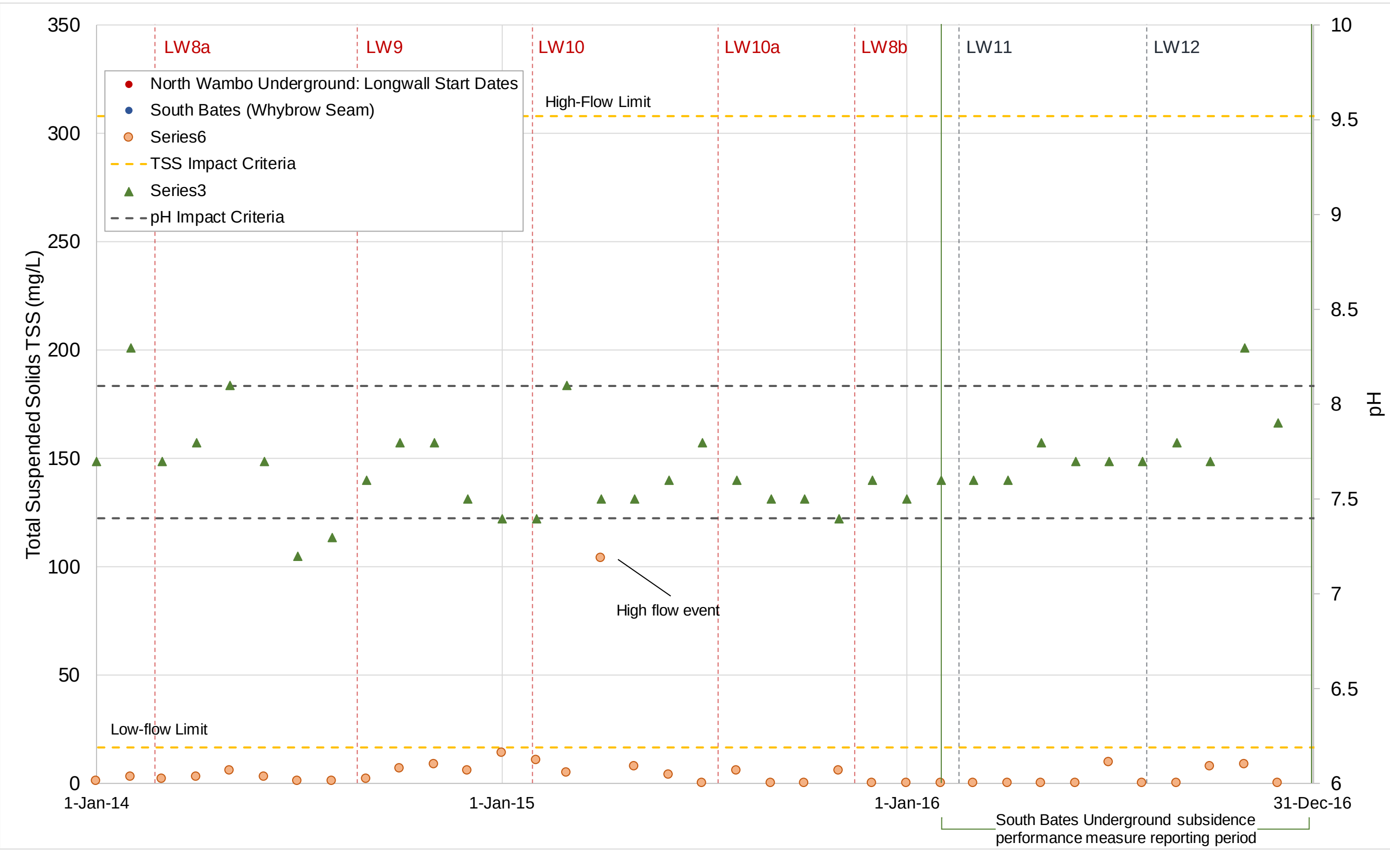

Figure 3 SW02 – pH and TSS Surface water quality trigger level

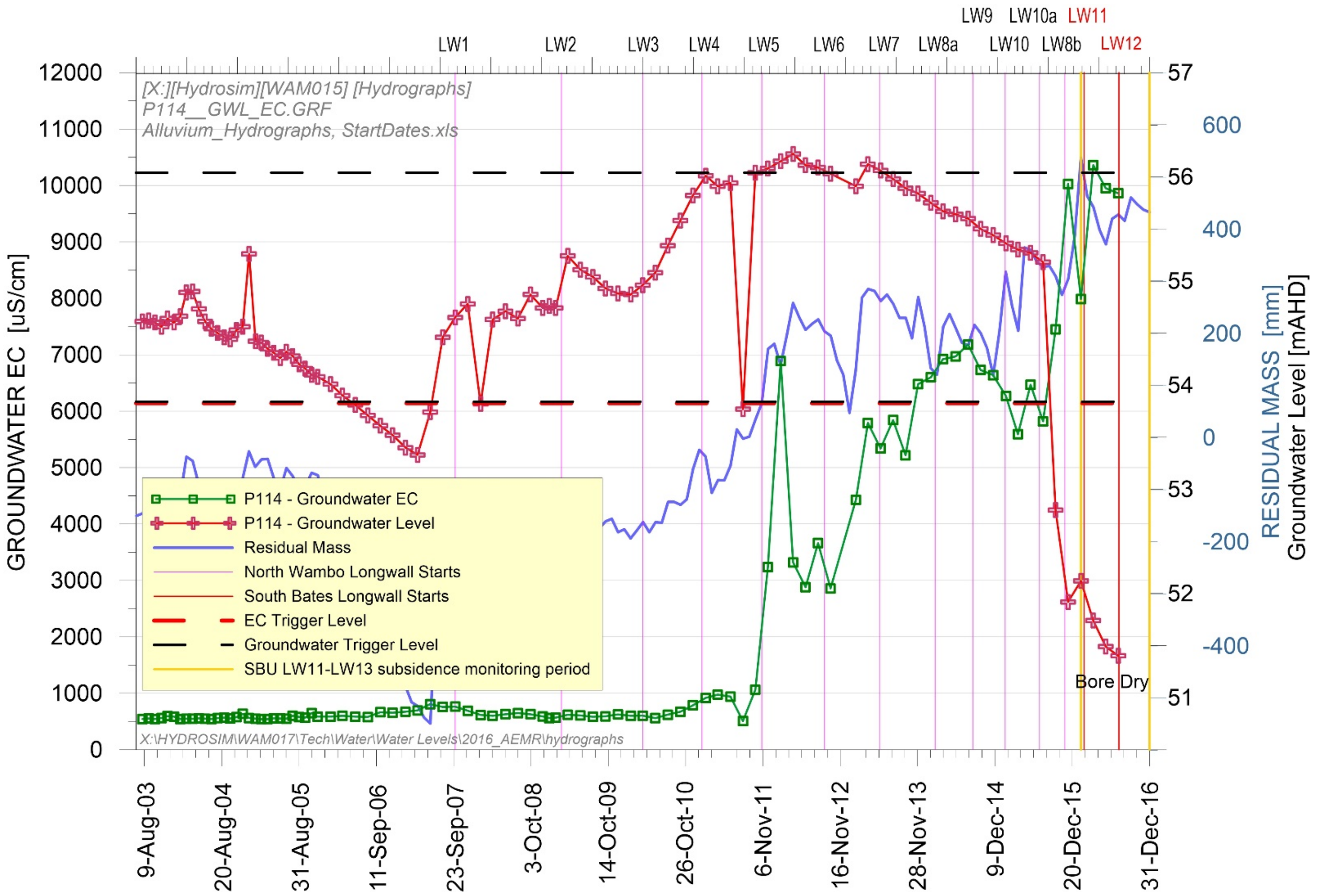

Figure 4 **P114 Groundwater Level and EC**

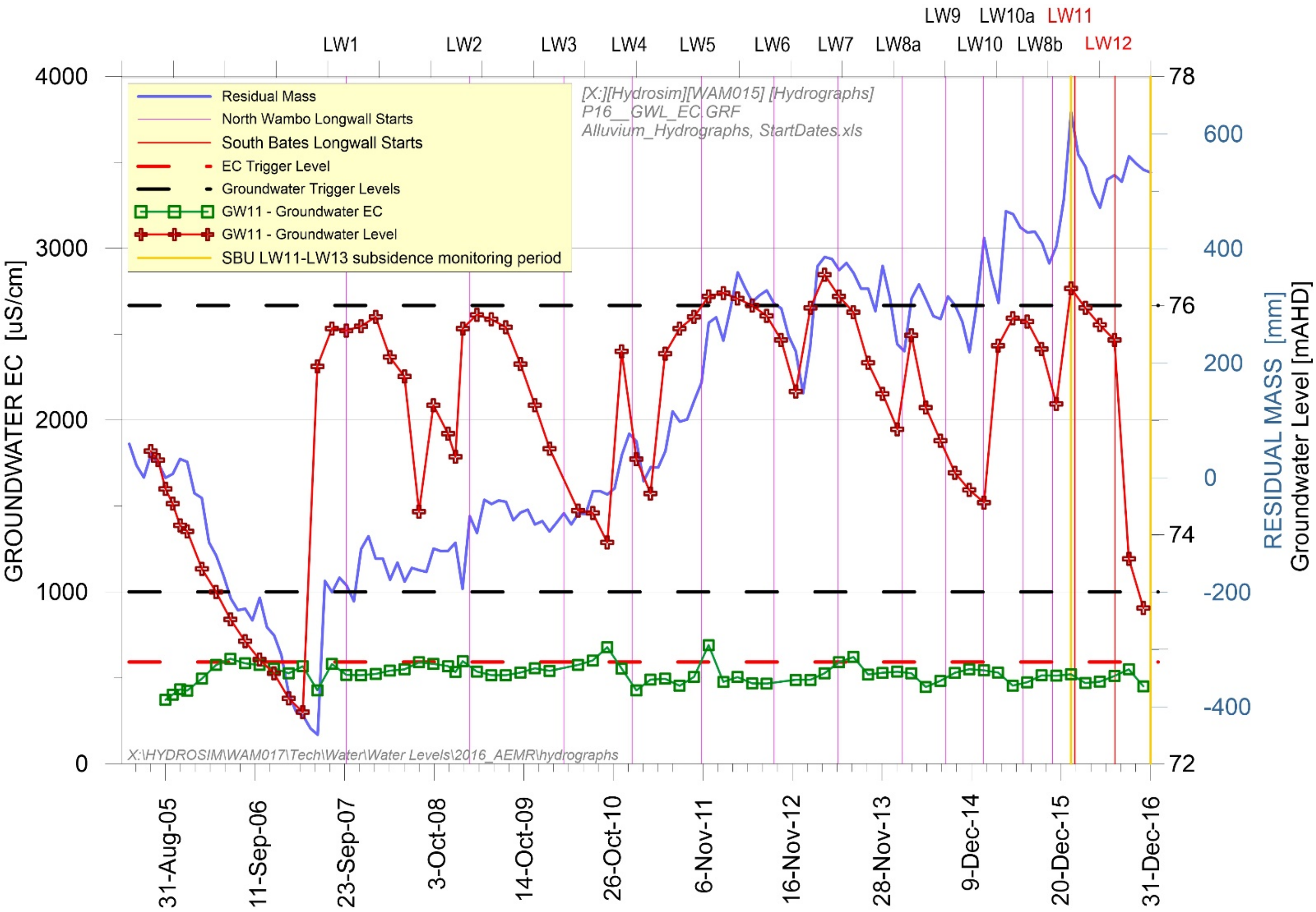

Figure 5 GW11 Groundwater Level and EC

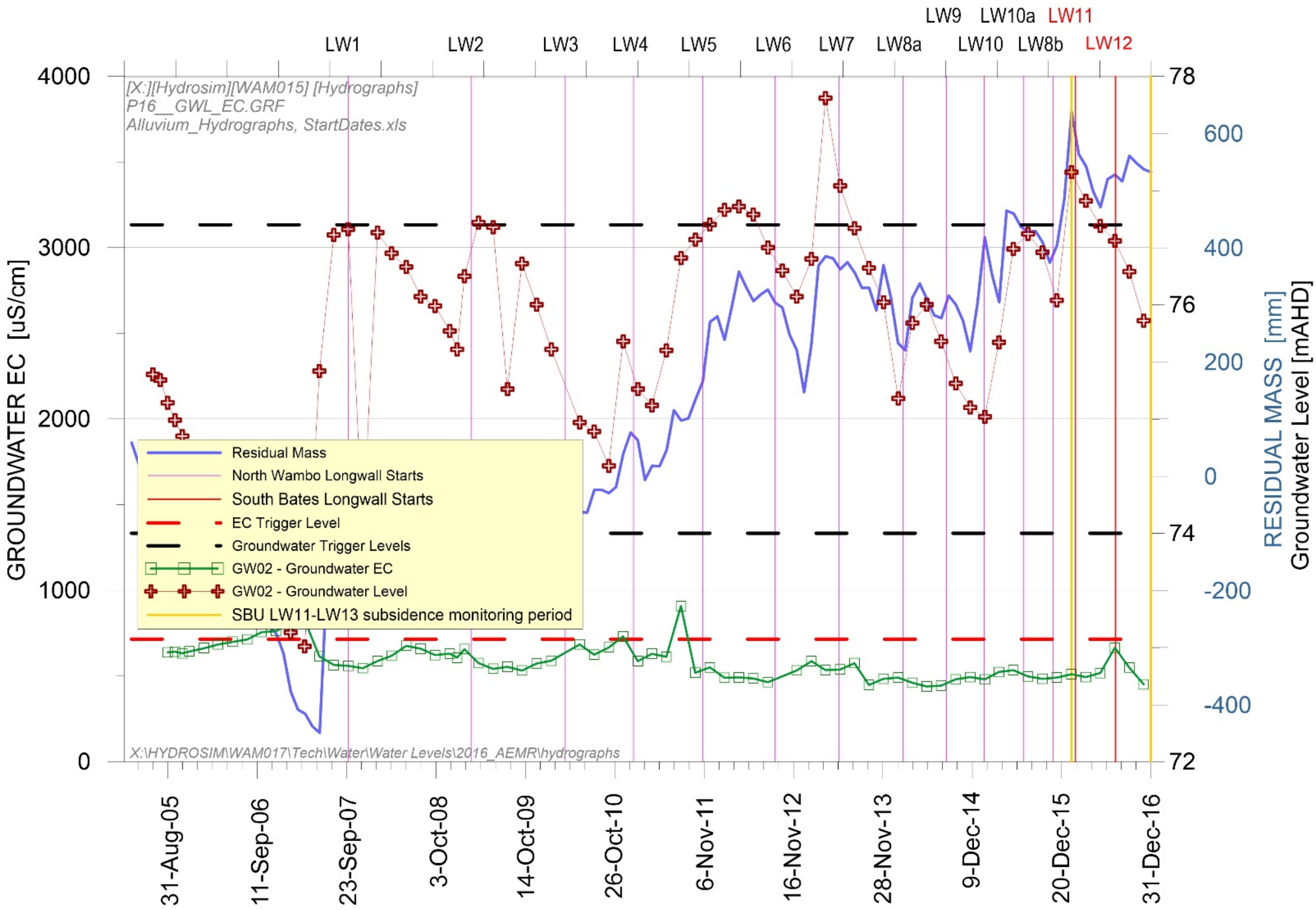

Figure 6 **GW02 Groundwater Level and EC**

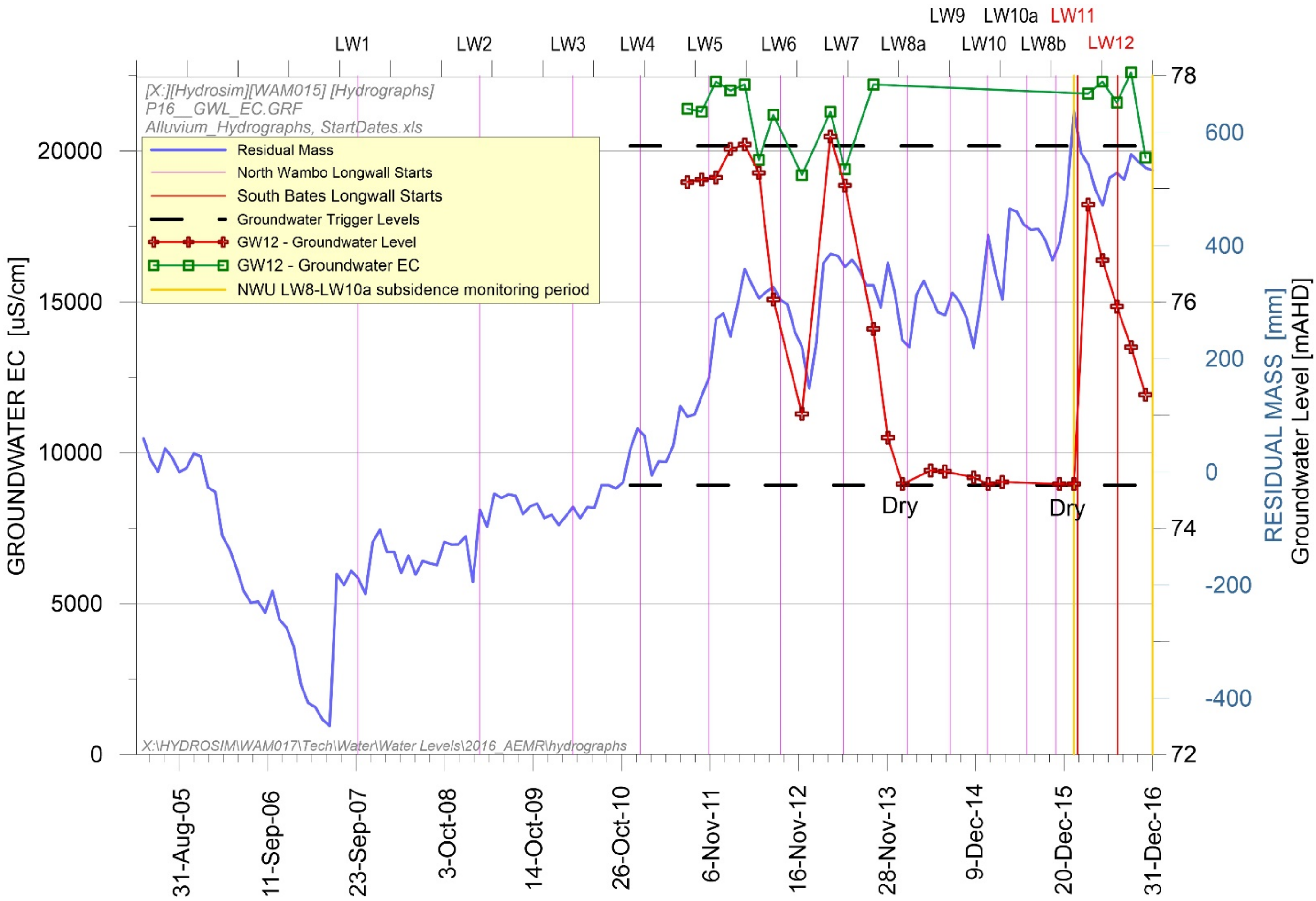

Figure 7 GW12 Groundwater Level and EC

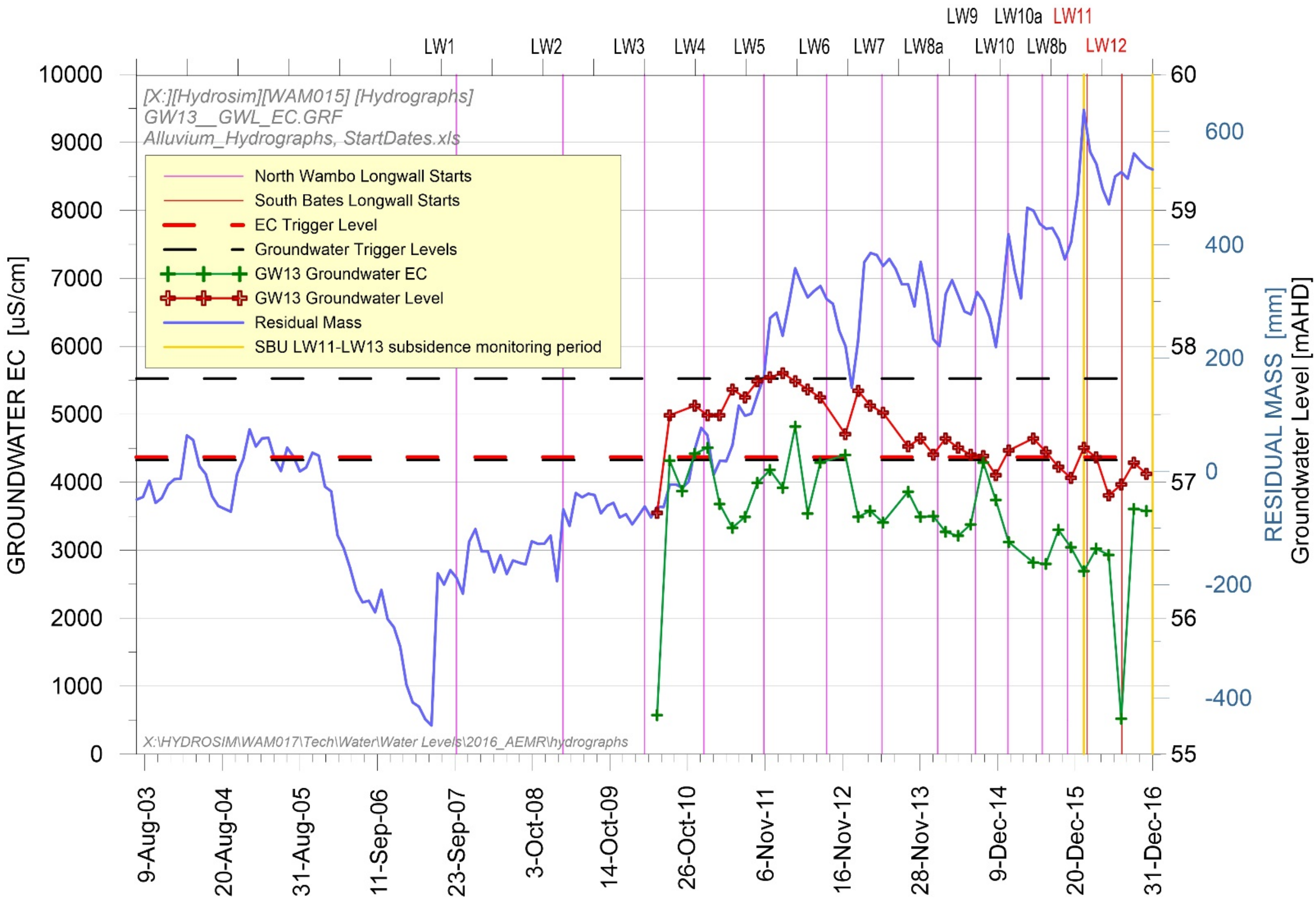

Figure 8 GW13 Groundwater Level and EC

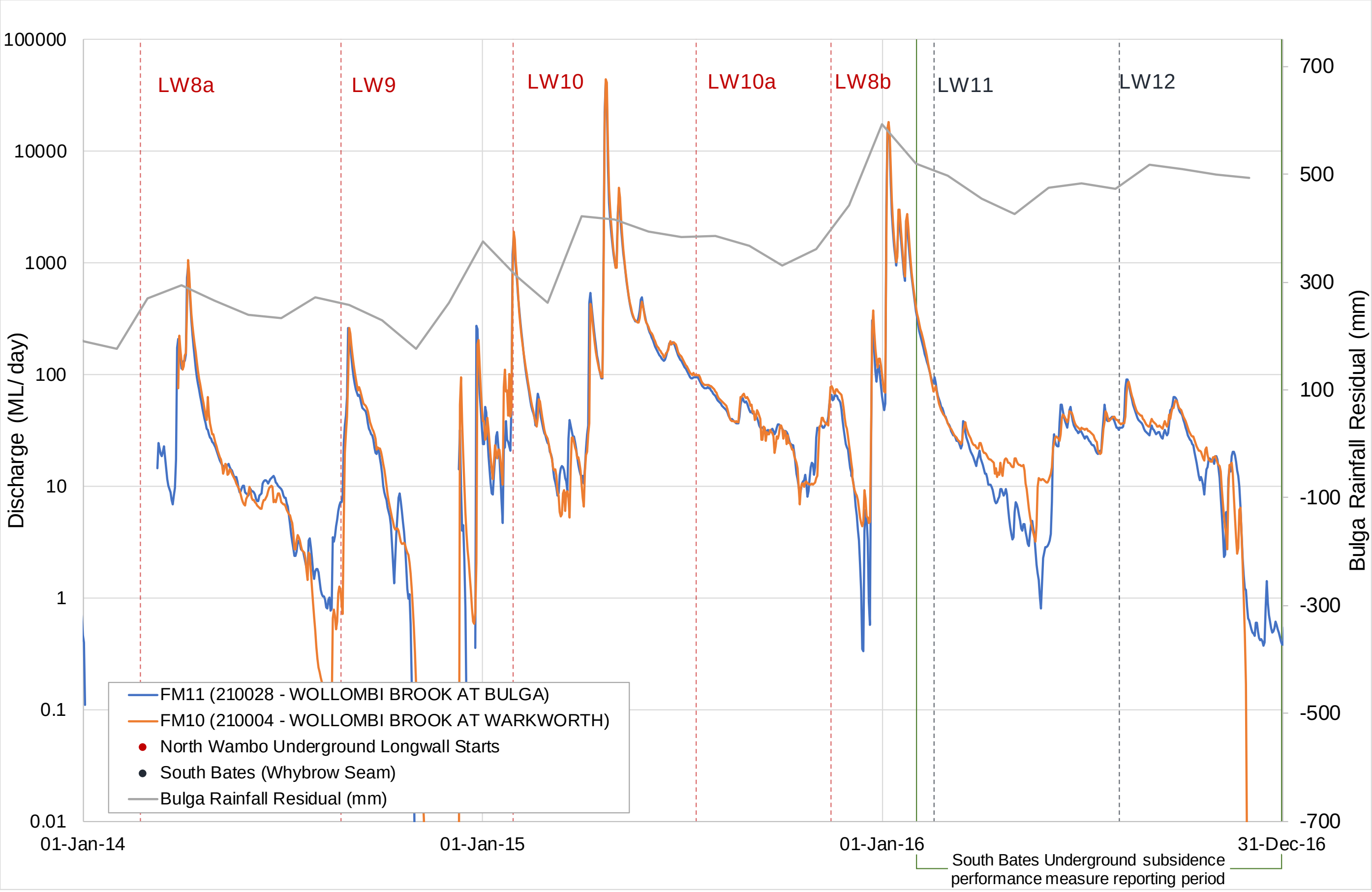

Figure 9 Wollombi Brook flow recording with logarithmic y-axis

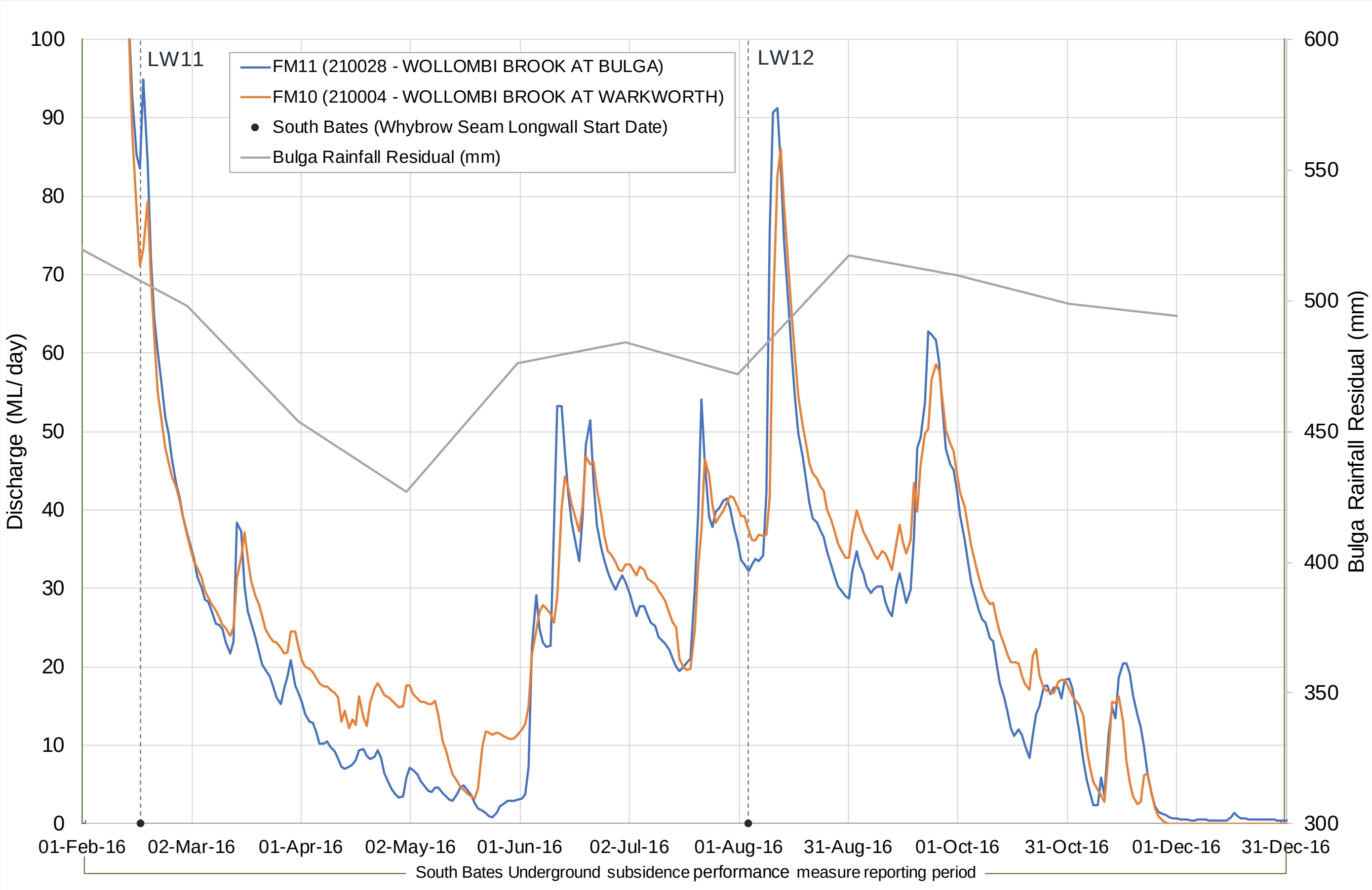

Figure 10 Wollombi Brook flow recording

APPENDIX H – RESPONSE TO DP&E COMMENTS

WAMBO COAL PTY LIMITED

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5 May 2017

Department of Planning and Environment
Level 1, Suite 14
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SINGLETON NSW 2330

Attention: Michael Frankcombe

RE: Wambo Coal Pty Ltd – DA 305-7-2003 Annual Review 2016 Department of Planning and Environment Comments Response

The Wambo Coal Pty Ltd (WCPL) 2016 Annual Review was submitted to the Department of Planning and Environment (DPE) on the 31 March 2017 in compliance with Schedule 6, Condition 5 of Development Consent (DA) 305-7-2003.

A request for further information from the DPE was received by WCPL on the 19 April 2017 in accordance with Schedule 3, Condition 4 of DA 305-7-2003.

Please find the WCPL response to the DPE request for further information included as **Attachment 1**. WCPL proposes that the below responses will be included as an appendix to the 2016 Annual Review upon receiving formal acceptance from the DPE that they are satisfactory.

If you have any further queries about any of the below responses or the Annual Review please feel free to contact me.

Yours faithfully

Steve Peart
Environment and Community Manager
WAMBO COAL PTY LTD

Attachment 1: WCPL Response to DPE Request for Further Information for the 2016 Annual Review

Attachment 2: Wambo Coal Montrose Sediment Dam Failure Incident Report – Condition 10, Schedule 6, DA 305-7-2003

ATTACHMENT 1: WCPL RESPONSE TO DPE REQUEST FOR FURTHER INFORMATION FOR THE 2016 ANNUAL REVIEW

DPE Comment	WCPL Response
A) Erosion and Sediment Control – Section 6.8.2 and Section 10.1 of the Annual Review identify an uncontrolled release from a sediment dam however an explanation of why the failure occurred or what measures were implemented to prevent future failures was not provided. Please provide a detailed explanation of why the failure occurred and what measures have been put in place to prevent future failures.	Please refer to the Wambo Coal Montrose Sediment Dam Failure Incident Report – Condition 10, Schedule 6, DA 305-7-2003 as provided to DPE on Monday 18 January 2016 (attached)
B) Surface Water Monitoring – Section 6.1.2 and Section 10.7 of the Annual Review identify failure to undertake flow monitoring in South Wambo Creek for periods ranging from 7 months (FM6 and FM9) to 46 months (FM5). Please provide an explanation of why it took such a long period of time to replace the flow monitors and what safeguards have been put in place to minimise the risk of future failures. Please update Figure 9 to show the location of FM9. Further, please provide to the Department further information relating to the flow and stream bed profile of South Wambo Creek at FM15 and FM16.	• FM9 was originally located 230 meters upstream of the confluence between Stoney and South Wambo Creeks. During high flow events in January and February 2013 the bed of South Wambo Creek in the vicinity of FM9 was significantly altered and not suitable to host a replacement flow monitoring station. An ideal replacement location was identified upstream on a private land holder's property but has been delayed due to ongoing land access negotiations with the private landholder. The replacement of FM6 with FM16 was scheduled to be installed concurrently with a new site at FM9. This was also delayed due to the above land access negotiations but was progressed separately when a resolution was identified as not being forthcoming. The destruction of FM5 was identified by current WCPL staff during 2015 and was reported on as being destroyed in the 2015 Annual Review. As recommended in the 2015 Annual Flow Monitoring Report, FM5 was replaced during 2016 with FM15. Prior to 2015 it appears that the failure to replace FM5 following its destruction was an oversight. • FM9 is not currently installed and as such cannot be shown on Figure 9. • Please refer to Appendix B Stream Theoretical Flow Rating and Profile Curves of the WCPL Annual Stream Flow Monitoring Report included as Appendix F in the WCPL Annual Review for the FM16 (New Flow Station 6) and FM15 (New Flow Station 5) flow and stream bed

DPE Comment	WCPL Response
	profiles. • WCPL is in the process of commissioning an independent audit of our site flow monitoring station network. This audit will assess historical data to determine the suitability of current equipment and locations. Where sites are deemed appropriate stream beds will be re surveyed to ensure accurate flow data is being collected.
C) Noise - Table 36, action number 27 requires a revised progress comment	The NMP is in the process of being finalised and the location of Muller will be commented on as part of this review.
D) Biodiversity – Section 5.6.2 of the Annual Return references the Annual Flora and Fauna Monitoring Report – 2016 Eco Logical 2017. This report: Recommends investigating and monitoring dieback of *Angophora floribunda* in the Warkworth Sands area of the Remnant Woodland Enhancement Area; Identifies species native to Western Australia in the Woodland rehabilitation areas (*Acacia saligna and Eucalyptus cladocalyx*); and Describes poor biodiversity outcomes for the North Wambo Creek Diversion includes limited native plant species, areas of bare soil and active erosion Please provide:	• Potential die back of *Angophore floribunda* was originally identified as part of the 2016 Annual Flora and Fauna Monitoring. Monitoring of the affected *Angophore floribunda* during the 2017 Annual Flora and Fauna Monitoring will continue with photo points established if necessary to determine if die back has continued or if recovery is occurring. Proposed management/mitigation measures will be developed based on the findings of this monitoring. • *Acacia saligna* and *Eucalyptus cladocalyx* were likely originally included in the woodland species mix due to their ability quickly establish and survive on a range of soil types, including saline and low rainfall areas and are native to Australia. *A. saligna* is a Western Australian species which has become naturalised along parts of the coast and southern inland areas of New South Wales. It has historically been planted widely in sand dune, road and mine site rehabilitation projects. *E. cladocalyx* is originally from South Australia and has been planted extensively as a windbreak and shelterbelt species in south-eastern Australia. *A. saligna* has become naturalised in some forest areas beyond its natural distribution, particularly where disturbance has occurred. This species has little biodiversity value and has potential to become weedy and spread throughout the site - particularly in disturbed post-mining areas. *E. cladocalyx* appears to have less potential to become weedy and impact biodiversity values onsite, but could potentially spread beyond planting areas in

DPE Comment	WCPL Response
• Details of the investigation that will be undertaken to assess the dieback of *Angophore floribunda* in the Warkworth Sands area of the Remnant Woodland Enhancement Area and any mitigation measures undertaken or proposed to be undertaken; • An assessment of the suitability of *Acacia saligna* and *Eucalyptus cladocalyx* as Woodland rehabilitation species including the potential to become weeds and impact biodiversity values onsite. Describe any management actions undertaken during the reporting period to minimise this risk and future management actions to reduce risk; and • An explanation of why there are still areas of exposed soil, active erosion and poor native vegetation establishment on the North Wambo Creek diversion. Describe works undertaken during the reporting period to improve the biodiversity outcomes for the North Wambo Creek diversion and any proposed works for the next reporting period.	the future. These woodland rehabilitation areas have been designed and implemented applying old techniques that do not reflect the current best practice of utilising species of local provenance, in addition poor rehabilitation techniques appear to have been used in these areas creating a lack of groundcover at several monitoring sites. However these areas are currently providing structure suitable for use by some fauna species (birds and small reptiles) and may become suitable for a wider range of fauna as trees continue to develop. Considering the intended use for the zone (woodland corridor), the likely time and expense associated with the alternative of removing these older stabilised rehabilitation areas, risks and time involved with the subsequent planting and or seeding of local native species, and the potential risks of *E. cladocalyx* and *A. saligna* spreading, it is recommended to control *A. saligna* and *E. cladocalyx* where they occur outside of original plantings and use alternative local native species in current and future woodland rehabilitation areas. No management actions were undertaken during the reporting period. Monitoring of this rehabilitation will continue as part of scheduled annual monitoring. As such, the geographical dispersal of *A. saligna* and *E. cladocalyx* will be monitored and where identified as having expanded beyond its intended rehabilitation area will be subject to manual removal as appropriate. • Until recently the North Wambo Creek Diversion has a history of poor rehabilitation outcomes. In late 2015 the approved North Wambo Creek Diversion Inspection and Action Plan (July 2015) was trialled with rehabilitation works across Stage 3 primarily consisting of: A) Tree planting B) Soil amelioration C) Deep ripping

DPE Comment	WCPL Response
	D) Weed management E) Seeding During 2016 the success of the trial was monitored to determine if the implemented rehabilitation methods had been effective and justified continuation. It has been determined that rehabilitation was largely successful and Stage 2 rehabilitation works, consistent with those completed in late 2015, commenced in early 2017. As per section 5.6.2 of the WCPL 2017 Annual Review works undertaken during 2016 consisted of the installation of 250 tree guards to protect tube stock and seeded mid and upper story tree species from Kangaroos.