Hunter Valley Operations

2017 Annual Review

March 2018

This page has been left blank intentionally

Name of Operations	Hunter Valley Operations
Name of Operator	HV Operations Pty Ltd
Development consent /project approval	DA 450-10-2003 / PA 06_0261
Name of holder of development consent/project approval	HV Operations Pty Ltd
Mining Lease Number	Contained within Section 3.1 of this report
Name of Mining Lease Holder	Contained within Section 3.1 of this report
Water Licence Number	Contained within Section 3.1 of this report
Name of Water Licence Holder	Contained within Section 3.1 of this report
MOP/RMP Start Date	HVO North – 18/12/2016 HVO South – 1/11/2015
MOP/RMP End Date	HVO North – 31/12/2018 HVO South – 31/12/2018
Annual Review Start Date	01/01/2017
Annual Review End Date	31/12/2017

I, *Jason McCallum*, certify that this audit report is a true and accurate record of the compliance status of Hunter Valley Operations for the period 1st January 2016 to 31st December 2016 and that I am authorised to make this statement on behalf of Hunter Valley Operations.

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 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 the 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	Jason McCallum
Title of Authorised Reporting Officer	General Manager – Hunter Valley Operations
Signature of Authorised Reporting Officer	
Date	27-3-18

This page has been left blank intentionally

Executive Summary

This Annual Environmental Review (Annual Review) reports on the environmental performance of Hunter Valley Operations (HVO) during the 2017 calendar year and satisfies the requirements of HVO's Development Consents and Mining Leases. The structure of the 2017 Annual Review intends to align with the NSW Government *Post-approval requirements for State significant mining developments – Annual Review GUIDELINE (October 2015).*

HVO extracted 19.5 million tonnes of run-of-mine (ROM) coal during 2017 against an approved ROM extraction rate of 42 million tonnes per annum (mtpa). The Coal Handling Preparation Plants produced 14.8 million tonnes of saleable coal.

Noise

HVO manages noise to ensure compliance with permissible noise limits at nearby private residences. During the reporting period there were no non-compliances recorded against HVO's development consent limits. During 2017, 18 haul trucks were retrofitted with full sound attenuation kits, making a total of 46 out of 95 trucks (48%) of the haul fleet now sound attenuated. A total of 181 hours of equipment downtime was recorded due to proactive and reactive measures to minimise noise.

Blasting

During the reporting period 288 blast events were initiated at HVO all complied with consent and licence conditions. HVO employs a blast fume management protocol to mitigate generation of post blast fume emissions. Two blasts produced fume ranked as category 3 (AEISG scale) but did not leave the mine boundary. There were no category 4 or 5 fume events recorded.

Air Quality

Air quality monitoring is undertaken in accordance with the HVO Air Quality Monitoring Programme. An extensive network of monitoring equipment is utilised to assess performance against the relevant conditions of HVO's approvals. During 2017, HVO complied with all short term and annual average air quality criteria with the exception of one exceedance of short term PM10 criteria measured at the Hunter Valley Glider Club on 29th July 2017. A total of 8,584 hours of equipment downtime was recorded due to proactive and reactive measures to minimise dust. A total of 214 ha of land was aerial seeded during autumn to minimise wind eroded dust from overburden areas not yet available for rehabilitation.

Heritage

Under the provisions of both the HVO South and HVO North Aboriginal Cultural Heritage Management Plans (ACHMP), an ACHMP Compliance Inspection was conducted within both ACHMP areas. The inspection found that all sites have been managed in conformance with the ACHMP requirements. There were no incidents nor any unauthorised disturbance caused to cultural heritage sites at HVO during 2017. Three field work programs totalling 22 days were conducted at HVO North during the reporting period. During these programs 255 new ACH sites were recorded, 69km of transects were assessed and 339 extant Aboriginal cultural heritage sites were salvage mitigated.

Water

2017 was another dry year with a substantial reduction in water inputs from rainfall runoff compared to 2016. The amount of water imported from the Hunter River and neighbouring mines has increased to offset this deficit. Improvements to water management in 2017 have focused on reducing the risk of unauthorised water releases from site. Augmentation of both the Hunter Valley Load Point (HVLP) sediment sump and Parnells discharge point catch dam commenced in 2017.

One water related incident required notification to government agencies. As a result of this notification HVO was issued a $15,000 penalty notice from the EPA in relation to an incident at the HVLP sediment sump. No material environmental harm resulted from the incident.

Rehabilitation and Land Management

A total of 103.2 ha of mined land was rehabilitated in 2017 and 72.9 ha of land was disturbed. Rehabilitation quality improvements included the use of mixed waste compost to improve soil fertility, direct drilling of seed, cover crops and utilising seed harvesting areas to facilitate use of locally sourced seed. During 2017, 239 feral pigs were euthanised by control programmes undertaken by HVO and licensees on HVO owned non-mining land.

Biodiversity Management

Weed control, track and fence repairs and vertebrate pest management activities were conducted during 2017 in the Goulburn River, Condon View, Wandewoi, Mitchel Hill and Cresent Head Biodiversity Areas (BAs) in accordance with the Regional Offsets Management Plan.

Table of Contents

Figures

Tables

Appendices

1 STATEMENT OF COMPLIANCE

Table 1 is a Statement of compliance against the relevant approvals. Table 2 provides a brief summary of the non-compliances and a reference to where these are addressed within this Annual Review.

Table 1: Statement of compliance

Were all conditions of the relevant approval(s) complied with?	
PA 06_02161 (HVO South)	No
DA 450-10-2003 (HVO North)	No

Table 2: Non-compliances

Relevant approval	Condition number	Condition description (summary)	Compliance status[1]	Where addressed in Annual Review
PA 06_02161 (HVO South)	Schedule 3 Condition 19	Air Quality – Impact Assessment Criteria	Non-Compliant (Low)	11.3
DA 450-10-2003 (HVO North)	Schedule 4 Condition 20.	Pollution of waters	Non-Compliant (Low)	11.4

[1]Compliance status key for Table 2

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 unlikely 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 unlikely 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)

2 INTRODUCTION

2.1 Document Purpose

This Annual Review is written to satisfy the requirements of the Hunter Valley Operations (HVO) Development Consents and conditions of mining leases for events which occurred during the 2017 calendar year. The Annual Review has been written in accordance with the NSW Government *Post-approval requirements for State significant mining developments – Annual Review Guideline* (October 2015).

This report is distributed to:

- NSW Department of Planning and Environment (DP&E);
- NSW Department of Planning and Environment, Division of Resources and Geosciences (DRG)
- NSW Department of Primary Industries Water (DPI Water)
- Singleton Council and Singleton Library;
- Muswellbrook Shire Council (MSC) and Muswellbrook Library; and
- HVO Community Consultative Committee (CCC).

2.2 Background

HVO is situated in the Upper Hunter Valley between Singleton and Muswellbrook, approximately 24 km northwest of Singleton, and approximately 100 km northwest of Newcastle. The Hunter River geographically divides HVO into HVO North and HVO South; however they are integrated operationally with personnel, equipment and materials utilised as required. This improves operational efficiency, rationalisation of infrastructure and resource utilisation.

HVO is managed and operated by Yancoal Australia Ltd[1].

The regional context and layout of the HVO pits and facilities are shown in Figure 1 and Figure 2 respectively.

Note: Aerial used in Figure 2 Site Layout was taken 5 January 2018.

[1] On 1 September 2017, Yancoal Australia Ltd acquired Rio Tinto's interest in Coal & Allied Industries Limited.

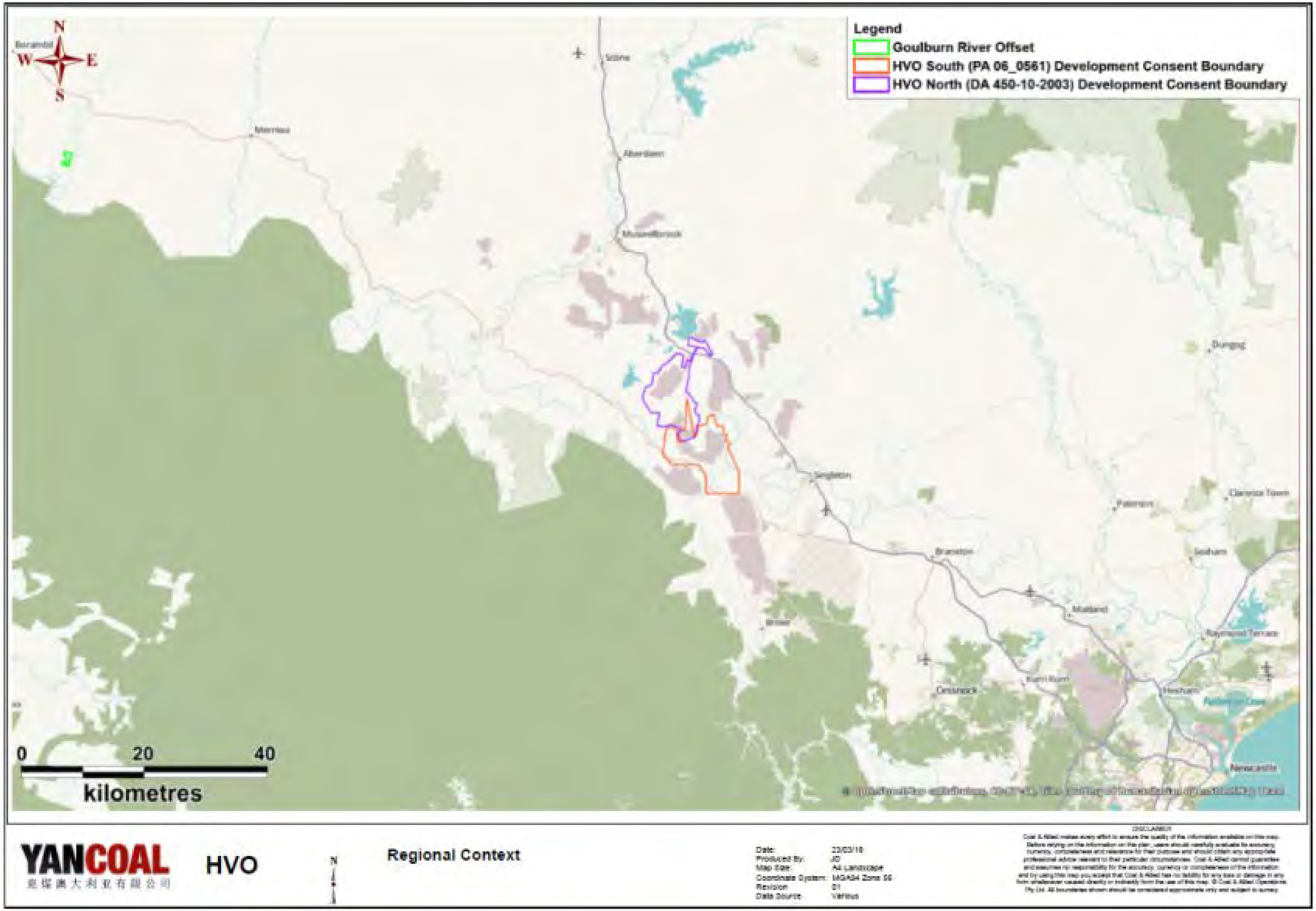


Figure 1: Regional Context

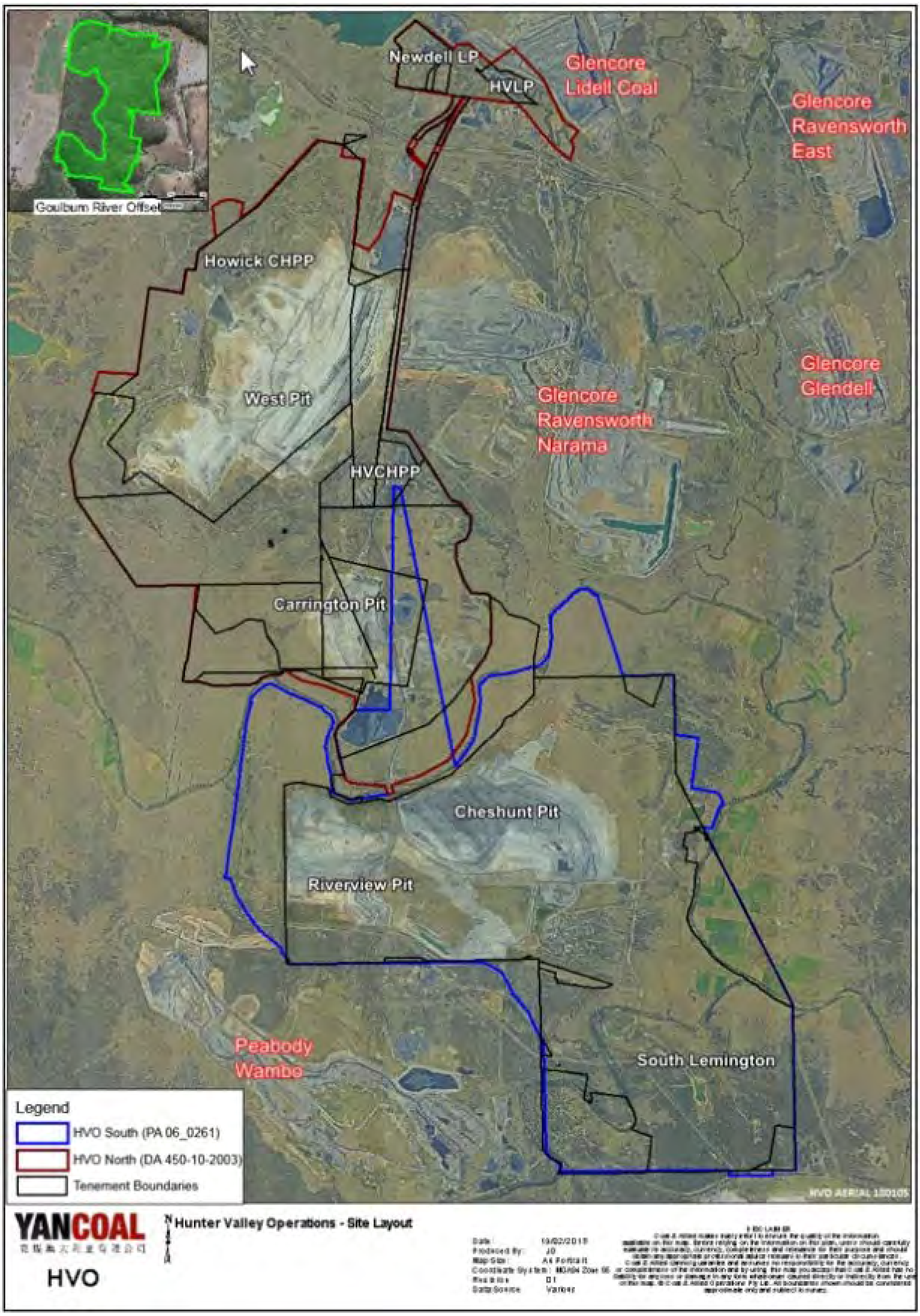


Figure 2: Hunter Valley Operations - Site Layout

2.3 Mine Contacts

Jason McCallum **General Manager – HVO**

Phone 02 6570 0228

Email: Jason.McCallum@yancoal.com.au

Andrew Speechly **Manager – Environment & Community NSW**

Phone 02 6570 0497

Email: Andrew.speechly@hvo.com.au

3 APPROVALS

3.1 Approvals, Leases and Licenses

3.1.1 Current Approvals

The status of HVO development consents, licenses and relevant approvals are listed in the following tables:

- Table 3: HVO Major Approvals;
- Table 4: Summary of Mining Tenements;
- Table 5: HVO Leases and Permits;
- Table 6: Water Related Approvals; and
- Table 7: Water Access Licence.

Table 3: HVO Major Approvals

Approval Number	Description	Issue Date	Expiry Date
HVO North DA 450-10-2003 MOD 7	HVO West Pit Extension & Minor Modifications (2003); and associated modifications. Covers West Pit (approved production limit of 12mtpa), Carrington Pit (approved production limit of 10mtpa), HVCHPP (approved processing limit of 20mtpa) and WCHPP (approved processing limit of 6mtpa).	12/06/2004	12/06/2025
HVO South PA 06_0261 MOD 4	Hunter Valley Operations – South Coal Project & associated modifications Covers Riverview Pit, Cheshunt, Deep Cheshunt, and Lemington South, with a combined production limit of 16mtpa.	24/03/2009	24/03/2030

Table 4: Summary of Mining Tenements

Title	Mining Tenement	Purpose	Grant Date	Expiry Date	Status
AUTH 72	Authorisation	Prospecting	08/03/1977	24/03/2018	Granted
EL 5291	Exploration Licence	Prospecting	28/04/1997	28/04/2018	Granted
EL 5292	Exploration Licence	Prospecting	28/04/1997	28/04/2020	Granted
EL 5417	Exploration Licence	Prospecting	23/12/1997	08/05/2018	Granted
EL 5418	Exploration Licence	Prospecting	23/12/1997	08/05/2017	Renewal Pending
EL 5606	Exploration Licence	Prospecting	11/08/1999	10/08/2019	Granted
EL 8175	Exploration Licence	Prospecting	23/09/2013	22/09/2018	Granted
(Part) CCL 708	Sub-Lease	Prospecting and Mining Coal	17/05/1990	29/12/2023	Granted

Title	Mining Tenement	Purpose	Grant Date	Expiry Date	Status
CCL 714	Consolidated Coal Lease	Prospecting and Mining Coal	23/05/1990	30/08/2030	Granted
CCL 755	Consolidated Coal Lease	Prospecting and Mining Coal	24/01/1990	05/03/2030	Granted
CL 327	Coal Lease	Prospecting and Mining Coal	06/03/1989	05/03/2031	Granted
CL 359	Coal Lease	Prospecting and Mining Coal	21/05/1990	20/05/2032	Granted
CL 360	Coal Lease	Prospecting and Mining Coal	29/05/1990	28/05/2032	Granted
CL 398	Coal Lease	Prospecting and Mining Coal	04/06/1992	03/06/2034	Granted
CL 584	Coal Lease	Prospecting and Mining Coal	01/01/1982	31/12/2023	Granted
CML 4	Consolidated Mining Lease	Prospecting and Mining Coal	02/03/1993	03/06/2033	Granted
ML 1324	Mining Lease	Prospecting and Mining Coal	19/08/1993	18/08/2014	Renewal Pending
ML 1337	Mining Lease	Prospecting and Mining Coal	01/02/1994	09/09/2014	Renewal Pending
ML 1359	Mining Lease	Prospecting and Mining Coal	01/11/1994	31/10/2015	Renewal Pending
ML 1406	Mining Lease	Prospecting and Mining Coal	27/02/1997	10/02/2027	Granted
ML 1428	Mining Lease	Prospecting and Mining Coal	15/04/1998	14/04/2019	Granted
ML 1465	Mining Lease	Prospecting and Mining Coal	21/02/2000	20/02/2021	Granted
ML 1474	Mining Lease	Prospecting and Mining Coal	24/11/2000	23/11/2021	Granted
ML 1482	Mining Lease	Prospecting and Mining Coal	19/03/2001	14/04/2019	Granted

Title	Mining Tenement	Purpose	Grant Date	Expiry Date	Status
ML 1500	Mining Lease	Prospecting and Mining Coal	21/12/2001	20/12/2022	Granted
ML 1526	Mining Lease	Prospecting and Mining Coal	03/12/2002	02/12/2023	Granted (Transfer registered on 2nd December 2015)
ML 1560	Mining Lease	Prospecting and Mining Coal	28/01/2005	27/01/2026	Granted
ML 1589	Mining Lease	Prospecting and Mining Coal	02/11/2006	01/11/2027	Granted
ML 1622	Mining Lease	Prospecting and Mining Coal	22/10/2010	10/03/2027	Granted
ML 1634	Mining Lease	Prospecting and Mining Coal	31/07/2009	30/07/2030	Granted
ML 1682	Mining Lease	Prospecting and Mining Coal	16/12/2012	15/12/2033	Granted
ML 1704	Mining Lease	Mining Purposes	05/12/2014	04/12/2035	Granted
ML 1705	Mining Lease	Prospecting and Mining Coal	17/12/2014	16/12/2035	Granted
ML 1706	Mining Lease	Mining Purposes	09/12/2014	08/12/2035	Granted
ML 1707	Mining Lease	Prospecting and Mining Coal	09/12/2014	08/12/2035	Granted
ML 1710	Mining Lease	Prospecting and Mining Coal	22/12/2016	10/03/2027	Granted (Part Transfer registered 22nd December 2016)
ML 1732	Mining Lease	Mining Purposes	06/04/2016	05/04/2037	Granted
ML 1734	Mining Lease	Mining Purposes	06/04/2016	05/04/2037	Granted
ML 1748	Mining Lease	Mining Purposes	05/12/2016	04/12/2037	
ML 1753	Mining Lease	Mining Purposes	19/04/2017	1 18/04/2038	Granted
ALA 52	Assessment Lease Application	Prospecting	Mining Lease Application lodged 10th September 2012		Offer of Grant – Pending Determination

Title	Mining Tenement	Purpose	Grant Date	Expiry Date	Status
ALA 58	Assessment Lease Application	Prospecting	Mining Lease Application lodged 1st December 2016		Application Pending
ALA 59	Assessment Lease Application	Prospecting	Mining Lease Application lodged 1st December 2016		Application Pending
ELA 5525	Exploration Licence Application	Prospecting	Exploration Licence Application lodged 3rd July 2017		Application Pending
ELA 5526	Exploration Licence Application	Prospecting	Exploration Licence Application lodged 3rd July 2017		Application Pending
ELA 5527	Exploration Licence Application	Prospecting	Exploration Licence Application lodged 3rd July 2017		Application Pending
MLA 489	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 10th March 2015		Application Pending
MLA 495	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 12th May 2015		Application Pending
MLA 496	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 12th May 2015		Application Pending
MLA 520	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 23rd December 2015		Application Pending
MLA 534	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 28th October 2016		Application Pending
MLA 535	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 28th October 2016		Application Pending
MLA 542	Mining Lease Application	Ancillary Mining Activities (Mining Purposes)	Mining Lease Application lodged 27th July 2017		Application Pending
MLA 543	Mining Lease Application	Ancillary Mining Activities (Mining Purposes)	Mining Lease Application lodged 27th July 2017		Application Pending

Table 5: HVO Leases and Permits

Licence No.	Description	Authority	Expiry Date
Environment Protection Licence			
EPL 640	Environment Protection Licence	EPA	N/A
Dangerous Goods / Explosives			
RR12709	Licence to Store	Workcover	06/7/2022
Radiation Licence			
RML5085293	Radiation Management Licence	EPA	14/11/2018
Aboriginal Heritage Permits			

Licence No.	Description	Authority	Expiry Date
C0001890	Care Agreement	OEH	3/06/2036
C0002193	Aboriginal Heritage impact Permit	OEH	6/12/2026
Road Closure Permits			
538338	Road Occupancy Licences– Golden Highway	RMS	29/06/2018
	Road Closure Approval Lemington Road	Singleton Council	30/06/2018

Table 6: Water Related Approvals

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL030566	Bore	Well	Part 5 Water Act 1912	East Open Cut	Perpetuity
20BL141584	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Carrington Work Licence	Perpetuity
20BL166637	Bore	Monitoring Bore	Part 5 Water Act 1912	No Current Bores	Perpetuity
20BL167860	Bore	Excavation - Mining	Part 5 Water Act 1912	HVO North – Carrington Pit	11/05/2020
20BL168820	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: CGW39, CGW45a, CGW46,CGW47, CGW47a, CGW48, CGW49, P50/38.5, ,CGW56, 4036C, 4035P, 4032P, 4034P, 4033P, 4053P, 4052P, 4051C, 4040P, 4038C, 4037P Destroyed:CGW7,CGW50, CGW57, CGW58, CGW59, CGW60, CGW61, CGW62, CGW63	Perpetuity
20BL169241	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: DM1, HF3, HF7 Destroyed DM2	Perpetuity

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL169641	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: CGW5, CGW51A, CGW52, CGW53, CGW54, CGW55A, CGW53A, CGW52A, CGW54A, CGW6, CFW55, CFW57, CFW57A, CFW59, and CFW55R. Destroyed CGW1, CGW2, CGW3, CGW5, CGW8,CGW9, CGW10, CGW12, CGW13, CGW14, CGW30, CGW33, CGW34, CGW35, CGW36, CGW37, CGW38, CGW40, CGW41, CGW42, CGW43, CGW44, CFW56, CFW56A, CFW58	Perpetuity
20BL170496	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ10 (CHPZ 2A), BZ11 (CHPZ 3A), BZ18 (CHPZ 10A), BZ20 (CHPZ 12A), BZ21 (CHPZ 13D) , BZ21A (CHPZ 13A), BZ20A (CHPZ 12D), BZ11A (CHPZ 3D) Destroyed AP50/47.5, AQ52, AV50/56.5, AS50/62.5, AR55, Bunc 3, BZ25 (Bunc 12) , BZ23 (Bunc 14), BZ24 (Bunc 13),	Perpetuity
20BL170497	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ15 (CHPZ 7A), BZ16 (CHPZ 8D), BZ17 (CHPZ 9A), BZ19 (CHPZ 11A), BZ16A (CHPZ 8A), Bunc 46D Destroyed Bunc 39 (Shallow & Deep), Bunc 44D	Perpetuity
20BL170498	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ12 (CHPZ 4A), BZ13 (CHPZ 5A), BZ14, BZ9 (CHPZ 1A), BC1, BC1a, BZ8-1, BZ8-2, BZ8-3, HG1, HG2, HG2a, HG3, S4, S6, BZ22 (CHPZ14D), BZ22A (CHPZ 14A), BZ5-1, BZ5-2 Destroyed S2, S3, S9, S11	Perpetuity
20BL171423	Bore	Monitoring Bore	Part 5 Water Act 1912	E1.5	Perpetuity

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL171424	Bore	Monitoring Bore	Part 5 Water Act 1912	Destroyed GW9711	Perpetuity
20BL171425	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: GW9701, GW9710	Perpetuity
20BL171426	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: GW9702 Destroyed D2(WH236),	Perpetuity
20BL171427	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: C335, C630 (BFS)	Perpetuity
20BL171428	Bore	Monitoring Bore	Part 5 Water Act 1912	D807	Perpetuity
20BL171429	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: B925 (BFS), C122 (BFS), C122 (WDH)	Perpetuity
20BL171430	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C613 (BFS), C809 (GM/WDH)	Perpetuity
20BL171431	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: B631 (BFS), B631 (WDH)	Perpetuity
20BL171432	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C130 (AFSH1), C130 (ALL), C130(BFS), C130 (WDH)	Perpetuity
20BL171433	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bore B334 (BFS)	Perpetuity
20BL171434	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C317 (BFS), C317 (WDH)	Perpetuity
20BL171435	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ3-1, BZ3-2, BZ3-3	Perpetuity
20BL171436	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ4A(1), BZ4A(2), BZ4B	Perpetuity
20BL171437	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: WG1, WG2, WG3	Perpetuity
20BL171439	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: BRN, E012	Perpetuity
20BL171492	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: C1(WJ039), GW9704, North, GWAR981	Perpetuity
20BL171681	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: Bunc 45A, Bunc 45D	Perpetuity
20BL171725	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: B425 (WDH), BRS, C621 (BFS), C919 (ALL), D317 (BFS), D317(ALL), D317(WDH) Destroyed D420, D425, D621, PB02	Perpetuity

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL171726	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: SR002, SR003, SR004, SR005, SR006, SR007	Perpetuity
20BL171727	Bore	Monitoring Bore	Part 5 Water Act 1912	SR001	Perpetuity
20BL171728	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ2B, BZ1-1, BZ1-2, BZ1-3, BZ2-1, BZ2-2	Perpetuity
20BL171762	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C817, D010 (BFS), D214 (BFS), D406 (BFS) (AFS), D510 (BFS), PB01 (ALL), D510 (AFS), D010 (GM), D010 (WDH), D406 (BFS) (AFS), D612 (AFS), D612 (BFS)	Perpetuity
20BL171851	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North/South – Bores: HV2, PZ1CH200, PZ2CH400, PZ3CH800, 4118P, 4119P	Perpetuity
20BL171852	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – PZ4CH1380	Perpetuity
20BL171853	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – DM3	Perpetuity
20BL171854	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: DM5, PZ6CH2450	Perpetuity
20BL171855	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – PZ5CH1800	Perpetuity
20BL171856	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: HV6, HV3, DM6, HV2 (2), 4113P, 4114P. 4116P, 4117P	Perpetuity
20BL171857	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: HV4, HV4 (2) (GA3), GA3,	Perpetuity
20BL171858	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – DM4	Perpetuity
20BL171895	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – NPZ4	Perpetuity
20BL171896	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – NPZ2	Perpetuity
20BL171897	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – Bores: NPZ5, NPZ1	Perpetuity
20BL171898	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – NPZ3	Perpetuity
20BL173062	Bore	Monitoring Bore	Part 5 Water Act 1912	RC14	Perpetuity

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL173065	Bore	Monitoring Bore	Part 5 Water Act 1912	HQ11	Perpetuity
20BL173063	Bore	Monitoring Bore	Part 5 Water Act 1912	RC07, RC08	Perpetuity
20BL173064	Bore	Monitoring Bore	Part 5 Water Act 1912	RC06	Perpetuity
20BL173069	Bore	Monitoring Bore	Part 5 Water Act 1912	RC11	Perpetuity
20BL173392 (cancelled - replaced by WAL39798)	Bore	Dewatering Bore	Part 5 Water Act 1912	LUG Bore	N/A
20BL173589 (cancelled - replaced by WAL40462)	Bore	Dewatering Bore	Part 5 Water Act 1912	HVO North – DM7 Dewatering Bore	N/A
20BL173587 (cancelled - replaced by WAL40462)	Bore	Dewatering Bore	Part 5 Water Act 1912	HVO North – DM9 Dewatering Bore	N/A
20BL173588 (cancelled - replaced by WAL40462)	Bore	Dewatering Bore	Part 5 Water Act 1912	HVO North – DM8 Dewatering Bore	N/A
20BL173847 (cancelled - replaced by WAL40462)	Bore	Dewatering Bore	Part 5 Water Act 1912	WB15HVO01	N/A
20CA201247	Works Approval	Pumping Plant	Water Management Act 2000	Associated with WAL965	Perpetuity
20CA212713	Works Approval	Pumping Plant	Water Management Act 2000	Associated with WAL36190	30/05/2025
20FW213280	Flood Work Approval	Levee	Water Management Act 2000	HVO North Carrington Levee 5	21/09/2021
20FW213281 Formerly 20CW802613	Flood Work Approval	Levee	Water Management Act 2000	HVO South – Barry Levee	21/09/2027
20FW213277 Formerly 20CW802603	Flood Work Approval	Block Dam	Water Management Act 2000	HVO South – Hobden Gully Levee	21/09/2027
20FW213278 Formerly 20CW802604	Flood Work Approval	Levee	Water Management Act 2000	HVO North – North Pit Levee 3	21/09/2021

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20WA210991 (see WAL 18307) Formerly 20SL050903	Stream Diversion	Stream Diversion	Water Management Act 2000	HVO West – Parnells Creek Dam	09/01/2023
20WA211427 Formerly 20SL061290	Stream Diversion	Cutting (Diversion Drain)	Section 10 Water Act 1912	Pikes Gully Creek Stream Diversion	07/09/2023
20WA210984 (see WAL 18327) 20SL042746	Diversion Works	Industrial	Water Management Act 2000	HV Loading Point Pump Bayswater Creek	08/09/2022
20WA211428 20SL061594	Stream Diversion	Cutting (Diversion Drain)	Water Management Act 2000	HVO North – Carrington Stream Diversion	31/7/2022
20WA201238 (see WAL 962)	Diversion Works	Pumping Plant	Water Management Act 2000	HVCPP River Pump	16/03/2018- Application for renewal pending
20WA201257 (see WAL 970)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO South – LCPP River Pump	Perpetuity
20WA201338 (see WAL 1006)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO South – LCPP River Pump	Perpetuity
20WA201501 (see WAL 1070)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO South – LCPP River Pump	Perpetuity
20WA201685 (see WAL 13387)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO West – "Lake Liddell" Licence	Perpetuity

Table 7: Water Access Licence

Licence Number	Description	Water Source	Water Sharing Plan	Water Source – Management Zone	Approved Extraction (ML)*	Actual Extraction 2017 (ML)
WAL18070	Hunter Regulated River Alluvial Water Source	Hunter River Alluvium	Hunter Unregulated and Alluvial Water Sources WSP	D/S GLENNIES CREEK MANAGEMENT ZONE	184	0
WAL962	HVO North – HVCPP River Pump – Water Access Licence	Hunter River	Hunter Regulated River WSP	Zone 1b (Hunter River From Goulburn River Junction To Glennies Creek Junction)	3,165	39#

Licence Number	Description	Water Source	Water Sharing Plan	Water Source – Management Zone	Approved Extraction (ML)*	Actual Extraction 2017 (ML)
WAL969	HVO South – Former Riverview pump	Hunter River	Hunter Regulated River WSP	Zone 1b (Hunter River From Goulburn River Junction To Glennies Creek Junction)	39	0
WAL970	HVO South – LCPP River Pump – Water Access Licence	Hunter River	Hunter Regulated River WSP	Zone 2a (Hunter River From Glennies Creek Junction To Wollombi Brook Junction)	500	
WAL1006	HVO South – LCPP River Pump – Water Access Licence	Hunter River	Hunter Regulated River WSP	Zone 2a (Hunter River From Glennies Creek Junction To Wollombi Brook Junction)	500	0
WAL1070	HVO South - LCPP River Pump – Water Access Licence	Hunter River	Hunter Regulated River WSP	Zone 2a (Hunter River From Glennies Creek Junction To Wollombi Brook Junction)	500	0
WAL13387	Macquarie Generation Hunter River Pump Station	Hunter River	Hunter Regulated River WSP	Zone 1b (Hunter River From Goulburn River Junction To Glennies Creek Junction)	20	0
WAL 13391	HVO North – Alluvial Rehabilitation Irrigation.	Hunter River	Hunter Regulated River WSP	Zone 1b (Hunter River From Goulburn River Junction To Glennies Creek Junction	420	0
WAL18127	Carrington BB1	Hunter River Alluvium	Hunter Unregulated and Alluvial Water Sources WSP	Hunter Regulated River Alluvial Water Source – Upstream Glennies Creek management zone	383	306[#]
WAL18158	Ollenberry	Hunter River Alluvium	Hunter Unregulated and Alluvial Water Sources WSP	Hunter Regulated River Alluvial Water Source – Upstream Glennies Creek management zone	65	52[#]

Licence Number	Description	Water Source	Water Sharing Plan	Water Source – Management Zone	Approved Extraction (ML)*	Actual Extraction 2017 (ML)
WAL18307	HVO West – Parnells Creek Dam (Diversion Works Bywash)	Unregulated River	Hunter Unregulated and Alluvial Water Sources WSP	Jerrys Water Source; Jerrys Management Zone	500	0
WAL18327	HV Loading Point Pump Bayswater Creek (Diversion Works)	Unregulated River	Hunter Unregulated and Alluvial Water Sources WSP	Jerrys Water Source; Jerrys Management Zone	150	0
WAL23889	Greenleek	Wollombi Brook	Hunter Unregulated and Alluvial Water Sources WSP	Lower Wollombi Brook Water Source	144	0
WAL36190	HVO North, old farm bore	Hunter River Alluvium	Hunter Unregulated and Alluvial Water Sources WSP	Hunter Regulated River Alluvial Water Source – Jerrys Management Zone	120	0
WAL39798	Lemington Underground (LUG) Bore	Permian Coal Seams	North Coast Fractured and Porous Rock Groundwater Sources WSP (commenced 1/7/16)	Permian Coal Seams	1,800	901
WAL40462	HVO Pit Excavations / Alluvial Lands Bores (x4)	Permian Coal Seams	North Coast Fractured and Porous Rock Groundwater Sources WSP (commenced 1/7/16)	Permian Coal Seams	2,400	928#
WAL40463					180	
WAL40466					460	
TBA (20BL167860)	HVO North (Carrington Pit)	Permian Coal Seams	North Coast Fractured and Porous Rock Groundwater Sources WSP (commenced 1/7/16)	Permian Coal Seams	220	0
TBA (20BL170000)	HVO North – Pit Excavation	Permian Coal Seams	North Coast Fractured and Porous Rock Groundwater Sources WSP (commenced 1/7/16)	Permian Coal Seams	20	0

* Approved extraction limits are for a financial year.
# Passive take / groundwater inflows to pit.

3.1.2 Management Plans, Programmes and Strategies

Under the Project Approvals, HVO is required to develop and submit a range of environmental management plans for approval prior to implementation. Issued in 2009, the HVO South Coal Project Approval (PA06_0261) required submission of a number of monitoring programmes, strategies and some management plans, while the January 2013 modification to the HVO North Consent (DA 450-10-2003) contains a contemporary list of comprehensive management plan requirements. The approval of the modification to the HVO North Consent (Mod 6) in January 2017 and the Independent Environmental Audit triggered a review of all management plans. Updated plans were submitted to DP&E in 2017. Where possible, the HVO South conditions, commitments and obligations have been included in the Management Plans which have been submitted for HVO North, allowing for a single plan to detail management measures which will be employed across the site.

In addition to the triggered updates, all management plans have been submitted for approval to DP&E in 2017 with updated Yancoal branding. Once approved, management plans are made publically available via Yancoal's Insite website (https://insite.yancoal.com.au/). The status of these management plans is shown in Table 8 and Table 9.

Table 8: Management plans and Mining Operations Plans (MOPs) required for HVO North

Management Plan	Date Approved
HVO Water Management Plan	10/07/2015
HVO Bushfire Management Plan	23/06/2015
HVO Noise Management Plan	25/08/2015
HVO Blast Management Plan	4/04/2014
HVO Air Quality and Greenhouse Gas Management Plan	12/02/2014
Hunter Valley Operations / Mount Thorley Warkworth Environmental Management Strategy	3/02/2016
Rehabilitation Management Plan (addressed in MOP)	19/02/2016
Agricultural Lands Reinstatement Management Plan (addressed in MOP)	19/02/2016
Landscape and Rehabilitation Management Strategy (addressed in HVO North MOP)	19/02/2016
MOP - HVO North 2012-2018	19/02/2016
HVO River Red Gum Rehabilitation & Restoration Strategy	24/03/2010
HVO North Heritage Management Plan	12/02/2014
HVGC Amenity Management Plan	22/01/2013
HVO Greenhouse and Energy Efficiency Plan (Addressed in HVO Air Quality and Greenhouse Gas Management Plan)	12/02/2014
Fine Reject Management Strategy	Originally submitted 30/6/2015, revised version submitted 3-2-2016 capturing DRE and DPE comments. Approved by DRE 24/10/2016. Yet to receive correspondence from DPE.

Table 9: Management Plans and MOPs required for HVO South

Management Plan	Date Approved
HVO River Red Gum Rehabilitation & Restoration Strategy	24/03/2010
HVO South Aboriginal Cultural Heritage Management Plan	24/04/2010
HVGC Amenity Management Plan	22/01/2013
HVO Water Management Plan	10/07/2015
HVO South Aboriginal Cultural Heritage Management Plan	24/04/2010
HVO Bushfire Management Plan	23/06/2015
Noise Monitoring Programme (addressed in HVO Noise Management Plan)	25/08/2015
Blast Monitoring Programme (addressed in HVO Blast Management Plan)	4/04/2014
HVO Air Quality and Greenhouse Gas Management Plan	12/02/2014
Hunter Valley Operations / Mount Thorley Warkworth Environmental Management Strategy	3/02/2016
MOP - HVO South 2015-2018 (Incorporates: - **Landscape Management Plan** - **Rehabilitation and Biodiversity Management Plan** - **Mine Closure Plan** - **Final Voids Management Plan)**	30/11/2017
Rehabilitation and Biodiversity Management Plan (Offsets component)	26/06/2017- Goulburn River Biodiversity Area Management Plan

4 OPERATIONS SUMMARY

4.1 Mining

Areas to be mined are geologically modelled, a mine plan is formed and the relevant mining locations are surveyed prior to mining. Figure 3 illustrates the mining process. HVO have no active underground workings.

No changes were made to the mining method during the reporting period. Mining progress deviated slightly from the schedule of the MOPs as a result of normal variations in productivity and utilisation.

The mining equipment fleet employed to carry out mining operations at HVO is detailed in

Table 10, along with the fleet transformation from 2017 to 2018 predictions. Changes in the data appear in bold.

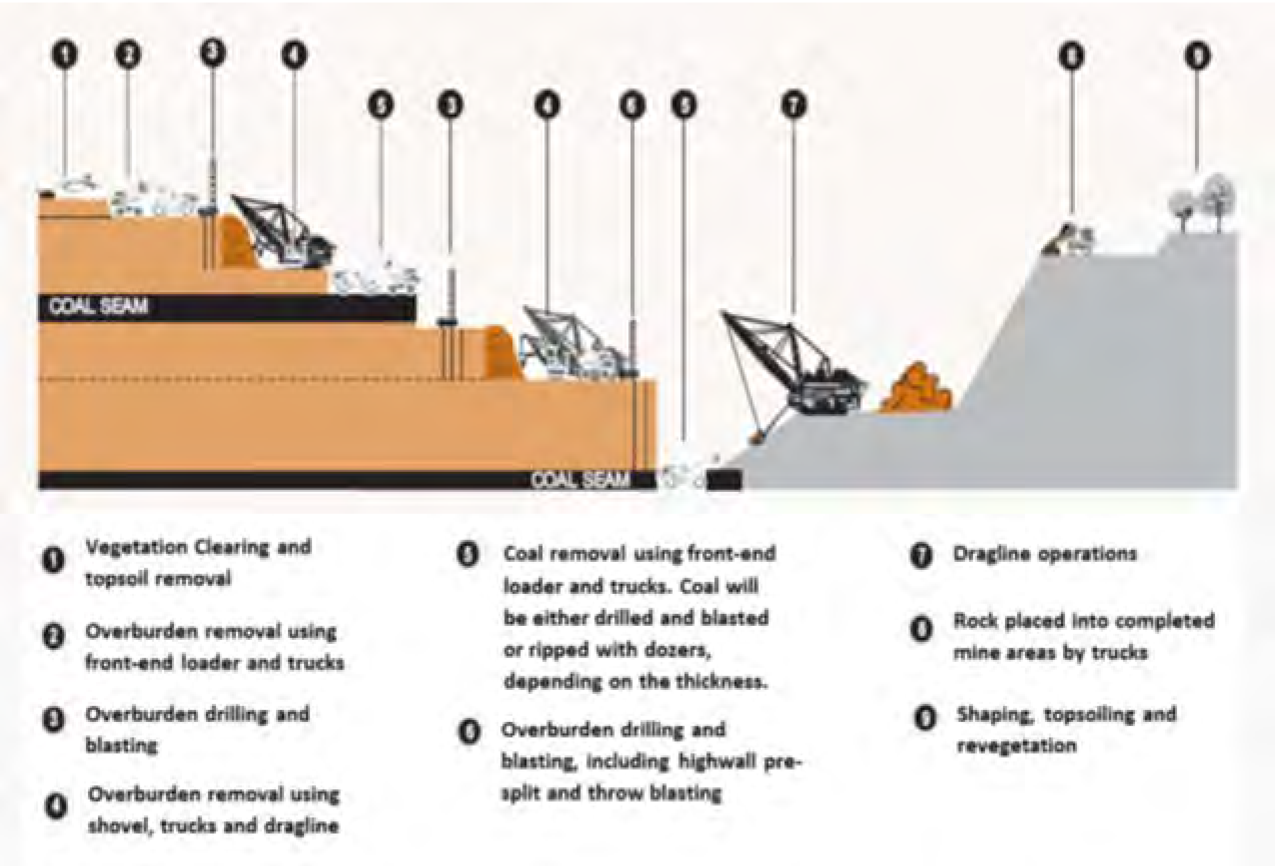


Figure 3: Open Cut Mining Schematic

Table 10: HVO Equipment Used 2016-2018

Equipment Type	Number Used in 2016	Number Used in 2017	Forecast numbers in 2018
Scrapers	2	2	2
Drills	8	8	8
Draglines	2	2	2
Shovels	3.5	3	3

Equipment Type	Number Used in 2016	Number Used in 2017	Forecast numbers in 2018
Excavators	7.5	9	8
Trucks	95	105	95
Loaders	7	7	6
Service Trucks	5	5	5
Track Dozers	33	33	30
Rubber Tyre Dozers	5	5	5
Graders	11	11	11
Surface Miner*	**0**	**0**	0
Water Trucks	10	10	10
Floats	1	1	1
Cable Reeler	1	1	1
Cable Tractors	5	5	5
Total	**196**	**206**	**192**

4.1.1 Mineral Processing

Coal is transported to one of two CHPPs, where it is crushed to size and processed to remove impurities. Processing produces saleable coal, along with coarse and fine reject materials. Coarse rejects are disposed of in pit, and fine rejects are placed in a tailings dam, according to commitments outlined in the MOP. Each CHPP site has storage facilities for processed (saleable) and unprocessed (ROM) coal. The capacity of each site is listed in Table 11. No changes or additions were made to process or facilities during the reporting period.

Table 11: Stockpile Capacities

Location	ROM stockpile(t)	Saleable stockpile (t)
Hunter Valley CHPP	176,000	29,700
West CHPP	15,000	30,000
Newdell CHPP	0	450,000

Processed, or product coal is transported to one of the two loading points via conveyor belt or road, detailed in Table 12. The coal from HVCHPP is transported to the Hunter Valley Load Point (HVLP) by means of overland conveyor whereas coal from West CHPP (Howick) is trucked to Newdell Load Point. After the coal has reached either HVLP or the Newdell Load Point, it is transported to Newcastle by rail.

Table 12: Methods of Coal Transportation

Category of Transport	Quantity (million tonnes)
Coal transported from the site via trains	14.7
Amount of coal received from Hunter Valley Operations South of the Hunter River	10.91
Amount of coal hauled by road to the Hunter Valley Loading Point	Nil

Coal hauled by road to the Newdell Load Point	1.5
Amount of coal hauled by road from the Newdell Loading Point to the Ravensworth Coal Terminal	Nil
Amount of coal hauled by road from the Hunter Valley Loading Point to the Ravensworth Coal Terminal	Nil
Number of coal haulage truck movements generated by the development. (includes - coal hauled to stockpile, coal hauled to bins, coal hauled from stockpile to bins)	51,630

4.1.2 Production statistics

Project approvals allow for the extraction of up to 22 million ROM tonnes from operations north of the Hunter River and 20 million ROM tonnes from operations south of the Hunter River. A summary of production and waste at HVO during 2017 in comparison to previous years and approval limits is provided in Table 13.

Product coal includes low-ash, semi-soft and steaming coals. During 2017, total product coal increased compared to 2016 production.

Table 13: Production Statistics and Correlating Project Approval Limits

	Approved Limit (PA 06_0261 and DA 450-10-2003)	Reporting Period 2017	Reporting Period 2016	Forecast for 2018
Prime Waste (Mbcm)	-	97.3	106.46	102.3
ROM Coal (Mtpa) (mined)	42	19.48	17.97	18.9
- HVO South	*20*	*13.42*	-	-
- West Pit	*12*	*6.04*	-	-
- Carrington Pit	*10*	*0.01*	-	-
Coarse Reject (Mt)	-	3.2	2.66	3.0
Fine Reject- Tailings (Mt)	-	1.6	1.62	1.8
Product (Mtpa)	-	14.8	13.69	14.0
ROM Coal Processed	26	19.59	17.2	18.9
- Hunter Valley CHPP	20	16.25	-	-
- Howick CHPP	6	3.33	-	-

4.1.3 Summary of Changes (developments, equipment upgrades)

Similar levels of production and equipment were used throughout 2017 to 2018. Older trucks were retired reducing truck numbers and excavators were replaced reducing overall equipment output. A small loader

(WA900) was parked up with west pit coal now completed using the mine fleet with excavators as opposed to a contract fleet with a small loader.

Coal extraction in Glider Pit, a satellite pit located to the east of Riverview Void, was completed in 2017. Dumping and rehabilitation in Glider Pit is to be completed in 2018.

Mining in the Carrington West Wing location has not yet commenced; at this time mining in this area will not commence in 2018.

5 ACTIONS REQUIRED FROM PREVIOUS ANNUAL REVIEW

The DRG conducted an annual inspection of HVO on the 31st August 2017 to review mining activities as reported in the 2016 Annual Environmental Review. The Department was satisfied with the contents of the report and provided no further feedback.

6 ENVIRONMENTAL PERFORMANCE

6.1 Meteorological Data

The collection of meteorological data is carried out to assist in day to day operational decisions, planning, environmental management and to maintain a historic record. The meteorological (weather) stations record wind speed, wind direction, temperature, humidity, solar radiation and rainfall. HVO operates two real time weather stations; the HVO Corporate Meteorological Station and the Cheshunt Meteorological Station. Data is publically available via the Monthly Environmental Reports published on the Yancoal Website (insite.yancoal.com.au).

6.2 Noise

6.2.1 Management

Mining activities are undertaken at HVO are managed to ensure adverse noise impacts are minimised, and to ensure compliance with permissible noise limits at nearby private residences. A combination of both proactive and reactive control mechanisms are employed to ensure effective management of noise.

6.2.2 Sound Attenuation of Heavy Equipment

During 2017, 18 haul trucks were retrofitted with full sound attenuation kits to achieve a sound power level of 115 dB(A). This is in addition to 28 trucks that have previously received Stage 1 noise attenuation, achieving a sound power level of 118 dB(A), making a total of 46 out of 95 trucks (48%) now sound attenuated.

In 2018, HVO is scheduled to complete fitment of a further 31 sound attenuation kits haul trucks with all the haul fleet to be sound attenuated by the end of 2019.

6.2.3 Real Time Noise Management

HVO operates a network of directional real-time noise monitors to ensure noise emissions remain within compliance limits and to minimise community impact.

During 2017, the HVO Mine Monitoring and Control Team received and responded to 885[2] noise alarms, recording a total of 181 hours of equipment stoppage due to noise management.

The real-time system generates alarms when elevated noise is measured, triggering the implementation of reactive controls to reduce noise levels. The location of real time and attended noise monitoring locations are shown in Figure 4.

During 2017, HVO commenced the installation of an Environmental Noise Compass in Maison Dieu, to further improve the real-time noise monitoring system surrounding HVO. HVO plans to commission and implement the use of this noise monitor in 2018.

[2] Noise alarm triggers are based on internally set noise criteria. Alarms received include noise exceedances from non-mine sources.

Figure 4: HVO Attended and Real-time Noise Monitoring Locations

6.2.4 Operational Noise Performance

To assess compliance with the relevant Project Approval noise criteria, HVO engages Global Acoustics to undertake routine compliance monitoring at nearby private residences, in accordance with the HVO Noise Management Plan. Monitoring is undertaken at a frequency of one night per month so as to ensure that noise impacts are adequately assessed under a range of meteorological conditions throughout the year.

A total of 100 measurements were taken during 2017. Each measurement involves an assessment of HVO mine noise against the various L_{Aeq} and $L_{A1\ 1min}$ noise criteria in place under the HVO North and South Approvals (a total of 600 assessments). One measurement exceeded criteria but did not constitute a non-compliance as the issue was promptly addressed (within 75 minutes of detection, per approved Noise Management Plan). A summary of noise monitoring results are presented in Table 15. Noise measurements which exceeded criteria are detailed in Section 11.1. Full details for all noise assessments completed can be found in the Hunter Valley Operations Monthly Environmental Monitoring Report, published on the Yancoal Australia website (www.insite.yancoal.com.au).

6.2.5 Noise Non-compliances

See Section 11.1 of the report for non-compliance details.

6.2.6 Comparison to previous years' results

Table 14 and Table 15 show comparisons between the for 2017 L_{Aeq} attended noise monitoring results (maximum HVO contribution levels measured under applicable meteorological conditions) and the predictions made in the HVO West Pit Extension and Minor Modifications EIS (2003) and the HVO South Coal Project Environmental Assessment (2008).

Table 14: Comparison of 2017 noise monitoring results against previous years.

Year	Number of measurements	Number of measurements which exceeded allowable noise limits by 2dB or greater (under applicable meteorological conditions)*	Number of non-compliances*
2017	100	1	0
2016	109	2	0
2015	107	3	2
2014	75	2	0
2013	85	5	2
2012	75	4	1
2011	95	7	5
2010	114	7	2
2009	71	3	1

* The NSW Industrial Noise Policy (INP) allows for the measured result to be less than or equal to 2 dB above the applicable noise limit without constituting a non-compliance. Note: Where the measured result is greater than 2dB above the applicable noise limit, the site has 75 minutes to reduce noise levels below applicable noise limits before constituting a non-compliance. As of late October 2017, the NSW INP was superseded by the Noise Policy for Industry (NPfI), the requirements of this policy are yet to be embedded to HVO's Noise Management Plan which at the time of this report is before DP&E for approval.

Comparisons against the predicted noise levels in the HVO Carrington West Wing EA (2010) have not been made in this years' Annual Review, as this project has not commenced. Mining activity in the Carrington Pit area was limited to bulk dozer push on the eastern boundary of Carrington pit.

Comparisons against the predicted noise levels in the HVO West Pit Extension and Minor Modifications EIS (2003) have been made against the modelled scenario for Year 14 of the development (Table 5.2 of Part J – Hunter Valley Operations West Pit Extension and Minor Modifications Technical Reports Part 3) are shown in Table 15.

Comparison of measured results against the modelled predictions for Year 14 in the HVO West Pit EIS (2003) demonstrates noise levels equal to or lower than predicted at all monitoring locations, with the exception of the Kilburnie South monitoring location.

Table 15: Comparison of 2017 monitoring against HVO North (Year 14, West Pit EIS, 2003) - Night Period

Location	Units	EIS Prediction (INP)	2017 (max. measured $L_{Aeq\ 15min}$ under applicable met. conditions)
Knodlers Lane	dB(A)	27	Not Measureable
Maison Dieu	dB(A)	26	Not Measureable
Kilburnie South	dB(A)	34	36
Jerrys Plains	dB(A)	<35	35
Jerrys Plains East	dB(A)	38	31

Comparisons against the predicted noise levels in the HVO South Coal Project Environmental Assessment have been made against Mitigated Scenario C2 (indicative of mining operations in 2019), (Table 5.4 of Annexure H – Hunter Valley Operations South Coal Project Approval Environmental Assessment Report Volume 2).

Comparison of HVO South Pit area data measured through routine compliance assessment indicates noise lower than predicted levels for all receptors with the exception of Knodlers Lane and Maison Dieu.

Table 16: Comparison of 2017 noise monitoring results against previous years.

Location	Units	EIS Prediction (INP)	2017 (max. measured $L_{Aeq\ 15min}$ under applicable met. conditions)
Knodlers Lane	dB(A)	35	37
Maison Dieu	dB(A)	38	41
Shearers Lane	dB(A)	38	38
Kilburnie South	dB(A)	33	Not measurable
Jerrys Plains	dB(A)	28	28
Jerrys Plains East	dB(A)	32	31

6.3 Blasting

6.3.1 Blasting Management

The objective of blasting operations is to ensure that optimal fragmentation is obtained whilst minimising dust and fume generation, adhering to safety standards and conforming to approvals criteria for vibration and overpressure.

During 2017, HVO operated a blast monitoring network under Benchmark Monitoring's' Kaboom Blast Monitoring System. HVO achieved 100% blast data capture during 2017. Monitors are located at or in close proximity to nearby privately owned residences and function as regulatory compliance monitors as shown in Figure 5. These monitors are located at:

- Jerrys Plains Village;
- Warkworth;
- Maison Dieu;
- Moses Crossing; and
- Knodlers Lane

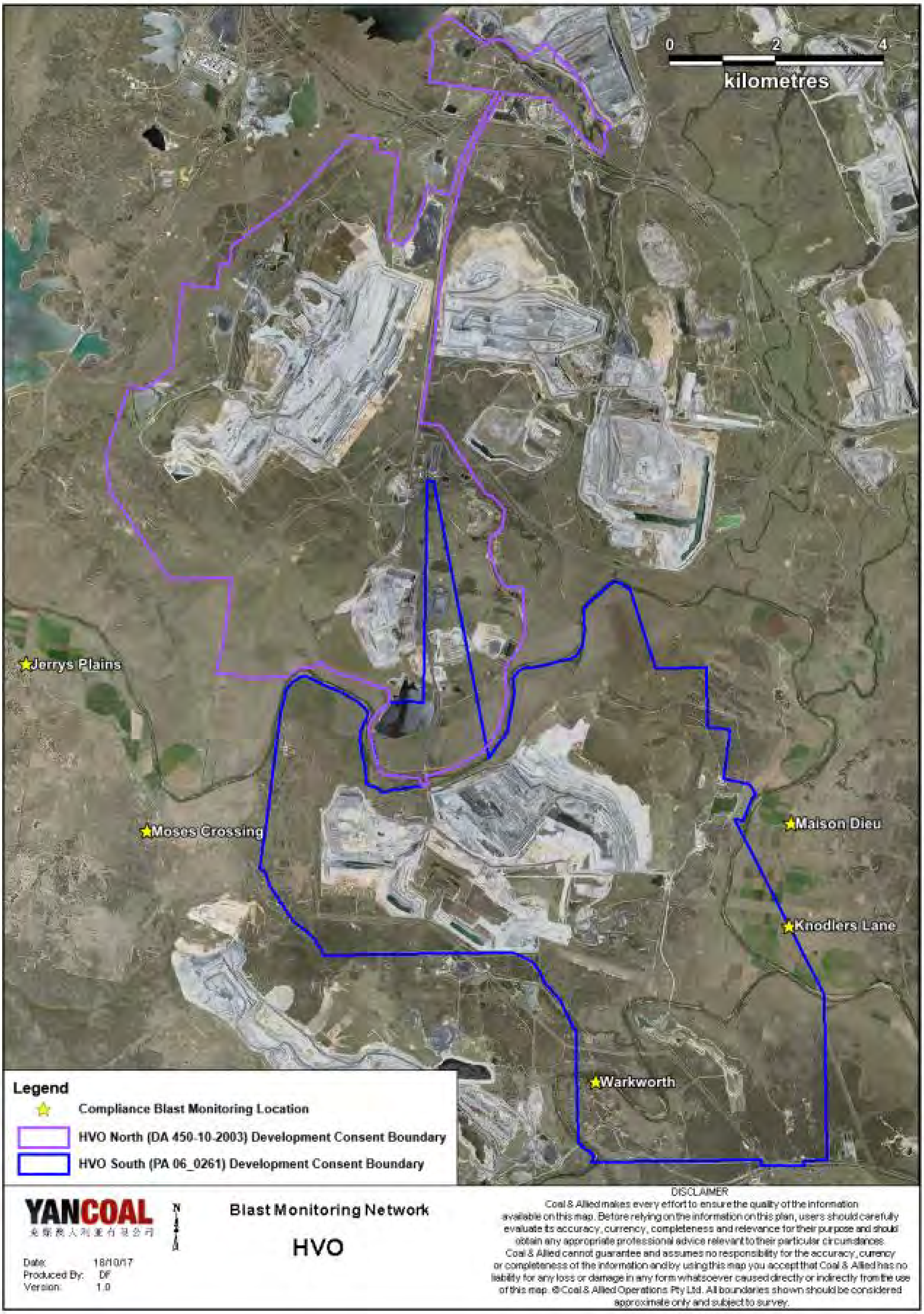


Figure 5: Blast Monitoring Network

6.3.2 Blasting Performance

During the reporting period 288 blast events were initiated at HVO. HVO complied with all blasting related consent and licence conditions. Airblast Overpressure and Ground Vibration results for all blasts fired during the reporting period are displayed in Figure 6 to Figure 10.

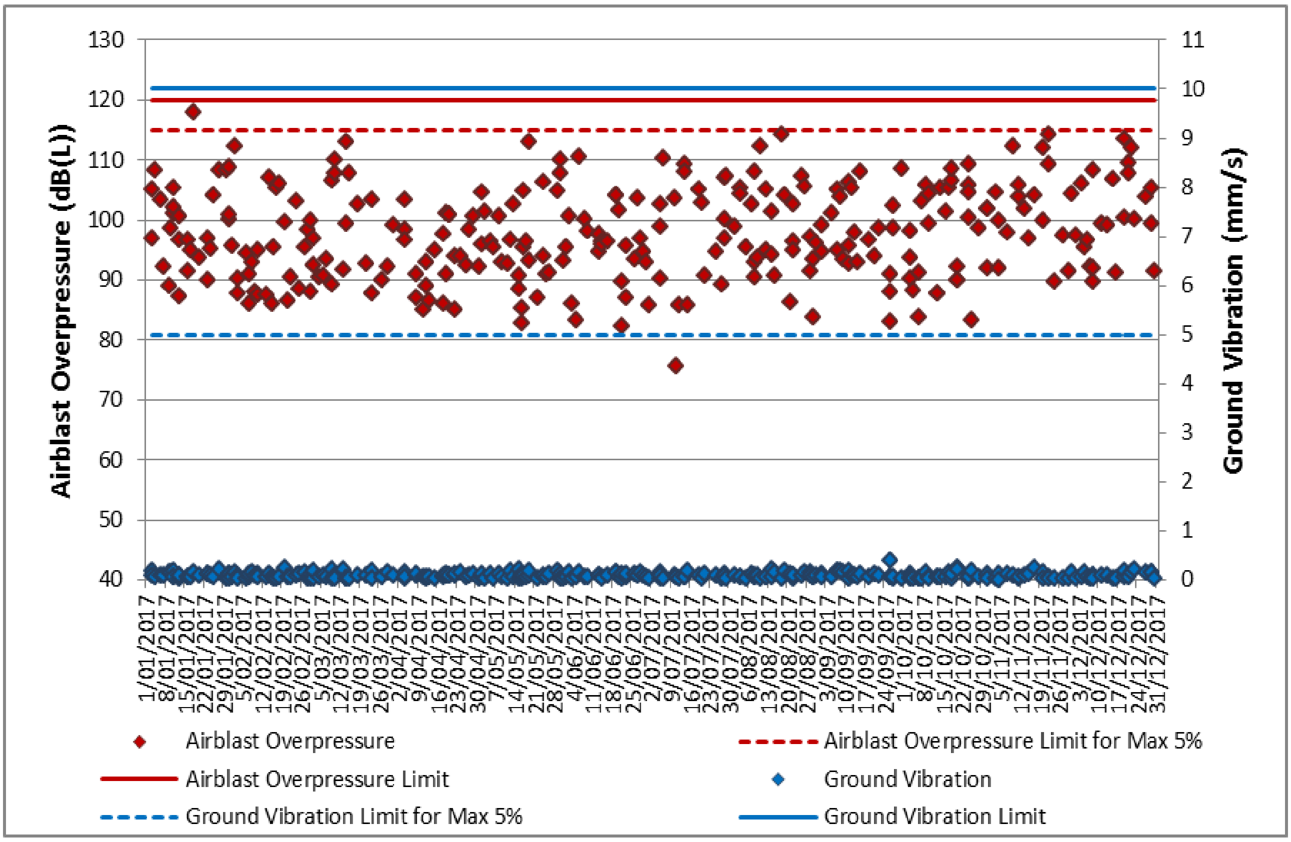


Figure 6: Jerrys Plains Blast Monitoring Results 2017

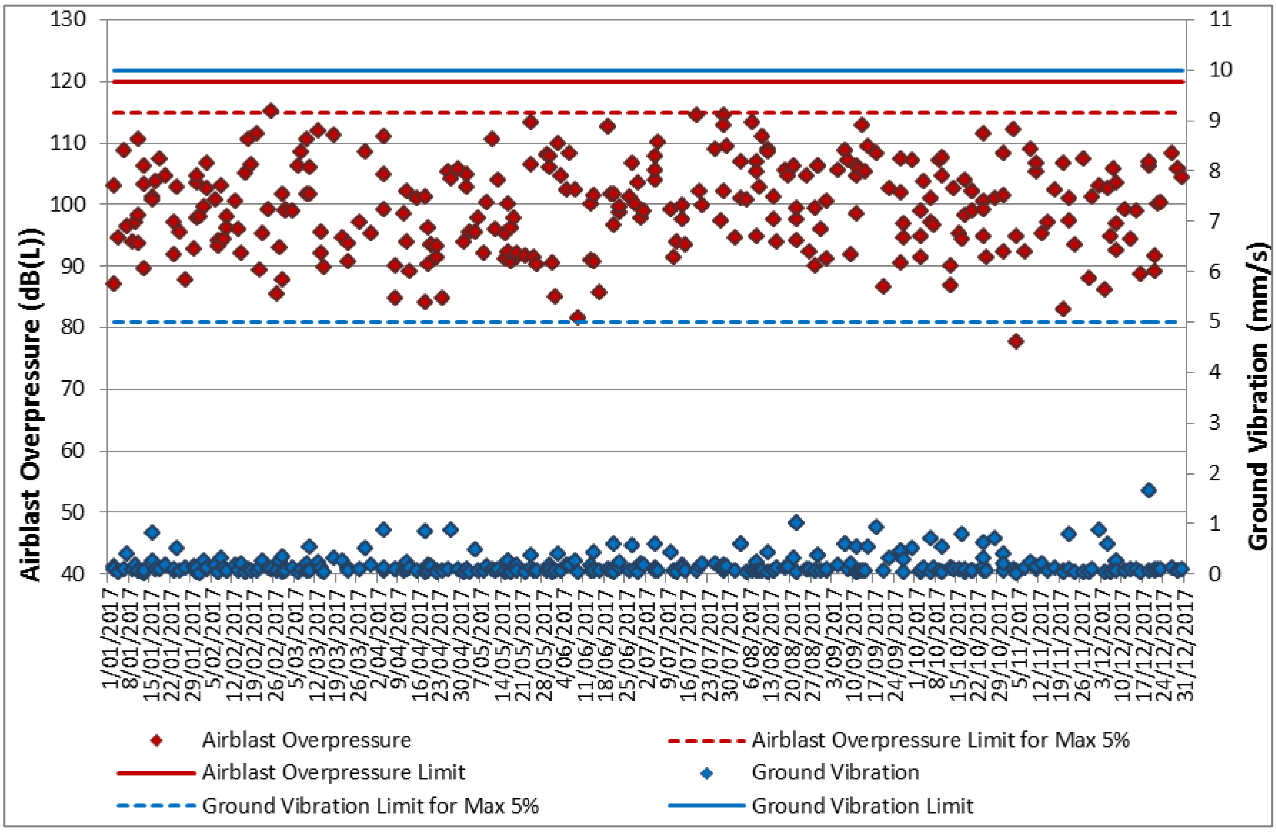


Figure 7: Knodlers Lane Blast Monitoring Results 2017

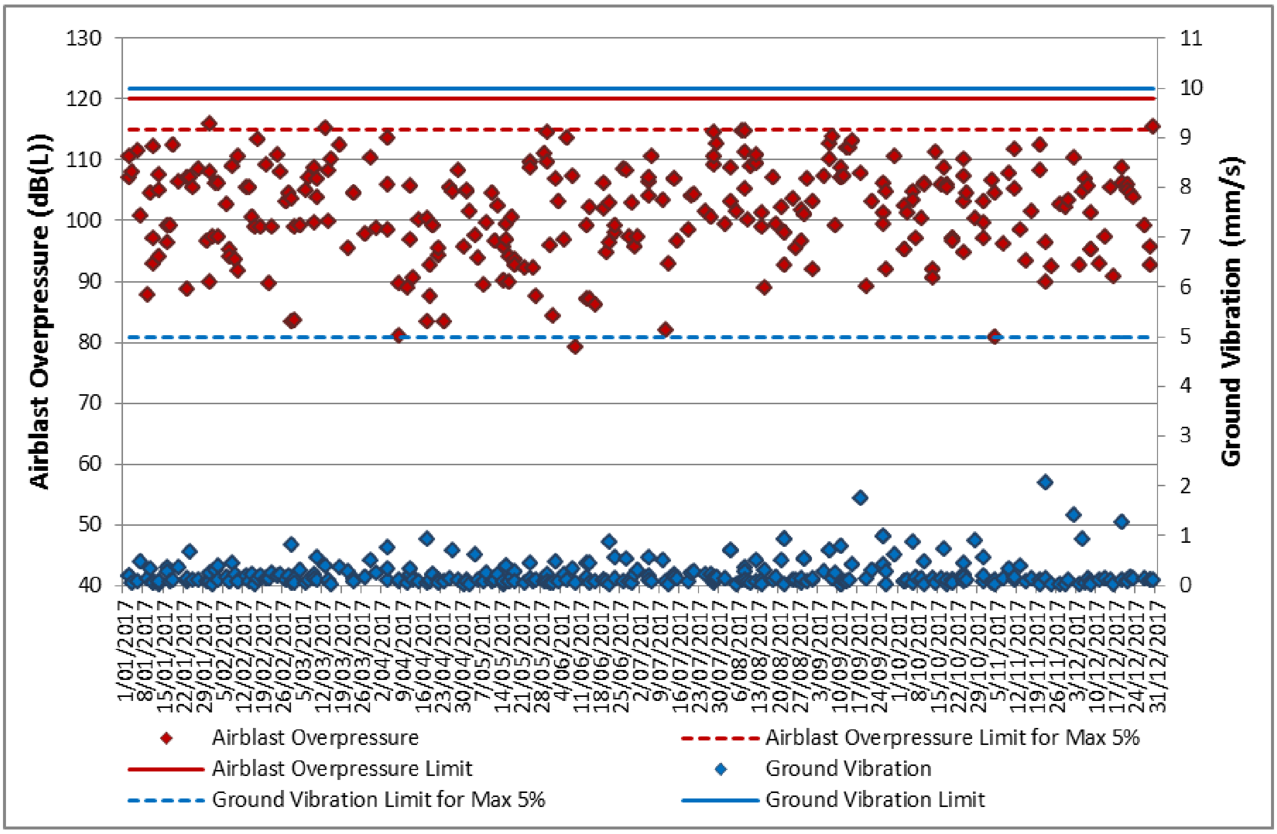


Figure 8: Maison Dieu Blast Monitoring Results 2017

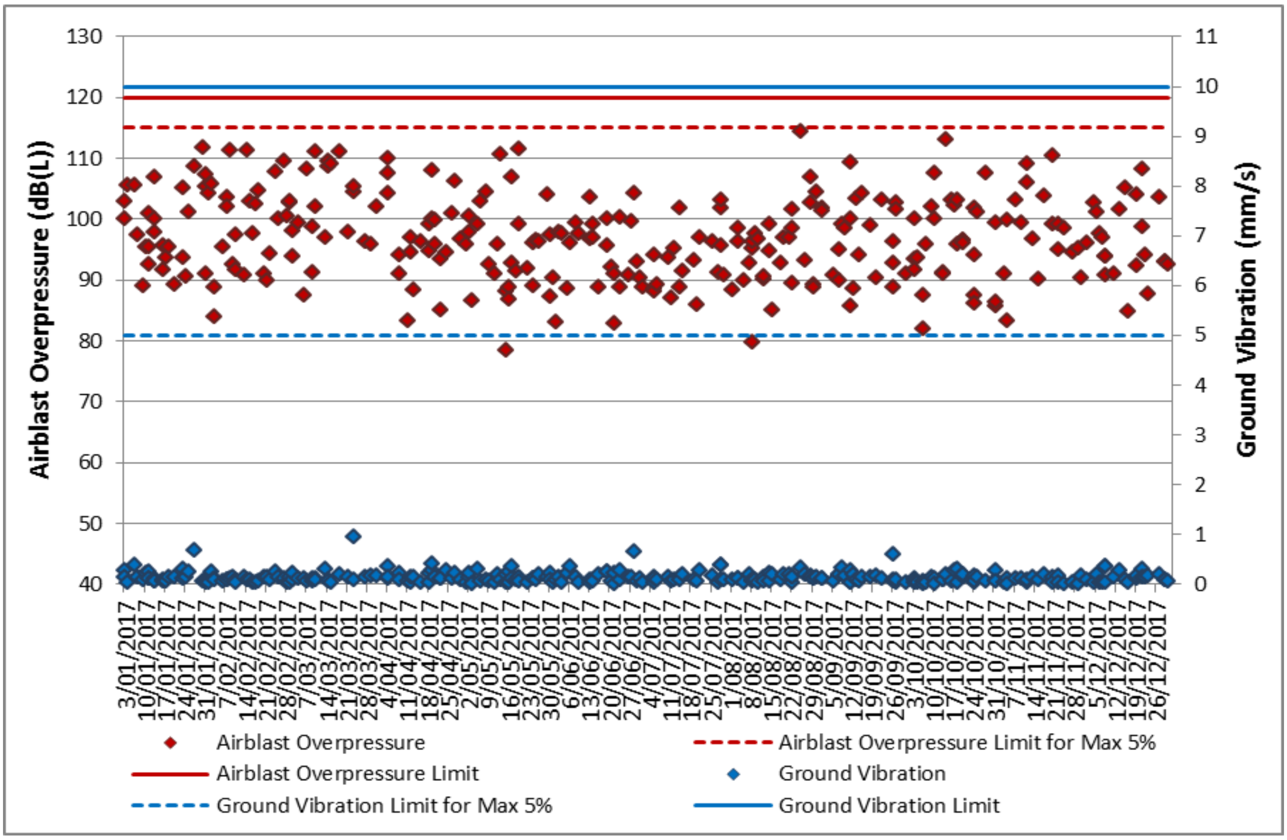


Figure 9: Moses Crossing Blast Monitoring Results 2017

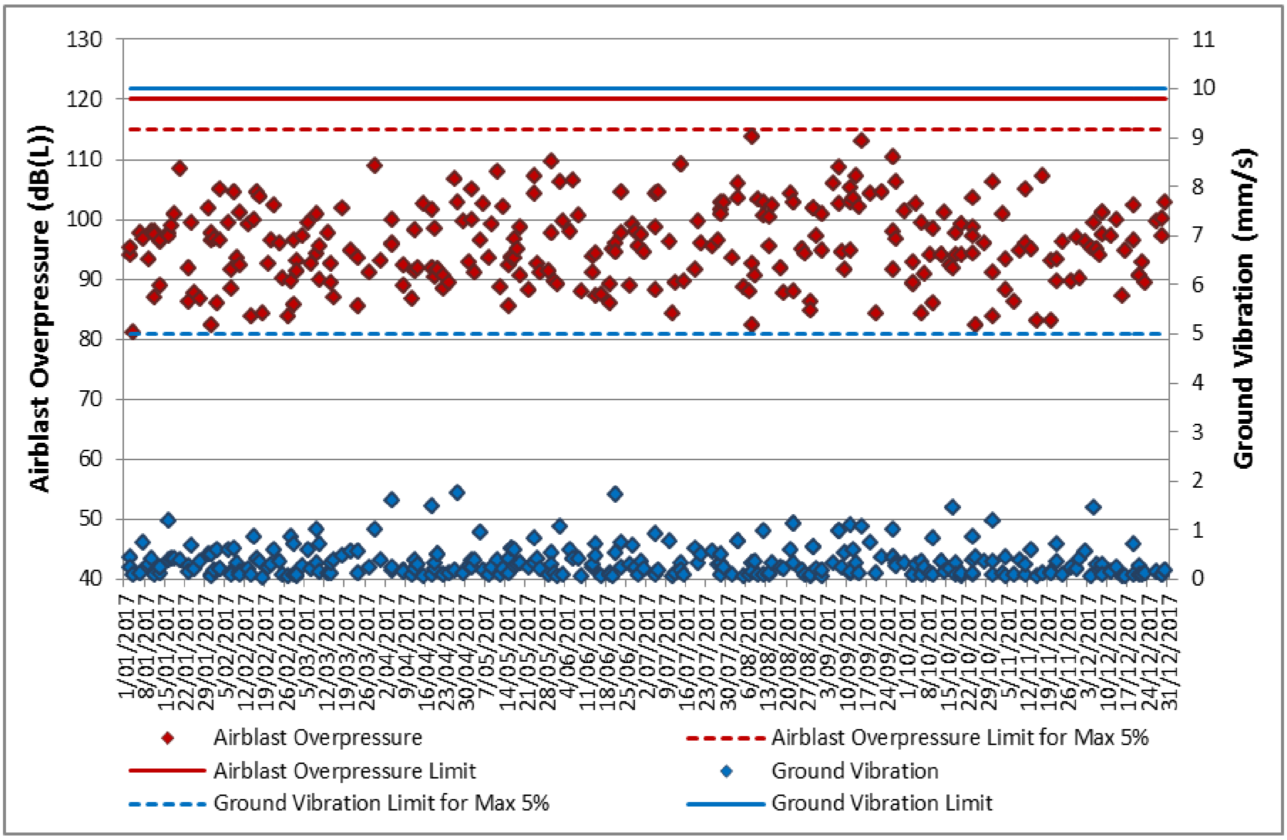


Figure 10: Warkworth Blast Monitoring Results 2017

6.3.3 Blast Fume Management

HVO operates a Post Blast Fume Generation Mitigation and Management Plan. This document outlines the practices to be utilised to reduce the risk of generation of post blast fume, and reduce potential offsite impact from any fume which may be produced. This includes specialised blasting design, appropriate product selection, on-bench water management, implementation of fume management zones and use existing blasting permissions to identify likely path of any fume which may be produced.

All blasts are observed for fume and any fume produced is ranked according to the Australian Explosive Industry & Safety Group (AEISG) Scale.

Fume rankings for shots fired during 2017 and comparison to previous years is provided in Table 17. Two blasts produced fume ranked as category 3 (AEISG scale) but did not leave the mine boundary. No fume ranked as category 4 and 5 occurred during 2017.

Table 17: Visible blast fume rankings according to the AEISG colour scale

AEISG Ranking	2017	2016	2015
0	272	275	310
1	39	49	37
2	11	13	17
3	2	1	1
4	0	0	1
5	0	0	0
Total*	**324**	**338**	**366**

* Where a number of individual blasts were fired as a blast event, fume was assessed for each individual blast pattern rather than for the event as a whole.

6.3.4 Blasting Non-compliances during the Reporting Period

During the reporting period there were no blasting related non-compliances.

6.4 Air Quality

6.4.1 Air Quality Management

Air quality management initiatives are implemented at HVO to ensure that:

- Air quality impacts on surrounding residents are minimised;
- All statutory requirements are adhered to; and
- Local community and regulators are kept informed through prompt and effective response to issues and complaints.

Air quality control mechanisms employed at HVO are described in detail in the Hunter Valley Operations Air Quality and Greenhouse Gas Management Plan, publically available via the Yancoal Australia Website (https://insite.yancoal.com.au).

6.4.2 Air Quality Performance

6.4.2.1 Real Time Air Quality Management

HVO's real time air quality monitoring stations continuously log information and transmit data to a central database, generating alarms when particulate matter levels exceed internal trigger limits.

A total of 750 real time alarms for air quality and wind conditions were received and acknowledged during 2017. In response, 8,584 hours of equipment downtime was recorded due to air quality management. A detailed breakdown of air quality related equipment stoppages (per month, per equipment type) presented in Figure 11 which shows that trucks experienced the greatest amount of downtime due to dust.

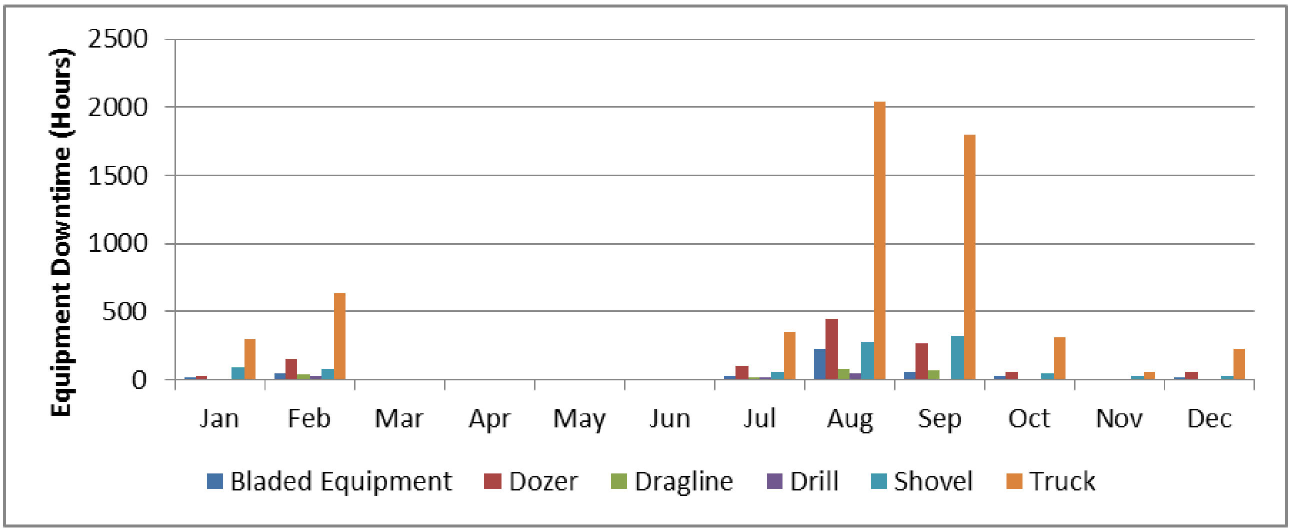


Figure 11: Equipment Downtime Hours for Air Quality Management 2017

6.4.2.2 Temporary Stabilisation

Aerial Seeding was undertaken in July 2017 by a fixed wing aircraft to provide temporary cover to areas exposed to wind generated dust and erosion at HVO. Waste dumps and exposed areas were selected for seeding if they were not planned to be disturbed within six months. The 214 ha of area seeded included waste dumps ahead of mining disturbance (Figure 12). All areas were seeded using an exotic pasture and legume mix suitable for autumn sowing. A starter fertiliser was mixed with the seed prior to loading to provide sufficient nutrients for plant growth.

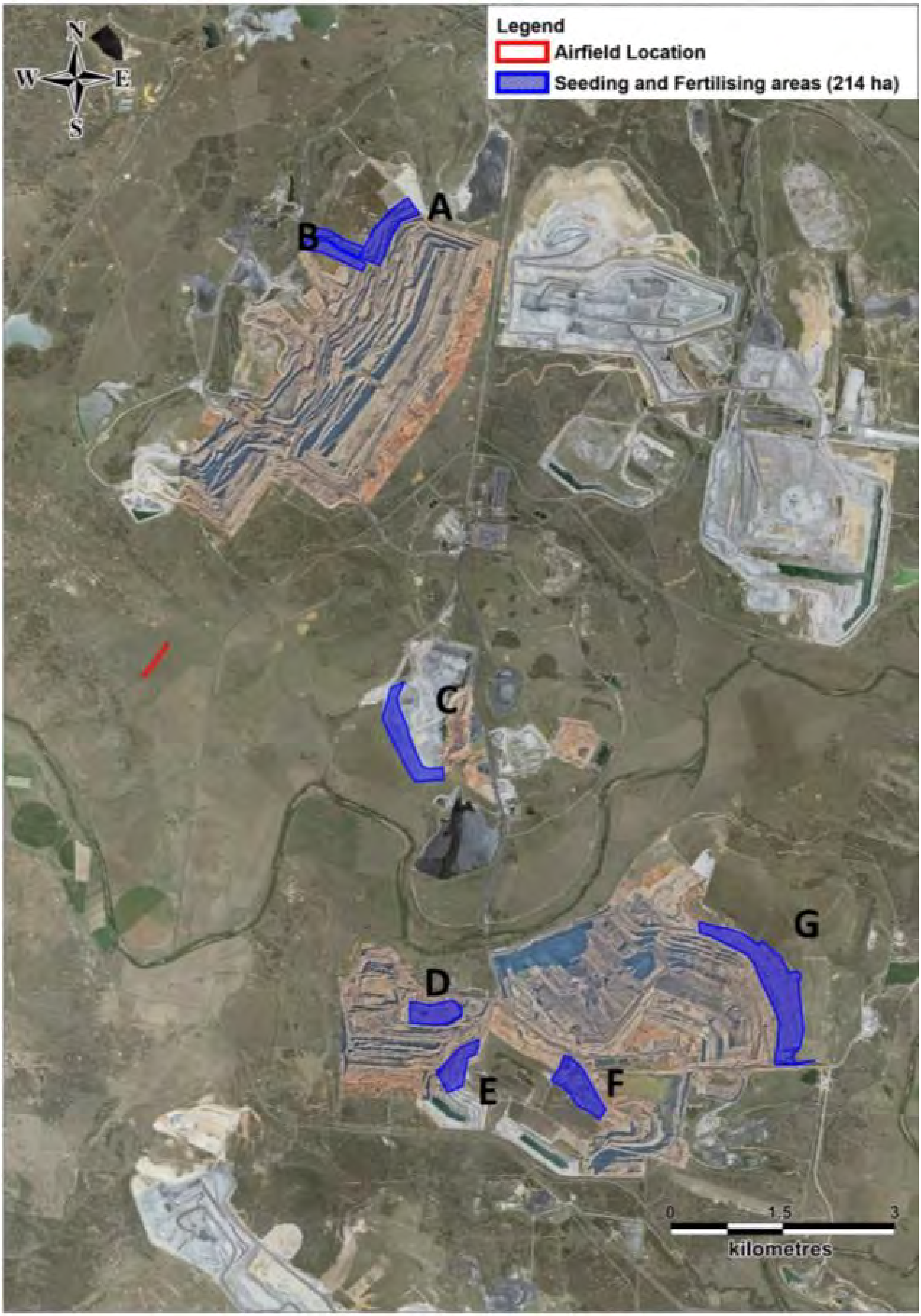


Figure 12: Areas Aerial Seeded in 2017

6.4.2.3 Air Quality Monitoring

Air quality monitoring at HVO is undertaken in accordance with the HVO Air Quality Monitoring Programme. An extensive network of monitoring equipment is utilised to assess performance against the relevant conditions of HVO's approvals. Air quality monitoring locations are shown in Figure 13. During 2017, HVO complied with all short term and annual average air quality criteria; refer to Table 18 and Table 19, along with a summary of HVO's performance against the criteria. HVO currently operates under two separate Planning Approvals (DA450-10-2003 – HVO North, and PA 06-0261 – HVO South). With the exception of the percentile frequency of short term PM_{10} non-compliance allowable under the HVO South Approval (Table 12 in Schedule 3, Condition 20 of PA 06_0261), the air quality criteria are identical in both approvals. As such it should be noted that the following compliance assessment has been undertaken on a 'whole of HVO site' basis, rather than individually assessing the contribution of each approval area to the measured results. Air quality monitoring data is made publically available through the HVO Monthly Environmental Monitoring Report, which can be viewed on the Yancoal Australia Website (insite.yancoal.com.au).

Table 18: Air quality impact assessment criteria and 2017 compliance assessment (HVO North DA 450-10-2003 and HVO South PA 06_0261)

Pollutant	Criterion	Averaging Period	Compliance
Deposited Dust	4 g/m^2/month	Maximum total deposited dust level	100%
	2 g/m^2/month	Maximum increase in deposited dust level	100%
Total Suspended Particulate matter (TSP)	90 µg/m^3	Long Term (Annual)	100%
Particulate matter <10µm (PM_{10})	30 µg/m^3	Long Term (Annual)	100%
	50 µg/m^3	Short Term (24 hour)	99.7%

Table 19: Air quality land acquisition criteria and 2017 compliance assessment (HVO North DA 450-10-2003 and HVO South PA 06_0261)

Pollutant	Criterion	Averaging Period	Compliance
Deposited Dust	4 g/m^2/month	Maximum total deposited dust level	100%
	2 g/m^2/month	Maximum increase in deposited dust level	100%
Total Suspended Particulate matter (TSP)	90 µg/m^3	Long Term (Annual)	100%
Particulate matter <10µm (PM_{10})	30 µg/m^3	Long Term (Annual)	100%
	150 µg/m^3 [a]	Short Term (24 hour)	100%
	50 µg/m^3 [b]	Short Term (24 hour)	100%

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

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

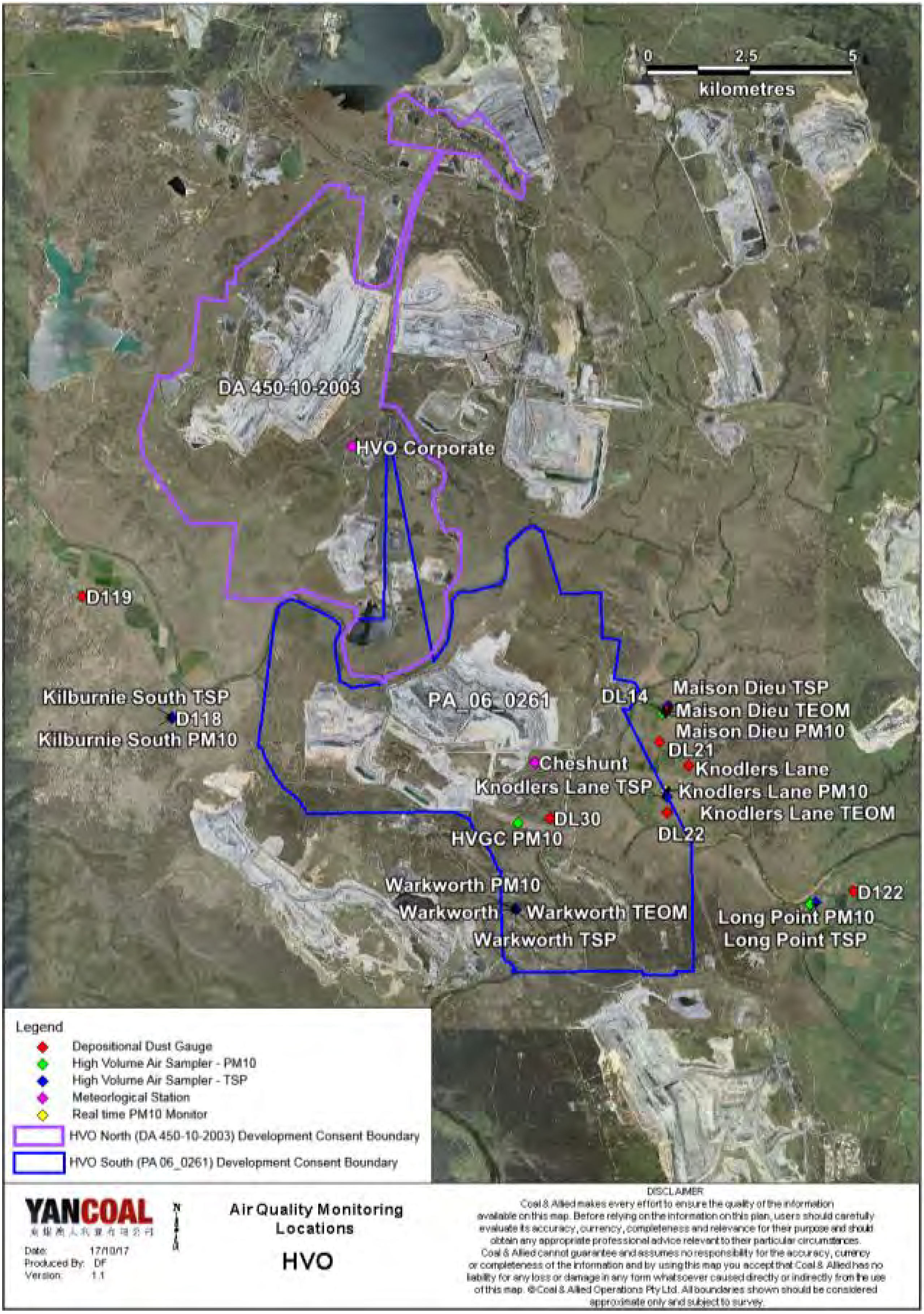


Figure 13: Air Quality Monitoring Locations

6.4.2.4 Deposited Dust

Deposited dust is monitored at nine locations on privately-owned land, in accordance with AS3580.10.1 (2003). The annual average insoluble matter deposition rates in 2017 compared with the depositional dust impact assessment criterion and previous years' data are shown in Figure 14.

During 2017 all annual average insoluble matter deposition rates were compliant with the long-term impact assessment and land acquisition criteria. All monitoring locations also demonstrated compliance with the maximum allowable insoluble solids increase criteria of 2 g/m^2/month (Figure 15).
There were two exceedances of the long term impact assessment criteria, for maximum total deposited dust level, recorded at DL30 and Warkworth monitoring locations. An external consultant was engaged to conduct an investigation which determined maximum HVO contribution to be not more than 2.4 g/m^2/month, or 59% of the total level of 4.1g/m^2/month at DW20A and also not more than 1.05 g/m^2/month or 25% of the total level of 4.2 g/m^2/month at Warkworth. As per HVO's approved Air Quality Management Plan, this does not constitute non-compliance and no further action is required.

During 2017 monthly dust deposition rates equal to or greater than the long-term impact assessment criteria of 4 g/m^2/month were recorded at number of sites. Where field observations denote a sample as contaminated (typically with insects, bird droppings or vegetation), the results are excluded from Annual Average compliance assessment. Meteorological conditions and the results of nearby monitors for the sampling period are also considered when determining HVO's level of contribution to any elevated result. Details of excluded results are presented in the relevant HVO Monthly Environmental Monitoring Report.

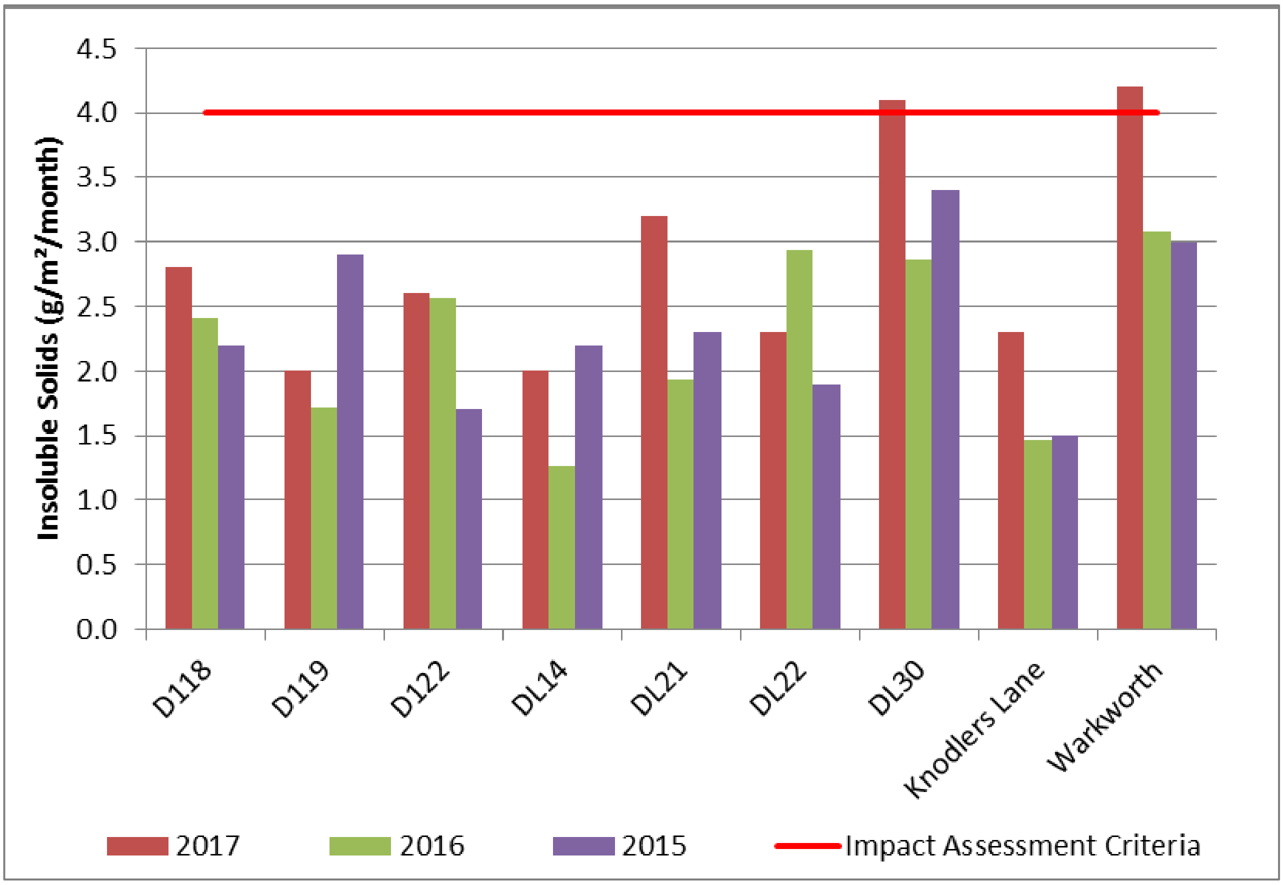


Figure 14: Annual average insoluble matter deposition rates 2015-2017

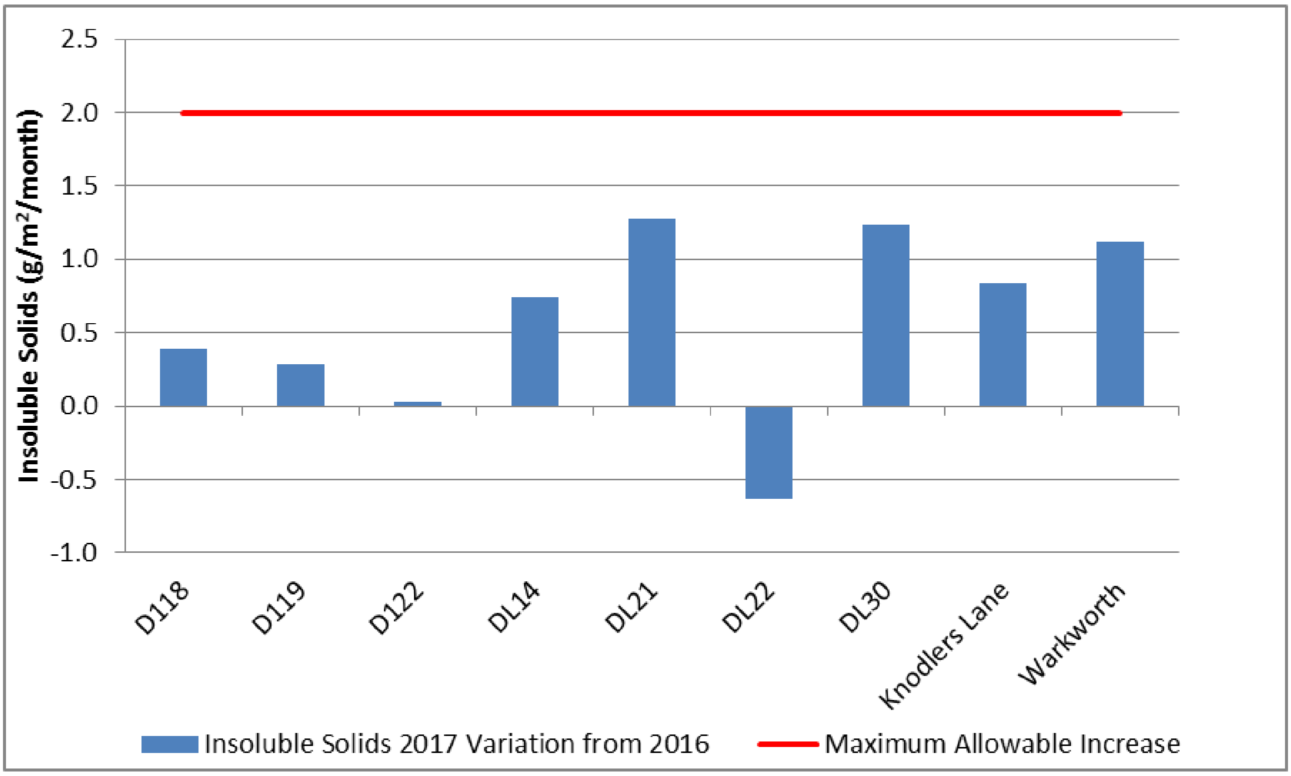


Figure 15: Annual average total insoluble solids variation, 2017 from 2016

6.4.2.5 Total Suspended Particulates (TSP)

Total Suspended Particulates (TSP) are measured at five locations on privately owned land in accordance with AS3580.9.3 (2015). Annual average TSP concentrations recorded in 2017 compared with the long term impact assessment criterion and previous years' data, are shown in
Figure 16: Annual average TSP concentrations 2015 to 2017
During 2017 all annual average results were compliant with the impact assessment and land acquisition criteria.
One high volume air sample exceeded the annual TSP impact assessment criteria during the reporting period. This was investigated to determine the level of contribution from HVO activities in accordance with the compliance protocol outlined in the HVO Air Quality Management Plan. The recorded exceedance was determined to be compliant with the relevant criteria. A summary of the investigation undertaken for the annual TSP exceedance is provided in Table 20.

Table 20: Annual TSP investigation - 2017

Date	Site	Annual Average PM_{10} result ($\mu g/m^3$)	Calculated Annual TSP ($\mu g/m^3$)	Discussion
2017	Long Point HVAS PM_{10}	95.3	86.9	An external consultant was engaged to investigate the exceedance, which determined that the result, excluding extraneous livestock dust impacted days (from livestock “immediately” adjacent to the monitor), is below the criterion of 90µg/m3. Inspections of the site indicated the influence of round yard/chicken coop/ bare ground in the direct vicinity of the HVAS units. Negotiations were held with the occupier to relocate this equipment. It is also noted that monitors on a similar wind axis, and closer to mining activity recorded significantly lower TSP levels on 2017. This indicates that the relatively high levels at this location (even when excluding periods with known livestock activity) are most likely to be significantly affected by the influence of local sources, rather than mining dust. This may for example include dust from the nearby dirt driveway, mowing activities, and dust stirred up by livestock in the general vicinity. As the measured result is not solely attributable to HVO, it does not constitute non-compliance, as per HVO’s approved Air Quality Management Plan and so no further action is required.

During the reporting period, 4 out of 300 TSP measurements were not able to be collected on the scheduled sampling date (based on a sampling frequency of every six days) due to power failures and technical issues with the monitors.

The annual average TSP concentrations recorded in 2017 are higher than those recorded in previous years (Figure 16), which are likely related to below average rainfall for the year.

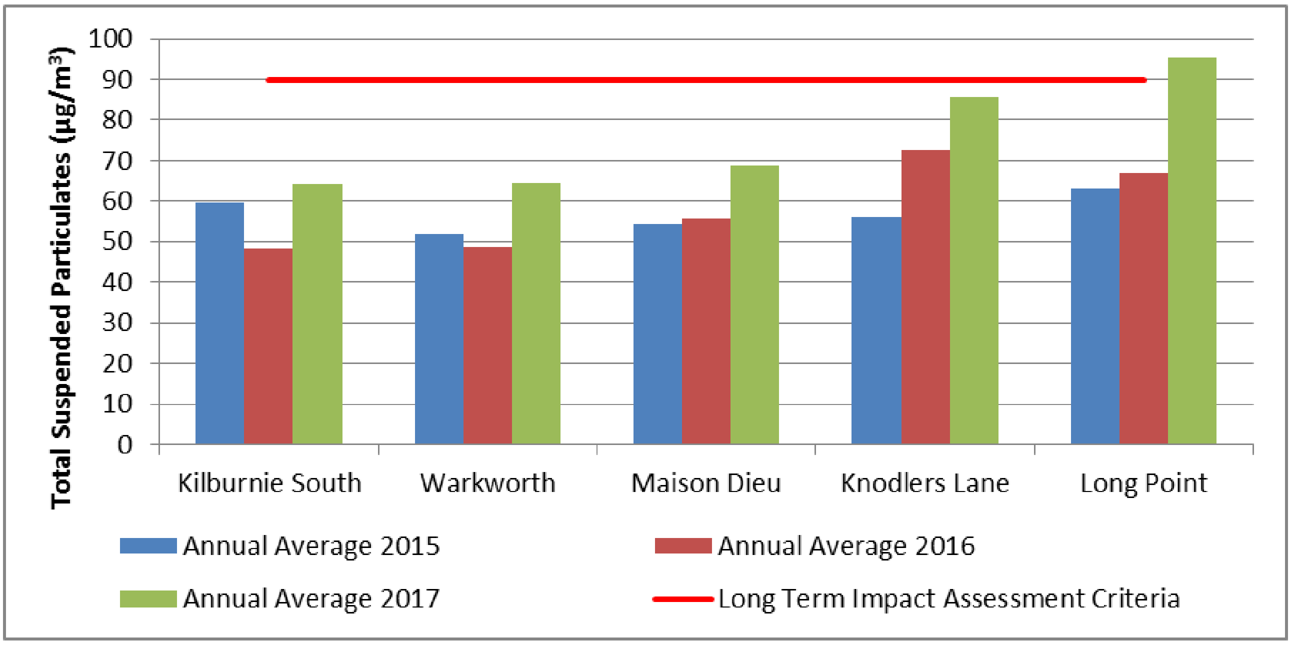


Figure 16: Annual average TSP concentrations 2015 to 2017

6.4.2.6 Particulate Matter <10µm (PM_{10})

Compliance assessment for Particulate Matter <10 µm (PM_{10}) is measured at six locations on privately owned land in accordance with AS3580.9.6 (2003). During 2017 all short term and annual average results were compliant with the impact assessment and land acquisition criteria.

Routine monitoring of PM_{10} at the Hunter Valley Glider Club (HVGC) commenced on 24th November 2014 in accordance with the HVGC Amenity Management Plan, and following consultation with the HVGC.

6.4.2.7 Short term PM_{10} impact assessment criteria

Monitoring results for 2017 PM_{10} (24 hr) collected through the High Volume Air Sampler monitoring regime compared against the short term impact assessment criteria are shown in Figure 17. All 24 hr average results recorded by HVO's surrounding network of TEOM monitors are presented on a quarterly basis in Figure 17 to Figure 21.

During 2017, 34 High Volume Air Sampler measurements and 24 TEOM PM_{10} measurements exceeded the 24 hr short term impact assessment criteria. Each was investigated to determine the level of contribution from HVO activities to the elevated result (Table 21). Where it was determined that HVO was non-compliant with relevant criteria, these results were reported to the Department of Planning and Environment and other stakeholders as required. Details of the non-compliance are included in Table 21 and Section 11.3

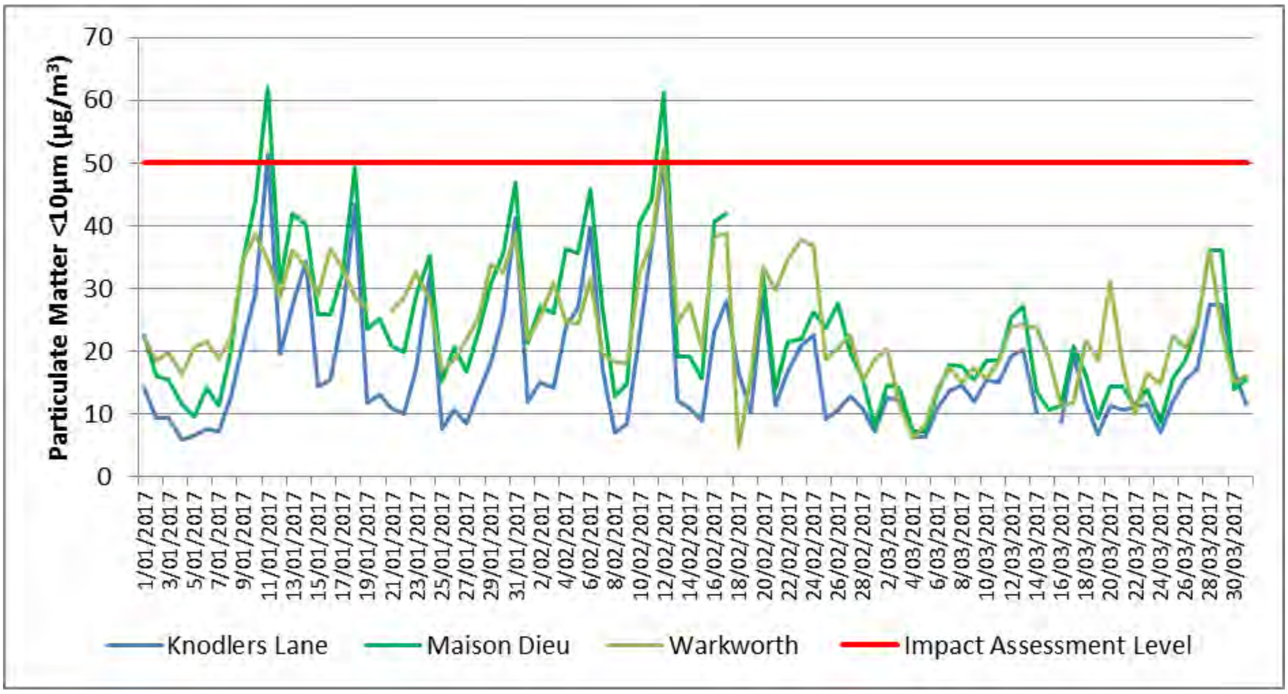


Figure 17: 24 hr average PM10 (real time monitors) – Quarter One 2017

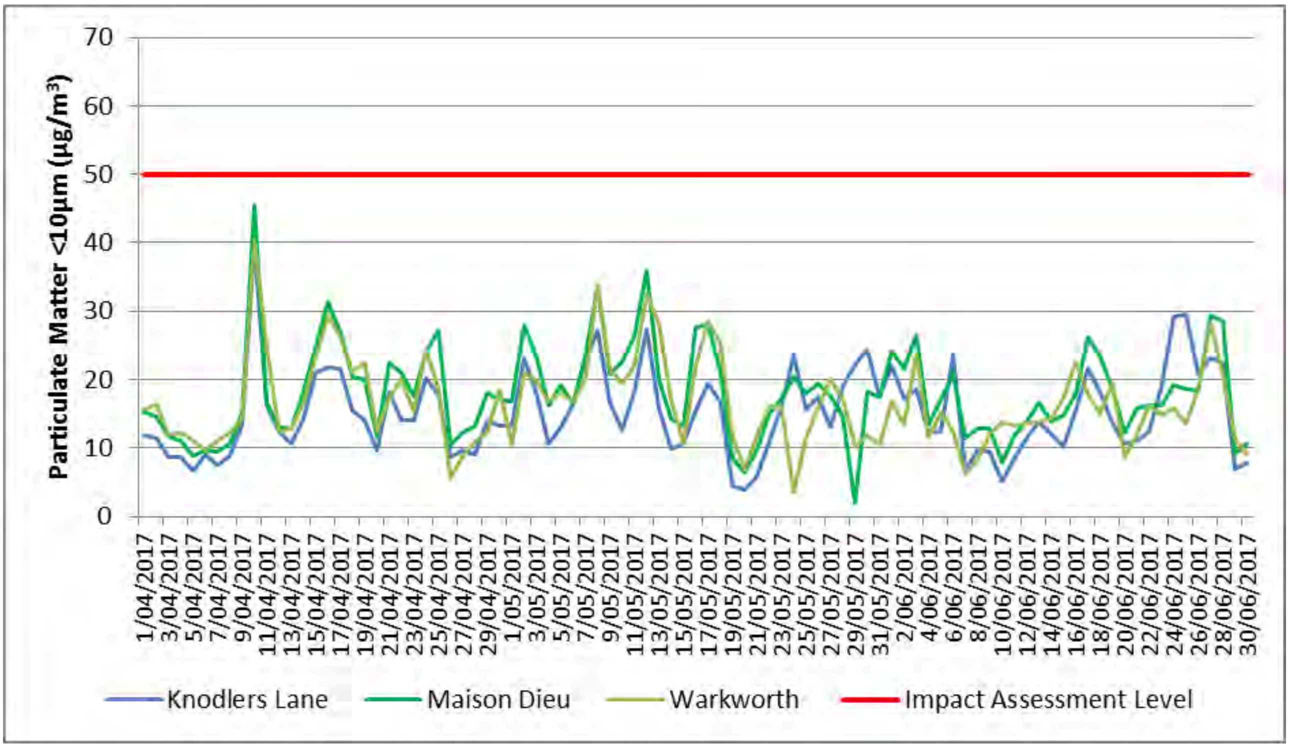


Figure 18: 24 hr average PM10 (real time monitors) - Quarter Two 2017

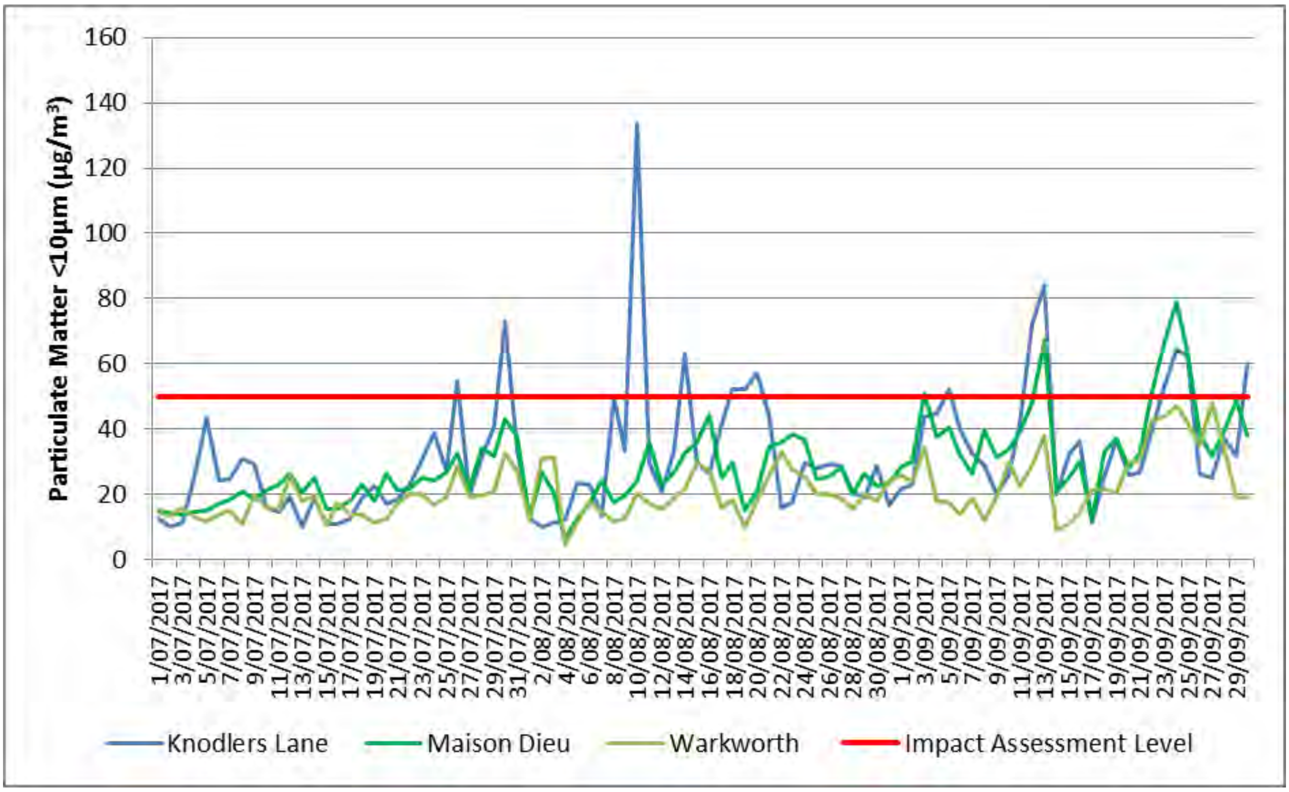


Figure 19: 24 hr average PM10 (real time monitors) - Quarter Three 2017

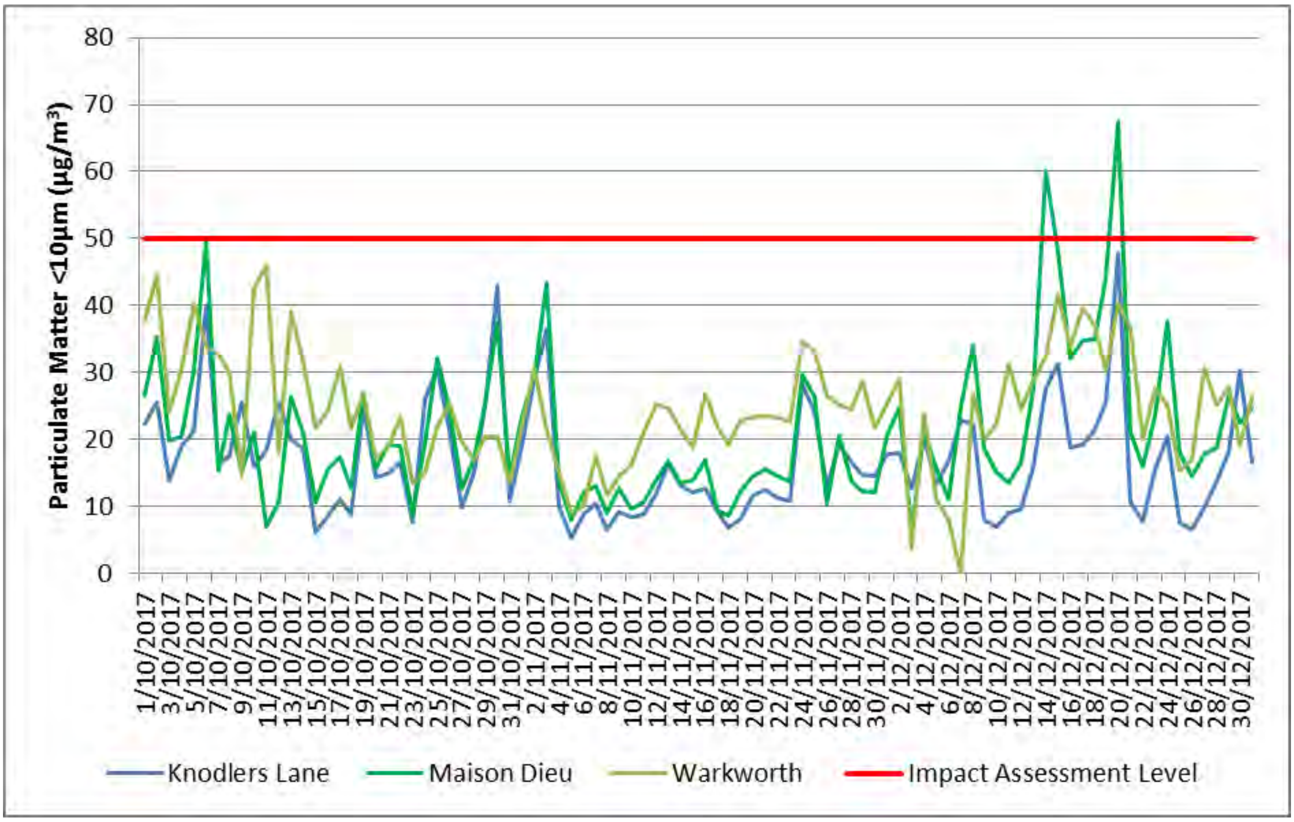


Figure 20: 24 hr average PM10 (real time monitors) - Quarter Four 2017

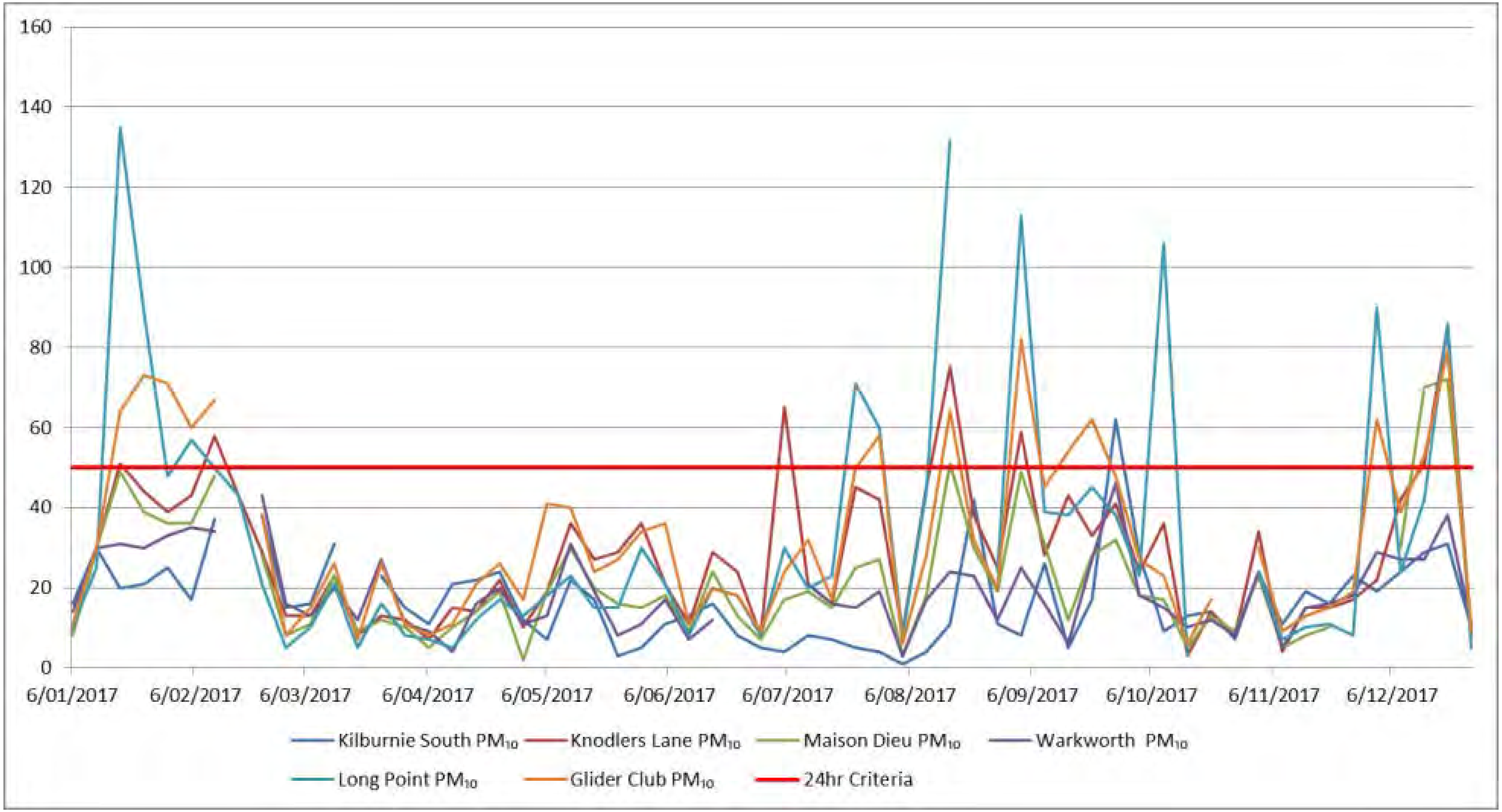


Figure 21: 2017 PM10 Results (measured through HVAS network)

Table 21: 24 hour PM10 investigations – 2017

Date	Site	24 hr result (µg/m³)	Estimated max. contribution from HVO (µg/m³)	Estimated max. contribution (%)	Discussion
11/01/2017	Knodlers Lane PM_{10} (TEOM)	51	38	73	An internal investigation determined maximum potential HVO contribution to be 73% of the measured result based on prevailing wind conditions. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
	Maison Dieu PM_{10} (TEOM)	62	41	66	An internal investigation determined maximum potential HVO contribution to be 66% of the measured result based on prevailing wind conditions. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
18/01/2017	Gliding Club PM_{10} (HVAS)	64	36	56	An internal investigation determined maximum potential HVO contribution to be 56% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
18/01/2017	Long Point PM_{10} (HVAS)	135	50	37	An internal investigation determined maximum potential HVO contribution to be 37% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan. An inspection of the monitoring location revealed nearby livestock activity would have likely influenced the measured result.
18/01/2017	Knodlers Lane PM_{10} (HVAS)	51	27	52	An internal investigation determined maximum potential HVO contribution to be 52% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
24/01/2017	Long Point PM_{10} (HVAS)	89	40	48	An internal investigation determined maximum potential HVO contribution to be 48% of the measured result based on prevailing wind conditions. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
24/01/2017	Gliding Club PM_{10} (HVAS)	73	49	67	An internal investigation determined maximum potential HVO contribution to be 67% of the measured result based on prevailing wind conditions. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
30/01/2017	Gliding Club PM_{10} (HVAS)	71	44	61	An internal investigation determined maximum potential HVO contribution to be 61% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.

Date	Site	24 hr result (µg/m³)	Estimated max. contribution from HVO (µg/m³)	Estimated max. contribution (%)	Discussion
5/02/2017	Long Point PM_{10} (HVAS)	57	38	66	An internal investigation determined maximum potential HVO contribution to be 66% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
5/02/2017	Gliding Club PM_{10} (HVAS)	60	41	68	An internal investigation determined maximum potential HVO contribution to be 68% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
11/02/2017	Knodlers Lane PM_{10} (HVAS)	58	27	46	An internal investigation determined maximum potential HVO contribution to be 46% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
11/02/2017	Gliding Club PM_{10} (HVAS)	67	35.5	53	An internal investigation determined maximum potential HVO contribution to be 53% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
12/02/2017	Warkworth OEH PM_{10} (TEOM)	53	5	10	An internal investigation determined maximum potential HVO contribution to be 10% of the measured result based on prevailing wind conditions. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
5/07/2017	Knodlers Lane PM_{10} (HVAS)	65	47	72	An internal investigation determined maximum potential HVO contribution to be 72% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
23/07/2017	Long Point PM_{10} (HVAS)	71	<34	<47	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be <47% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
29/07/2017	Long Point PM_{10} (HVAS)	60	<33	<56	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be <56% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.

Date	Site	24 hr result (µg/m³)	Estimated max. contribution from HVO (µg/m³)	Estimated max. contribution (%)	Discussion
29/07/2017	Gliding Club PM_{10} (HVAS)	58	49	85	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be 49µg/m³ or 85% of the measured result based on prevailing wind conditions and upwind monitoring results. The Hunter Valley Glider Club was operating on this day. Whilst the impact of the Club's activities is unable to be quantified with the available data, it would have also contributed to the PM_{10} levels recorded. The result was deemed non-compliant and reported to the Hunter Valley Glider Club and the Department of Planning and Environment.
30/07/2017	Knodlers Lane PM_{10} (TEOM)	73	43	59	Contribution estimated to be 43ug/m3 when the up wind monitor at Howick is subtracted from the Knodlers value. Similar value (41ug/m3) is calculated using contribution when wind direction was from the arc of influence.
7/08/2017	Knodlers Lane PM_{10} (TEOM)	134	41	31	An internal investigation determined maximum potential HVO contribution to be 31% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan. It should be noted that the result on this day was influenced by grass fire nearby to the monitor.
11/08/2017	Knodlers Lane PM_{10} (TEOM)	63	44	70	An internal investigation determined maximum potential HVO contribution to be 70% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan. It should be noted that the result on this day was influenced by livestock nearby to the monitor.
15/08/2017	Knodlers Lane PM_{10} (TEOM)	52	32	62	An internal investigation determined maximum potential HVO contribution to be 62% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan. It should be noted that the result on this day was influenced by livestock nearby to the monitor.
16/08/2017	Knodlers Lane PM_{10} (TEOM)	52	30	58	An internal investigation determined maximum potential HVO contribution to be 58% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan. It should be noted that the result on this day was influenced by livestock nearby to the monitor.
16/08/2017	Knodlers Lane PM_{10} (HVAS)	75	40	54	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be 54% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.

Date	Site	24 hr result ($\mu g/m^3$)	Estimated max. contribution from HVO ($\mu g/m^3$)	Estimated max. contribution (%)	Discussion
16/08/2017	Gliding Club PM_{10} (HVAS)	64	44	69	An internal investigation determined maximum potential HVO contribution to be 69% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
16/08/2017	Long Point PM_{10} (HVAS)	132	<40	<31	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be <31% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
16/08/2017	Maison Dieu PM_{10} (HVAS)	51	31	61	An internal investigation determined maximum potential HVO contribution to be 61% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
17/08/2017	Knodlers Lane PM_{10} (TEOM)	57	32	56	An internal investigation determined maximum potential HVO contribution to be 56% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan. It should be noted that the result on this day was influenced by livestock nearby to the monitor.
3/09/2017	Maison Dieu PM_{10} (TEOM)	51	34	67	An internal investigation determined maximum potential HVO contribution to be 67% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
3/09/2017	Knodlers Lane PM_{10} (HVAS)	59	22	38	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be 38% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
3/09/2017	Long Point PM_{10} (HVAS)	113	22	20	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be 20% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.

Date	Site	24 hr result ($\mu g/m^3$)	Estimated max. contribution from HVO ($\mu g/m^3$)	Estimated max. contribution (%)	Discussion
3/09/2017	Gliding Club PM_{10} (HVAS)	82	<61.5	<75	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be <61.5ug/m^3 or <75%of the measured result based on prevailing wind conditions and upwind monitoring results. The reported value also includes contribution from the Hunter Valley Gliding club however their contribution could not be quantified. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
05/09/2017	Knodlers Lane PM_{10} (TEOM)	52	41	80	An internal investigation determined maximum potential HVO contribution to be 41ug/m3 or 80% of the measured result based on prevailing wind conditions and upwind monitoring results. As real time monitoring is not included as a measure of compliance HVO is not considered to be non-compliant in accordance with the HVO Air Quality and Greenhouse Gas Management Plan.
12/09/2017	Knodlers Lane PM_{10} (TEOM)	72	50	70	An internal investigation determined maximum potential HVO contribution to be 70% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
13/09/2017	Knodlers Lane PM_{10} (TEOM)	84	40	49	An internal investigation determined maximum potential HVO contribution to be 49% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
13/09/2017	Maison Dieu PM_{10} (TEOM)	67	41	61	An internal investigation determined maximum potential HVO contribution to be 61% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
15/09/2017	Gliding Club PM_{10} (HVAS)	54	<40.4	<75	An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be <40.4µg/m^3 or <75% of the measured result based on prevailing wind conditions and upwind monitoring results. It is the consultants opinion and experience that given the Gliding Club activities are generally close to the monitor (i.e. some within tens of metres), that it is likely that the contribution from the Gliding Club activities would have been greater than 4.9µg/m^3 on 15 September 2017, and that the contribution from the activities at HVO would have been less than 40.4µg/m^3, or less than 75% of the contributed level. Taking this into consideration, as the likely contribution is less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan and is not considered to be non-compliant.

Date	Site	24 hr result (µg/m³)	Estimated max. contribution from HVO (µg/m³)	Estimated max. contribution (%)	Discussion
21/09/2017	Gliding Club PM_{10} (HVAS)	62	45	73	An internal investigation determined maximum potential HVO contribution to be 73% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
22/09/2017	Maison Dieu PM_{10} (TEOM)	51	34	66	An internal investigation determined maximum potential HVO contribution to be 66% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
23/09/2017	Knodlers Lane PM_{10} (TEOM)	53	31	58	An internal investigation determined maximum potential HVO contribution to be 58% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
23/09/2017	Maison Dieu PM_{10} (TEOM)	66	15	22	An internal investigation determined maximum potential HVO contribution to be 22% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
24/09/2017	Knodlers Lane PM_{10} (TEOM)	64	31	48	An internal investigation determined maximum potential HVO contribution to be 48% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
24/09/2017	Maison Dieu PM_{10} (TEOM)	79	46	58	An internal investigation determined maximum potential HVO contribution to be 58% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
25/09/2017	Maison Dieu PM_{10} (TEOM)	64	41	64	An internal investigation determined maximum potential HVO contribution to be 64% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
25/09/2017	Knodlers Lane PM_{10} (TEOM)	63	39.7	63	An internal investigation determined maximum potential HVO contribution to be 63% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.

Date	Site	24 hr result (µg/m³)	Estimated max. contribution from HVO (µg/m³)	Estimated max. contribution (%)	Discussion
27/09/2017	Kilburnie South PM_{10} (HVAS)	62	23	37	An internal investigation determined maximum potential HVO contribution to be 37% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
30/09/2017	Knodlers Lane PM_{10} (TEOM)	60	46	76	An internal investigation determined maximum potential HVO contribution to be 76% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
9/10/2017	Long Point PM_{10} (HVAS)	106	36	34	An internal investigation determined maximum potential HVO contribution to be 34% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
02/12/2017	Gliding Club PM_{10} (HVAS)	62	42.5	69	An internal investigation determined maximum potential HVO contribution to be 69% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
2/12/2017	Long Point PM_{10} (HVAS)	90	22	24	An internal investigation determined maximum potential HVO contribution to be 24% of the measured result based on prevailing wind conditions and upwind monitoring results. HVO could not have contributed any more than the level measured at Knodlers Lane on this day as it is significantly closer to HVO and also upwind of the Long Point Monitor indicating that a local source would be the primary influencer at this location. It can be assumed then that HVO's Contribution would have been 22ug/m3 at Knodlers Lane given when wind was blowing from HVO to Long Point it was primarily in line with Knodlers Lane. This equates to 24% of the total measured result. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
14/12/2017	Knodlers Lane PM_{10} (HVAS)	51	20.5	39	An internal investigation determined maximum potential HVO contribution to be 39% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
14/12/2017	Maison Dieu PM_{10} (TEOM)	60	40	67	An internal investigation determined maximum potential HVO contribution to be 67% of the measured result based on prevailing wind conditions and upwind monitoring results.

Date	Site	24 hr result ($\mu g/m^3$)	Estimated max. contribution from HVO ($\mu g/m^3$)	Estimated max. contribution (%)	Discussion
14/12/2017	Maison Dieu PM_{10} (HVAS)	70	39.5	56	An internal investigation determined maximum potential HVO contribution to be 56% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
14/12/2017	Glider Club PM_{10} (HVAS)	53	22.5	46	An internal investigation determined maximum potential HVO contribution to be 46% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
20/12/2017	Knodlers Lane PM_{10} (HVAS)	85	46	64	An internal investigation determined maximum potential HVO contribution to be 64% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
20/12/2017	Maison Dieu PM_{10} (TEOM)	67	40.6	61	An internal investigation determined maximum potential HVO contribution to be 61% of the measured result based on prevailing wind conditions and upwind monitoring results
20/12/2017	Maison Dieu PM_{10} (HVAS)	72	42.5	59	An internal investigation determined maximum potential HVO contribution to be 59% of the measured result based on prevailing wind conditions and upwind monitoring results. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
20/12/2017	Long Point PM_{10} (HVAS)	86	46	54	An internal investigation determined maximum potential HVO contribution to be 54% of the measured result based on prevailing wind conditions and upwind monitoring results. HVO could not have contributed any more than the level measured at Knodlers Lane on this day as it is significantly closer to HVO and also upwind of the Long Point Monitor indicating that a local source would be the primary influencer at this location. It can be assumed then that HVO's maximum contribution would have been in the order of <46ug/m3 at Long Point given when wind was blowing from HVO to Long Point it was primarily in line with Knodlers Lane. This equates to 54% of the total measured result. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.
20/12/2017	Gliding Club PM_{10} (HVAS)	79	49.5	63	An internal investigation determined maximum potential HVO contribution to be 63% of the measured result based on prevailing wind conditions and upwind monitoring results. There was a sudden change in wind speed/direction at 6pm on this day. The HVO contribution to the measured result can't be quantified so conservative value used and HVO's contribution assumed to be less than that value. As the calculated contribution was less than 75% of the measured result HVO is not considered to be a significant contributor to the result as per the HVO Air Quality and Greenhouse Gas Management Plan.

6.4.2.8 Long term PM_{10} impact assessment criteria

Annual average PM_{10} concentrations recorded at the six monitoring locations in 2017, compared with the long term PM10 impact assessment criterion and previous years' data, are shown on Figure 22. During 2017 all annual average PM10 concentrations recorded on privately owned land were compliant with the assessment criterion, and are consistent with annual average results measured in recent years.

Two high volume air samples exceeded the annual PM_{10} impact assessment criteria during the reporting period. The results were investigated to determine the level of contribution from HVO activities in accordance with the compliance protocol outlined in the HVO Air Quality Management Plan. The exceedances were determined to be compliant with the relevant criterion.

A summary of the investigations undertaken for the annual PM_{10} exceedances are provided in Table 22.

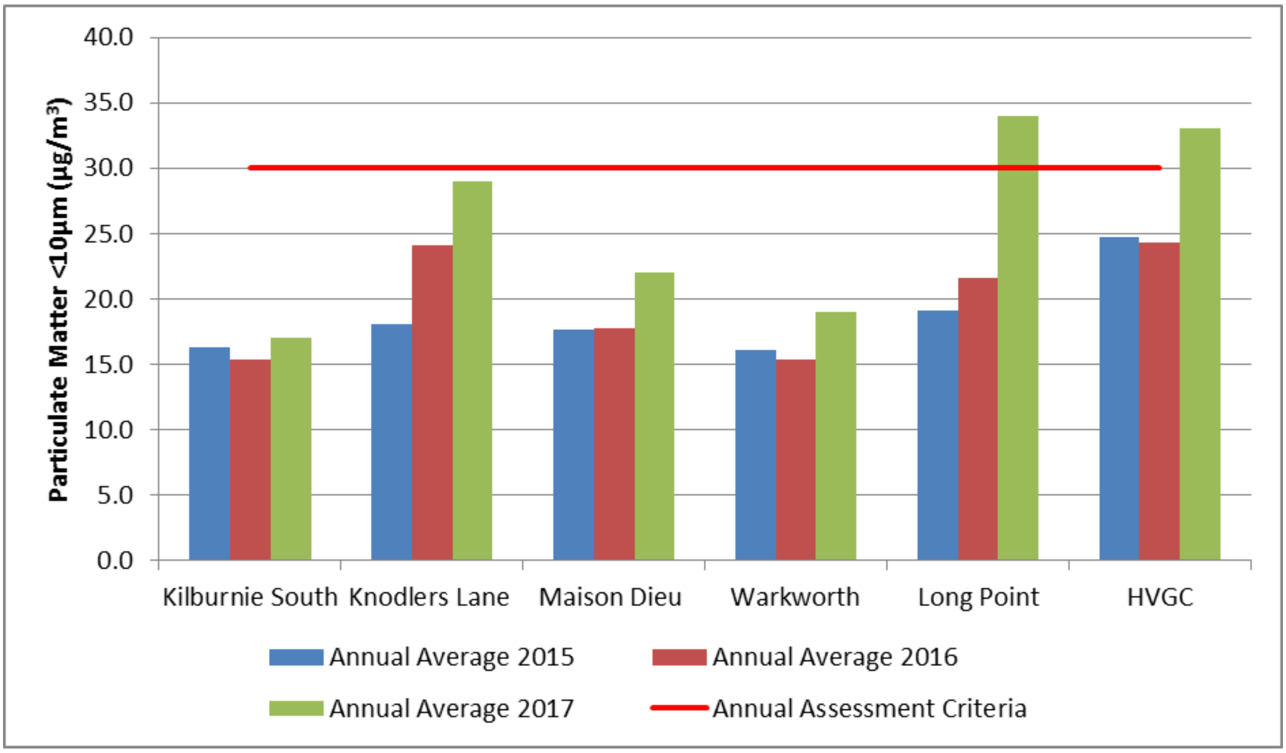


Figure 22: Annual average HVAS PM10 results 2014 to 2017

Table 22: Annual PM_{10} investigations - 2017

Date	Site	Annual Average PM_{10} result ($\mu g/m^3$)	Calculated Annual PM_{10} ($\mu g/m^3$)	Discussion
2017	HVGC HVAS PM_{10}	32.3	27.4	Internal and external investigations into 24 hour PM_{10} exceedances through the year, based on prevailing winds and upwind monitoring results, has determined that the maximum HVO contribution to the annual average PM_{10} result to be less than the criterion of 30 $\mu g/m^3$.

Date	Site	Annual Average PM_{10} result (µg/m³)	Calculated Annual PM_{10} (µg/m³)	Discussion
2017	Long Point HVAS PM_{10}	33.3	29.2	Investigation determined that the result, excluding extraneous livestock dust impacted days (from livestock “immediately” adjacent to the monitor), is below the criterion of 30 µg/m3. Inspections of the site indicated the influence of round yard/chicken coop/ bare ground in the direct vicinity of the HVAS units. Negotiations were held with the occupier to relocate this equipment. As the measured result is not solely attributable to HVO, it does not constitute non-compliance, as per HVO’s approved Air Quality Management Plan and so no further action is required.

6.4.3 Comparison of 2016 Air Quality data against EA predictions

Table 23 to Table 25 show a comparison between 2017 air quality data and the predictions made in the HVO South Environmental Assessment 2008 (EA). Comparisons have been made against the predictions listed in the EA for the nearest private residence to each monitoring location.

Annual average PM_{10} measurements in 2017 are generally consistent or slightly above predicted levels for all monitoring locations. Comparison of 2017 maximum 24 hr PM_{10} values against the predicted maximum values returned results either below or consistent with the predicted worst case results for all monitoring locations except for Kilburnie South and Long Point. An internal investigation determined maximum potential HVO contribution to be 37% of the measured maximum result at Kilburnie South and at Long Point based on prevailing wind conditions and upwind monitoring results. It should be noted that the worst case 24 hr PM_{10} predictions refer to maximum concentrations generated by HVO South alone, while the measurements provided in Table 23 include PM_{10} concentrations from HVO South and all other sources. Refer to Table 21 for estimates of HVO contribution to measured exceedances of 24 hr PM_{10} criteria during 2017.

TSP Annual Averages exceeded modelled predictions in 2017 at all monitoring locations. Section 9.1 of the HVO South Coal Project Air Quality Assessment (Holmes Air Sciences), notes that TSP concentrations are significantly under predicted. This is due to the fact that local dust sources (such as dust from local roads, stock movements and agricultural activity) have not been considered in the model.

Table 23: 2017 PM10 annual average results compared against cumulative predictions for 2014 and 2019 (HVO South Environmental Assessment)

Site (EA receptor)	Short Term (24hr) criteria			Long Term (annual average) criteria		
	Predicted maximum 24hr PM_{10} due to HVO South alone (µg/m³)		2017 maximum 24hr PM_{10} result (µg/m³)	Predicted PM_{10} annual averages (µg/m³)		2017 PM_{10} annual average (µg/m³)
	2014	2019		2014	2019	

Maison Dieu (47)	81.9	49.4	72	19.7	17.2	21.6
Warkworth (43)	50.8	29	46	32.9	24.8	19.1
Kilburnie South (4)	40.9	16.6	62	16.7	13.7	17.1
Knodlers Lane (32)	138	26.1	85	33.1	23	28.3
Long Point*	50-90	30-50	135	10-30	10-30	33.3
HVGC**	90-200	50-90	82	10-30	10-30	32.3

*No receptor identified in EIS (2008). Estimate has been made based on contours presented in the EIS.

**No receptor identified in EIS (2008). The HVGC has entered into an Amenity Management Plan with Hunter Valley Operations.

Table 24: HVO South Project Environmental Assessment cumulative predictions for 2014 and 2019 against 2017 TSP annual averages

Site (EA receptor)	Long Term (annual average) TSP Criteria		
	2014 prediction (µg/m^3)	2019 prediction (µg/m^3)	2017 annual average (µg/m^3)
Maison Dieu (47)	44.0	22.2	68.0
Warkworth (43)	60.1	29.8	63.9
Kilburnie South (4)	40.4	18.7	63.9
Knodlers Lane (32)	61.0	28.0	84.8
Long Point*	0-50	30-50	95.3

Table 25: HVO South Environmental Assessment cumulative predictions for 2014 and 2019 against 2016 Depositional Dust annual averages

Site (representative receptor ID)	Units (Insoluble Solids)	Assessment Criteria	2014 EA Predictions Annual Averages	2019 EA Predictions Annual Averages	2017 Actual Annual Average
D118 (Kilburnie Sth) (4)	g/m^2/month	4	0.8	1.1	2.8
D119 (Jerry's Plains) (13)	g/m^2/month	4	0.7	1.1	2.0
DL14 (Maison Dieu) (47)	g/m^2/month	4	1.0	1.3	2.0
DL21 (32)	g/m^2/month	4	2.0	1.9	3.2
DL22 (16)	g/m^2/month	4	2.2	1.9	2.3
Knodlers Lane (24/34)	g/m^2/month	4	1.5	1.6	2.3
Warkworth (43)	g/m^2/month	4	1.7	1.6	4.2

Table 26 and Table 27 detail comparisons between 2017 air quality monitoring results and the modelled predictions from the 2010 HVO North Carrington West Wing Air Quality Impact Assessment. Predictions have been sourced from modelled scenarios of Year One of the Carrington West Wing development. It should be noted that while Approval has been granted for the commencement of that project, works have not yet commenced.

Table 26: 2017 PM10 annual average results compared against cumulative predictions for Year One (CWW) - HVO North Environmental Assessment

Site (EA receptor)	Long Term (annual average) criteria	
	Predicted PM_{10} annual average (µg/m^3)	2017 PM_{10} annual average (µg/m^3)
Maison Dieu (6)	19.1	21.6
Warkworth (39)	20.8	19.1
Kilburnie South (4)	19.7	17.1

*no modelled predictions for the Long Point area

Table 27: 2017 TSP Annual Average results compared against cumulative predictions for Year One (CWW) - HVO North Environmental Assessment

Site (EA receptor)	Long Term (annual average) criteria	
	Predicted TSP annual average (µg/m^3)	2017 TSP annual average (µg/m^3)
Maison Dieu (6)	44.7	68.0
Warkworth (39)	46.6	63.9
Kilburnie South (4)	45.2	63.9

*no modelled predictions for the Long Point area

Comparison of measured PM_{10} with modelled predictions demonstrates close alignment for all monitoring locations; however TSP measurements have exceeded predictions in a similar fashion to the comparison undertaken for HVO South. Given that the TSP fraction settles out of suspension faster than PM_{10} (and thus much closer to the operation), it is not reasonable to suggest that nearby private residences are being impacted by mine-generated TSP to a greater degree than by PM_{10}, on the basis of measured data exceeding the predictions. Rather, the data suggests the assumptions in the model relating to extraneous dust sources are under predicting total TSP levels which are experienced at receptors.

Regardless of correlation with the modelled predictions, TSP levels measured remain well below the impact assessment criteria of 90µg/m^3 and have been relatively stable in recent years.

6.4.4 Air Quality Non-compliances During the Reporting Period

HVO complied with all air quality criteria; with the exception of one exceedance of short term PM10 criteria measured at the Hunter Valley Glider Club on 29 July 2017. Details of the non-compliance are included in Table 21 and Section 11.3.

6.5 Greenhouse Gas and Energy Management

During 2017, HVO continued to comply with Australian Government legislation for Greenhouse reporting. Under NGER, HVO is required to report its annual greenhouse gas emissions, energy use and energy production. Results of greenhouse gas and energy information are publicly available online at http://www.cleanenergyregulator.gov.au/.

A summary of greenhouse gas emissions for HVO including fugitive coal seam gas emissions and land management emissions compared to 2017 is displayed in Table 28 below.

Total emissions in 2017 increased on 2016 results, this is attributed to an increase in Process and Diesel Emissions which is a reflection of the increase in the amount of raw coal mined and diesel used and also a change to the emission factors specifically due to an increase in the methane emission factor.

Table 28: Total Greenhouse Gas Emissions

Hunter Valley Operations Greenhouse Gas Emissions	2017	2016
Electricity (tCO_2-e)	117,408[1]	120,540
Diesel and other fuels (tCO_2-e)	361,655[1]	350,817
Process Emissions (tCO_2-e)	198,694	133,064*
Land Management (tCO_2-e)	1,689	3,581
Total Site (tCO_2-e)	679,446	608,003

* Fugitive (Coal Seam Gas) emissions may be updated after the reporting period on occasion following revision to emission factors.
[1] Electricity and diesel emissions do not include emissions related to the use of vehicles which are fuelled off site and minor

6.5.1.1 Recycling

HVO has continued to have a focus on training and reinforcing the principles of a good waste management across the site including recycling. In 2017 33 per cent of non-mineral waste material generated at HVO was disposed to licensed offsite landfill facilities. A recycling result of 67 per cent was achieved in 2017,

The overall recycling percentage has reduced from 2016 (72%) to 2017 (69%). The reduction in recycled waste is attributed to;

- Changes to waste oil recycling, the company which collected, refined and delivered waste oil to HVO for use in blasting ceased to operate;
- Increase in oily water removed from site due upgrade work being conducted on the sites oily water separators.

HVO will explore further opportunities to continue to improve recycling rates in 2018.

6.5.1.2 Sewage Treatment/Disposal

The sewage treatment and disposal facilities at HVO consist of packaged sewage treatment plants which treat, disinfect and re-use the treated effluent on-site. The remaining effluent from some septic systems that can't be treated on site is sent to approved facilities for disposal.

HVO currently has 5 main grouped on-site sewerage management systems, these are interconnected from multiple systems forming the 5 main systems. These facilities are located at Howick, HVO North, HVO South and two in-pit locations.

6.5.1.3 Hydrocarbons

During 2017, 1124 kL of waste oil was taken offsite to be refined into a base oil for reuse in new oil products. Other hydrocarbons recycled via a licensed waste hydrocarbon disposal company include approximately 32 tonnes of waste grease.

6.5.1.4 Contaminated Soil

Management of hydrocarbon contaminated soil employs the use of bioremediation areas that are maintained and operated in accordance with HVO procedures.

Contaminated soil is taken to one of the bioremediation areas and placed in cells based on the time of contamination. To maximise air circulation, contaminated soil is spread out in beds of no more than approximately 300 mm in height and approximately a grader width at the base. Beds are oriented north south where possible to achieve maximum exposure to sunlight. The beds are turned by a grader or equivalent on regular intervals in order to provide aeration for beneficial microbial activity.

Soil in the treatment area is sampled and tested on a regular basis until total hydrocarbon levels are below relevant guidelines. Soil meeting these criteria is then removed and disposed of in the spoil dump.

Waste and Hazard Management Non-compliances during reporting period

There were no externally reportable incidents related to waste or hazard management during the reporting period.

6.6 Heritage Summary

6.6.1 Management and Community Consultation

Aboriginal cultural heritage is managed under the provisions of separate Aboriginal Cultural Heritage Management Plans (ACHMP) approved for these development consents. At HVO North, where mining or associated development activities may impact Aboriginal cultural heritage sites, an Aboriginal Heritage Impact Permit (AHIP) must also be sought from the OEH under Part 6 of the National Parks and Wildlife Act 1974 (NPW Act), on the basis of the management requirements established through the ACHMP process. The HVO South ACHMP area was approved as a State Significant Development which excludes the requirement for obtaining AHIPs prior to implementing cultural heritage management measures authorised under the provisions of the ACHMP.

The Upper Hunter Valley Aboriginal Cultural Heritage Working Group (CHWG) is the primary forum for Aboriginal community consultation on matters pertaining to cultural heritage at HVO. The CHWG is comprised of representatives from HVO and Registered Aboriginal Parties (RAPs) from Upper Hunter Valley Aboriginal community groups, corporations and individuals. The CHWG met and discussed cultural heritage management matters associated with HVO on six occasions during 2017: 14th February, (in the form of a workshop), 23rd February, 4th May, 8th June, 24th August and 9th November.

Aboriginal cultural heritage at HVO is managed in consultation with the RAPs through the CHWG in accordance with the ACHMPs, development consent conditions, and the HVO Cultural Heritage Management System (CHMS) Work Procedures. The HVOCHMS combines several elements to protect, manage and mitigate cultural heritage at HVO, including:

- Ongoing consultation and involvement of the local Aboriginal community in all matters pertaining to Aboriginal cultural heritage management;
- Compliance with existing ACHMP’s and Development Consent conditions;
- A cultural heritage Geographic Information System (GIS) and Cultural Heritage Zone Plan (CHZP) incorporating cultural heritage spatial and spatial data (site location, description, assessments, date recorded, associated reports, management provisions and various other details to assist with the management of sites);
- A Ground Disturbance Permit (GDP) system for the assessment and approval of ground disturbing activities to ensure these activities do not disturb cultural heritage places;
- Limit of Disturbance Boundary (LODB) procedures to demarcate approved disturbance areas and delineate areas not to be disturbed;
- Ongoing cultural heritage site inspections, monitoring and auditing along with regular compliance inspections of development works;
- Protective management measures such as fencing/barricading sites to avoid disturbance, protective buffer zones, cultural heritage off-set areas; and
- Communicating cultural heritage issues and site awareness to personnel via internal electronic and face to face processes.

In consultation with the CHWG and OEH, a Cultural Heritage Storage Facility (CHSF) was established at Hunter Valley Services. The CHSF is a storage shed, with an adjacent sea container, fitted out to allow safe and secure storage of cultural materials, such as stone artefacts. It is a central repository for all materials collected during community collection and salvage activities on all lands related to HVO (including offset properties).

6.6.2 Aboriginal Archaeological and Cultural Heritage Investigations

In February and March 2017, a ten day fieldwork programme was conducted at Wandewoi Biodiversity Area, HVO North, in the form of pedestrian survey and ACH site recording. During the fieldwork program, 255 new ACH sites were recorded and 69km of transects were assessed.

In March and April 2017, an eight day fieldwork programme was conducted at Mitchell Pit, HVO North in the form of a salvage collection of cultural heritage sites under the authority of Aboriginal Heritage Impact Permit (AHIP) #C0002193. During the fieldwork program, 327 extant Aboriginal cultural heritage sites were salvage mitigated.

In July 2017, a four-day fieldwork programme was conducted at West Pit, HVO North in the form of the salvage mitigation and sub-surface assessment of extant Aboriginal cultural heritage sites in the HVO West Pit Dam 17 area under the authority of AHIP #C0002525. During the fieldwork program, 12 extant Aboriginal cultural heritage sites were salvage mitigated, and a further three new sites were recorded and salvaged.

These works were conducted in accordance with the relevant AHIPs, the HVO North HMP and the OEH Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales (2010). The results of these programs were presented to the CHWG at the 4th May and 24th August meetings respectively.

6.6.3 Audits and Incidents

Under the provisions of the HVO South ACHMP and the HVO North HMP, a Compliance Inspection was conducted within both areas during 2017. The purpose of the compliance inspection is to provide the RAPs with:

- The opportunity to visit mine operations and mine areas to inspect operational compliance with ACHMP/HMP provisions and GDP procedures;
- To inspect and monitor the condition and management of sites; and
- To review the effectiveness and performance of the ACHMP/HMP provisions in the management of cultural heritage at the mine.

This compliance inspection was conducted by RAP representatives of the CHWG and assisted by HVO personnel. The 2017 HVO South and North compliance inspection was conducted over five days in December, with 43 Aboriginal cultural heritage sites inspected. The inspection found that all sites have been managed in conformance with the ACHMP/HMP requirements.

During the reporting period there were 45 GDPs assessed for cultural heritage management considerations at HVO. There were no incidents nor any unauthorised disturbance caused to cultural heritage sites at HVO during 2017.

A comprehensive desktop review and ground-truthing audit of all Aboriginal cultural heritage sites located on HVO leases and land has continued in 2017. The purpose of the process is to confirm or revise and update the Aboriginal sites data held in the OEH Aboriginal Heritage Information Management System (AHIMS) sites database. HVO and OEH agree that there are inconsistencies between the AHIMS data and ground truthed data verified by HVO. These inconsistencies generally relate to errors in historical site location recording conducted over the last 20 years, resulting in incorrect information being recorded in the AHIMS database.

6.6.4 Historic Heritage - Management and Community Consultation

In 2012, the Community Heritage Advisory Group (CHAG) was established as a community consultation forum for all matters pertaining to management of historic (non-Indigenous) heritage located on, amongst other places, HVO lands. The CHAG is comprised of HVO personnel and community representatives with particular knowledge and interests in historic heritage of the region such as historical groups, individuals and local government. The CHAG was convened on four occasions in 2017 – 24th February, 3rd May, 9th June and 23rd August.

7 WATER MANAGEMENT

7.1 Water Balance

7.1.1 Water Management

HVO manages surface and ground water according to three main objectives:

- Fresh water usage is minimised;
- Impacts on the environment and HVO neighbours are minimised; and
- Interference to mining production is minimal.

This is achieved by:

- Minimising freshwater use from the Hunter River;
- Preferentially using mine water for coal preparation and dust suppression;
- An emphasis on control of water quality and quantity at the source;
- Segregating waters of different quality where practical;
- Recycling on-site water;
- Ongoing maintenance and review of the system; and
- Disposing of water to the environment in accordance with statutes and regulations.

Plans showing the layout of all water management structures and key pipelines are shown in Figure 23 to Figure 25. The HVO Water Management Plan contains further detail on management practices and is available on Yancoal Australia's website.

During the 2017 reporting period significant improvement works commenced at the Hunter Valley Load Point to improve the containment of runoff from the train loading facility. Installation of a secondary containment basin downstream of Parnell's Dam (dam 9W) also commenced during the reporting period.

Figure 23: West Pit water management infrastructure

Figure 24: North Pit water management infrastructure

Figure 25: South Pit water management infrastructure

7.1.2 Water Performance

7.1.2.1 Water Balance

The 2017 static water balance for HVO is presented in Table 29 and a simplified schematic of this balance is included as Figure 26. The water balance is for a coal production rate of 19.5 million tonnes per year ROM and 14.8 million tonnes per year of product. Total water inputs were significantly lower in 2017, compared to the previous reporting period, as a result of lower runoff volumes generated by rainfall. Outputs were broadly consistent with the 2016 reporting period. A salt flux schematic is shown in Figure 27.

Table 29: 2017 HVO Water Balance

Water Stream	Volume (ML)
Inputs	
Fresh Water (potable)	40 (0.5%)
Fresh Water (Hunter River extraction)	12 (0.2%)
Groundwater	1,325 (17.8%)
Rainfall Runoff	4,345 (58.2%)
Recycled to CHPP from Tails & Storage (not included in total)	2,653
Imported (Liddell)	285 (3.8%)
Water from ROM Coal	1,453 (19.5%)
Total Inputs	**7,460**
Outputs	
Dust Suppression	3,156 (35.4%)
Evaporation - Mine Water & Tailings Dams	1,347 (15.1%)
Entrained in Process Waste	1,399 (15.7%)
Discharged (HRSTS)	0 (%)
Vehicle Wash-down	310 (3.5%)
Sent to Third Party	300 (3.4%)
Miscellaneous Industrial Use	350 (3.9%)
Water in Coarse Reject	628 (7.1%)
Water in Product Coal	1,416 (15.9%)
Total Outputs	**8,905**
Change in Pit Storage	**- 1,446 (decreased)**

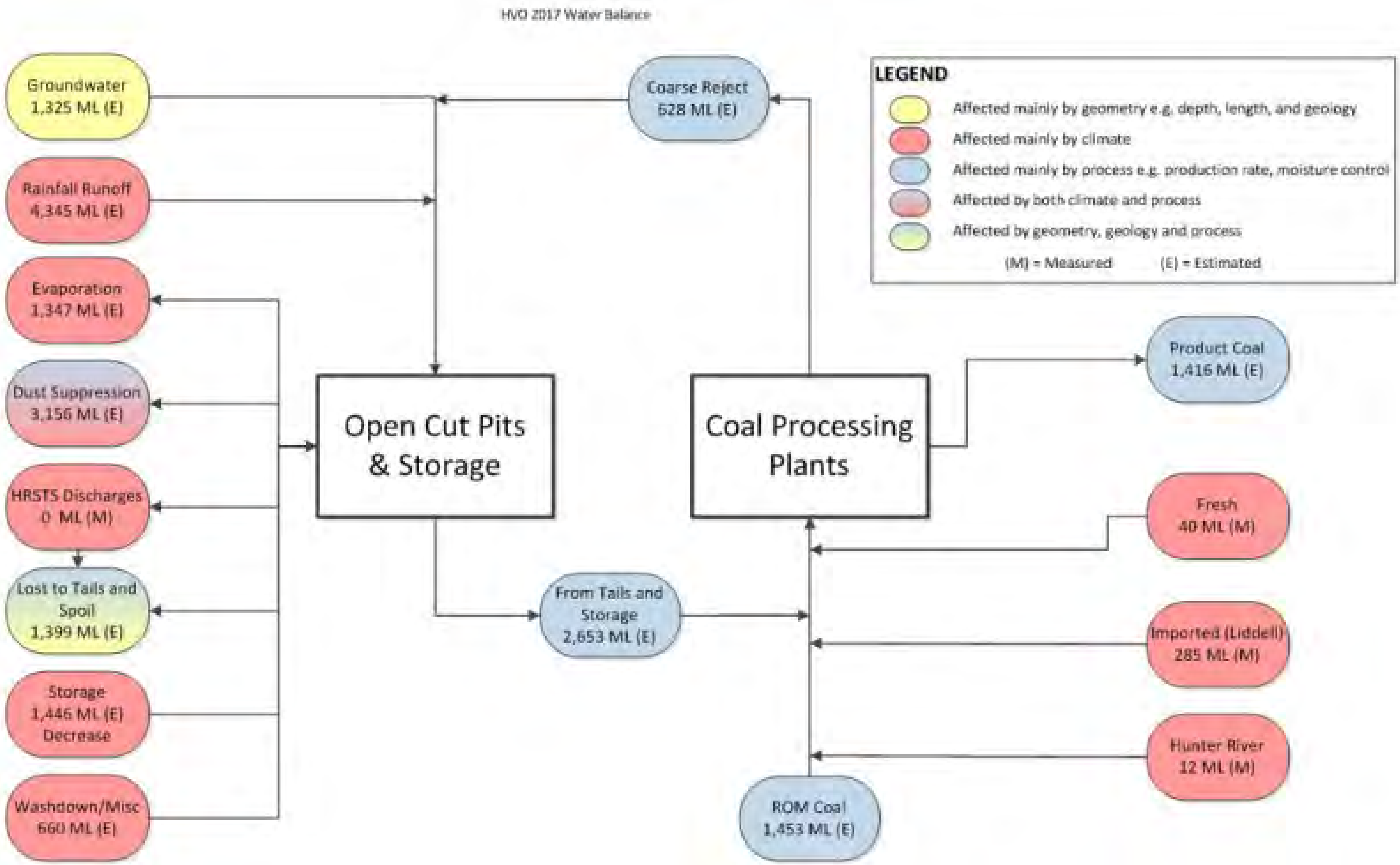


Figure 26: HVO water balance schematic diagram

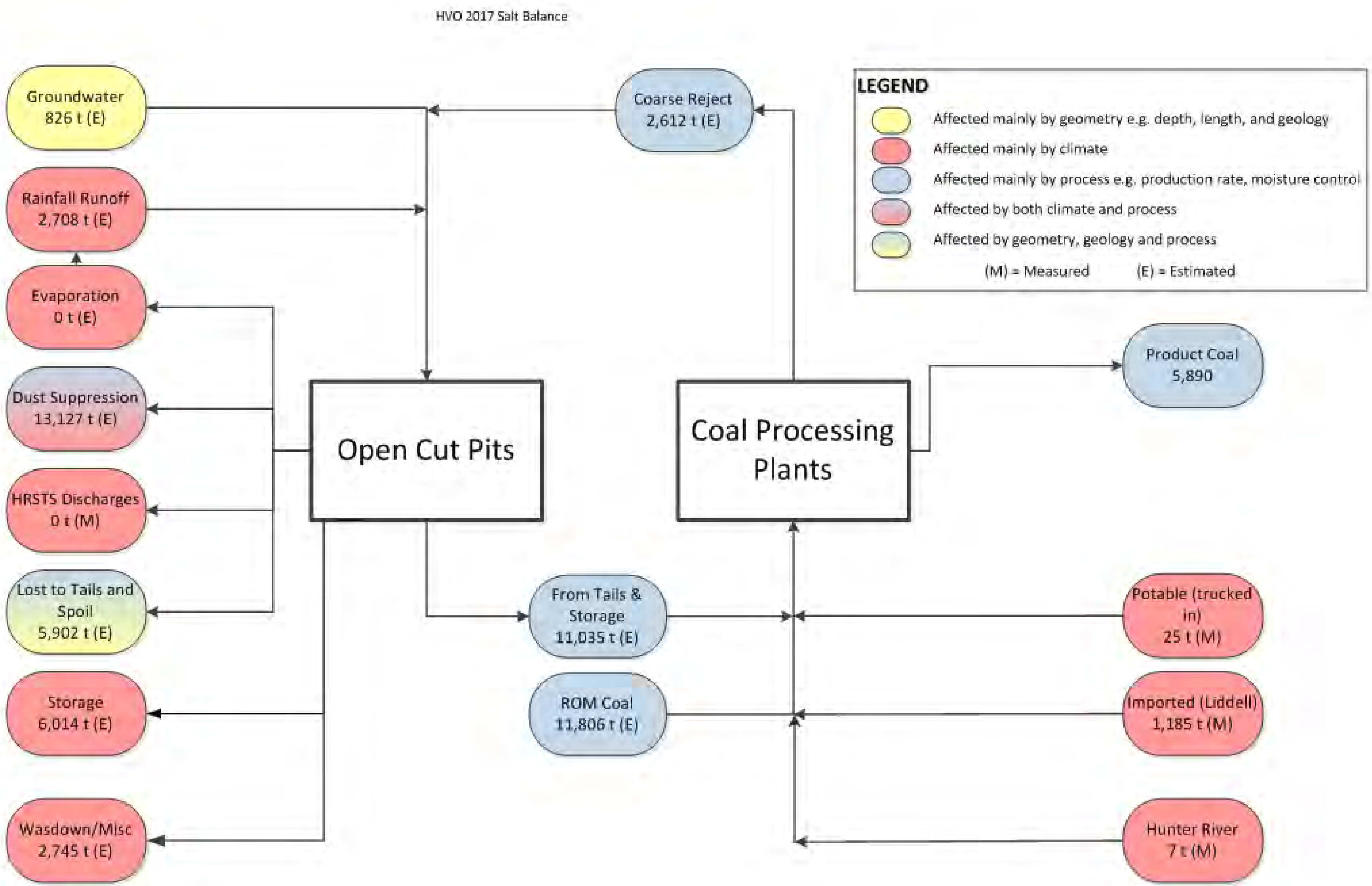


Figure 27: HVO salt balance schematic diagram

7.1.2.2 Water Inputs

A total of 470 mm of rainfall was recorded at HVO in 2017 producing an estimated 4,345 ML of runoff from approximately 5,985 ha of developed, disturbed and mining catchments. Water falling on undisturbed clean water catchments is diverted off site into natural systems where possible.

Groundwater inflows to the pits are calculated via numerical groundwater modelling methods; these are given in Table 29 for the reporting period. Groundwater inflows were estimated to have contributed 1,325 ML to the site during 2017. A small amount of fresh water was pumped from the Hunter River during the reporting period.

7.1.2.3 Water Outputs

The main outputs were water use for dust suppression (3,156 ML), evaporation from dams (1,347 ML), water entrained in process waste (1,399 ML) and water in product coal (1,416 ML).

HVO participates in the Hunter River Salinity Trading Scheme (HRSTS) allowing it to discharge from licensed discharge points during declared discharge events, associated with increased flow in the Hunter River. HVO maintains three licensed discharge monitoring locations:

- Dam 11N, located at HVO North, which discharges to Farrell’s Creek
- Lake James, located at HVO South, which discharges to the Hunter River; and
- Parnell’s Dam, located at HVO West, which discharges to Parnell’s Creek.

During 2017 Hunter Valley Operations discharged no water under the Hunter River Salinity Trading Scheme and Environment Protection Licence 640.

7.2 Surface Water

Surface water monitoring activities continued in 2017 in accordance with the HVO Water Management Plan and HVO Surface Water Monitoring Programme. HVO maintains a network of surface water monitoring sites located on mine site dams, discharge points and surrounding natural watercourses (Figure 28). Water quality monitoring is undertaken to verify the effectiveness of the water management system onsite, and to identify the emergence of potentially adverse effects on surrounding watercourses. A number of mine water dams are monitored routinely to verify the quality of mine water, used in coal processing, dust suppression, and other day to day activities around the mine.

Surface water monitoring data is reviewed on a quarterly basis. The review involves a comparison of measured pH, Electrical Conductivity (EC) and Total Suspended Solids (TSS) results against internal trigger values which have been derived from the historical data set. The response to measured excursions outside the trigger limits is detailed in the HVO Water Management Plan.

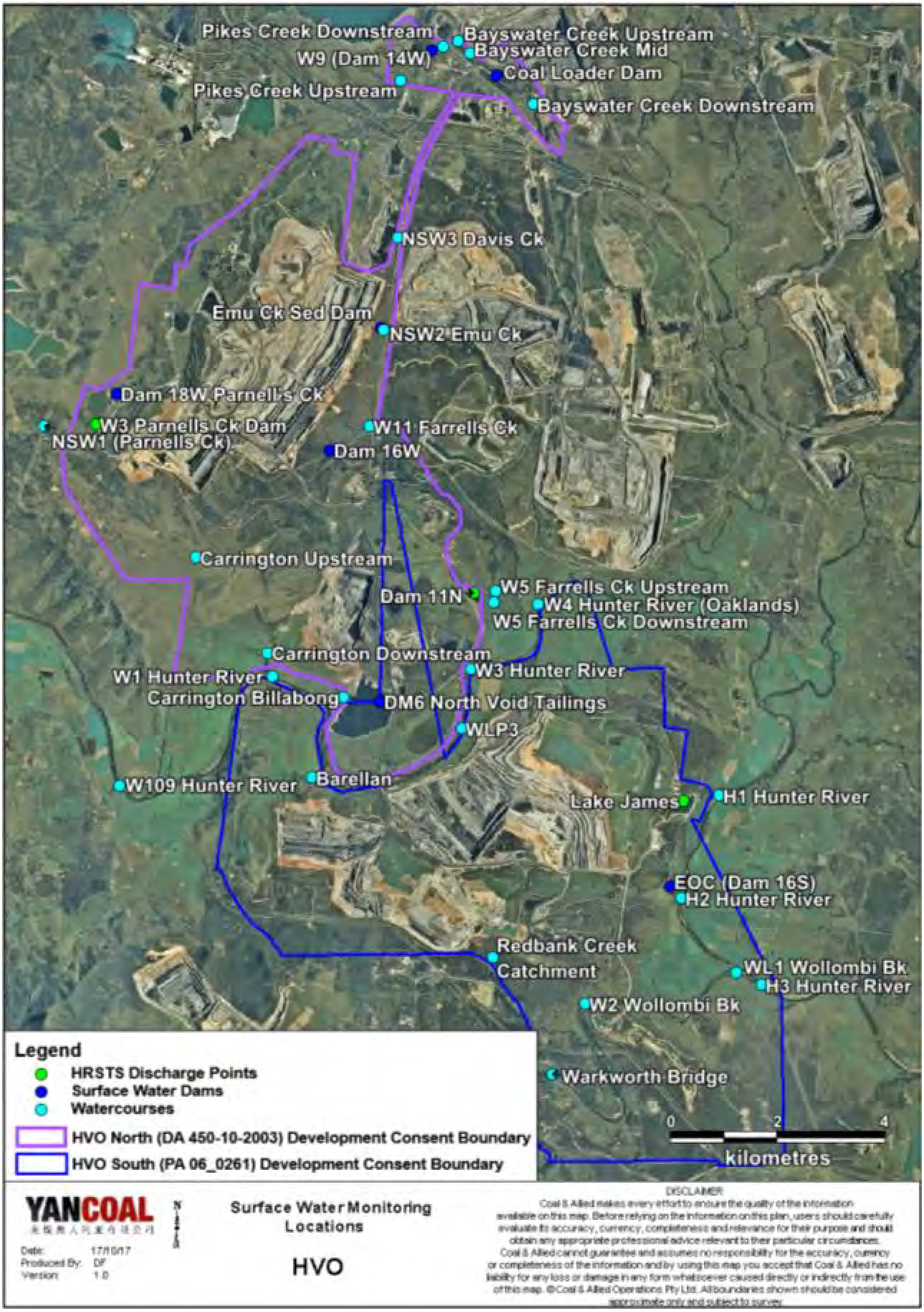


Figure 28: Surface Monitoring Locations

7.2.1 Surface Water Monitoring

Routine surface water monitoring was undertaken from 38 sites at the frequencies described in the Surface Water Monitoring Programme. All sampling of surface waters was carried out in accordance with AS/NZS 5667.6:1998 (R2016). All analysis of surface water was carried out in accordance with approved methods by a NATA accredited laboratory.

Water quality is evaluated through the parameters of pH, EC and TSS. Pertinent surface water sites were also sampled for comprehensive analysis annually. Long term water quality trends for the Hunter River, Wollombi Brook, other surrounding tributaries and site dams are presented in this section. The sampling frequency for ephemeral water sites was modified in 2016, from quarterly to a rain-event trigger system, in an effort to ensure samples taken were more representative of typical water quality for those streams (up to eight sampling events per annum can now be taken under the revised sampling protocol). Due to dry conditions during the reporting period resulted in fewer rain event sampling runs being completed in 2017, however there was an improvement in data recovery as fewer sites were recorded as dry during the monitoring events. All required sampling and analysis was undertaken, except as detailed in Table 30. ANZECC criteria are shown in the figures for comparative purposes.

Table 30: HVO Water Monitoring Data Recovery for 2017 (by exception)

Location	Data Recovery (%)	Comments
Carrington Billabong	0%	Site recorded as dry during all 2017 monitoring events.
NSW1 (Parnell's Ck)	0%	Site not accessible during 2017 rain event monitoring.
NSW 3 Davis Ck	0%	Site recorded as dry during all 2017 monitoring events.

7.2.1.1 Hunter River

The Hunter River was sampled on 28 occasions from seven monitoring locations during 2017. Long term trends for pH, EC and TSS are shown in Figure 29 to Figure 31. Results for water quality were consistent with historical trends; EC was seasonally variable and controlled by flow volumes through the catchment. Trigger tracking results are detailed in Table 31.

Table 31: Hunter River Internal Trigger Tracking Results

Location	Date	Trigger limit	Action taken in response
H2	20/09/2017	pH – 95th percentile (ANZECC criteria)	Watching brief *
H3	20/09/2017	pH – 95th percentile (ANZECC criteria)	Watching brief *
W3	1/03/2017 20/09/2017	pH – 95th percentile (ANZECC criteria)	Watching brief * Watching brief *
W4	08/06/2017 20/09/2017	pH – 95th percentile (ANZECC criteria)	Watching brief * Watching brief *

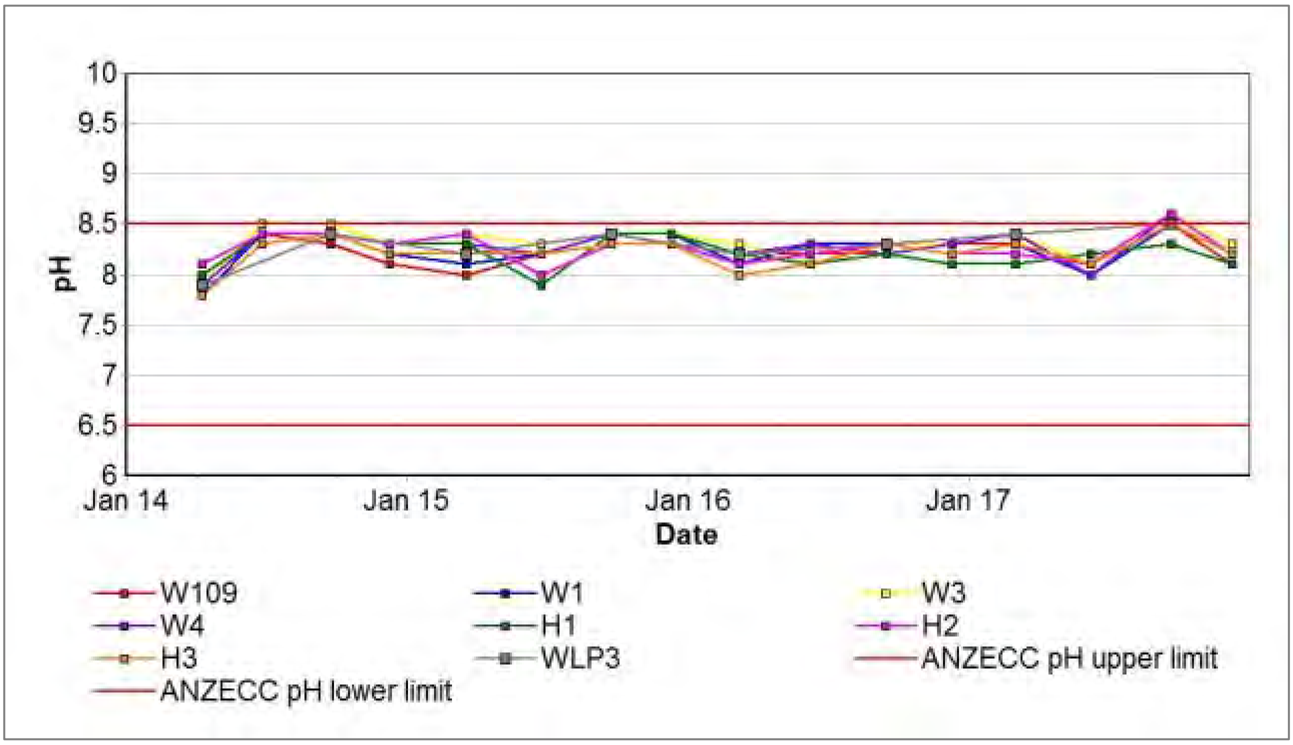


Figure 29: Hunter River pH Trends 2014 – 2017

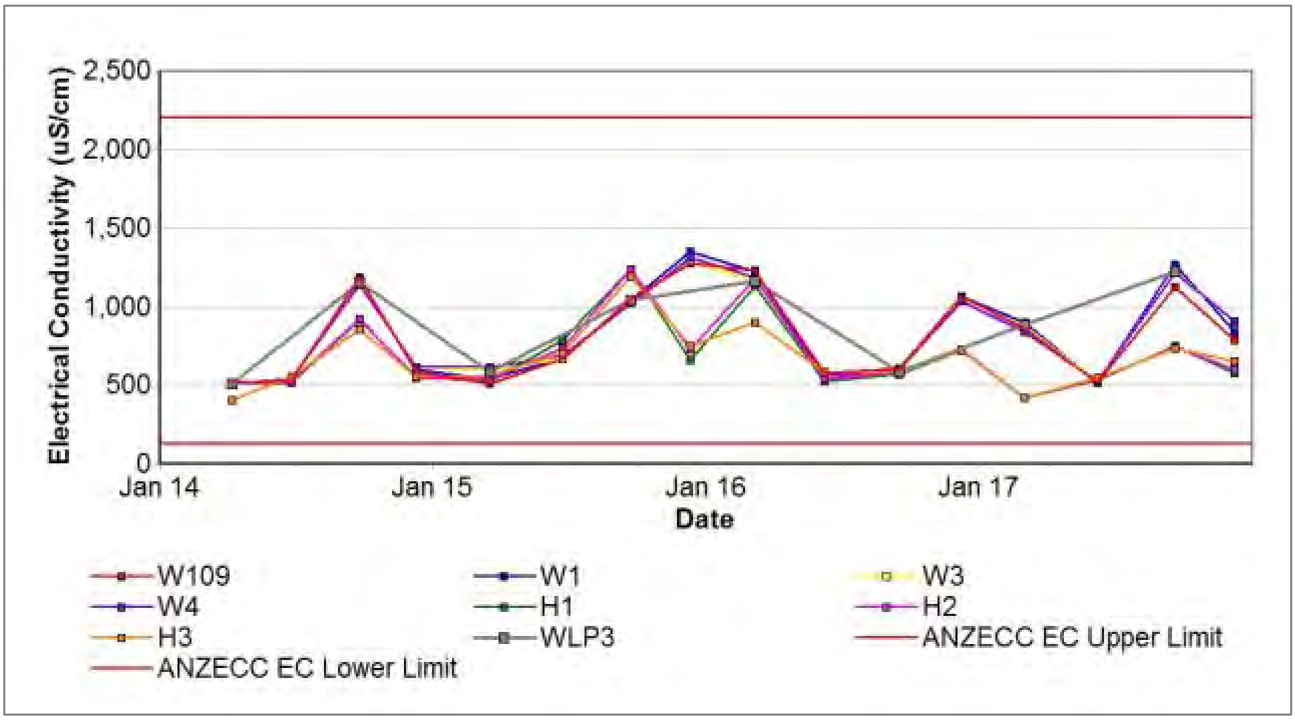


Figure 30: Hunter River EC Trends 2014 – 2017

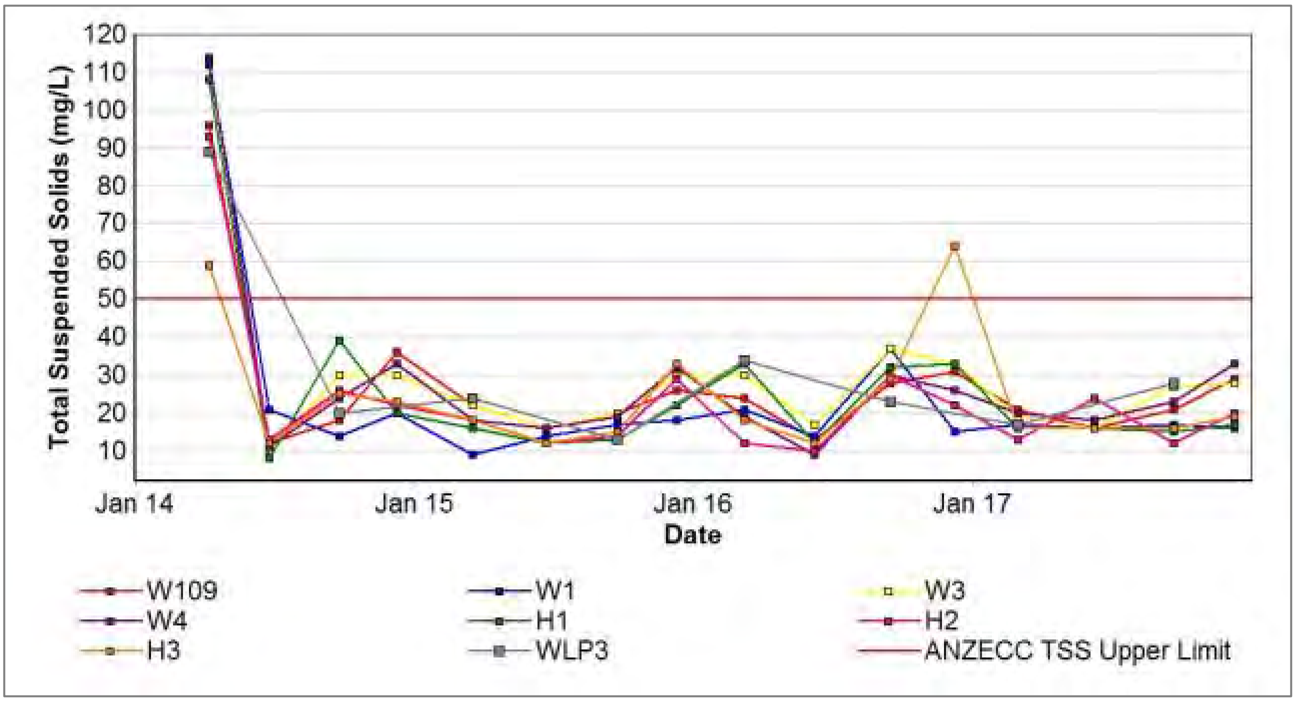


Figure 31: Hunter River TSS Trends 2014 – 2017

7.2.1.2 Wollombi Brook

Wollombi Brook was sampled on 12 occasions from three monitoring locations during 2017. Long term trends for pH, EC and TSS from Wollombi Brook are shown in Figure 32 to Figure 34. Results were consistent with historical trends and acceptable ranges; EC was seasonally variable and controlled by flow volumes through the catchment.

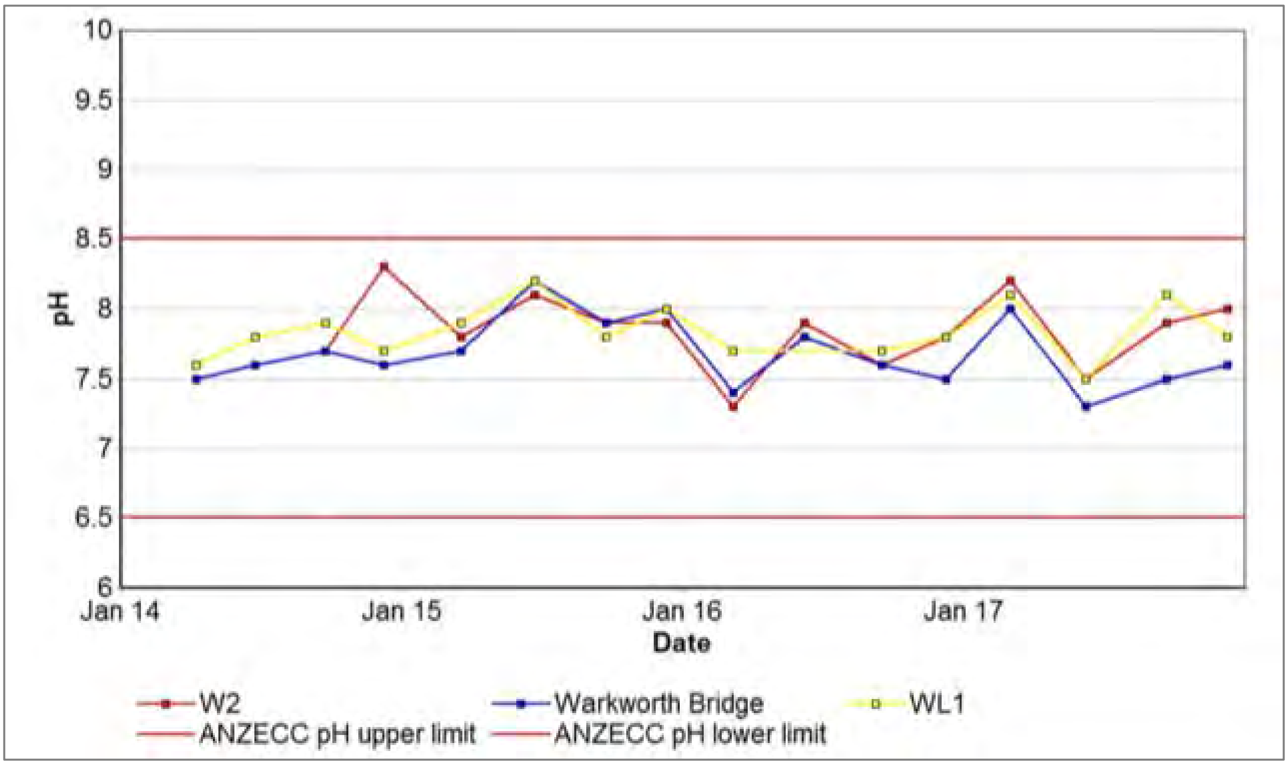


Figure 32: Wollombi Brook pH Trends 2014 – 2017

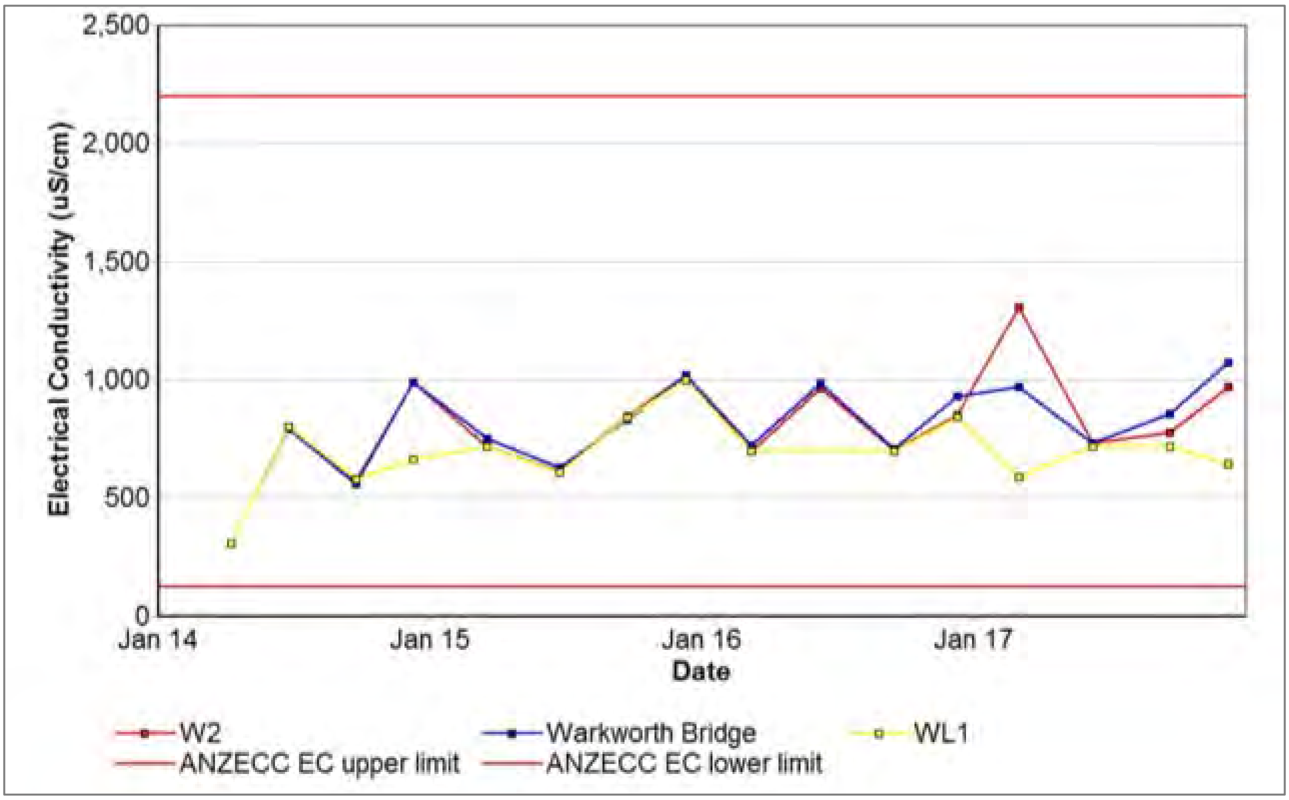


Figure 33: Wollombi Brook EC Trends 2014 – 2017

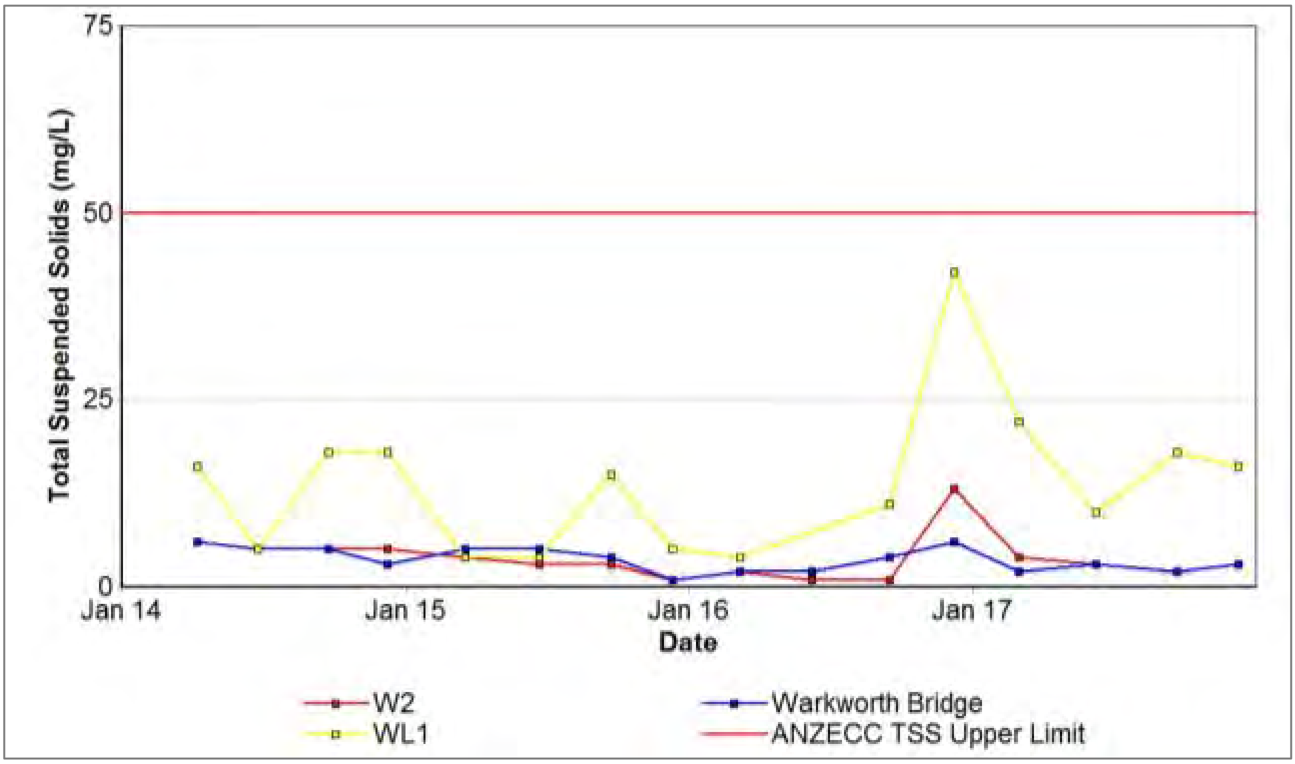


Figure 34: Wollombi Brook TSS Trends 2014 – 2017

7.2.1.3 Other Surrounding Tributaries

Event-based monitoring of natural tributaries surrounding HVO continued during 2017, one rain event sampling round was triggered in 2017. Monitoring during this rain event occurred on the following water courses:

- Comleroi Creek;
- Emu Creek;
- Farrells Creek;
- Pikes Creek;
- Davis Creek (dry during sampling event);
- Bayswater Creek; and
- Parnells Creek.

Long term trends for pH, EC and TSS are shown Figure 35 to Figure 37. Results for water quality remained generally within historical trends and acceptable ranges. The surface water monitoring programme will be reviewed in early 2018. The ephemeral nature of these monitoring locations is the primary reason for the considerable variation in physical water quality. Trigger tracking results are detailed in Table 32.

Table 32: Other Tributaries Internal Trigger Tracking Results

Location	Date	Trigger limit	Action taken in response
Pikes Creek Upstream	01/03/2017	EC –95th Percentile	Watching Brief*
Pikes Creek Downstream	01/03/2017	EC –95th Percentile	Watching Brief*

Location	Date	Trigger limit	Action taken in response
Bayswater Creek Midstream	01/03/2017	EC –95th Percentile	Watching Brief*
W2	01/03/2017	EC –95th Percentile	Watching Brief*
Comleroi Creek	01/03/2017	EC –5th Percentile	Watching Brief*
Bayswater Creek Midstream	01/03/2017	pH – 5th Percentile	Watching Brief*
W11	31/03/2017	pH – 5th Percentile	Watching Brief*
W3 Hunter River	01/03/2017	pH – 95th Percentile	Watching Brief*
Bayswater Creek Upstream	31/03/2017	TSS – 50mg/L (ANZECC criteria)	Elevated TSS associated with high-intensity rainfall event; any potential sources of sediment upstream from operations. No Further action taken.
W5 Farrells Creek Downstream	31/03/2017	TSS – 50mg/L (ANZECC criteria)	Elevated TSS associated with high-intensity rainfall event. Downstream results consistent with those upstream of Dam 11N Discharge Point. No Further action taken.
W5 Farrells Creek Upstream	31/03/2017	TSS – 50mg/L (ANZECC criteria)	Elevated TSS associated with high-intensity rainfall event. Result consistent with downstream of Dam 11N Discharge Point. No further action taken.

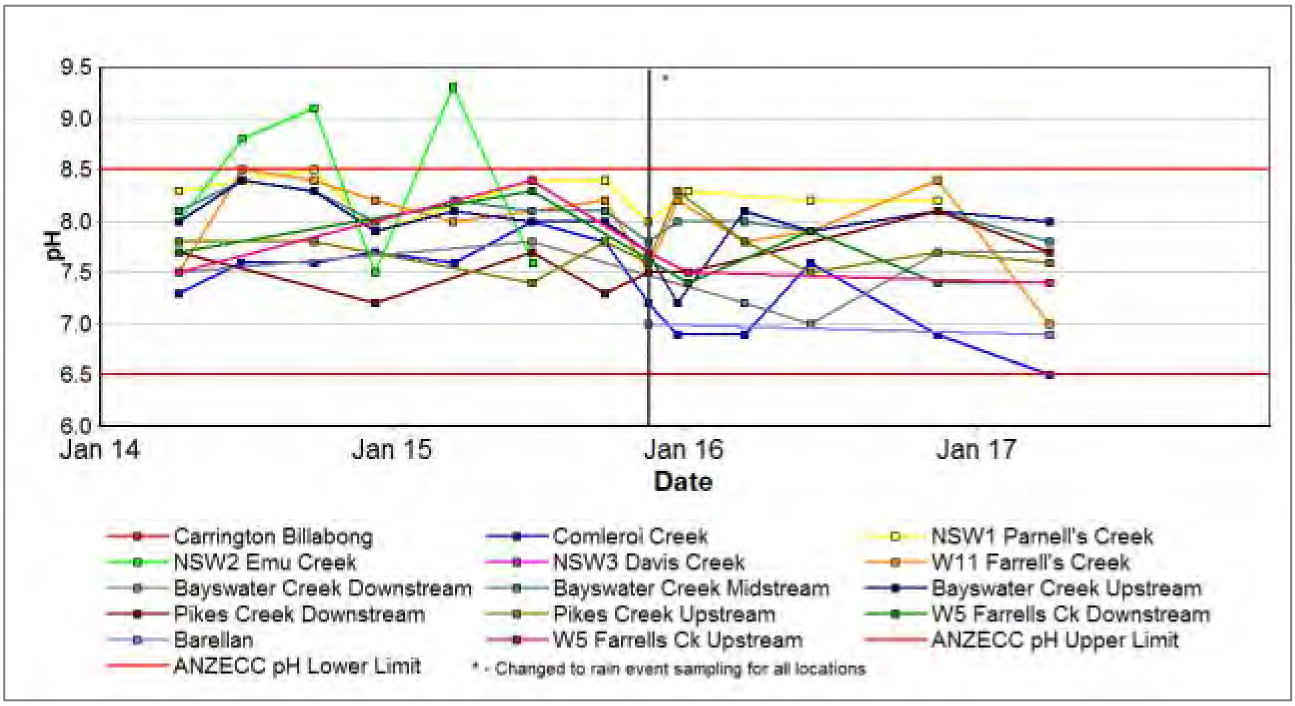


Figure 35: Other Tributaries pH Trends 2014 – 2017

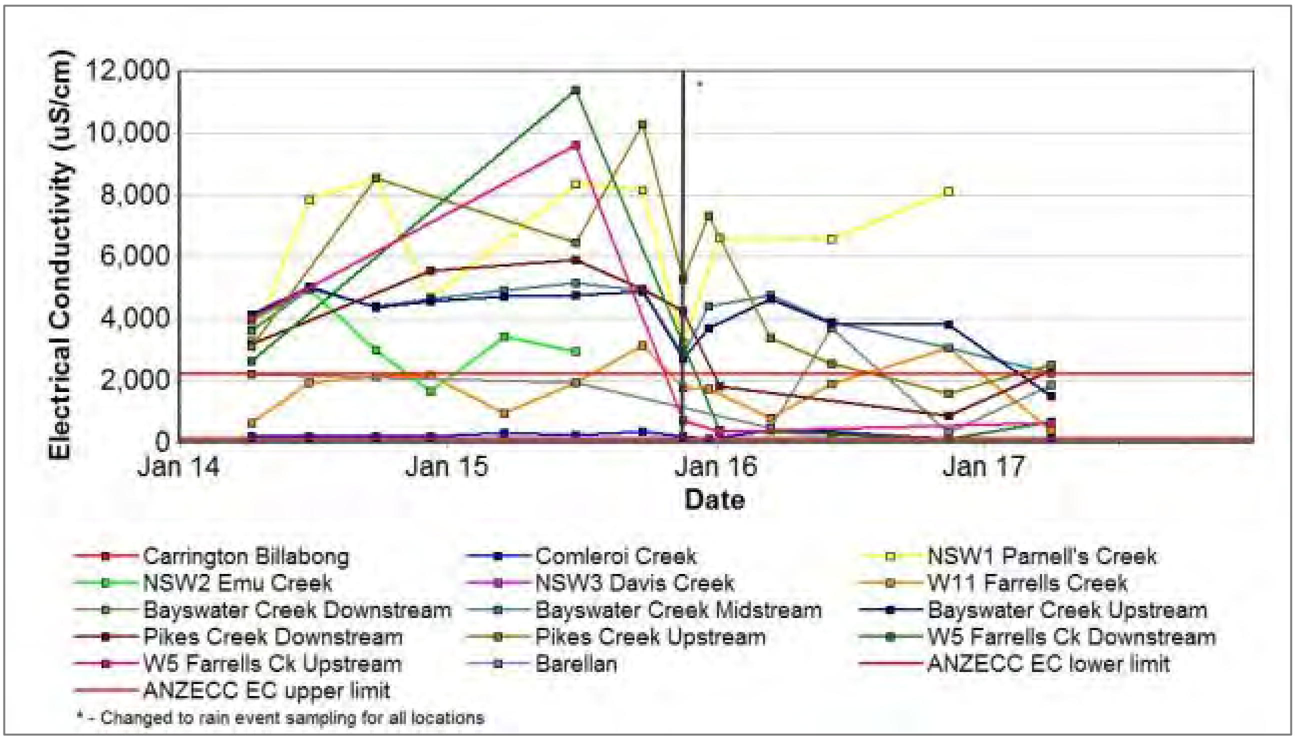


Figure 36: Other Tributaries EC Trends 2014 – 2017

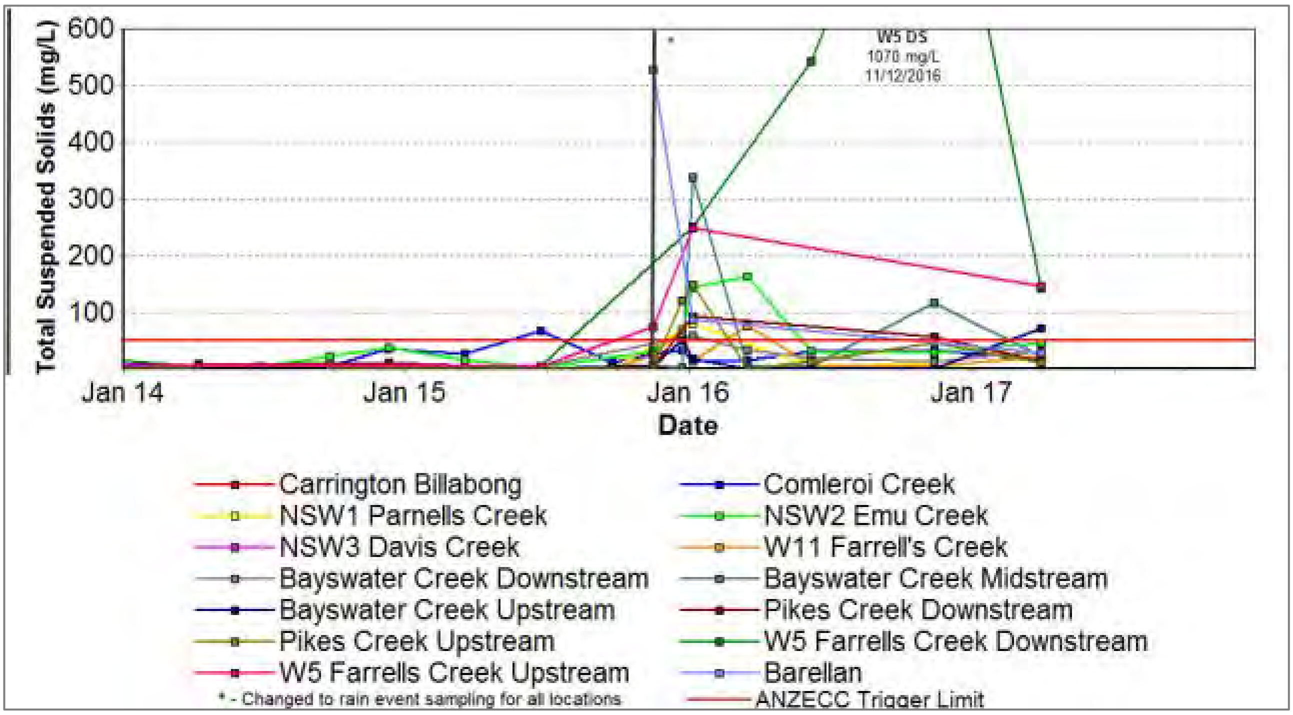


Figure 37: Other Tributaries TSS Trends 2014 – 2017

7.2.1.4 HVO Site Dams

40 samples were collected across 10 dams during 2017; long term trends for pH, EC and TSS are shown in Figure 38 to Figure 40. EC results show a slight increasing trend during the reporting period, as a result of drier weather conditions reducing rainfall runoff inflows to the mine water management system. Emu Creek Sed. Dam continues to record elevated TSS concentrations, associated with the advancement of mining around the dam; noting the dam is operated to spill back into the pit and will not flow offsite.

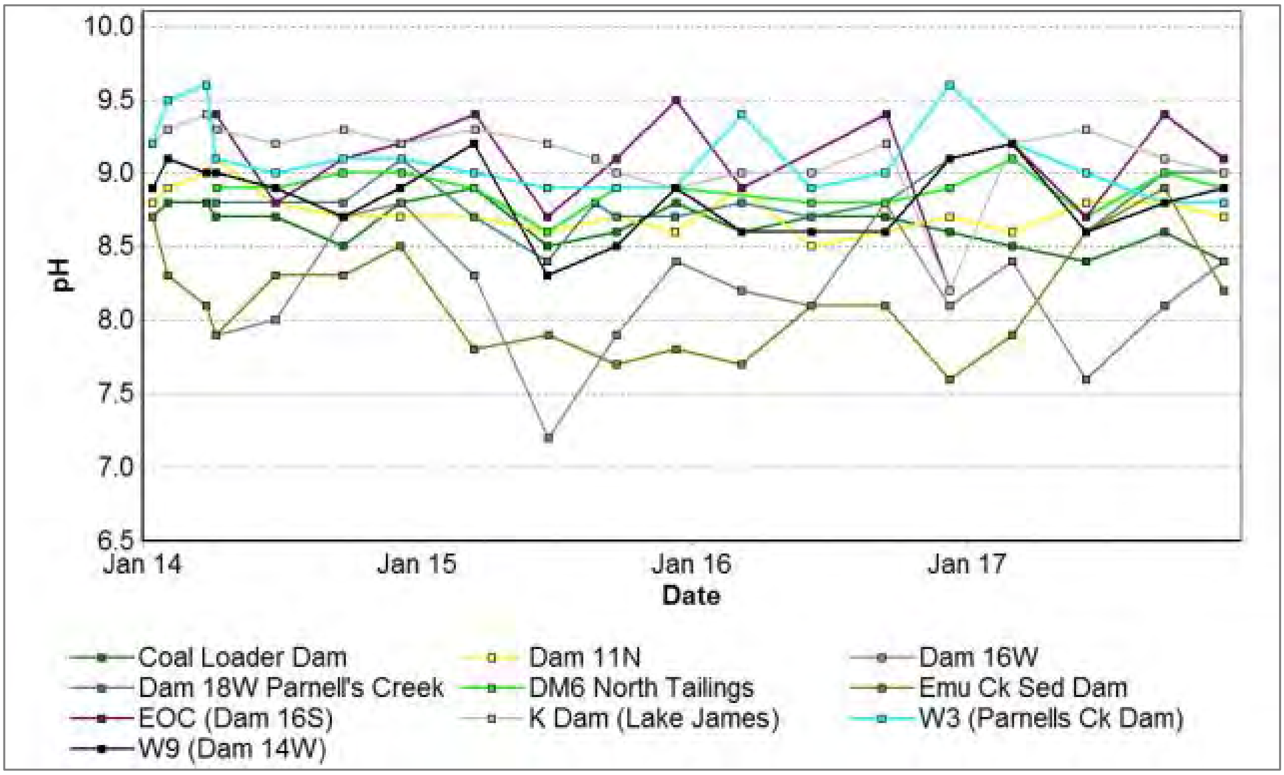


Figure 38: HVO Site Dams pH Trends 2014 – 2017

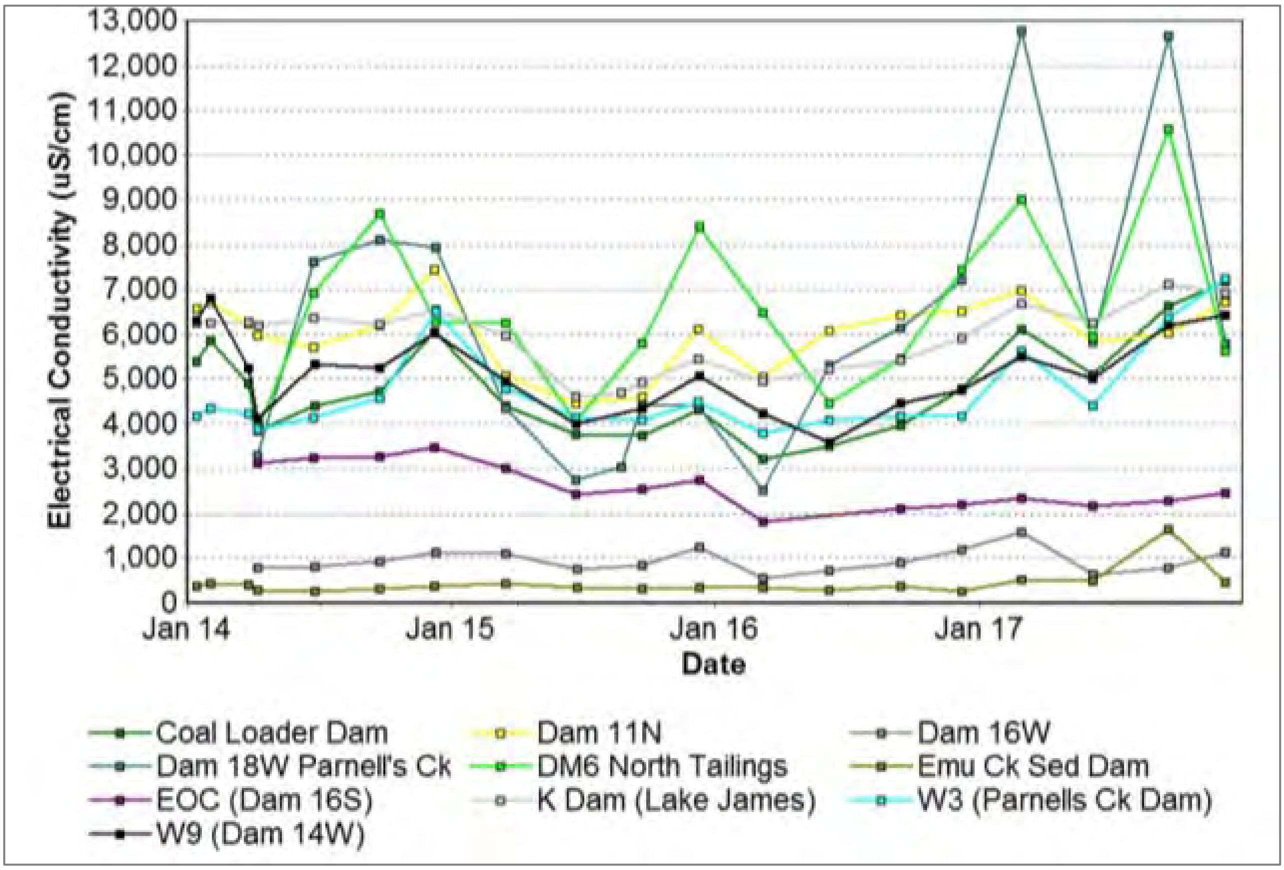


Figure 39: **HVO Site Dams EC Trends 2014 – 2017**

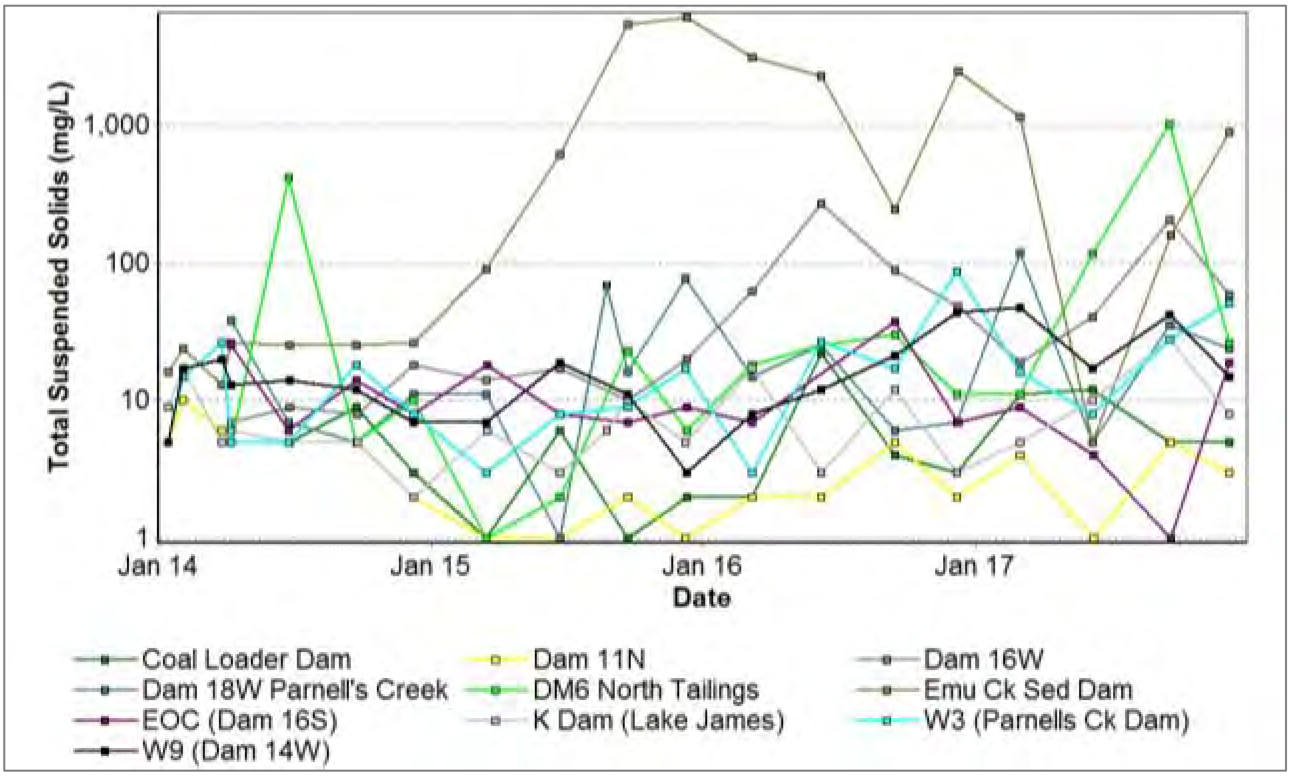


Figure 40: HVO Site Dams TSS Trends 2014 – 2017

7.3 Comparison of 2016 Water Quality Data with EIS Predictions

7.3.1 South Pit EIS Predictions

The South Pit EIS estimated an 'instantaneous' water quality for Electrical Conductivity of 5,700 µS/cm as an upper limit. Instantaneous water quality is a simple estimate obtained by dividing the total salt available by the maximum amount of possible void water. Electrical Conductivity measurements at Lake James averaged 6,745 µS/cm during 2017, the higher EC result is considered to be a result decreased rainfall across 2017 and decreasing water level in Lake James.

The South Pit EIS estimated average runoff water quality from undisturbed catchments to be 400 mg/L for TSS and 615 µS/cm for EC. Comleroi Creek, South of Cheshunt Pit was sampled once during a rain event in 2017 resulting in a TSS of 16 mg/L and EC of 106 µS/cm, demonstrating that runoff water from undisturbed catchments in the HVO South area is of better quality than that which was predicted in the EIS.

7.3.2 Carrington Pit EIS Predictions

The long term mine water quality for Carrington is discussed in the Carrington Mine Environmental Impact Statement (ERM 1999). The EIS estimated an "instantaneous" water quality for Electrical Conductivity of 7,050 µS/cm.

Dewatering from Carrington is a mixture of surface runoff from overburden emplacements, coal mining areas and seepage from the coal seams and alluvium. Water is directed to Dam 9N and into Dam 11N. The average EC and TSS in Dam 11N during 2017 was 6,390 µS/cm and 3 mg/L respectively, and is considered broadly representative of mine water quality for Carrington.

The Carrington EIS states that runoff from undisturbed catchments within the Carrington Pit will be directed around the mine via contour banks or surface drains to discharge where possible into natural creeks. The salinity of the runoff water was predicted to be approximately 615 µS/cm. Runoff from rehabilitated lands was initially predicted to have higher TSS, with levels approaching pre-mining conditions after several years. Carrington Billabong (where such water quality would be measured for this comparison) was reported as dry during the single rain event monitoring round in 2017 with no samples collected. An unnamed tributary that flows to the Hunter River immediately West of the active mining area recorded an EC of 115 µS/cm, well below the EIS prediction.

7.3.3 West Pit EIS Predictions

The West Pit EIS included the data in Table 33 as representative of water quality in the local catchment area. The pH and EC at Emu Creek (NSW2) averaged 8.4 and 783 µS/cm respectively during the review period, were within EIS predictions. The pH and EC at Farrells Creek (combined upstream and downstream monitoring sites) averaged 7.4 and 658 µS/cm respectively during the review period, were within EIS predictions. Davis Creek was reported as dry in 2017 thus no comparison can be made against the predicted water quality. Parnell's Dam (W3) measured an average EC of 5,905 µS/cm in 2017, within the predicted range.

Table 33: Representative Water Quality for West Pit

Watercourse	pH (pH Units)	EC (µS/cm)
Davis Creek	7.7 to 8.4	767 to +8,000
Emu Creek	7.5 to 8.8	365 to +1,000
Farrells Creek	7.0 to 9.2	195 to +12,000
Mine Water (Parnell's Dam)	-	2,400 to 6,300

7.4 Performance relating to HRSTS Discharges

HVO participates in the Hunter River Salinity Trading Scheme (HRSTS), allowing it to discharge to the Hunter River via three licensed discharge points, including Dam 11N, Dam 15S (Lake James) and Dam 9W (Parnells Dam). Discharges can only take place subject to the schemes regulations.

As required by the EPL, HVO submitted a discharge report for the 2016/17 financial year. No water was discharged off site during 2017 via the Hunter River Salinity Trading Scheme (HRSTS).

7.5 Complaints

HVO received two complaints regarding water quality in the Hunter River during 2017. These complaints were investigated and additional sampling was undertaking to determine potential impact from HVO. The investigations revealed that the concerns raised were not related to impact from HVO and no further action was required.

7.6 Non-compliances

See Section 11.4 of the report for non-compliance details.

7.7 Groundwater

7.7.1 Groundwater Management

Groundwater monitoring activities were undertaken in 2017 in accordance with the HVO Water Management Plan and Groundwater Monitoring Programme. The monitoring results are used to establish and monitor trends in physical and geochemical parameters of surrounding groundwater potentially influenced by mining.

The groundwater monitoring programme at HVO measures the quality of groundwater against background data, EIS predictions and historical trends. Ground water quality is evaluated through the parameters of pH, EC, and Standing Water Level (SWL) (measured as elevation in metres with respect to the Australian Height Datum, mAHD). On a periodic basis (nominally once per annum) a comprehensive suite of analytes are measured, including major anions, cations and metals. Prior to sampling for comprehensive analysis, bore purging is undertaken to ensure a representative sample is collected.

Groundwater monitoring data is reviewed on a quarterly basis. The review involves a comparison of measured pH and EC results against internal trigger values which have been derived from the historical data set. Trigger limits are calculated as the 95th percentile maximum value (EC and pH) and the 5th percentile minimum value (pH only) from data collected since 2011. Trigger levels have been set on the basis of geographical proximity and target stratigraphy. Bores that record as dry and bores of unknown seam have not been included in calculation of the trigger limits. The response to measured excursions outside the trigger limits is detailed in the HVO Water Management Plan. Where investigations and subsequent actions have been undertaken following review of monitoring data, these are detailed in this section. Monitoring locations are shown in Figure 41. The Annual Groundwater Review is provided in Appendix 1.

7.7.2 Groundwater Performance

Sampling of ground waters was carried out from 100 monitoring bores across Hunter Valley Operations in accordance with AS/NZS 5667.6 (1998). Where laboratory analysis was undertaken, this was performed by a NATA accredited laboratory. Sites with a data capture rate of less than 100 per cent are outlined in Table 34.

Table 34: HVO Groundwater Monitoring Data Recovery for 2017

Location	Data Recovery (%)	Comments
4051C	0%	Bore unable to be sampled in 2017 due to obstruction (potential bore collapse).
4036C	0%	Insufficient water during 2017 monitoring events.
4113P	0%	Bore unable to be sampled in 2017 due to obstruction (potential bore collapse).
B425(WDH)	75%	Insufficient water to sample during November monitoring event.
BC1	0%	Insufficient water during 2017 monitoring events.
BC1A	75%	Insufficient water during March.
BZ1-2	0%	Insufficient water during 2017 monitoring events.
C122(BFS)	33%	Insufficient water during 2017 monitoring events.
CGW45	50%	Bore unable to be sampled from September and December due to obstruction.
CGW45a	0%	Insufficient water during 2017 monitoring events.
CGW46	0%	Insufficient water during 2017 monitoring events.
CGW47	0%	Insufficient water during 2017 monitoring events.
D317(ALL)	33%	Insufficient water during February, May, August, December monitoring events.
DM2	0%	Insufficient water during 2017 monitoring events
DM3	75%	No access to bore, unable to be sampled.
DM7	0%	Insufficient water during 2017 monitoring events
DM8	0%	Unable to be sampled due to pump fitment on bore.
DM9	0%	Unable to be sampled due to pump fitment on bore.
GW-101	0%	Insufficient water during 2017 monitoring events
GW-107	0%	Insufficient water during 2017 monitoring events
GW-108	0%	Insufficient water during 2017 monitoring events
S4	0%	Insufficient water during 2017 monitoring events

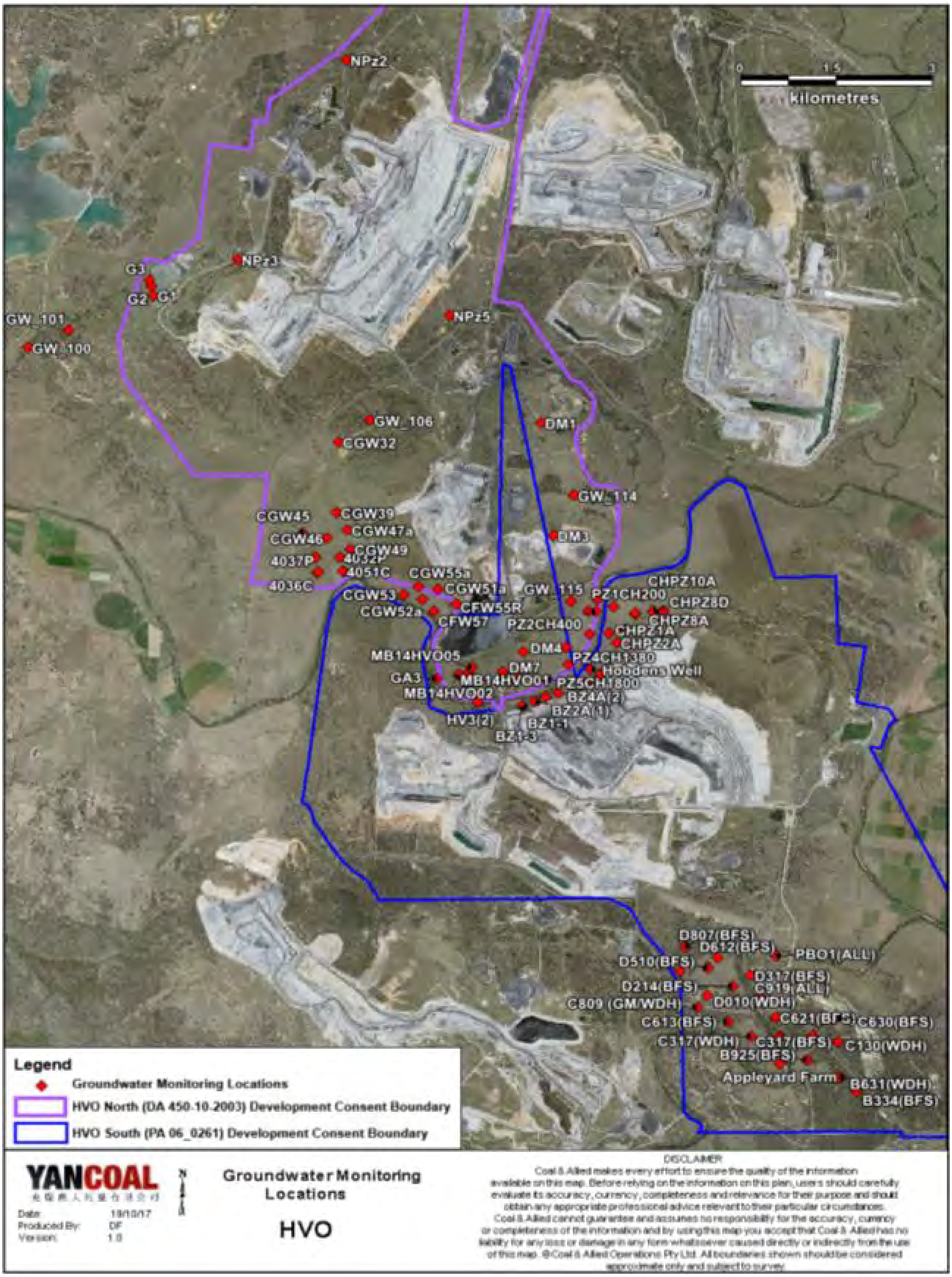


Figure 41: Groundwater Monitoring Network at HVO – 2017

7.7.3 Groundwater Monitoring Summary

The following section presents groundwater monitoring data in relation to the geographic locations and target stratigraphy for groundwater monitoring bores. Results are given for the following locations:

- Carrington Broonie;
- Carrington Alluvium;
- Carrington Interburden;
- Carrington West Wing Alluvium;
- Carrington West Wing LBL;
- Carrington West Wing Flood Plain;
- Cheshunt / North Pit Alluvium;
- Cheshunt Interburden;
- Cheshunt Mt Arthur;
- Cheshunt Piercefield;
- Lemington South Alluvium;
- Lemington South Arrowfield;
- Lemington South Bowfield;
- Lemington South Interburden;
- Lemington South Woodlands Hill;
- North Pit Spoil;
- West Pit Alluvium; and
- West Pit Sandstone / Siltstone.

Each location is discussed below, and a summary of monitoring data presented. Where monitoring results required further investigation following the recording of three consecutive measurements outside the internal statistical limits, these results are summarised in tables for each location.

7.7.3.1 Carrington Broonie

Carrington Groundwater was sampled on 8 occasions during 2017 from two monitoring locations. The EC, pH and SWL trends for 2014 to 2017 for Carrington Broonie Seam groundwater bores are shown in Figure 42 to Figure 44 respectively. Data was consistent with historical ranges.

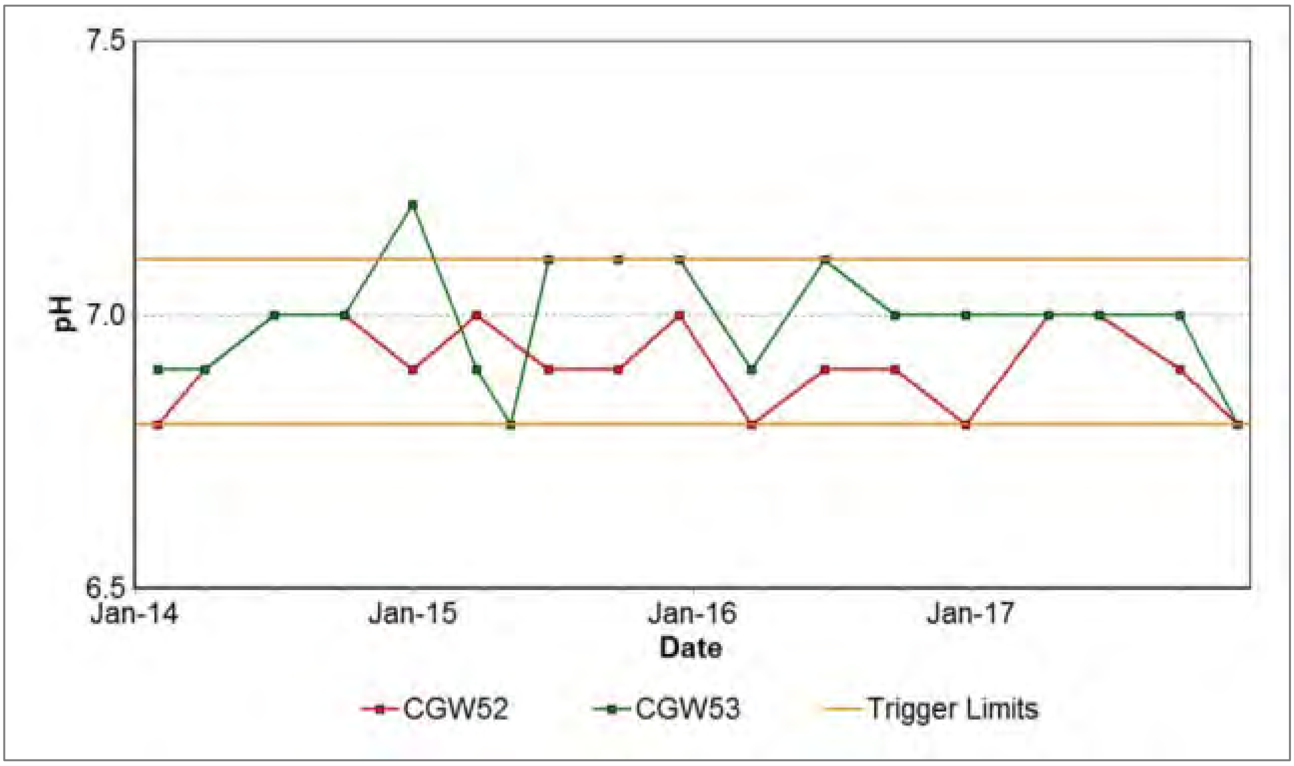


Figure 42: Carrington Broonie Groundwater pH Trends 2014 – 2017

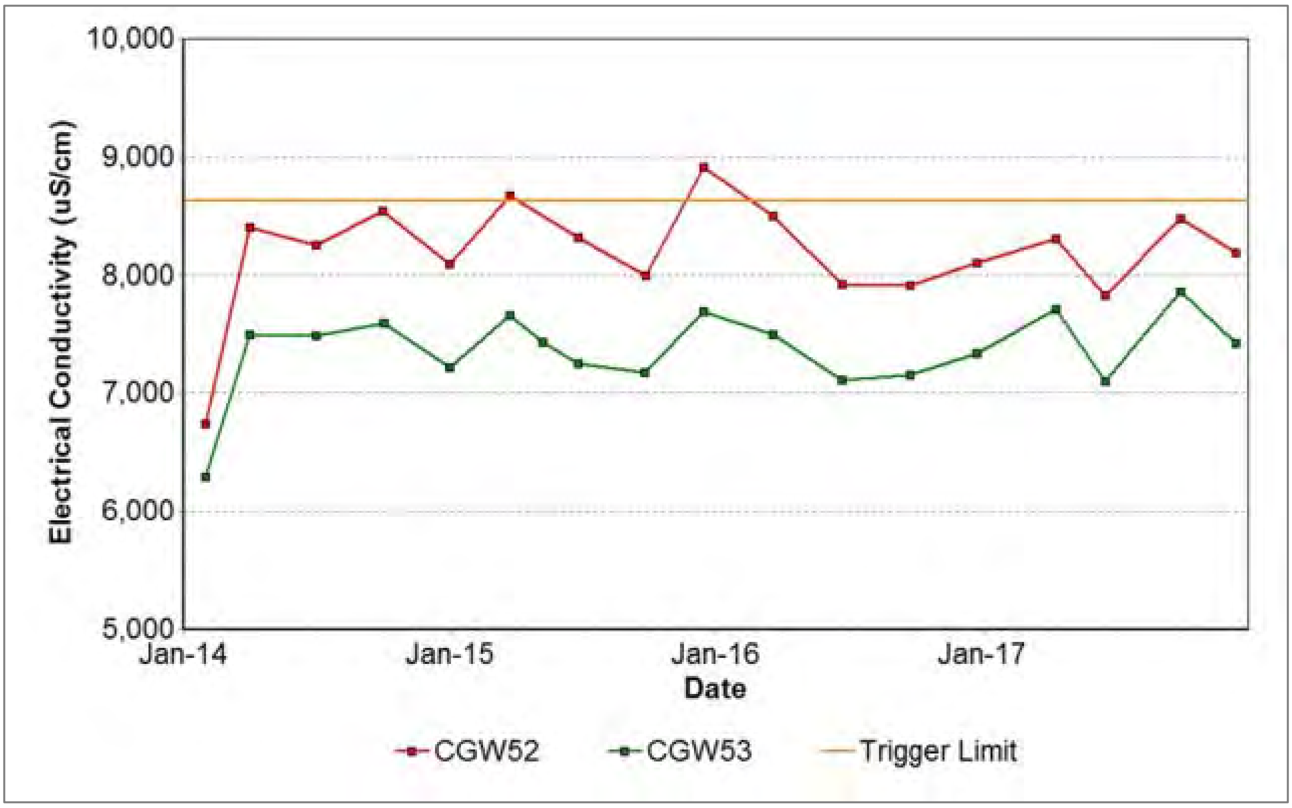


Figure 43: Carrington Broonie Groundwater EC Trends 2014 – 2017

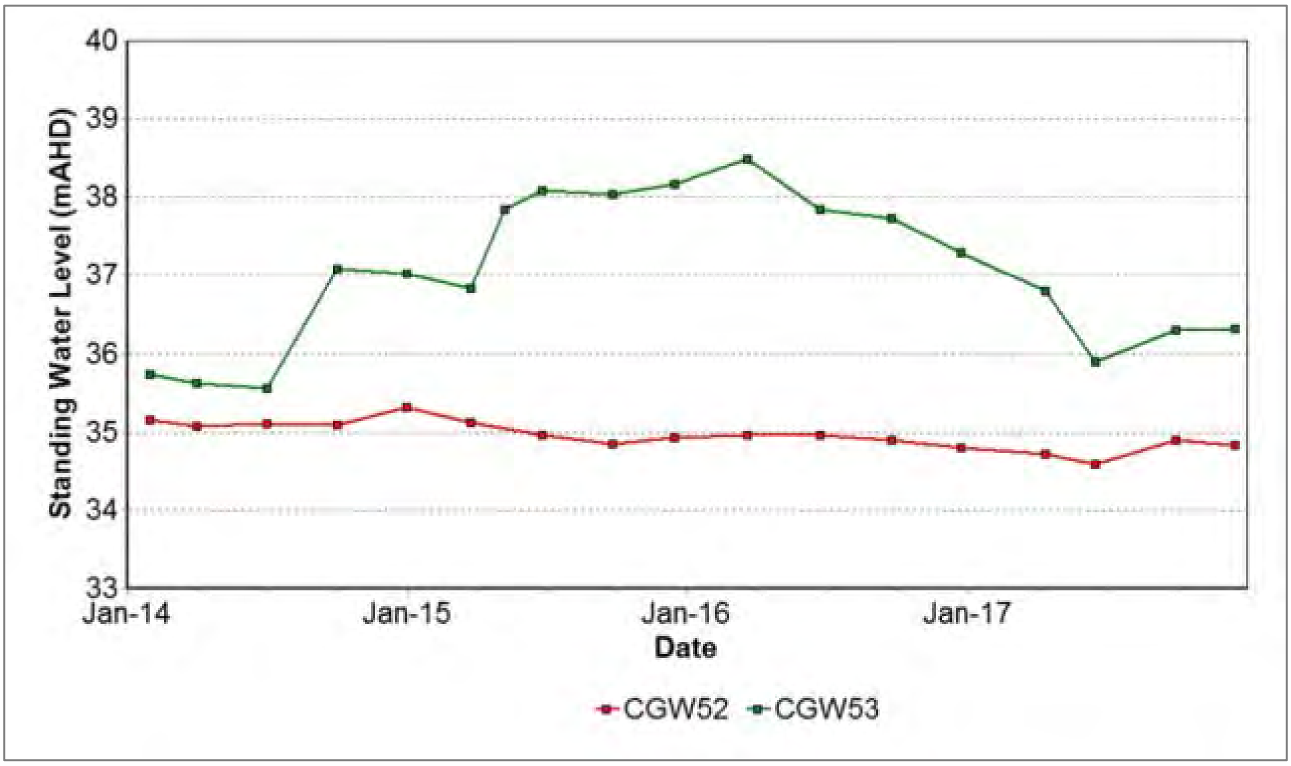


Figure 44: Carrington Broonie Groundwater SWL Trends 2014 – 2017

7.7.3.2 Carrington Alluvium

Groundwater monitoring in the Carrington Alluvium area was undertaken at five sites during 2017, with 20 samples collected during the reporting period. The EC, pH and SWL trends for 2014 to 2017 for Carrington Alluvium groundwater bores are shown in Figure 45 to Figure 47. Trigger tracking results are listed in Table 35. Water level increases coincide with flow events (increased water levels) in the Hunter River.

Table 35: HVO Carrington Alluvium Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
CFW55R	23/03/2017, 16/06/2017, 14/12/2017	PH - 5th percentile	pH has increased during the reporting period towards normal range. Further investigation will be undertaken.
CFW55R	23/03/2017, 16/06/2017, 28/09/2017, 14/12/2017	EC – 95th percentile	EC has remained stable during the reporting period. Further investigation will be undertaken.

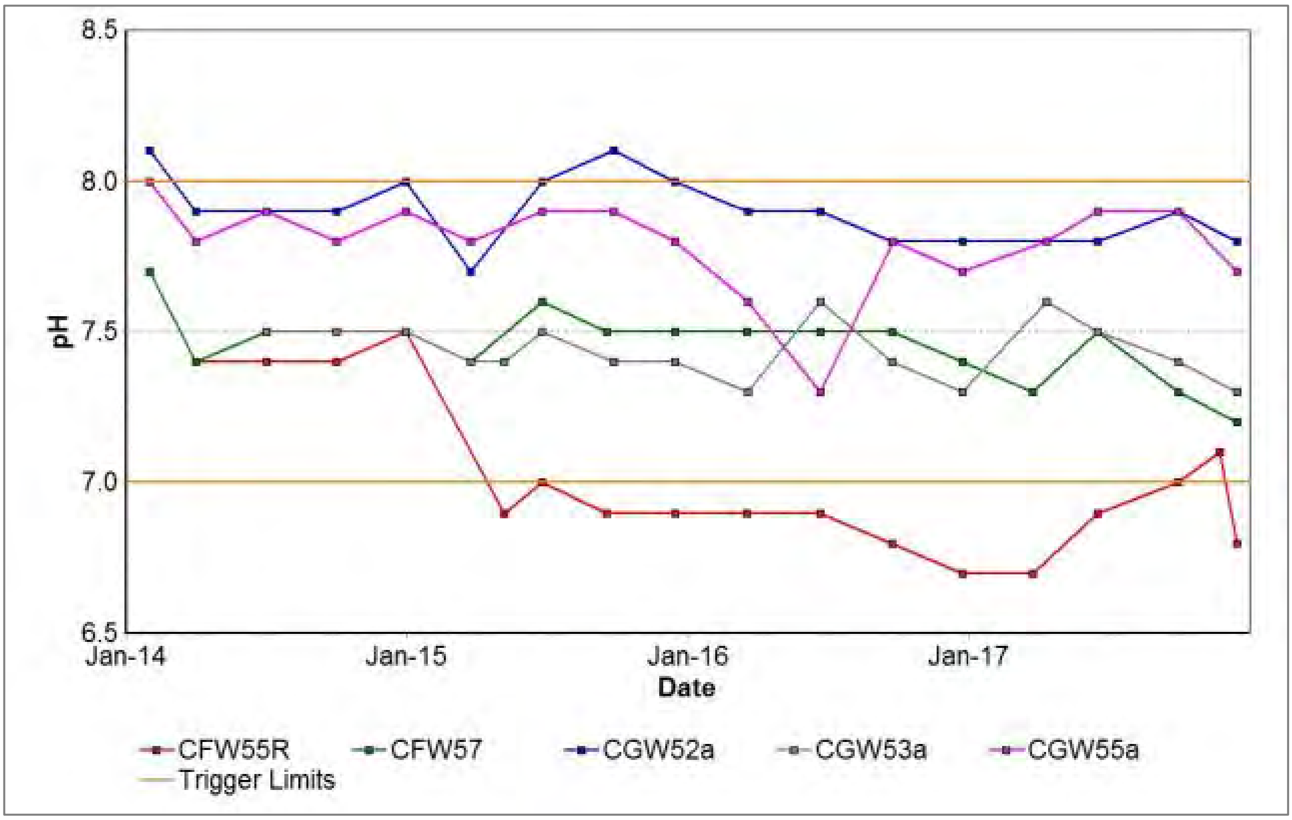


Figure 45: Carrington Alluvium Groundwater pH Trends 2014 – 2017

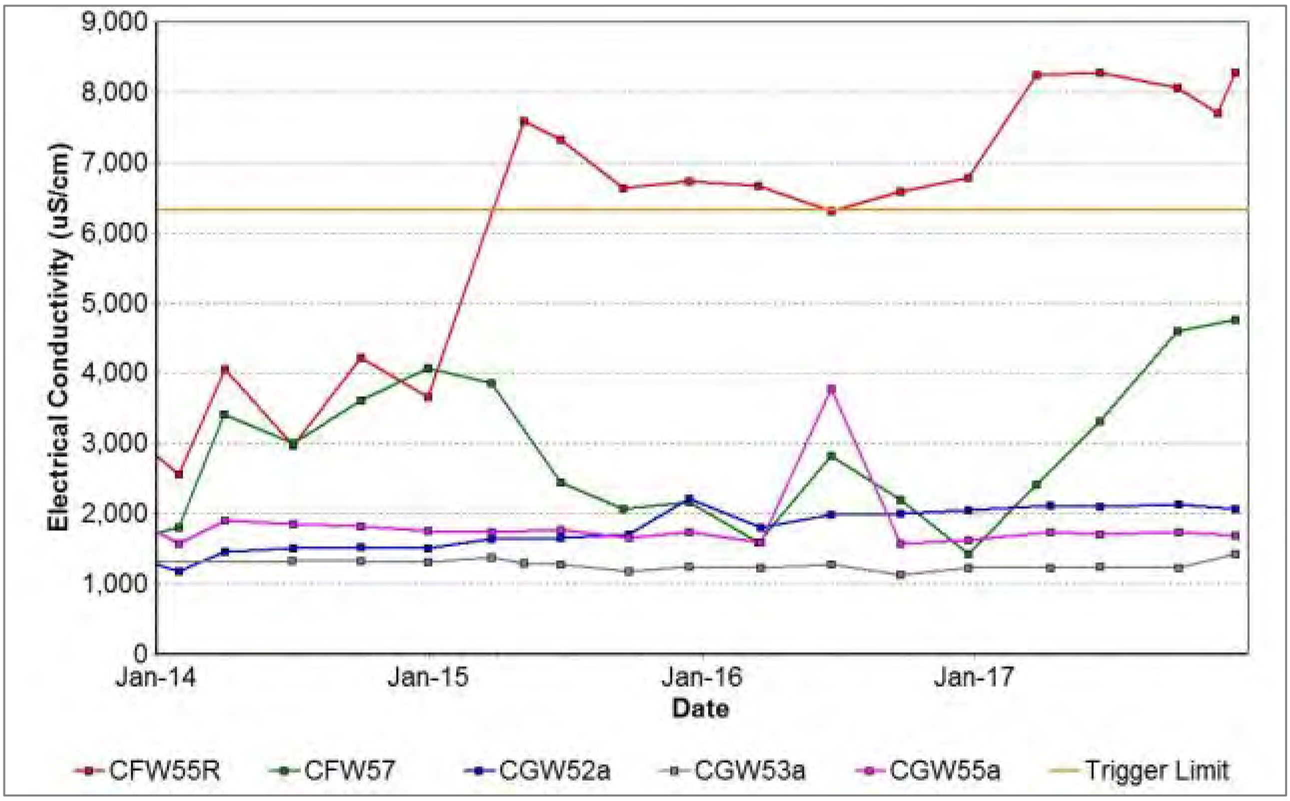


Figure 46:Carrington Alluvium Groundwater EC Trends 2014 – 2017

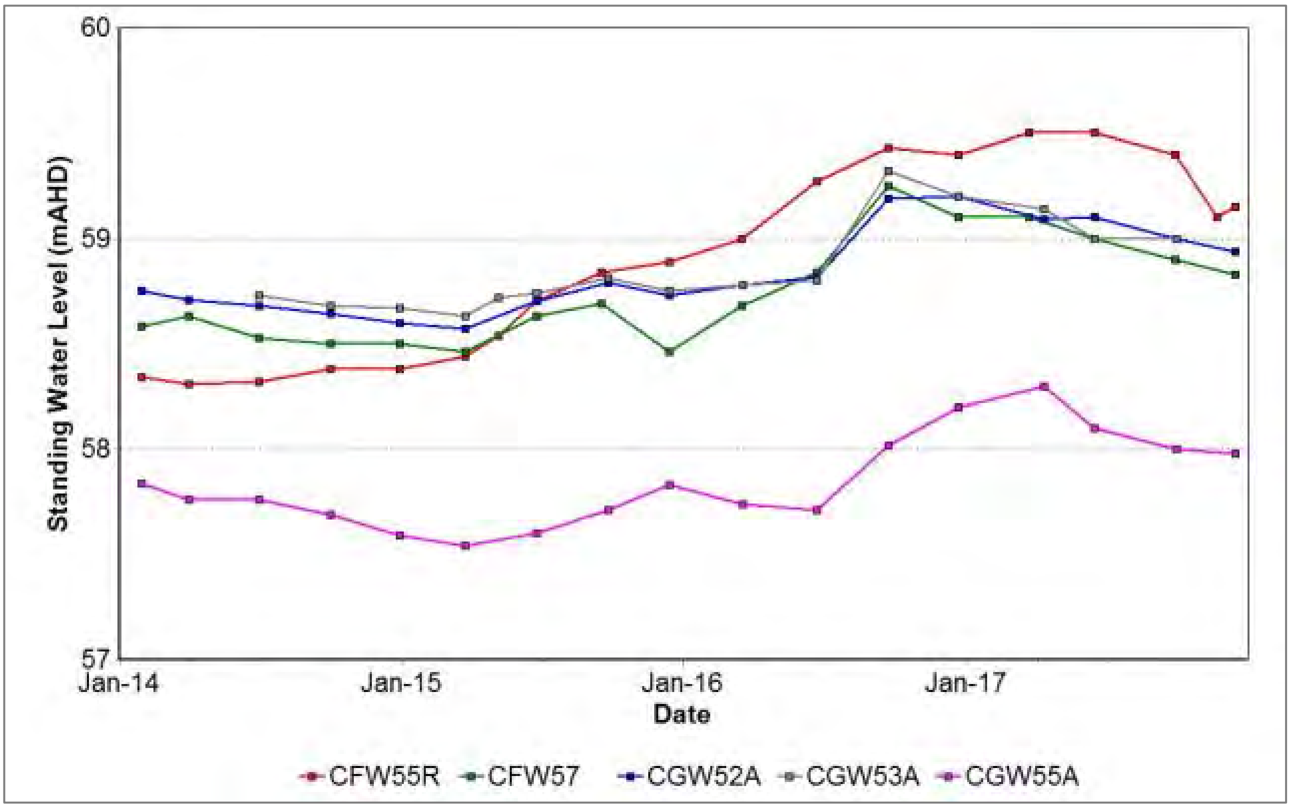


Figure 47:Carrington Alluvium Groundwater SWL trends 2014 – 2017

7.7.3.3 Carrington Interburden

Groundwater monitoring in the Carrington Interburden was undertaken three sites during 2017, with four samples collected for field analysis during the reporting period. The EC, pH and SWL trends for 2014 to 2017 for groundwater bores in the Carrington Interburden are shown in Figure 48 to Figure 50 respectively. Results were steady and consistent with historical trends. 4036C and 4051C bores contained insufficient water for accurate PH and EC analysis throughout 2017.

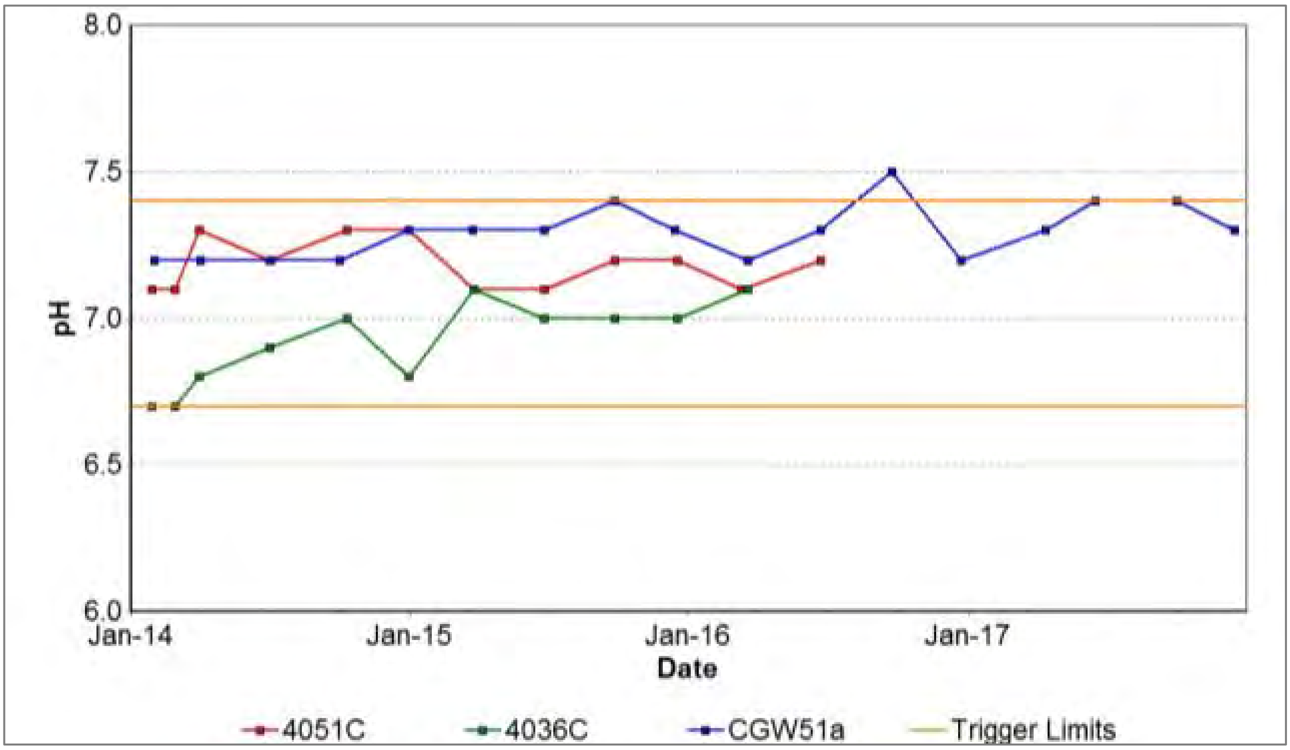


Figure 48: Carrington Interburden Groundwater pH Trends 2014 – 2017

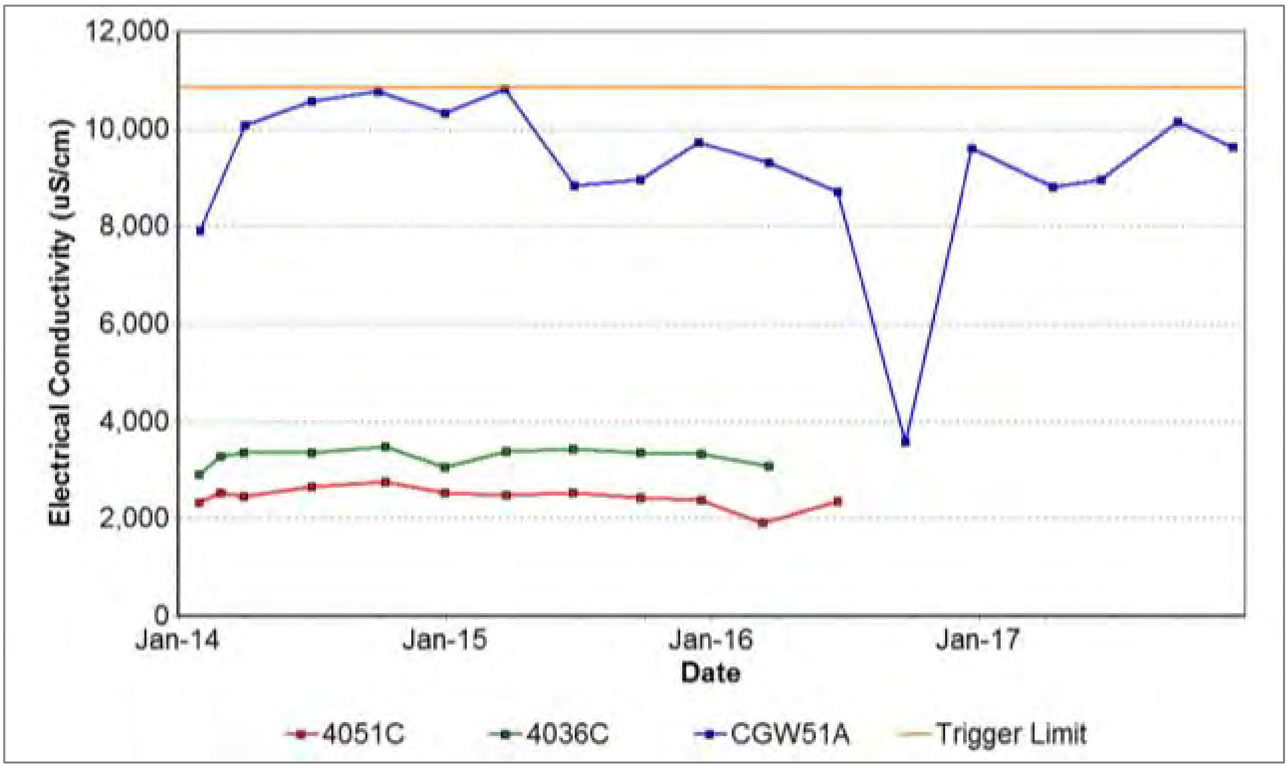


Figure 49: Carrington Interburden Groundwater EC Trends 2014 – 2017

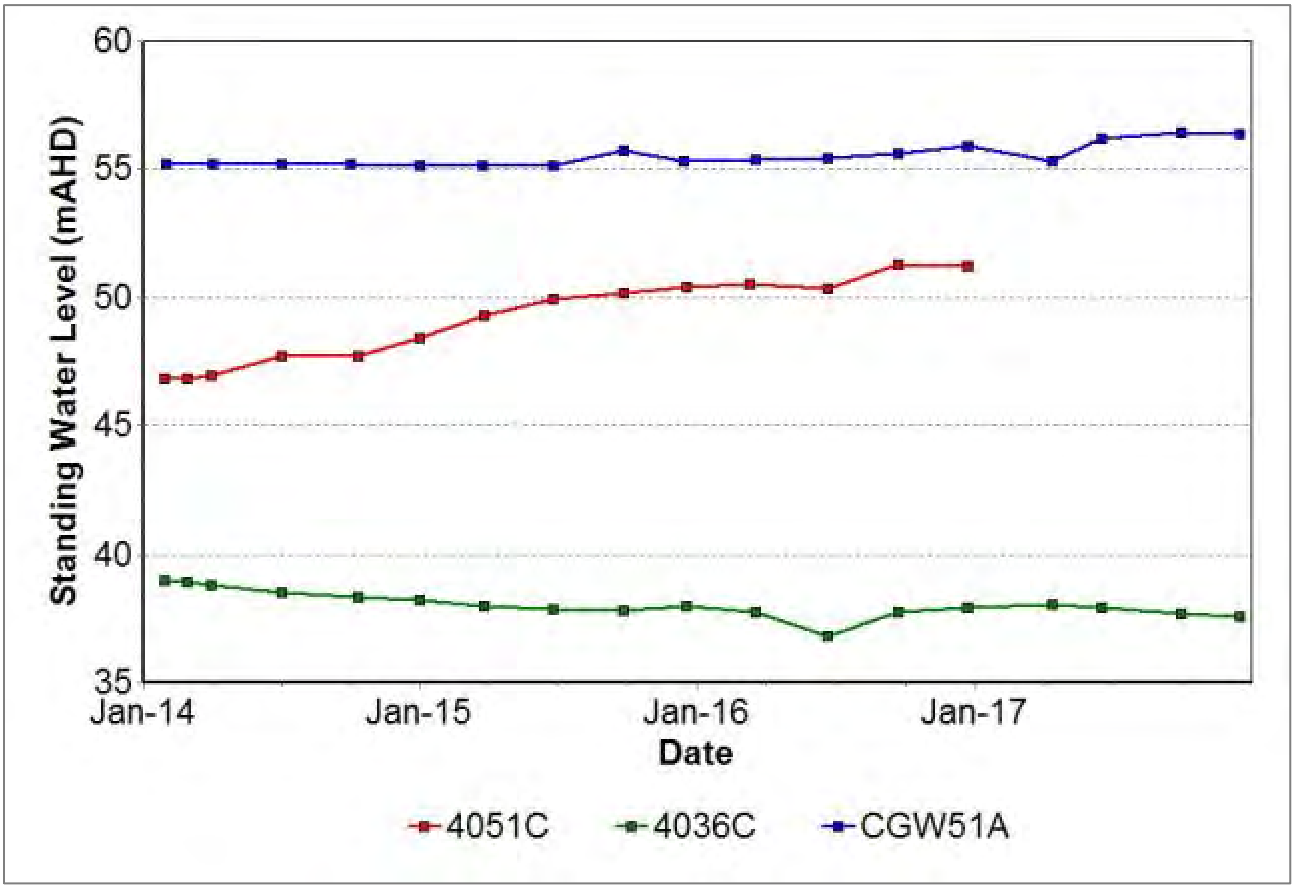


Figure 50: Carrington Interburden Groundwater SWL Trends 2014 – 2017

7.7.3.4 Carrington West Wing Alluvium

Groundwater monitoring in the Carrington West Wing Alluvium was undertaken at five sites in 2017 with 22 samples collected for field analysis during the reporting period. Results are shown in Figure 51 to Figure 53. Results during 2017 were steady and consistent with historical trends.

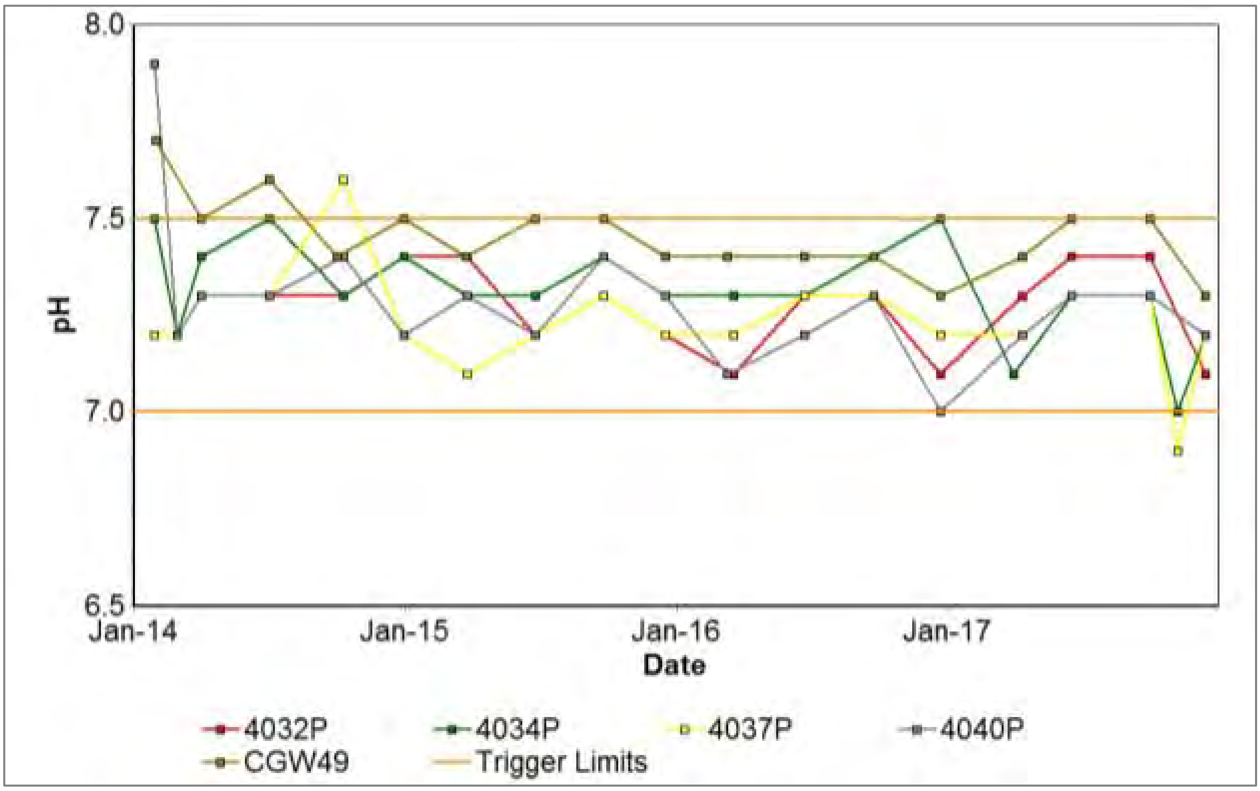


Figure 51: Carrington West Wing Alluvium Groundwater pH Trends 2014-2017

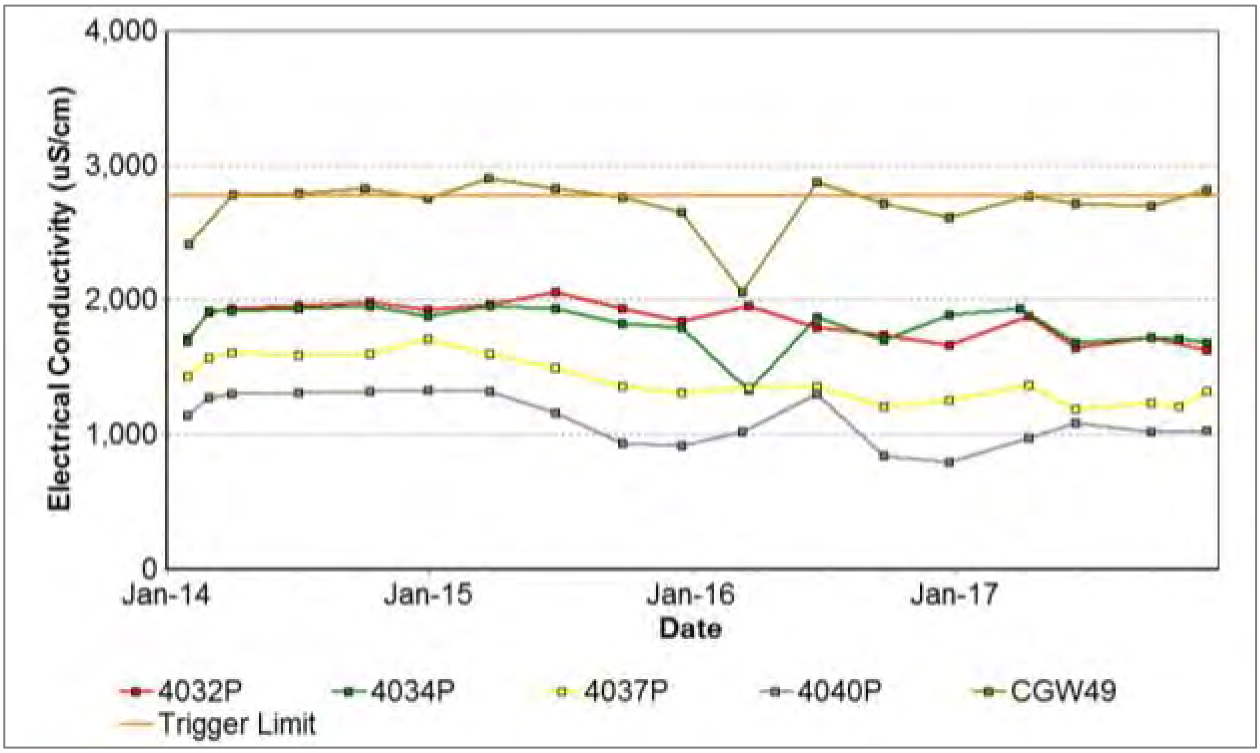


Figure 52: Carrington West Wing Alluvium Groundwater EC Trends 2014 – 2017

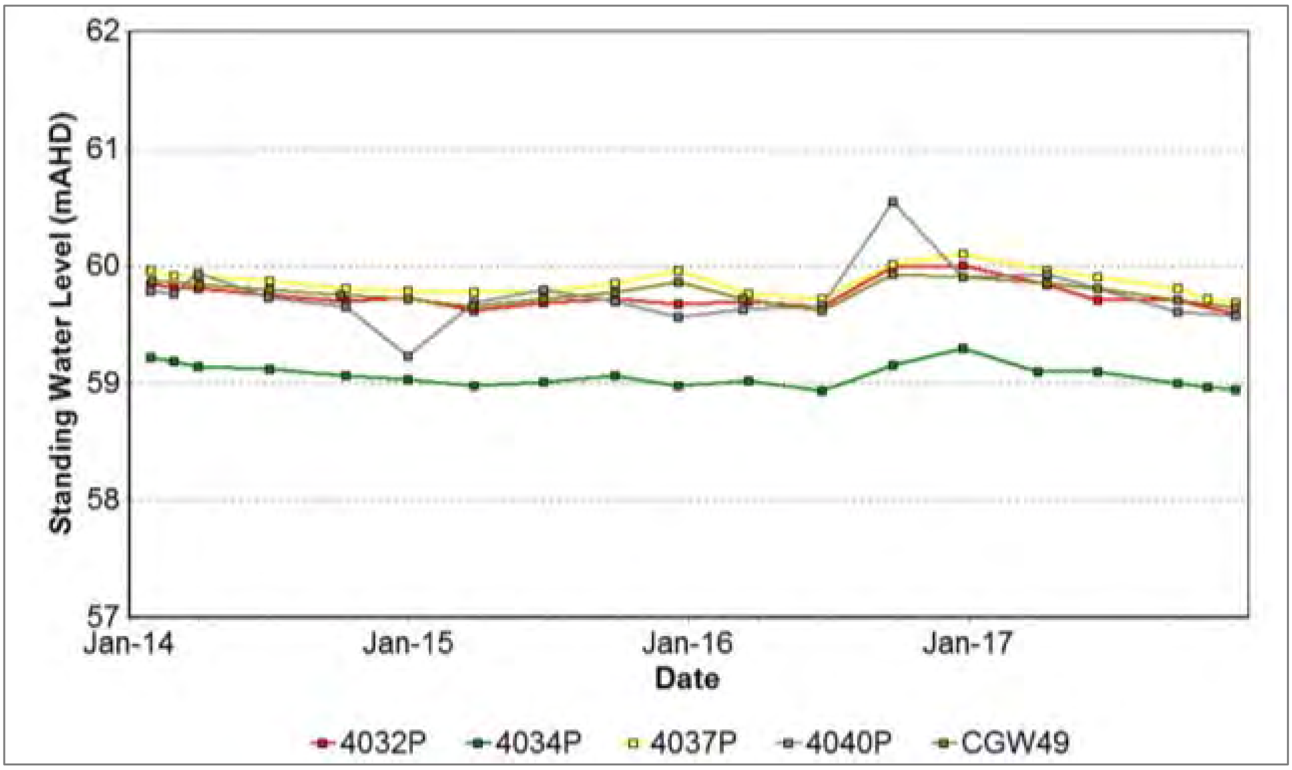


Figure 53: Carrington West Wing Alluvium Groundwater SWL Trends 2014 - 2017

7.7.3.5 Carrington West Wing Flood Plain

Groundwater monitoring in the Carrington West Wing Flood Plain was undertaken at four sites in 2017 with 16 samples collected for field analysis during the reporting period. Results are shown in. Results are shown in Figure 54 to Figure 56. A sharp fall in water level was recorded in CGW47A during December (cause indeterminable), this trend was seen in June 2015 and June 2016. No mine activities were undertaken in this area and the trend was not visible in surrounding bores, it is considered unlikely that the fall in water level is due to mining related activities. Trigger tracking results are listed in Table 36.

Table 36: Carrington West Wing Alluvium Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
CGW32	28/09/2017	EC – 95^{th} percentile	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

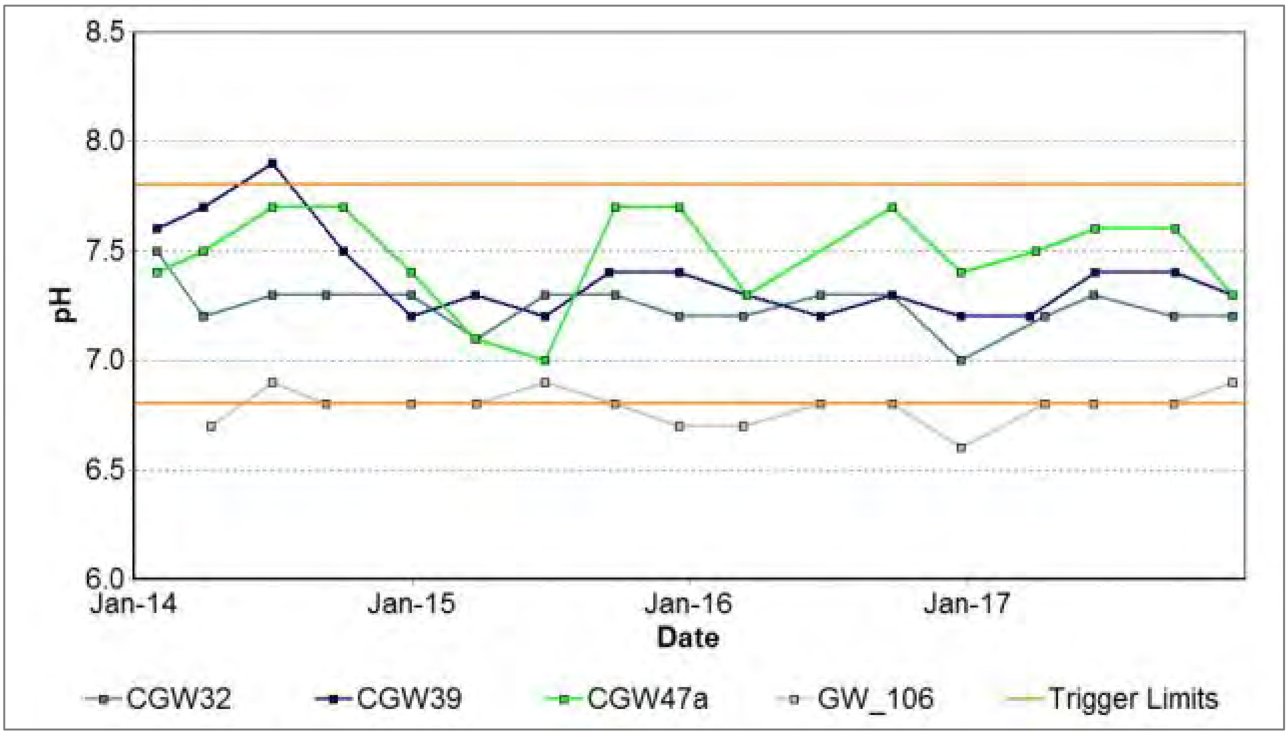


Figure 54: Carrington West Wing Flood Plain Groundwater pH Trends 2014 - 2017

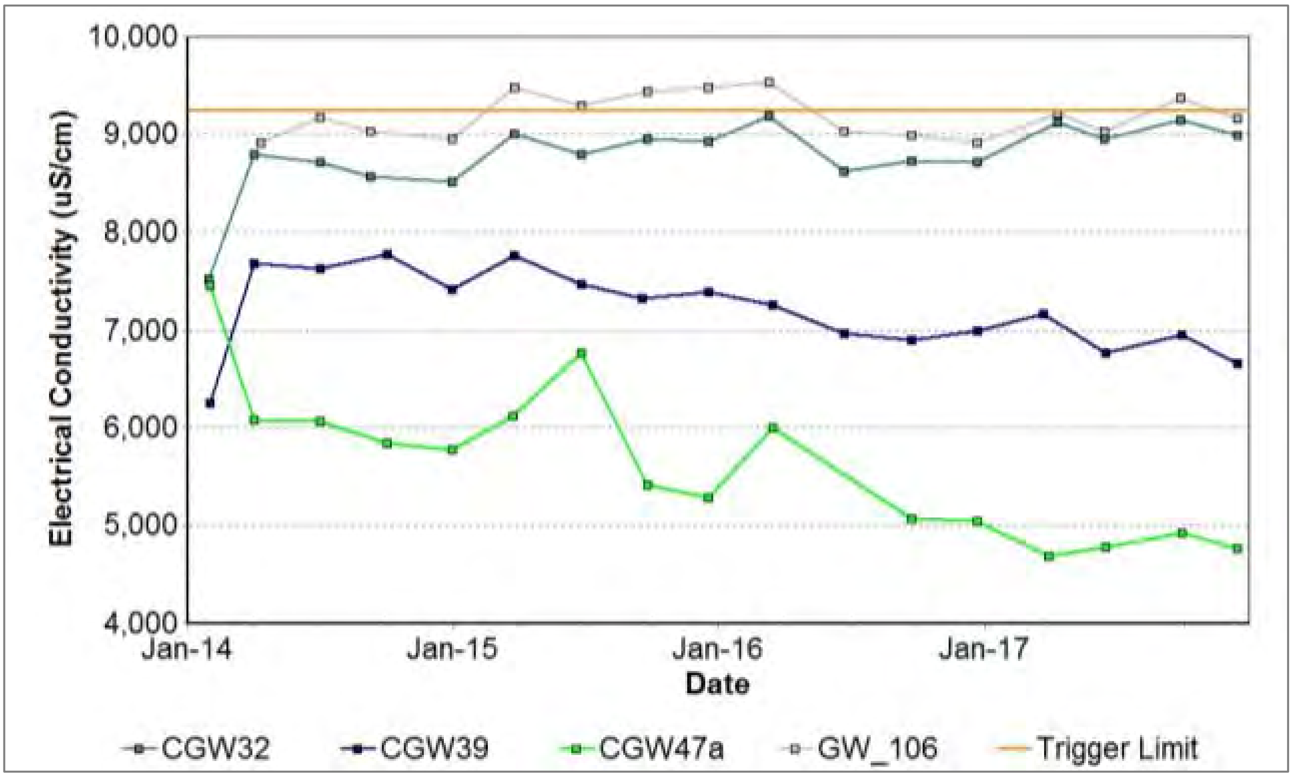


Figure 55: Carrington West Wing Flood Plain Groundwater EC Trends 2014 - 2017

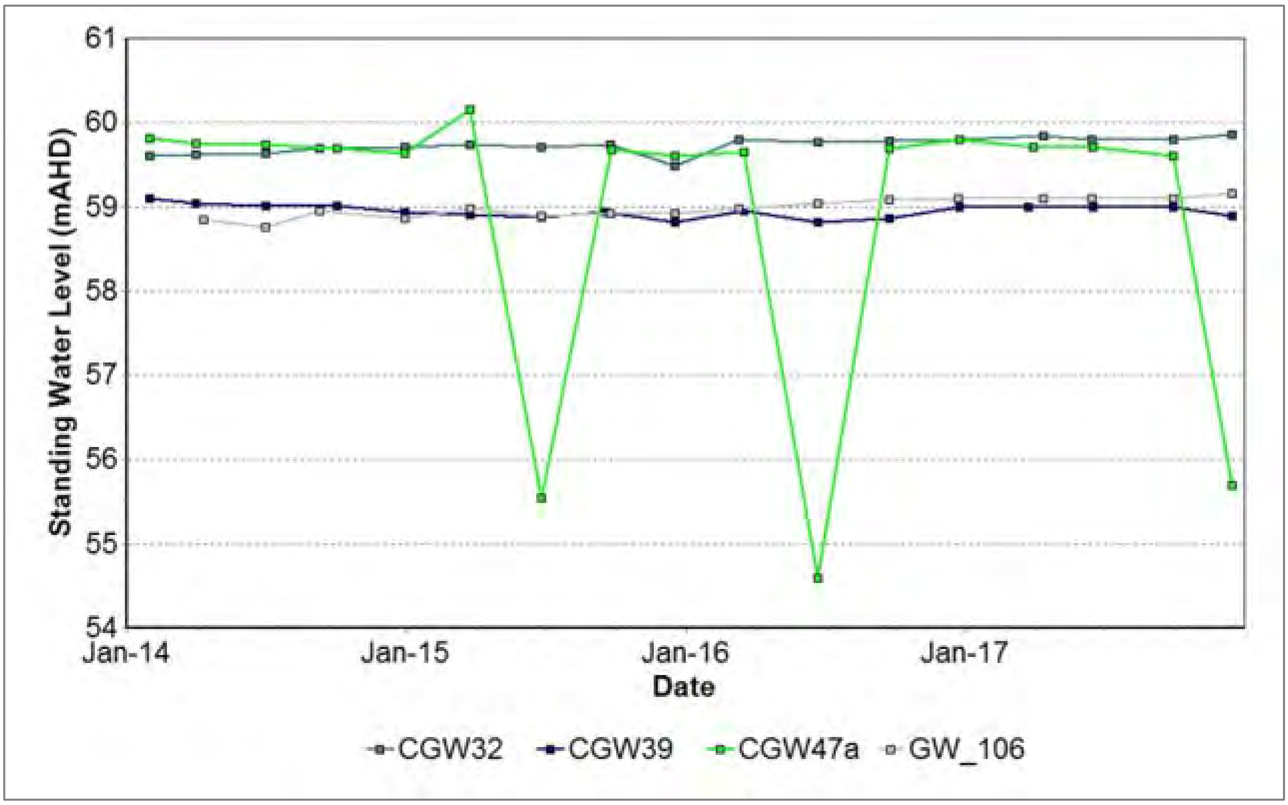


Figure 56: Carrington West Wing Flood Plain Groundwater SWL Trends 2014- 2017

7.7.3.6 Cheshunt / North Pit Alluvium

Groundwater monitoring in the Cheshunt / North Pit area was undertaken at 17 sites during 2017, with 68 samples collected during routine monitoring. Electrical Conductivity, pH and SWL trends for 2014 to 2017 are shown in Figure 57 to Figure 59. Trigger tracking results are listed in Table 37.

Table 37: Cheshunt/North Pit Alluvium Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
Hobdens Well	16/05/2017	PH - 95th percentile	Watching Brief *
	22/08/2017		Watching Brief *
	10/11/2017		Data analysis investigation suggests that pH result is within historic bandwidth for this site, continue to monitor.
BUNC45A	16/02/2017	PH – 5th percentile	Watching Brief *
CHPZ3A	16/02/2017	PH – 5th percentile	Watching Brief *
CHPZ8A	16/02/2017	PH – 5th percentile	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

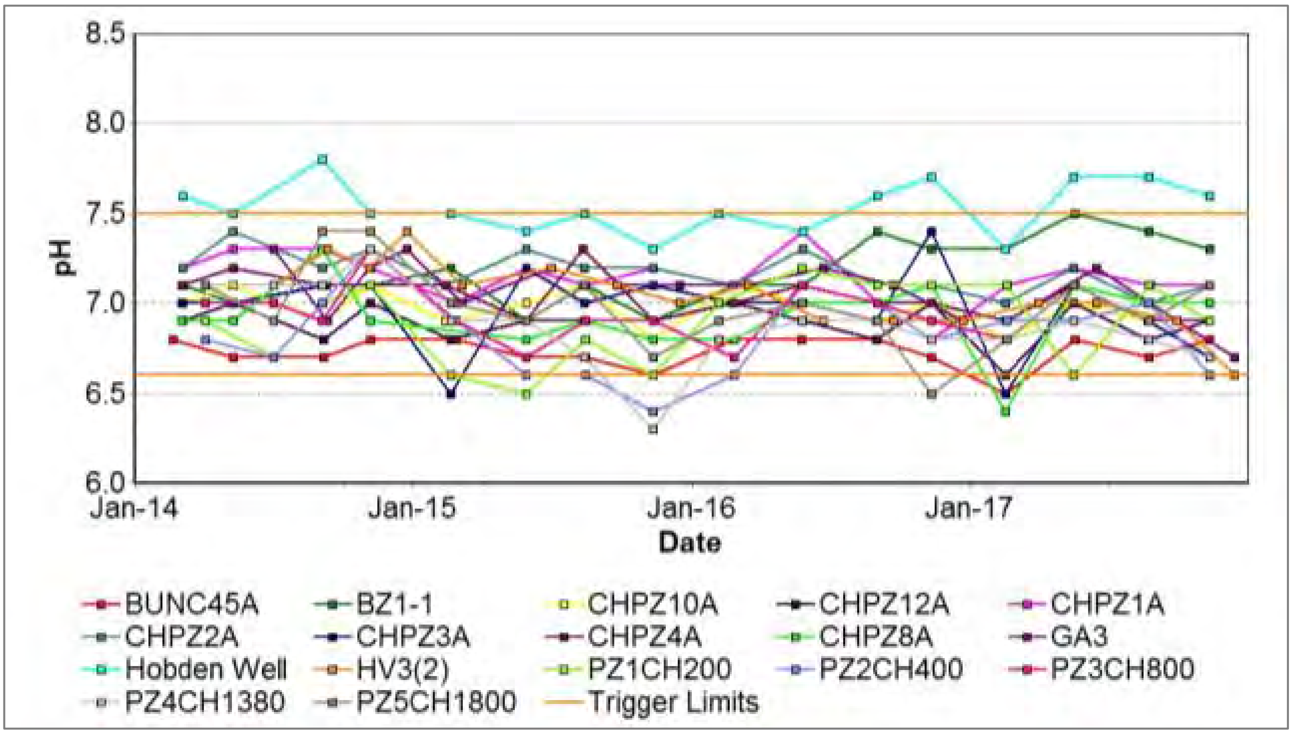


Figure 57: Cheshunt/North Pit Alluvium Groundwater pH trends 2014 – 2017

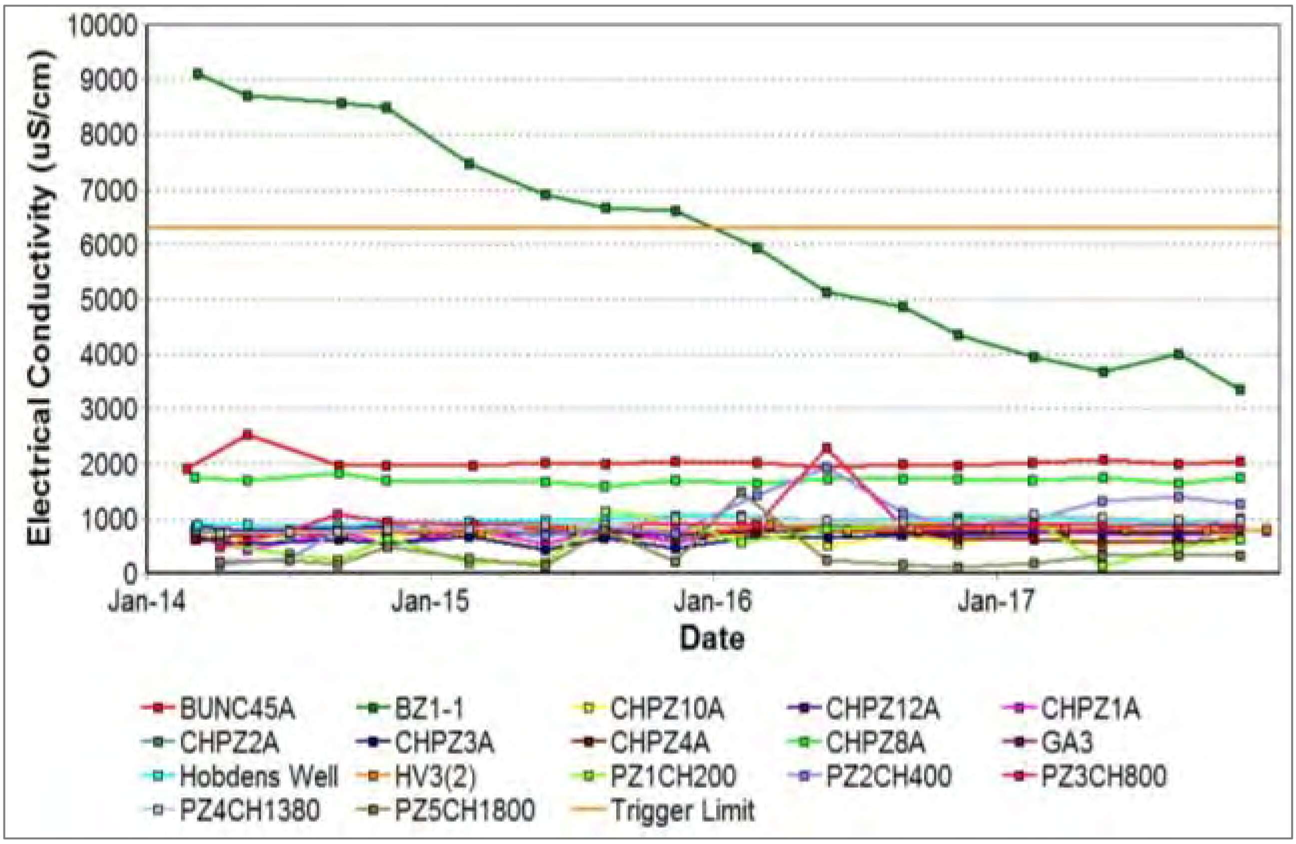


Figure 58: Cheshunt/North Pit Alluvium Groundwater EC Trends 2014 - 2017

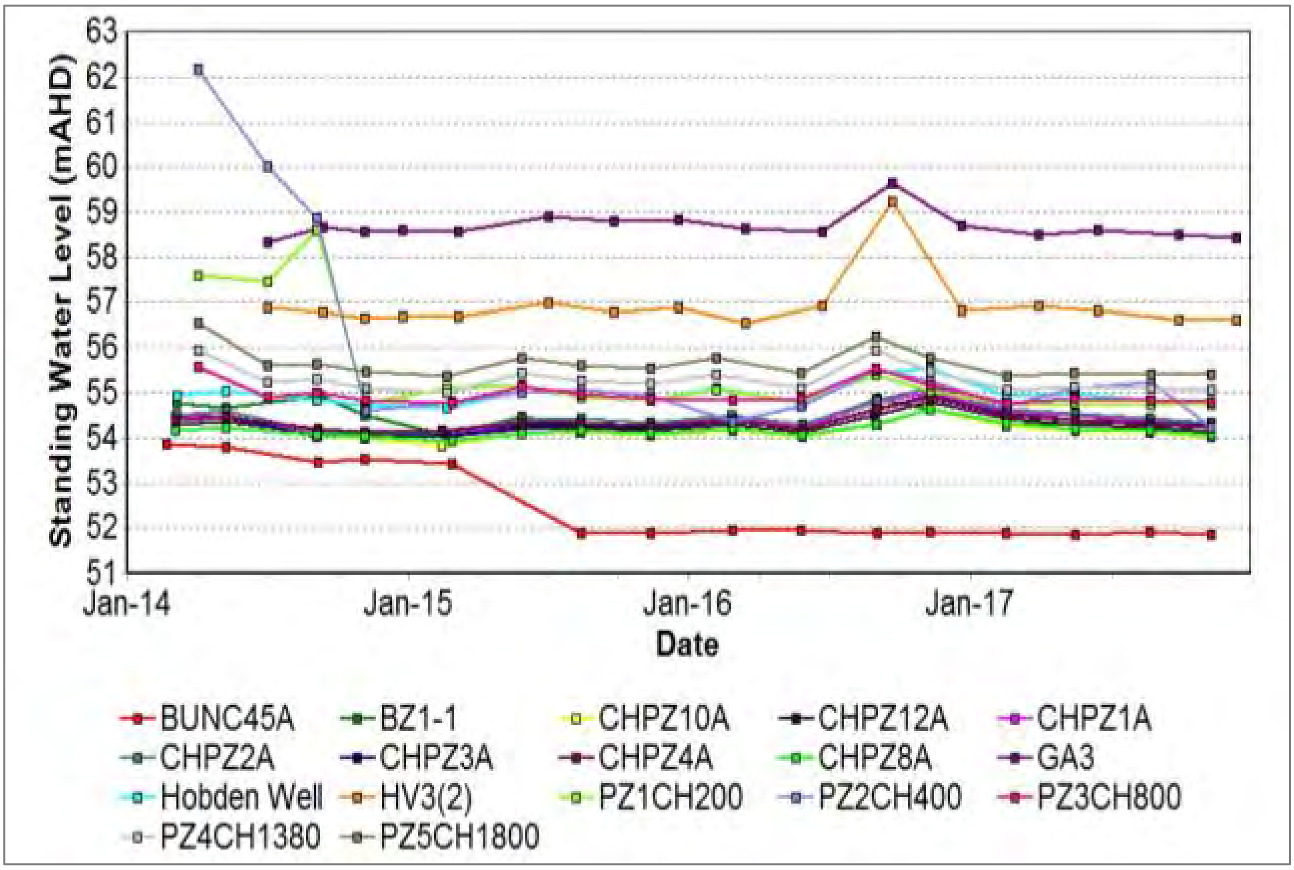


Figure 59: Cheshunt/North Pit Alluvium Groundwater SWL trends 2014 - 2017

7.7.3.7 Cheshunt Interburden

Groundwater monitoring in the Cheshunt Interburden area was undertaken at three sites during 2017, with 12 samples collected during the reporting period. The EC, pH and SWL trends for 2014 to 2017 are shown in Figure 60 to Figure 62

Figure 62: Cheshunt Interburden Groundwater SWL Trends 2014- 2017

. Trigger tracking results are listed in Table 38.

Table 38: Cheshunt Interburden Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
BZ8-2	16/02/2017	PH – 5th percentile	Watching Brief *
	10/11/2017		Watching Brief *
HG2	10/11/2017	PH – 5th percentile	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

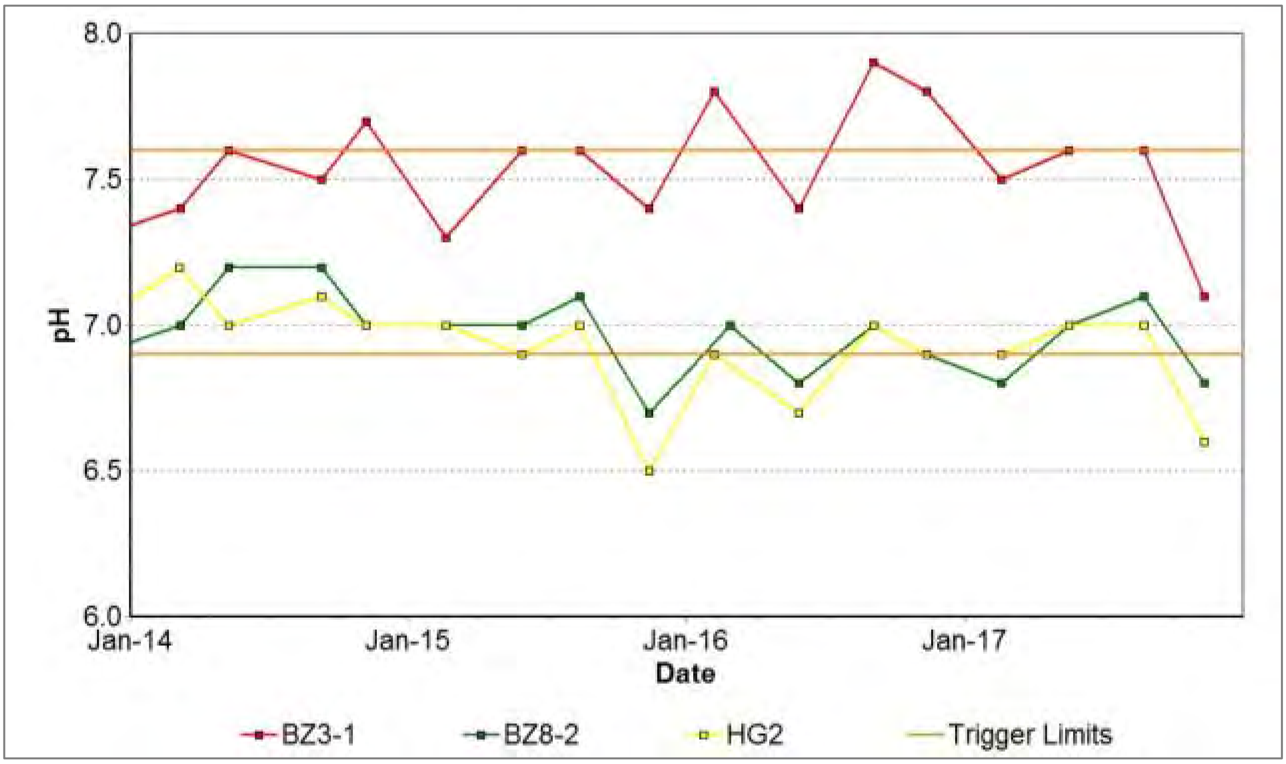


Figure 60: Cheshunt Interburden Groundwater pH Trends 2014 – 2017

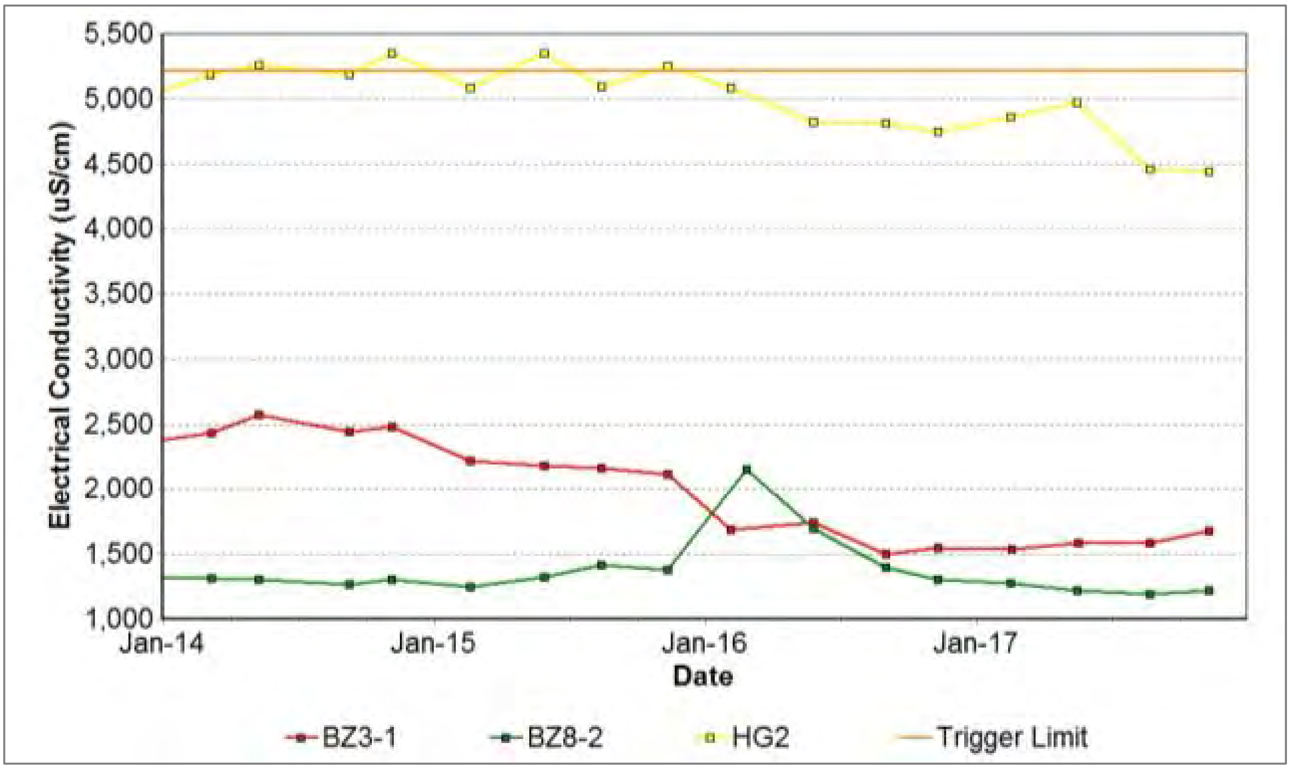


Figure 61: Cheshunt Interburden Groundwater pH Trends 2014 – 2017

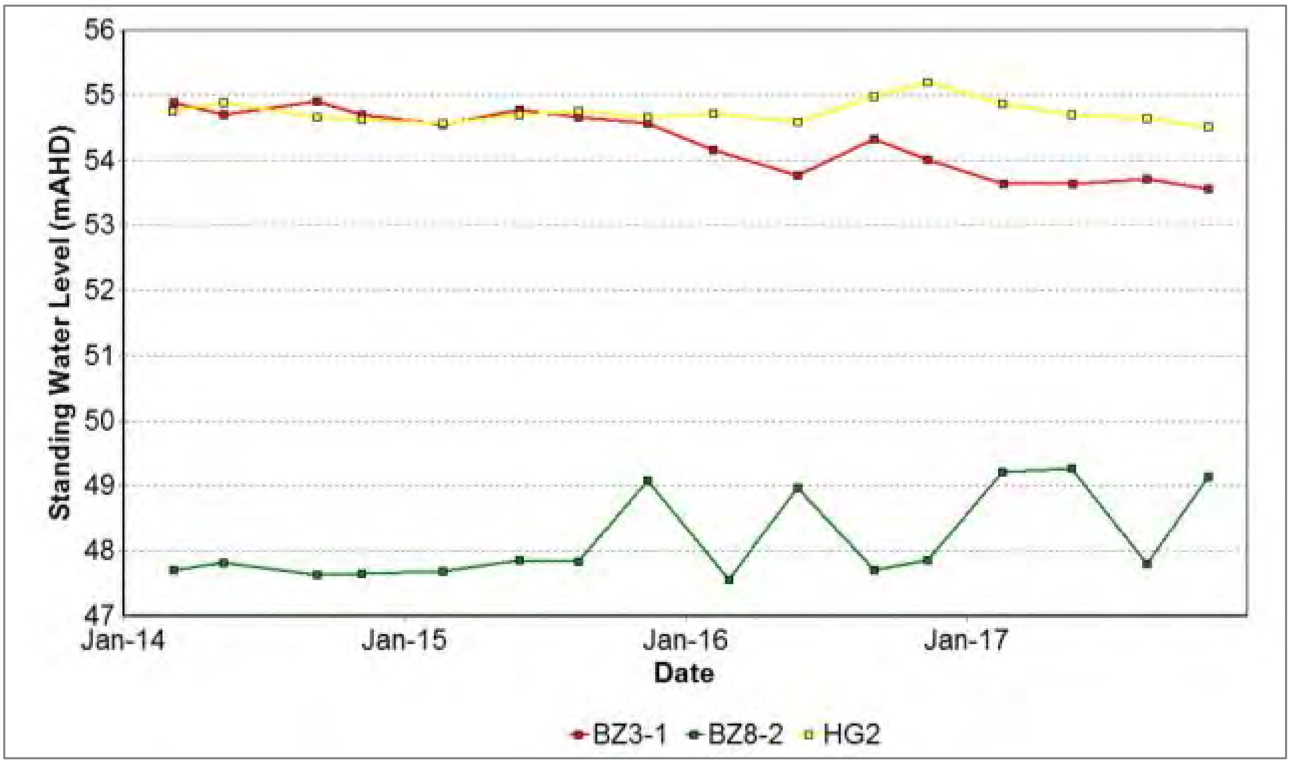


Figure 62: Cheshunt Interburden Groundwater SWL Trends 2014- 2017

7.7.3.8 Cheshunt Mt Arthur

Groundwater monitoring in the Cheshunt Mt Arthur area was undertaken at seven sites during 2017. A total of 28 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 63 to Figure 65. Monitoring results were steady and consistent with historical trends.

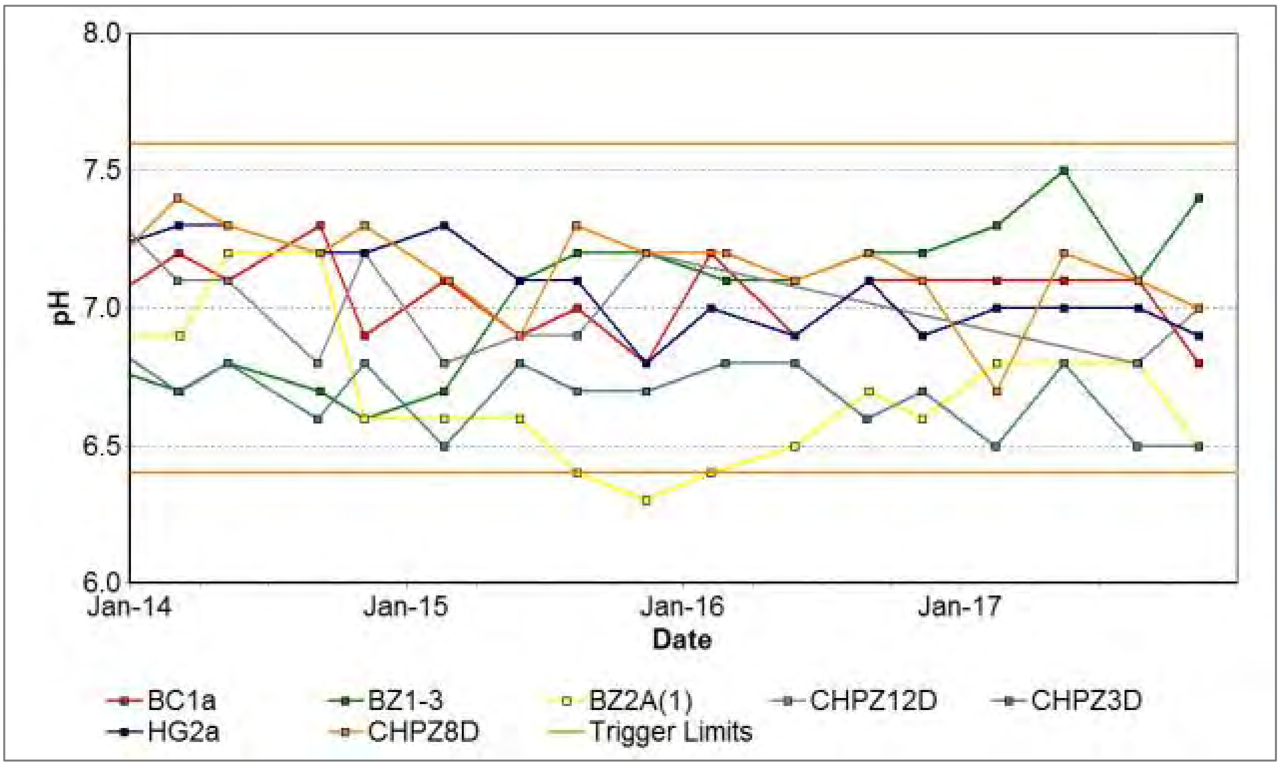


Figure 63: Cheshunt Mt Arthur Groundwater pH Trends 2014 – 2017

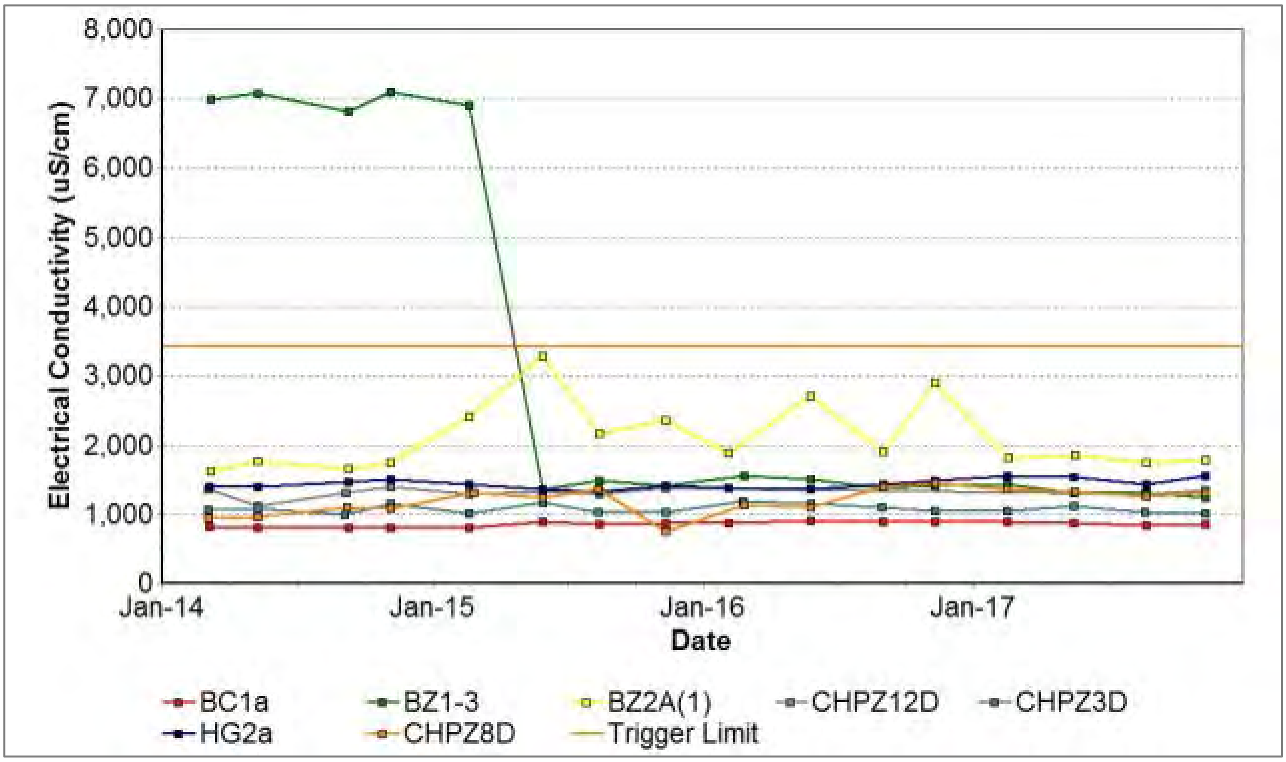


Figure 64: Cheshunt Mt Arthur Groundwater EC Trends 2014 – 2017

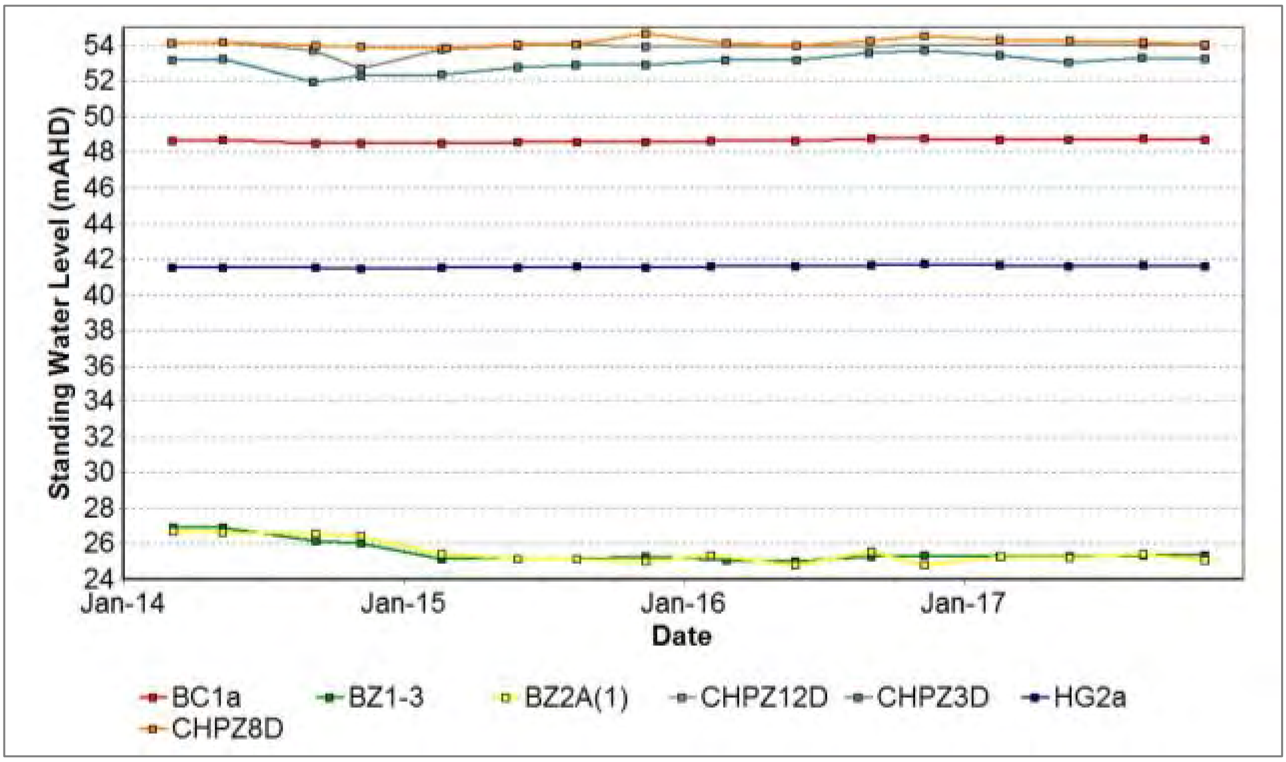


Figure 65: Cheshunt Mt Arthur Groundwater SWL Trends 2014 – 2017

7.7.3.9 Cheshunt Piercefield

Groundwater monitoring in the Cheshunt Piercefield area was undertaken from one site during 2017; a total of four samples were collected. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 66 to Figure 68. Trigger tracking results are listed in Table 39.

Water quality results were steady; the falling water level trend observed has ceased and stabilised during 2017.

Table 39: Piercefield Alluvium Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
BUNC45D	16/02/2017	PH – 5th percentile	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

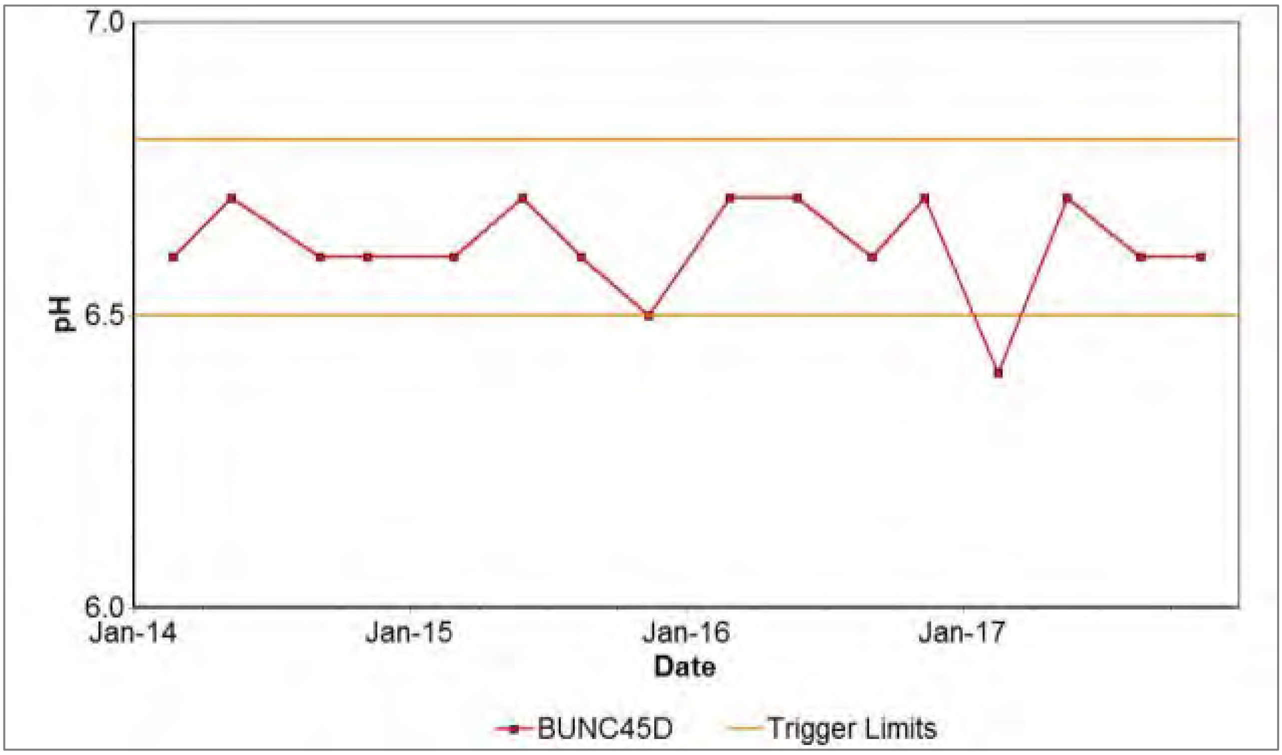


Figure 66: Cheshunt Piercefield Groundwater pH Trends 2014 - 2017

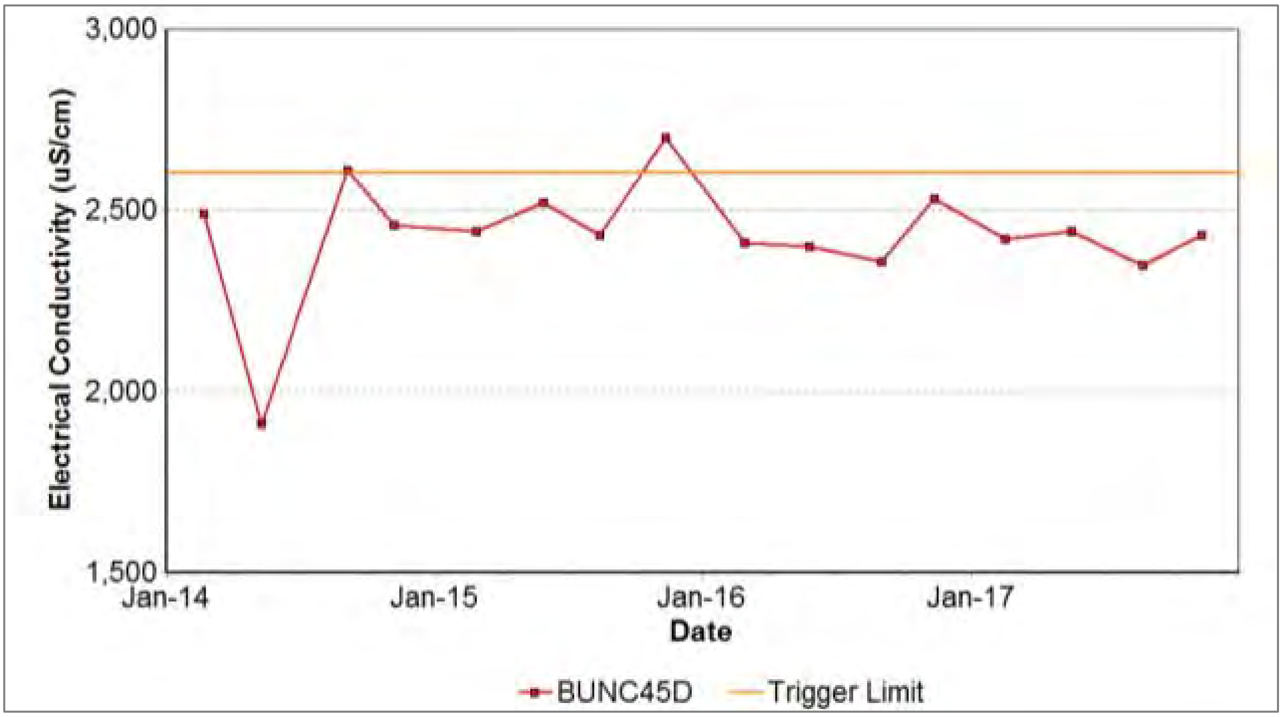


Figure 67: Cheshunt Piercefield Groundwater EC Trends 2014 – 2017

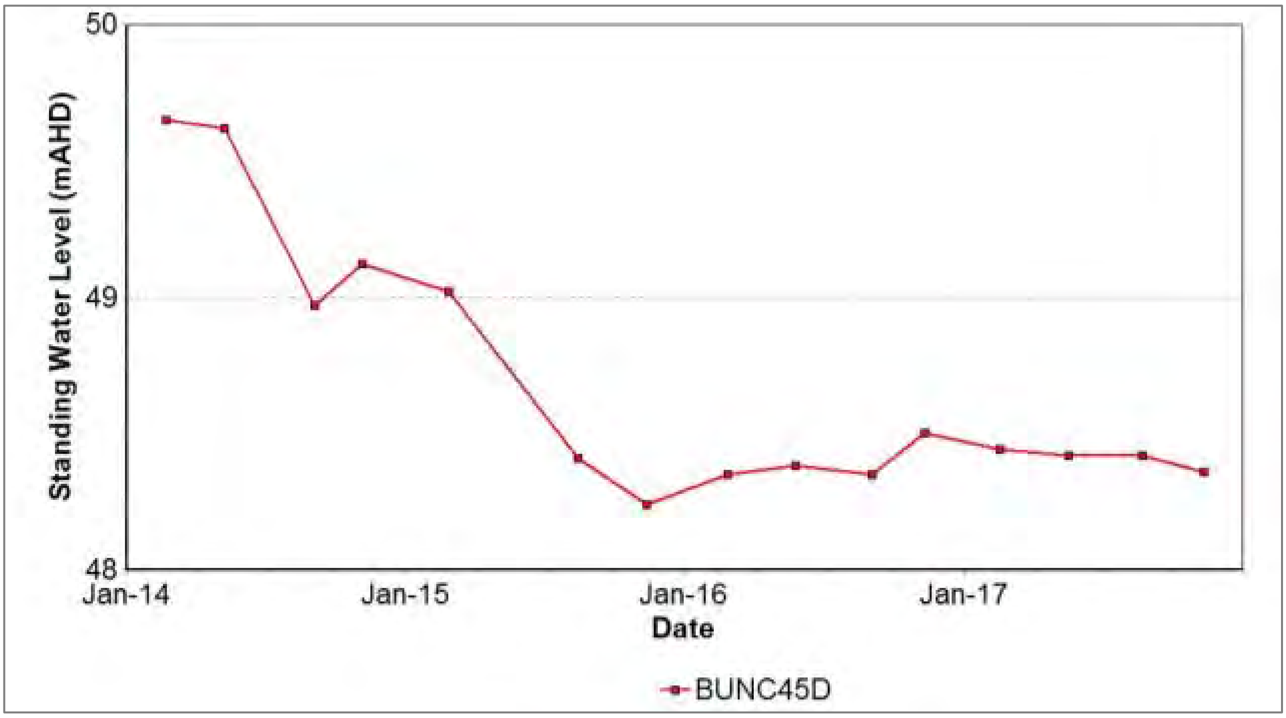


Figure 68: Cheshunt Piercefield Groundwater SWL Trends 2014 – 2017

7.7.3.10 Lemington South Alluvium

Groundwater monitoring in the Lemington South Alluvium area was undertaken at three sites during 2017. A total of 12 samples were collected during the reporting period with water level measured on a monthly basis. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 69 to Figure 71. Results were consistent with historical trends with the exception of the breach of internal EC trigger as listed in Table 40.

Table 40: Lemington South Arrowfield Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
PB01(ALL)	15/12/2017	EC – 95th percentile	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

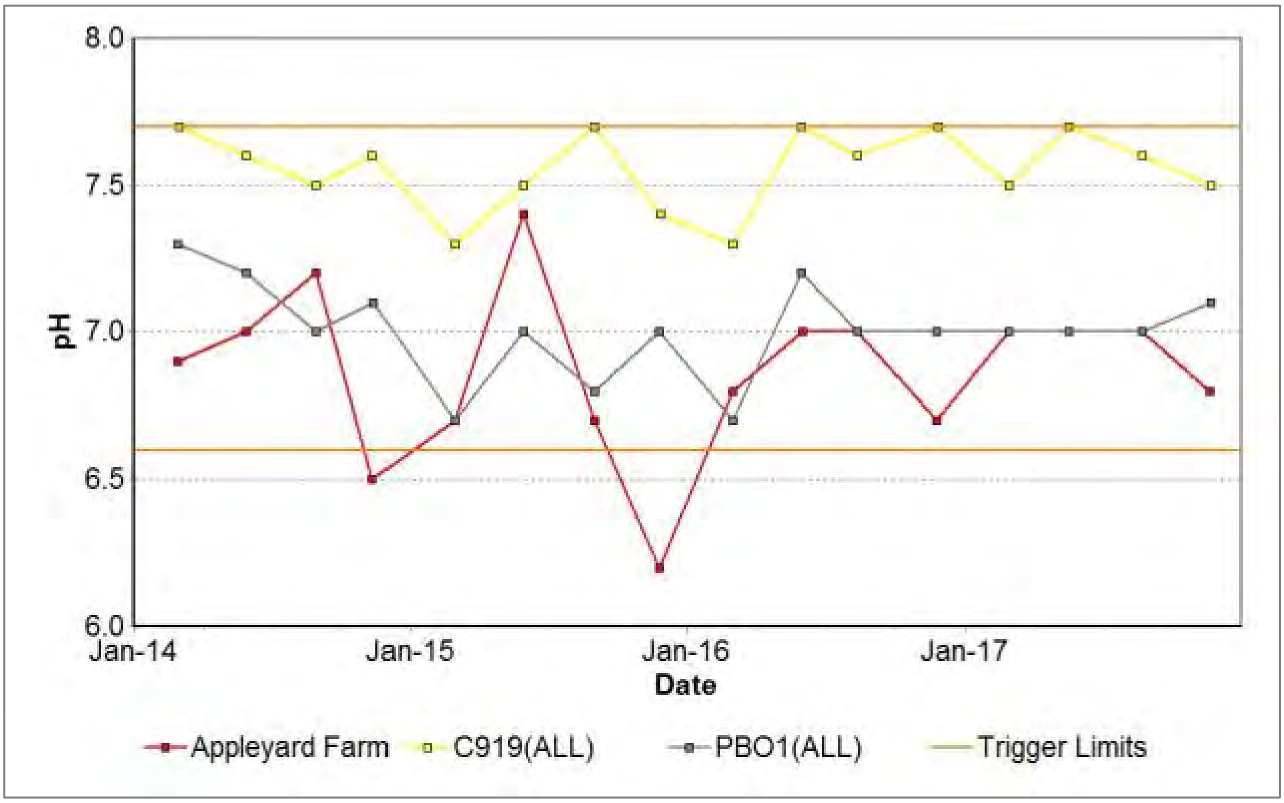


Figure 69: Lemington South Alluvium Groundwater pH Trends 2014 – 2017

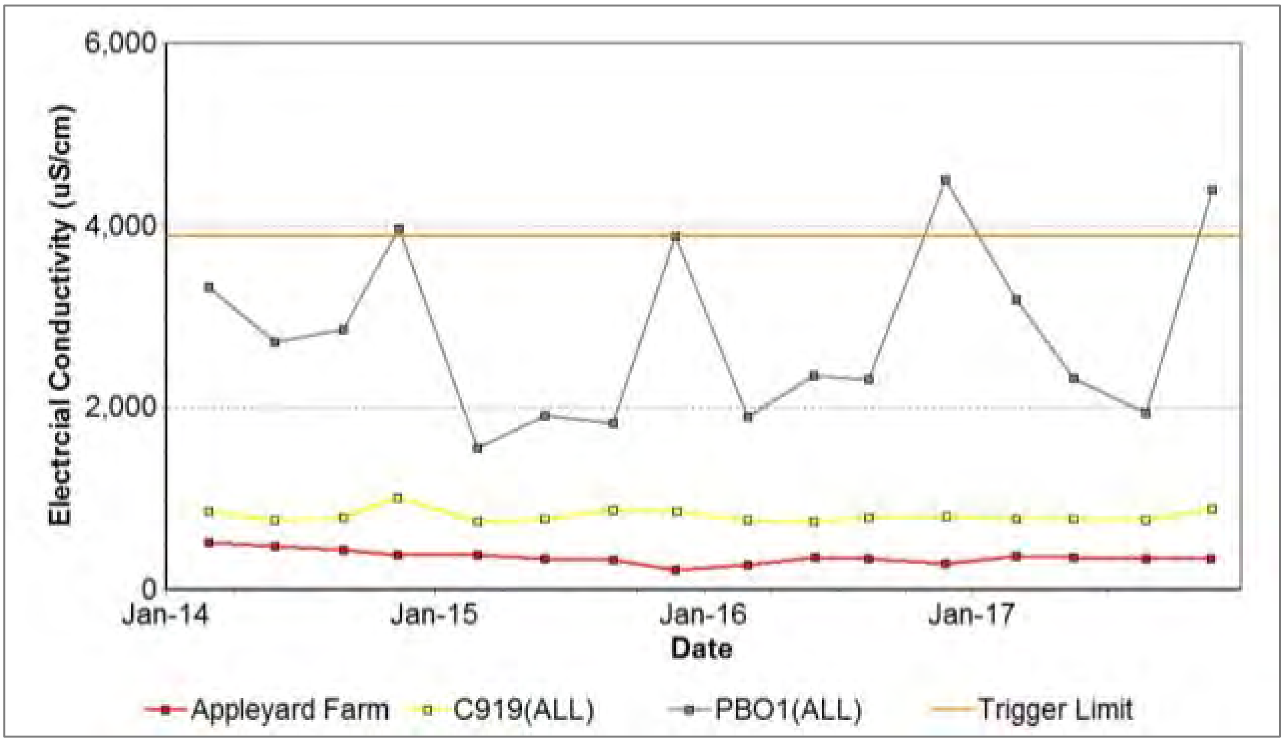


Figure 70: Lemington South Alluvium Groundwater EC Trends 2014 – 2017

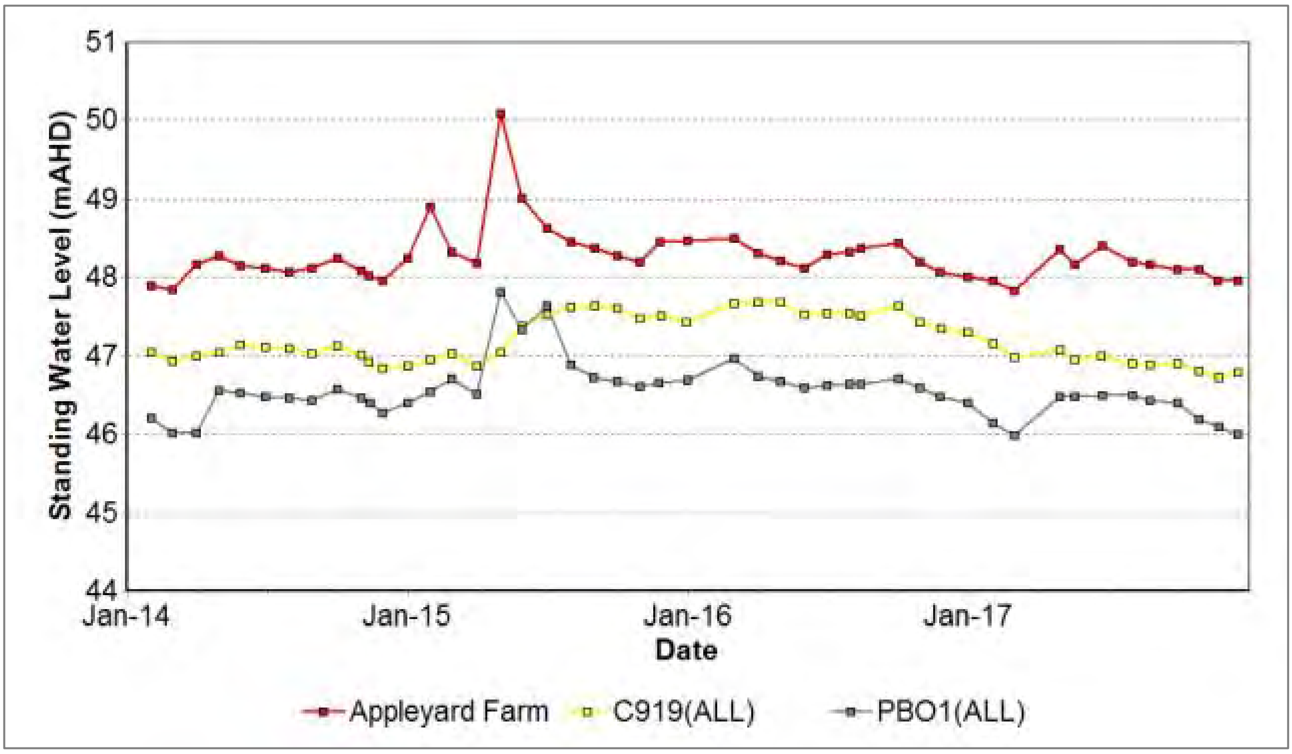


Figure 71: Lemington South Alluvium Groundwater SWL Trends 2014 - 2017

7.7.3.11 Lemington South Arrowfield

Groundwater monitoring in the Lemington South Arrowfield area was undertaken at four sites during 2017. A total of 8 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 72 to Figure 74. Results were consistent with historical trends with the exception of a breach of internal EC trigger for D612(AFS) as listed in Table 41.

Table 41: HVO Lemington South Arrowfield Seam Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
D612(AFS)	17/05/2017	EC – 95th percentile	Watching Brief *
	20/11/2017		Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

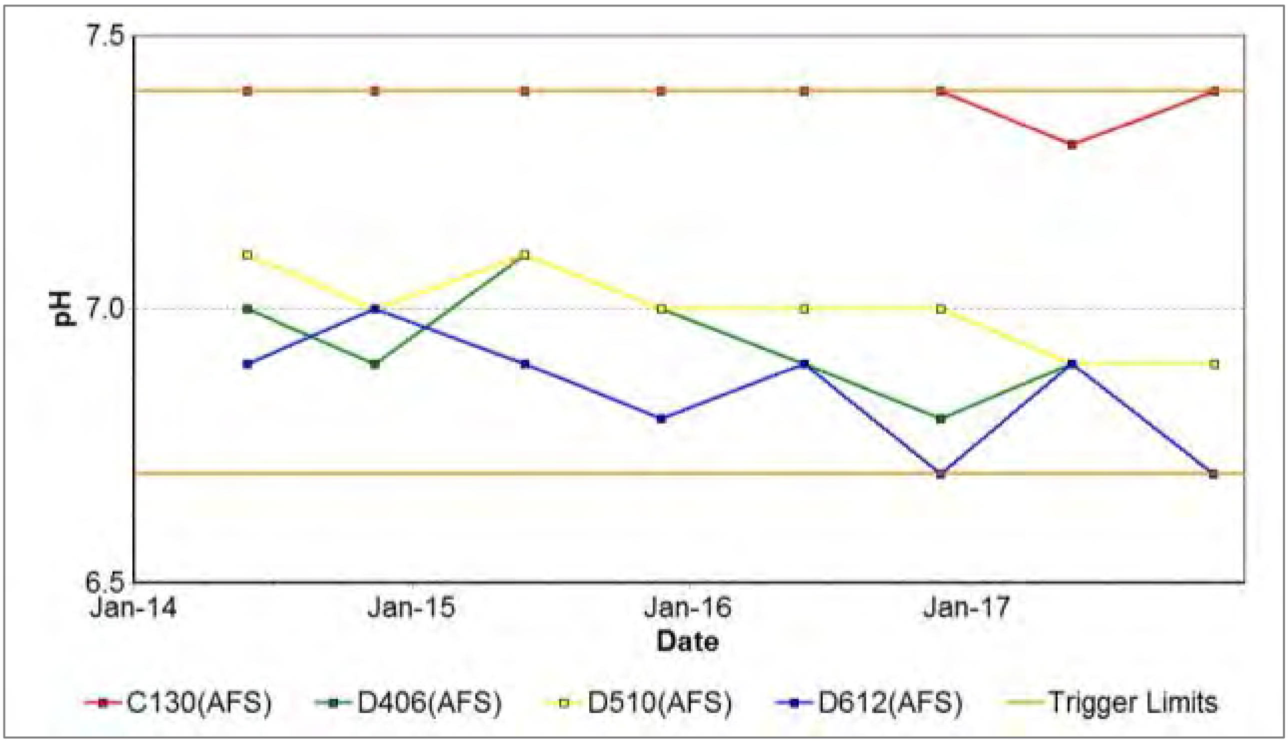


Figure 72: Lemington South Arrowfield Groundwater pH Trends 2014 - 2017

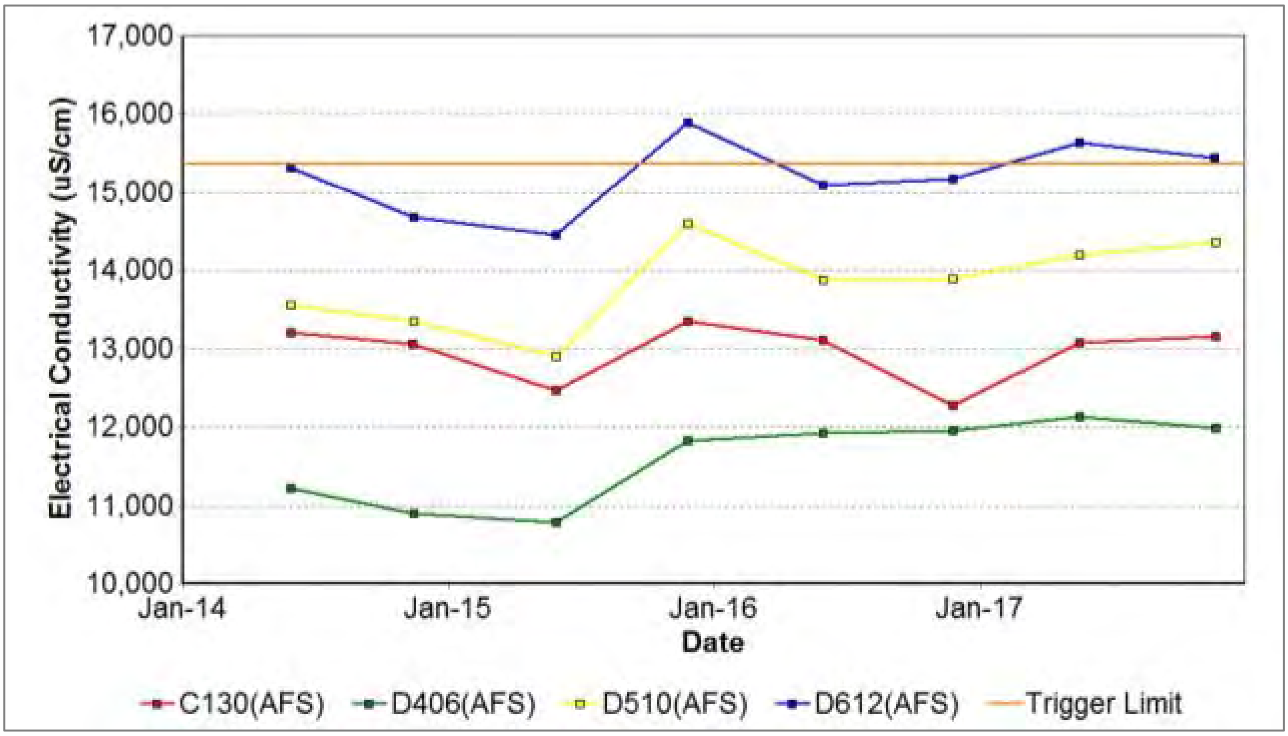


Figure 73: Lemington South Arrowfield Groundwater EC Trends 2014 -2017

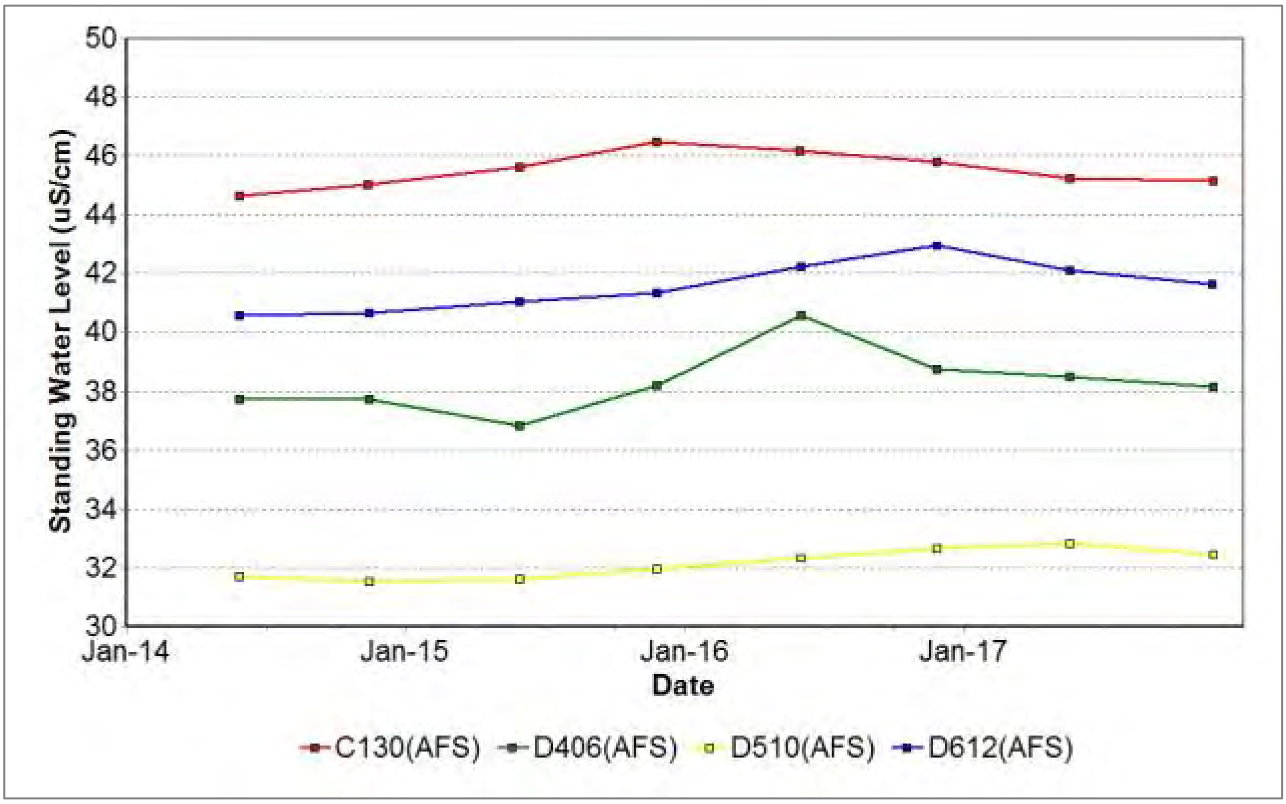


Figure 74: Lemington South Arrowfield Groundwater SWL Trends 2014 – 2017

7.7.3.12 Lemington South Bowfield

Groundwater monitoring in the Lemington South Bowfield area was undertaken at 16 sites during 2017. A total of 52 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 75 to Figure 77. Results were considered to be consistent with historical trends with the exception of two bores which had breaches of internal triggers as listed in Table 42.

Table 42: HVO Lemington South Bowfield Seam Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
D317 (BFS)	24/11/2016	pH - 95th percentile	Cause of elevated pH not identified – EC and water level trend is steady, results not supported by nearby bores in Bowfield seam. Bore not near active mining area. Watching brief will be maintained.
	28/02/2017		Watching Brief*
	01/12/2017		pH trend appears to have stabilised with no other changes to EC and Water Level trends, continue to watch and monitor
B631 (BFS)	18/05/2017	EC - 95th percentile	Watching brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

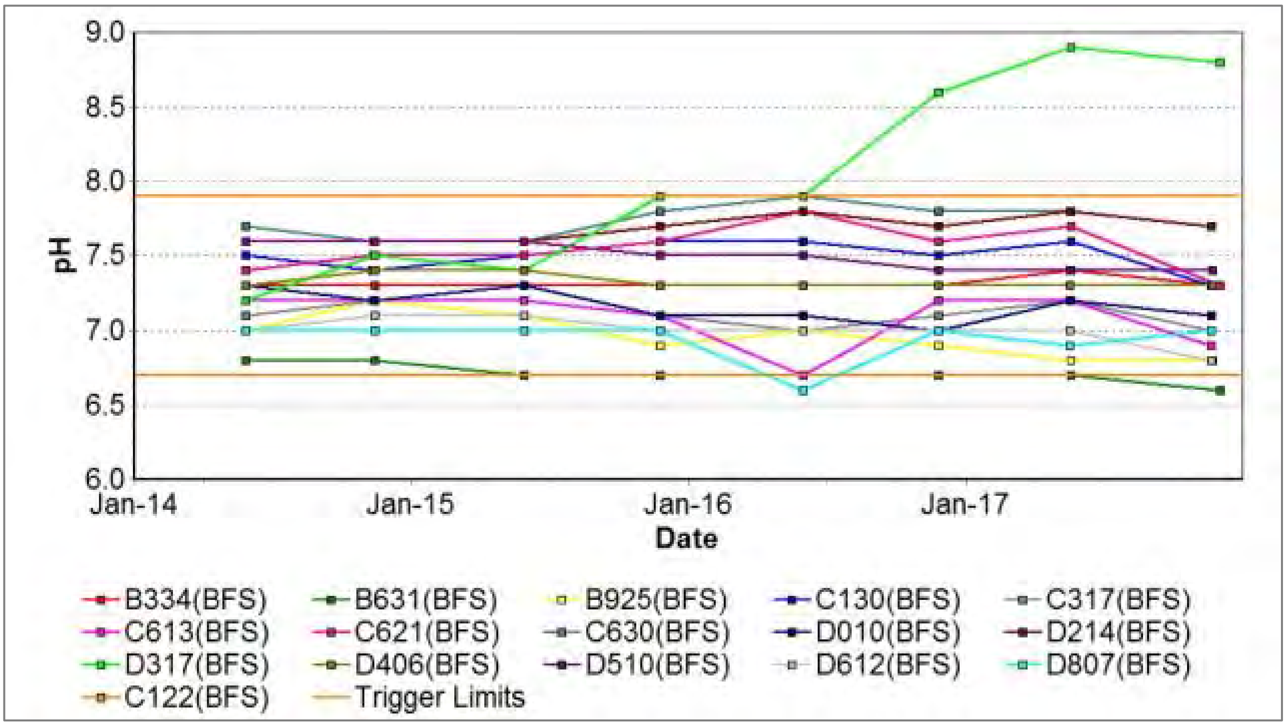


Figure 75: Lemington South Bowfield Groundwater pH Trends 2013 – 2017

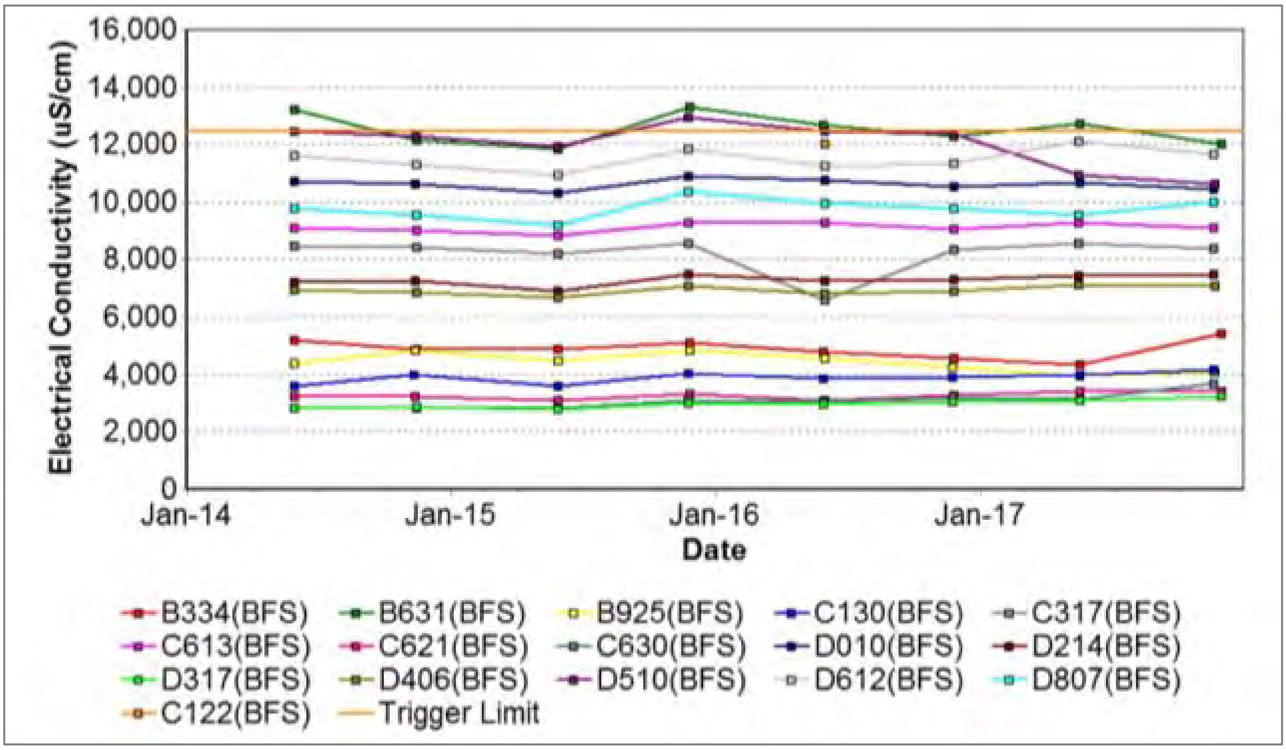


Figure 76: Lemington South Bowfield Groundwater EC Trends 2014 – 2017

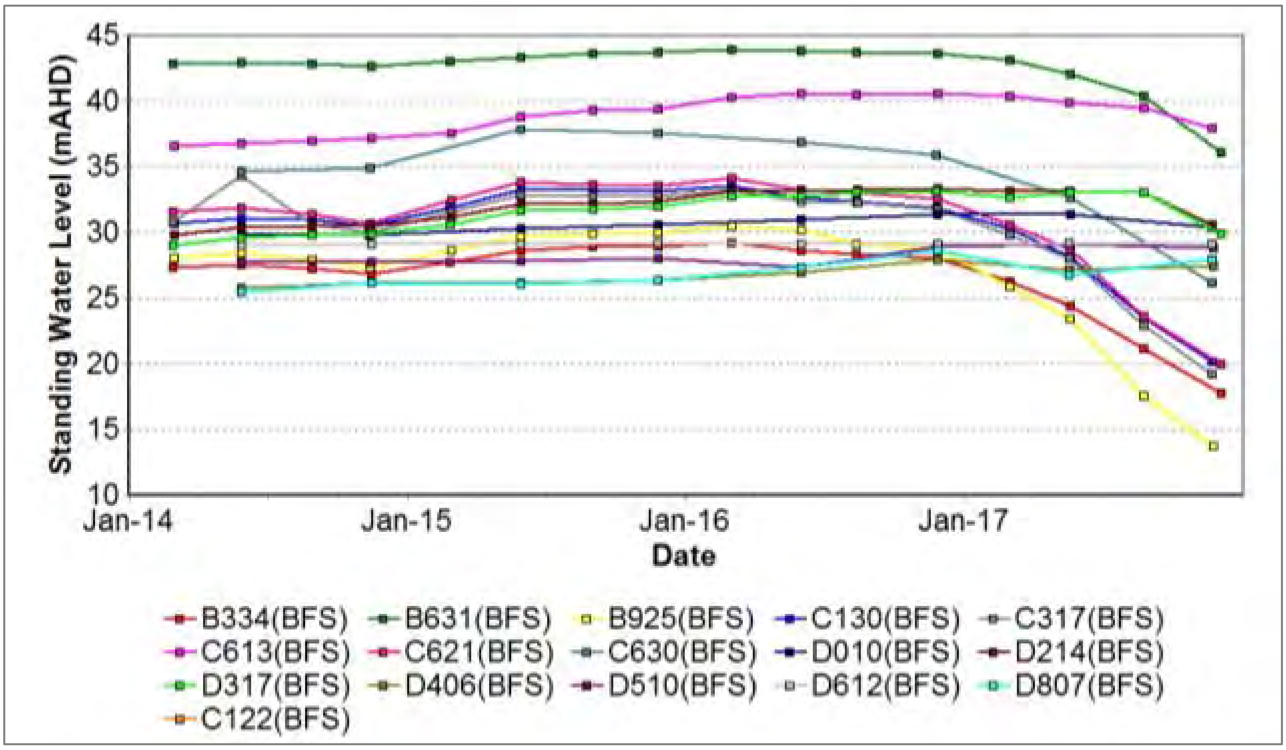


Figure 77: Lemington South Bowfield Groundwater SWL Trends 2014 – 2017

7.7.3.13 Lemington South Interburden

Groundwater monitoring in the Lemington South Interburden area was undertaken at one site during 2017; a total of four samples were collected. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 78 to Figure 80.

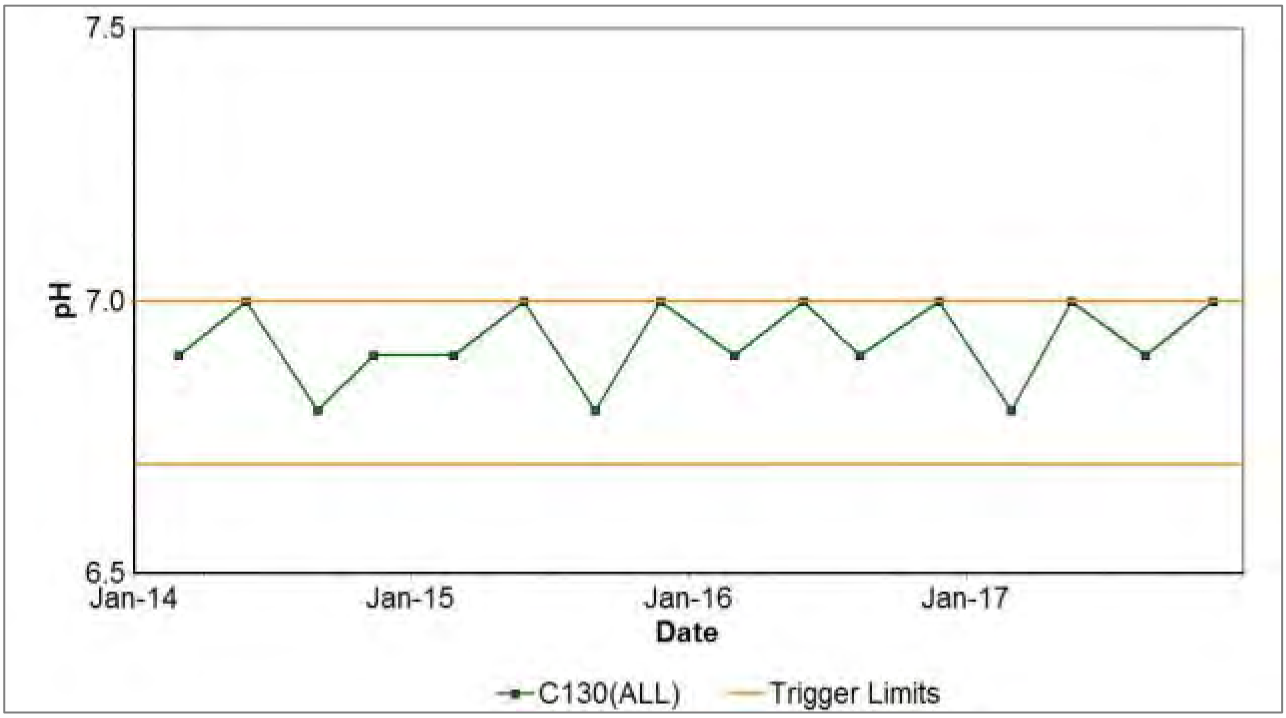


Figure 78: Lemington South Interburden pH Trends 2014 – 2017

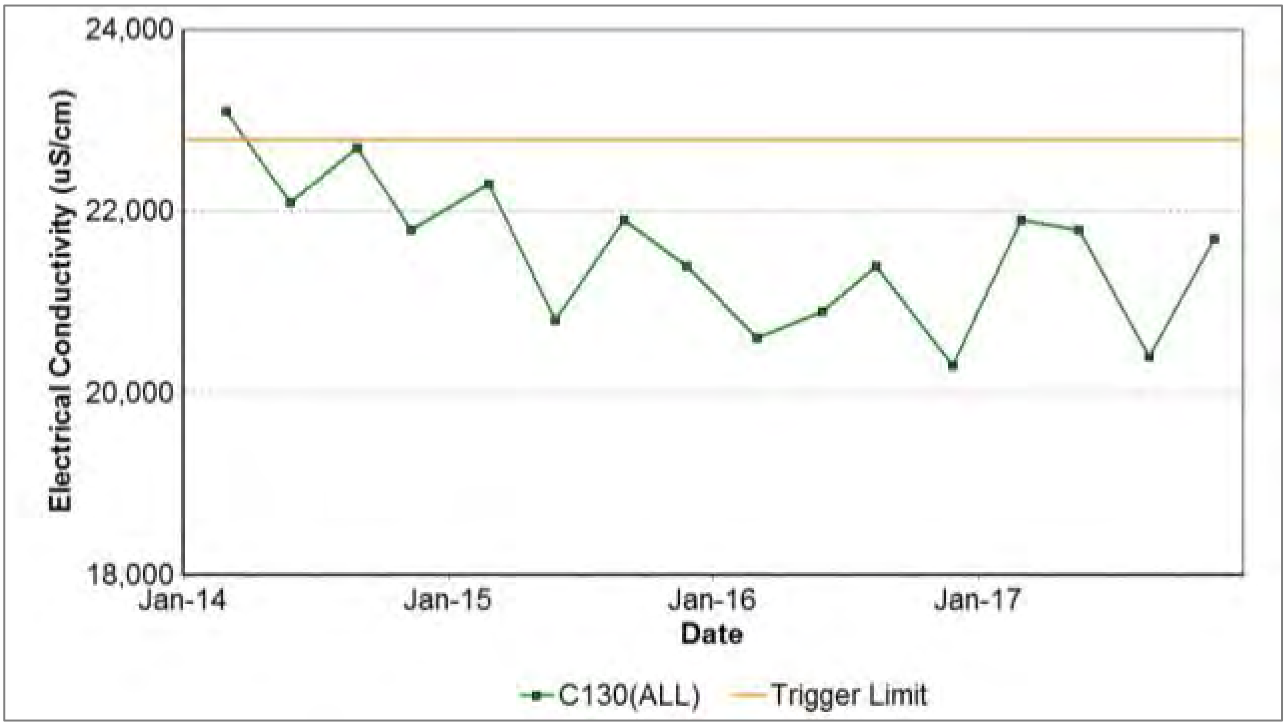


Figure 79: Lemington South Interburden EC Trends 2014 – 2017

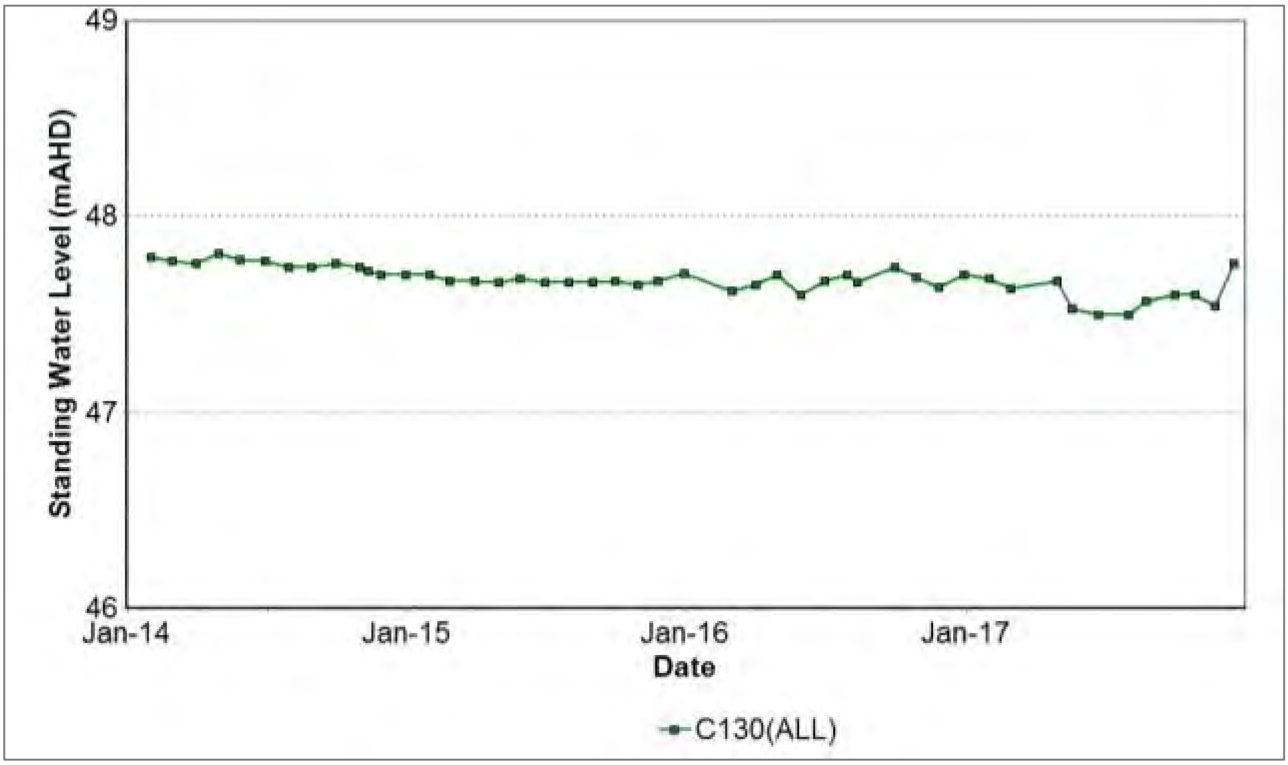


Figure 80: Lemington South Interburden SWL Trend 2014 – 2017

7.7.3.14 Lemington South Woodlands Hill

Groundwater monitoring in the Lemington South Woodlands Hill seam was undertaken at seven sites during 2017. A total of 13 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 81 to Figure 83. Results were stable and consistent with historical trends with the exception of breaches of internal trigger limits as listed in Table 43.

Table 43: HVO Lemington South Woodlands Hill Seam Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
C130 (WDH)	24/11/2016	EC - 95th percentile	Results are stable and consistent with historical trend. No further action required.
	18/05/2017		Watching Brief*
	20/11/2017		Data analysis investigation suggests that EC result is within historic bandwidth for this site, continue to monitor
C130 (WDH)	24/11/2016	pH - 5th percentile	Watching Brief*
	18/05/2017		Watching Brief*
	20/11/2017		Data analysis investigation suggests that pH result is within historic bandwidth for this site and generally lower than other sites in the series, continue to monitor.
B631(WDH)	18/05/2017	PH 5th percentile	Watching Brief*

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

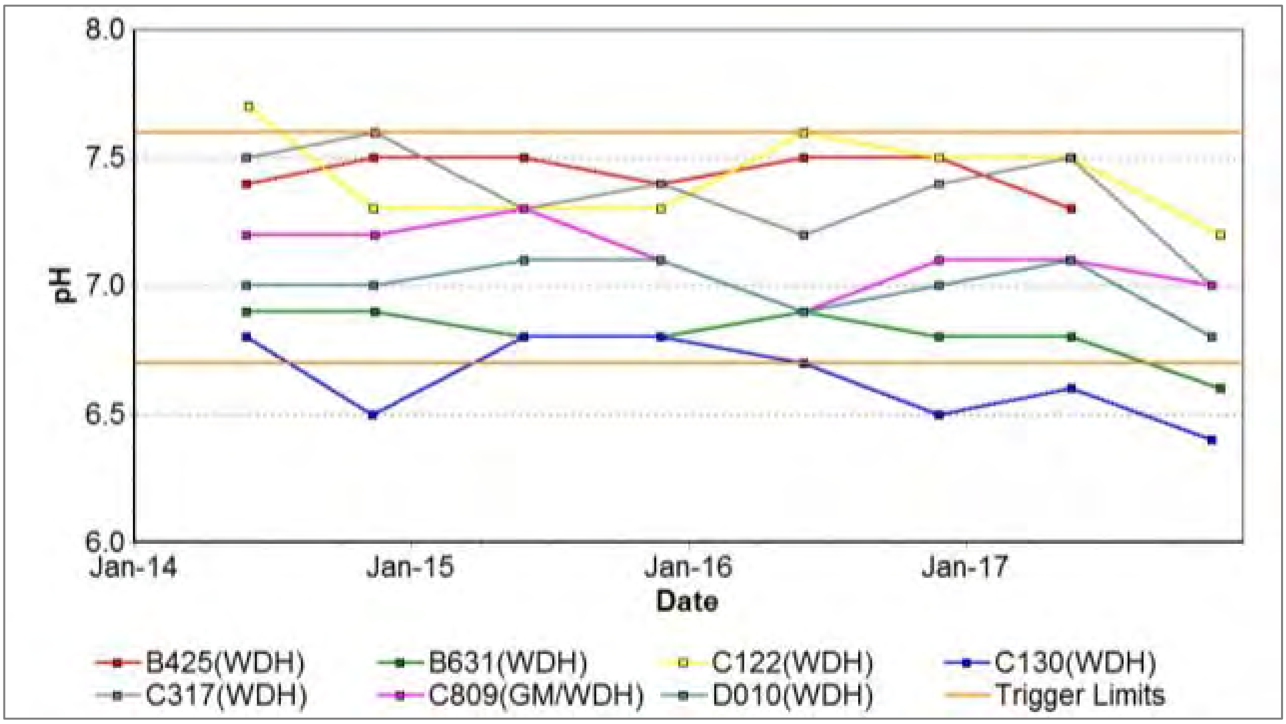


Figure 81: Lemington South Woodlands Hill Groundwater pH Trends 2014 – 2017

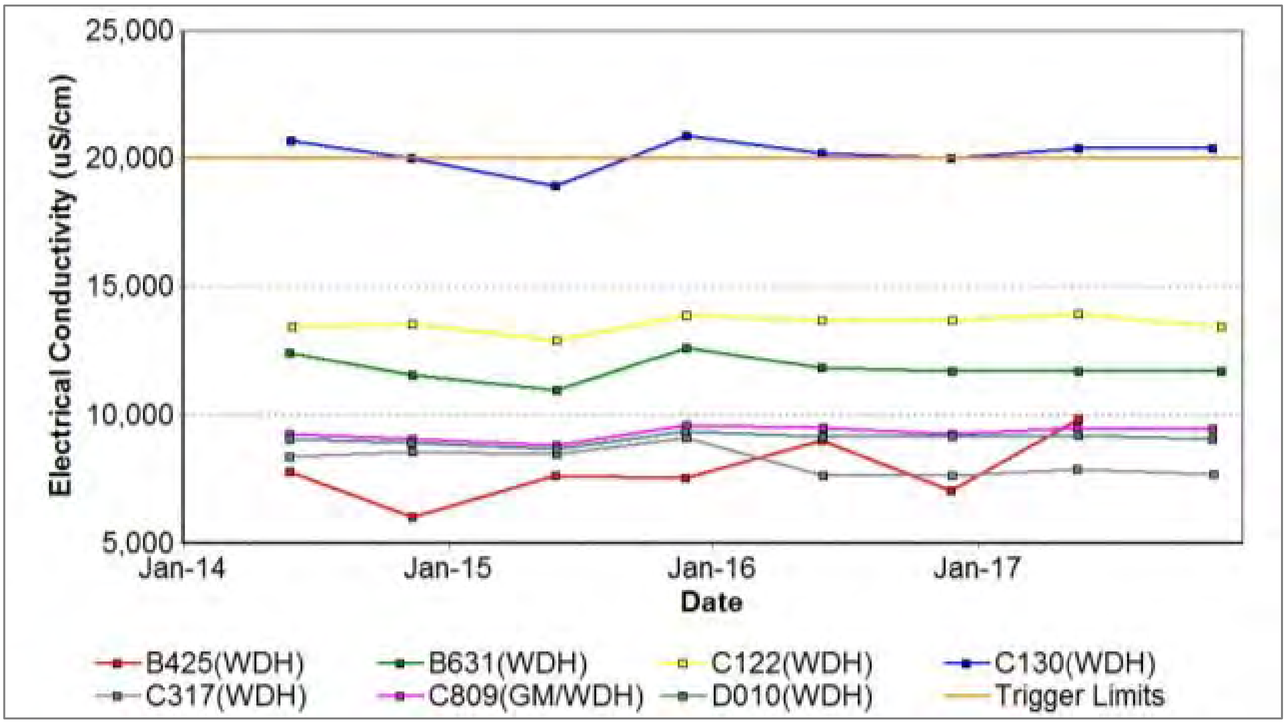


Figure 82: Lemington South Woodlands Hill Groundwater EC Trends 2014 – 2017

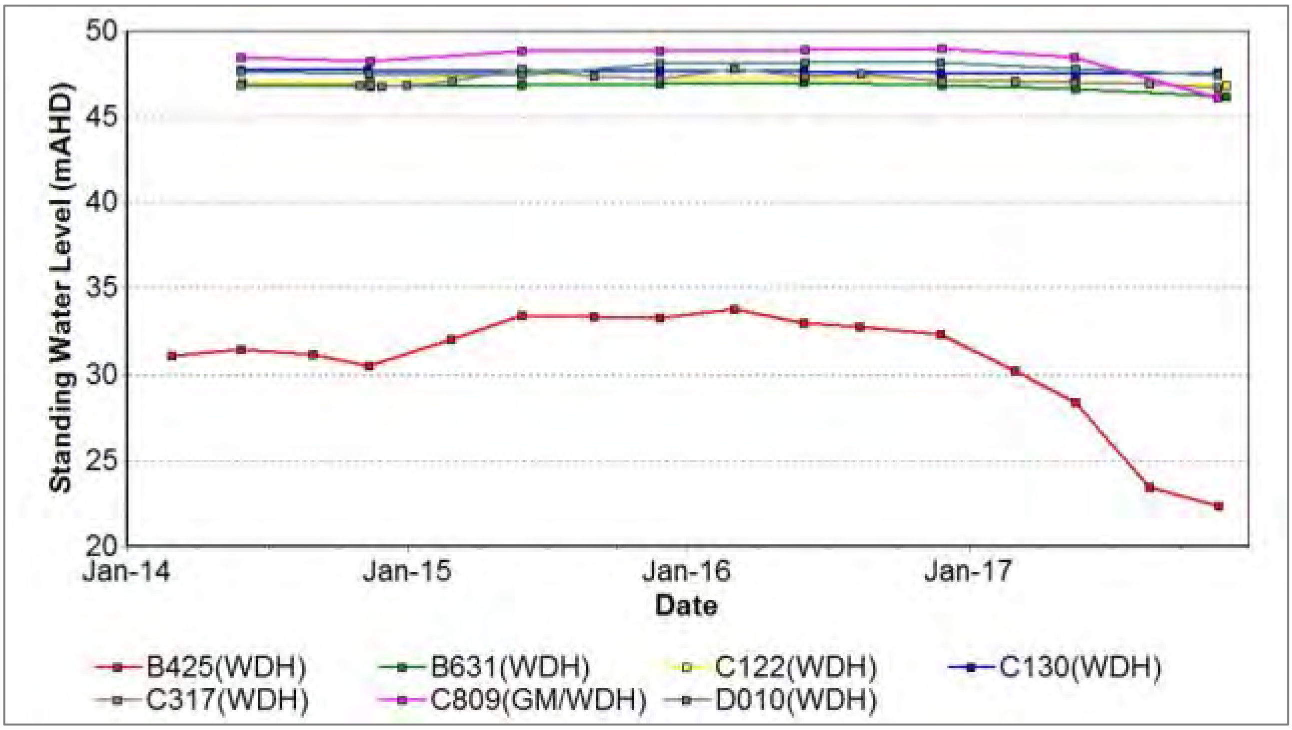


Figure 83: Lemington South Woodlands Hill Groundwater SWL Trends 2014 - 2017

7.7.3.15 North Pit Spoil

Groundwater monitoring in the North Pit Spoil area was undertaken at 13 sites during 2017. A total of 48 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 84 to Figure 86. Water quality and levels were generally stable and consistent with historical trends with the exception of breaches of internal triggers as listed in Table 44.

Table 44: North Pit Spoil Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Sample Date	Trigger limit	Action taken in response
DM1	25/09/2017	pH - 5th percentile	Watching Brief*
MB14HVO05	25/09/2017	pH - 5th percentile	Watching Brief*
4116P	25/09/2017 14/12/2017	EC – 95th percentile	Watching Brief*

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

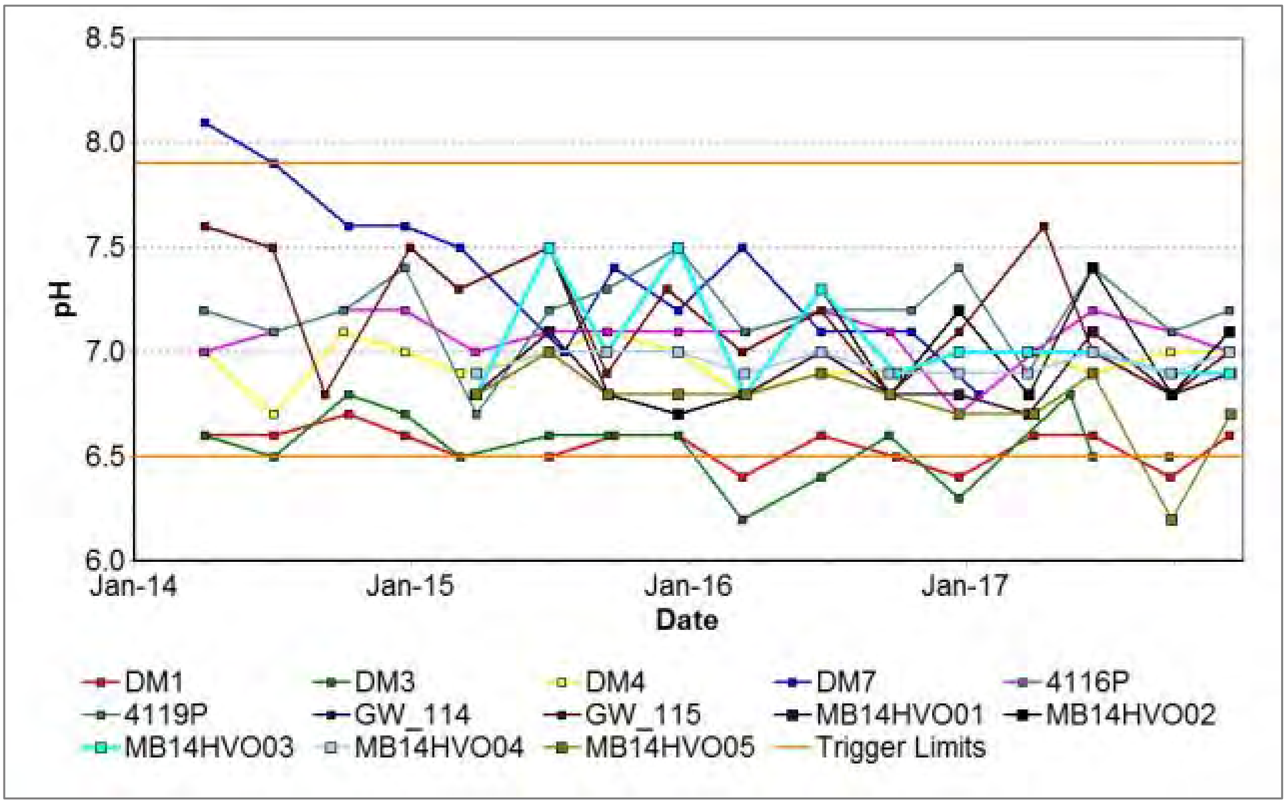


Figure 84: North Pit Spoil Groundwater pH Trends 2014 – 2017

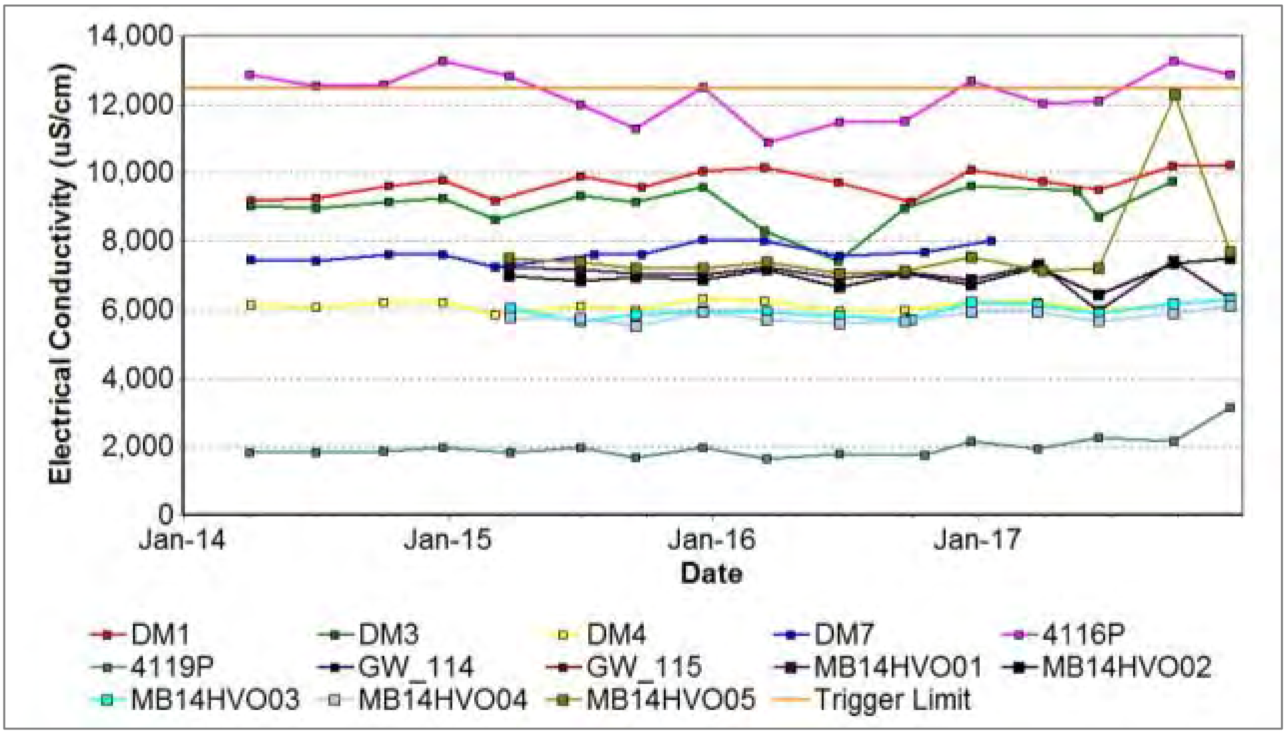


Figure 85: North Pit Spoil Groundwater EC Trends 2014 – 2017

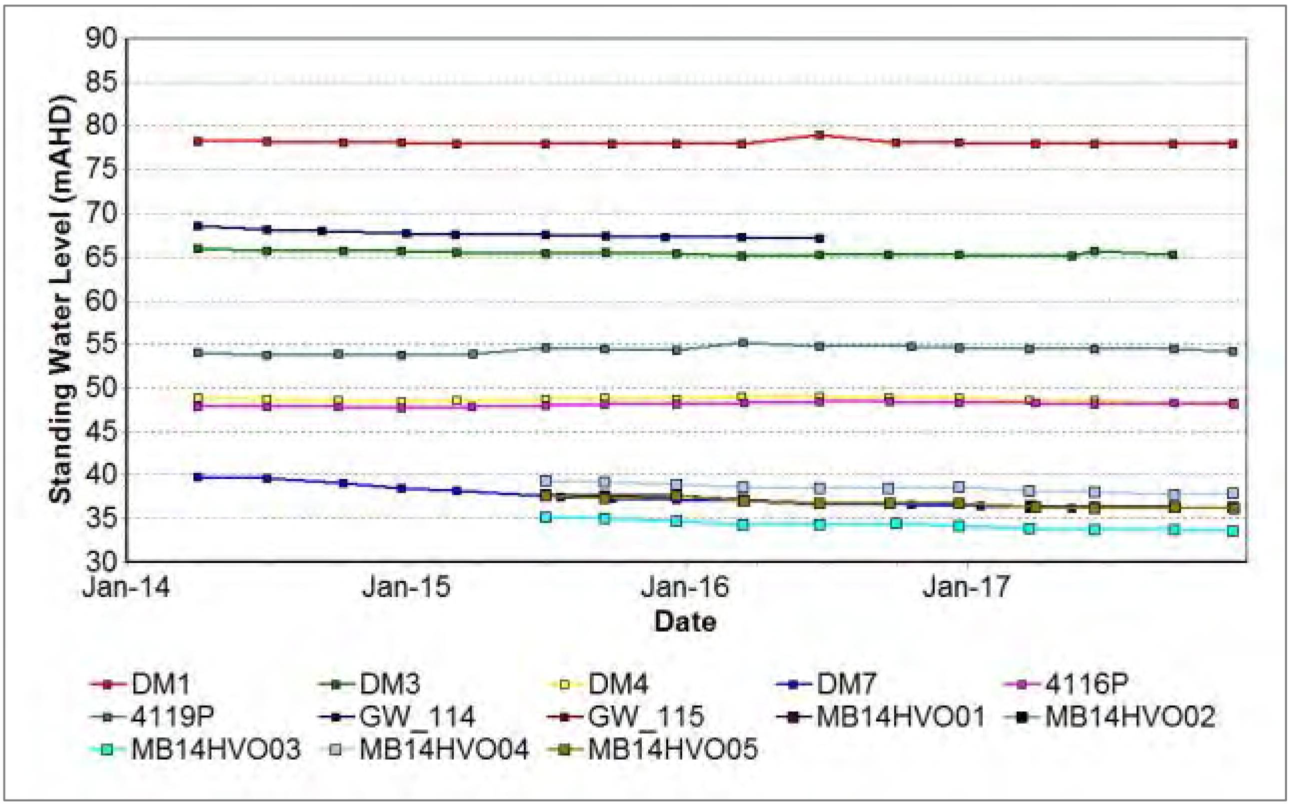


Figure 86: North Pit Spoil Groundwater SWL Trends 2014 – 2017

7.7.3.16 West Pit Alluvium

Groundwater monitoring in the West Pit Alluvium area was undertaken at three sites during 2017. A total of 12 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 87 to Figure 89. Results were consistent with historical trends with the exception of breaches of internal triggers as listed in Table 45.

Table 45: West Pit Alluvium Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
G2	29/03/2017	pH - 95th percentile	Watching Brief*
	15/06/2017		Measurements highly variable and consistent with historical range. Watch and monitor.
	13/12/2017		Watching Brief*
G3	29/03/2017	pH - 95th percentile	Watching Brief*

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

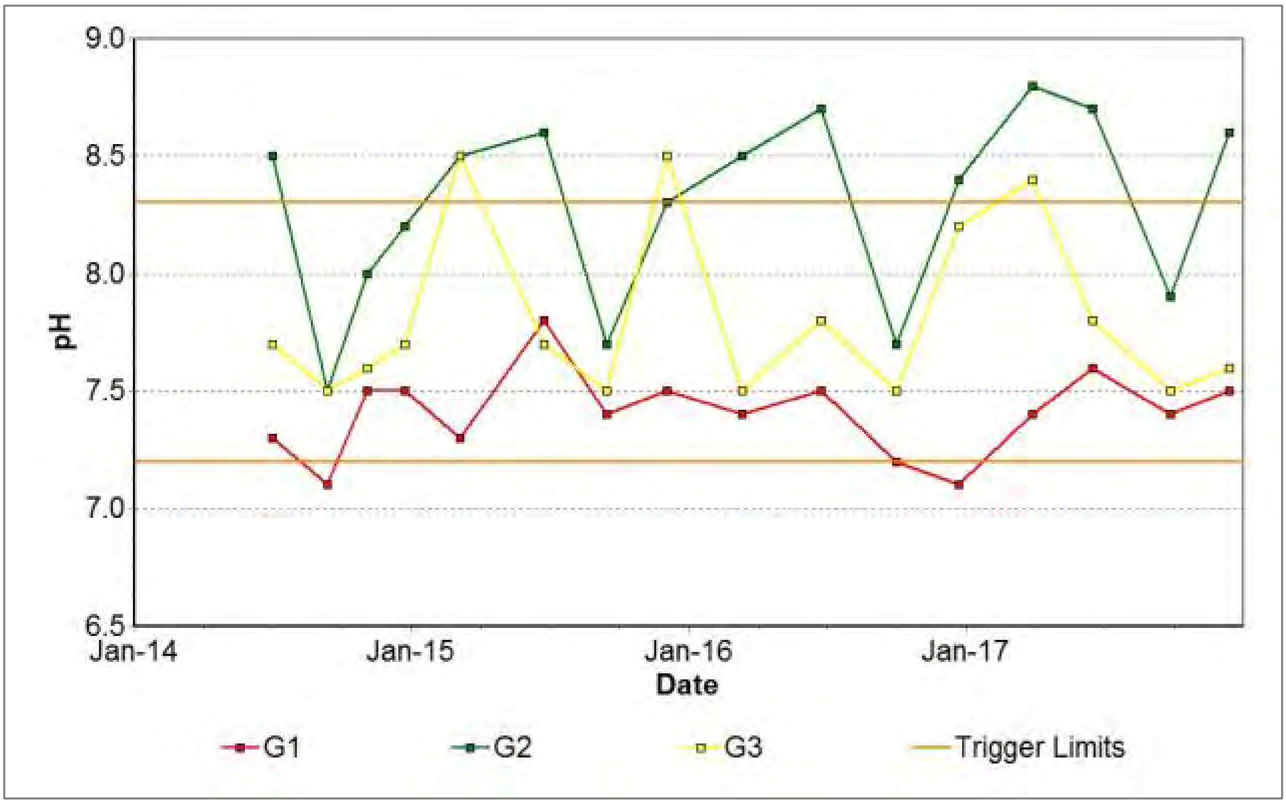


Figure 87: West Pit Alluvium Groundwater pH Trends 2014 – 2017

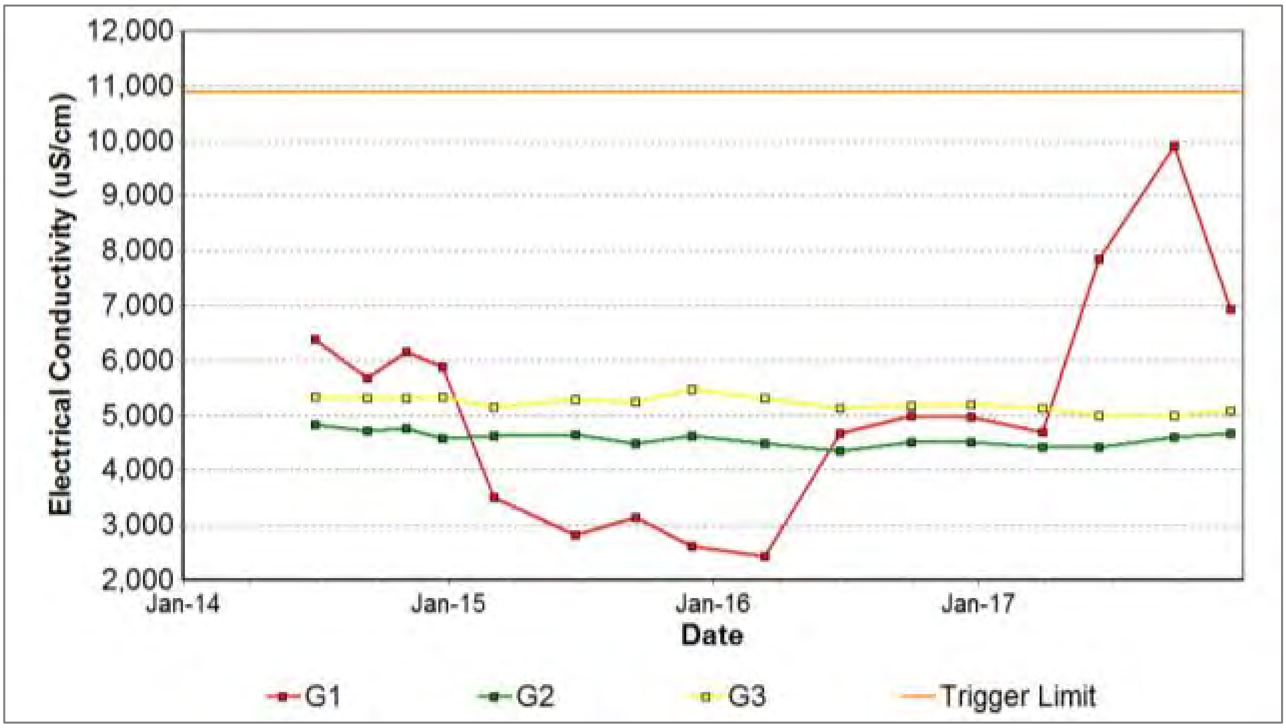


Figure 88: West Pit Alluvium Groundwater EC Trends 2014 – 2017

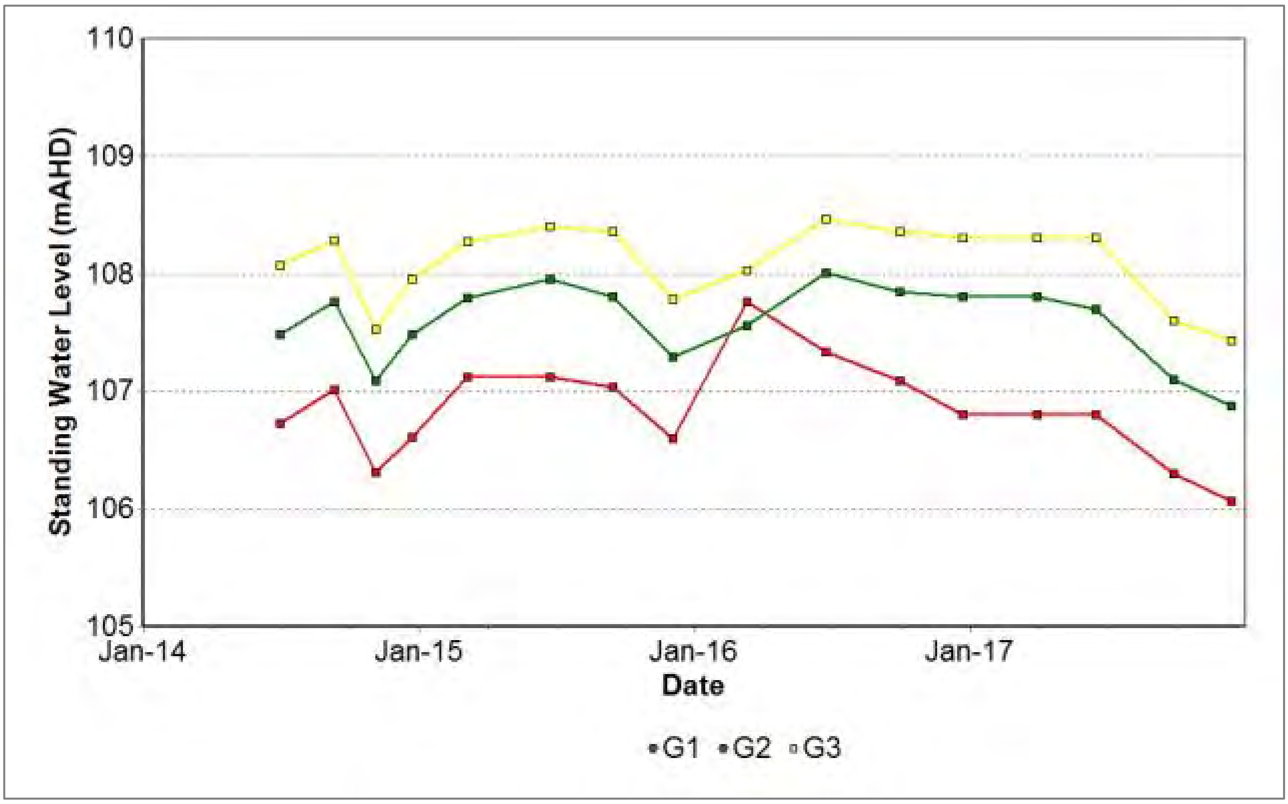


Figure 89: West Pit Alluvium Groundwater SWL Trends 2014 – 2017

7.7.3.17 West Pit Sandstone/ Siltstone

Groundwater monitoring in the West Pit Sandstone/ Siltstone area was undertaken at four sites during 2017. A total of 12 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 90 to Figure 92. Results were generally consistent with historical trends with the exception of the internal trigger breach listed in Table 46

Table 46: West Pit Sandstone/Siltstone Groundwater 2017 Monitoring Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
NPZ3	26/09/2017	PH - 95th percentile	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required.

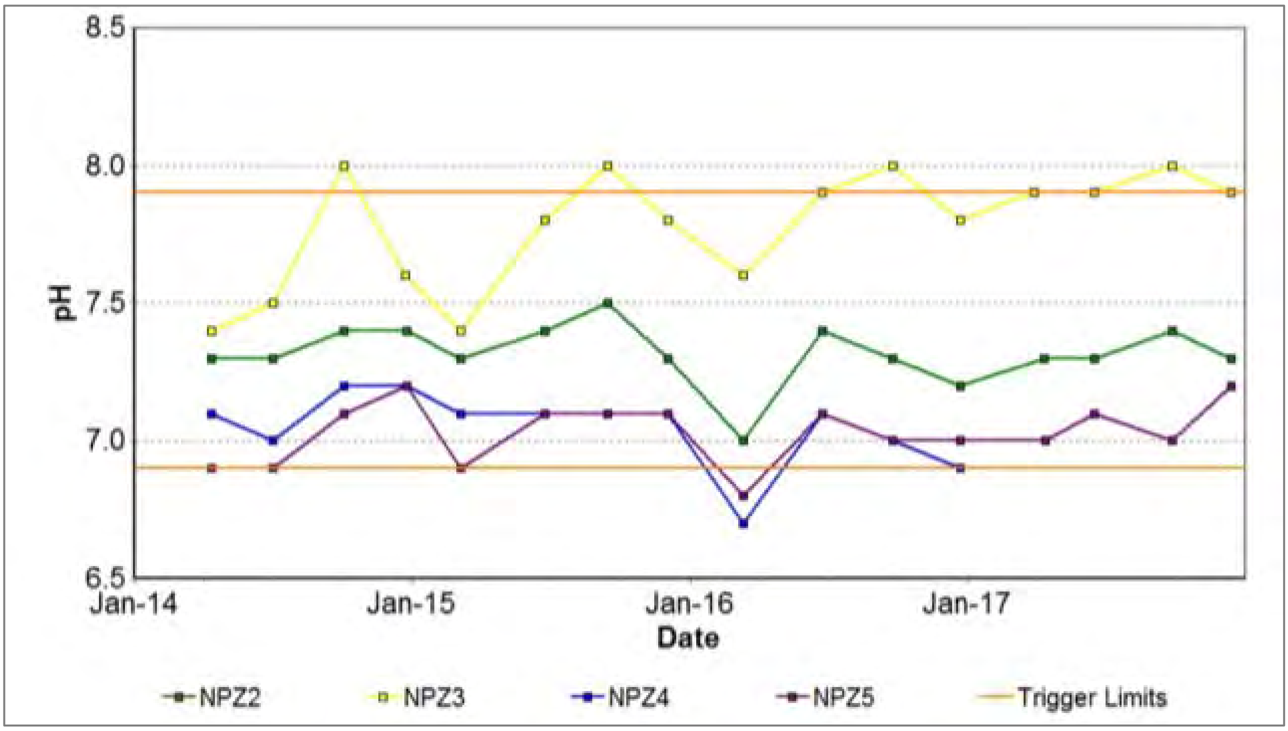


Figure 90: West Pit Sandstone/ Siltstone Groundwater pH Trends 2014 – 2017

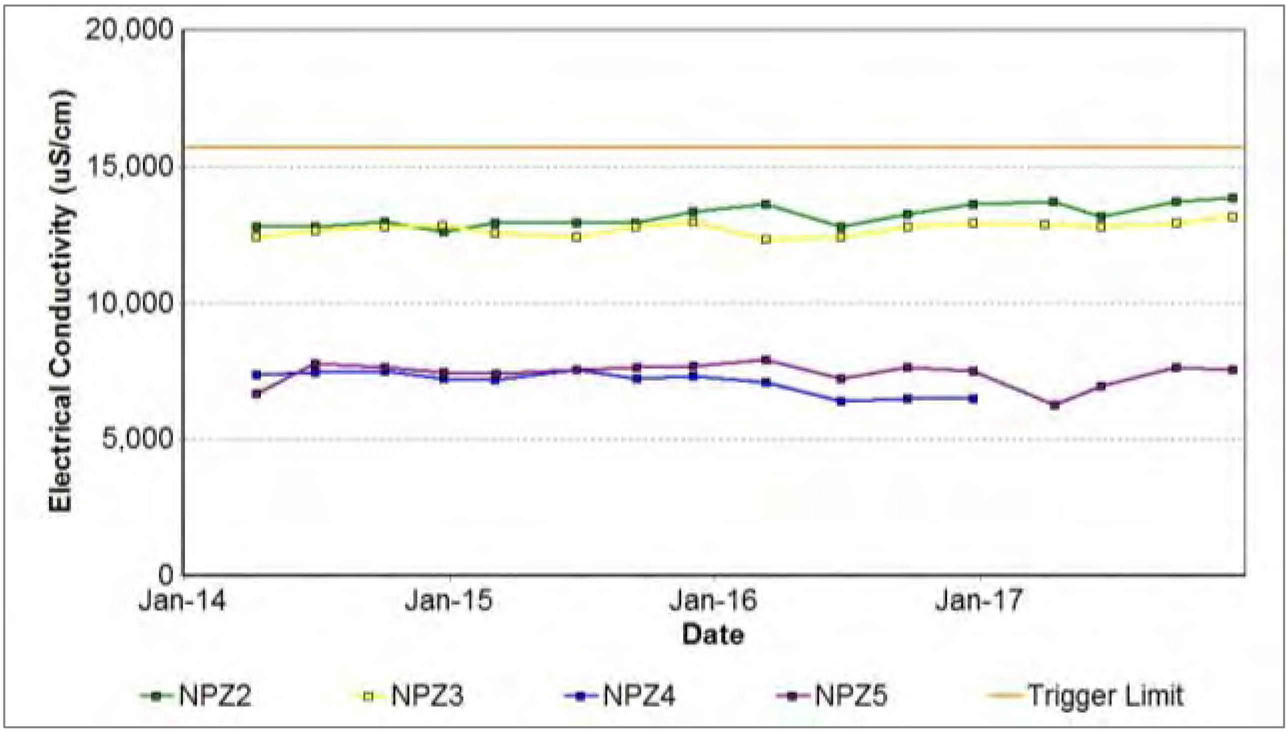


Figure 91: West Pit Sandstone/ Siltstone Groundwater EC Trends 2014 – 2017

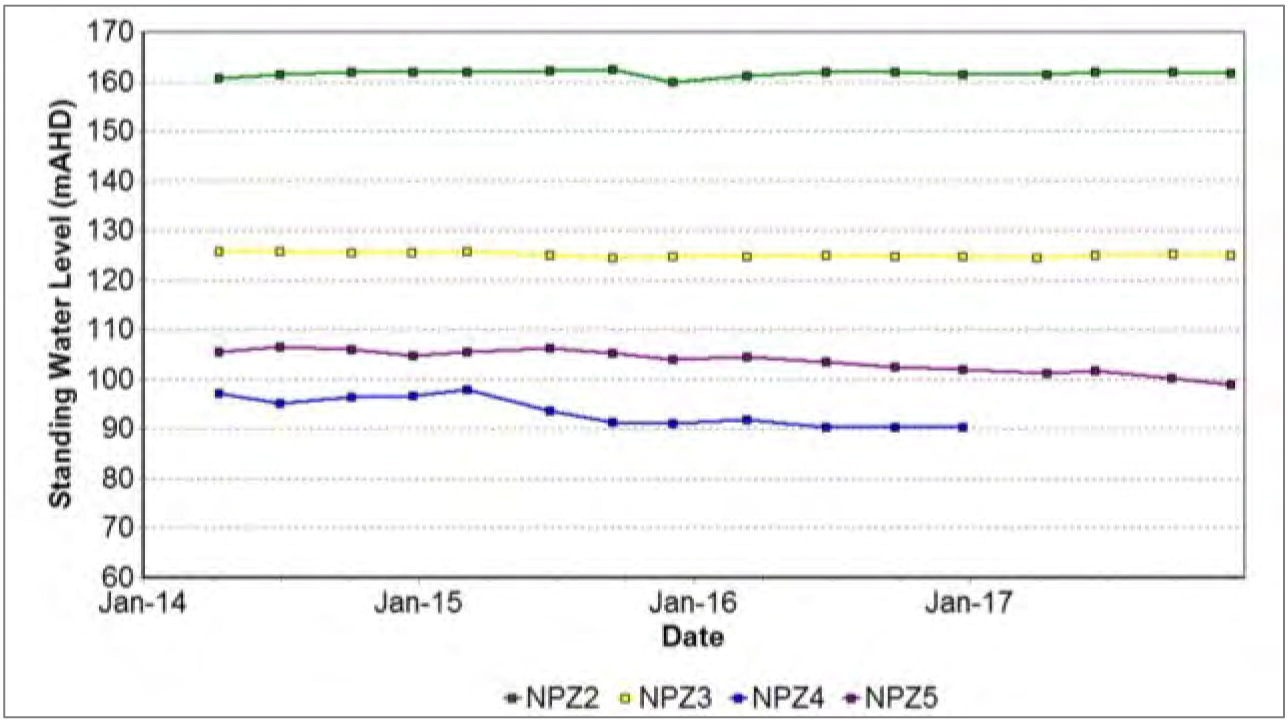


Figure 92: West Pit Sandstone/ Siltstone Groundwater SWL Trends 2014 – 2017

7.7.4 Ground Water Non-compliances during reporting period

There were no reportable incidents/non-compliances of consent or other approval conditions and no complaints relating to groundwater.

8 REHABILITATION AND LAND MANAGEMENT

8.1 Summary of Rehabilitation

Rehabilitation at HVO is undertaken in accordance with commitments made in the various Mining Operations Plans (MOPs) covering the site: Hunter Valley Operations North MOP (includes Newdell CHPP and Hunter Valley Load Point) and Hunter Valley Operations South MOP.

A summary of the key rehabilitation performance indicators is shown in Table 47.

Table 47: Key Rehabilitation Performance Indicators

Mine Area Type	Previous Reporting Period (Actual) Year 2017-1 (ha)	This Reporting Period (Actual) Year 2017 (ha)	Next Reporting Period (Forecast) Year 2017+1 (ha)
A. Total mine footprint[3]	6,399.0	6,443.4	6,607.4
B. Total Active Disturbance[4]	3,566.2	3,527.5	3,635.7
C. Land being prepared for rehabilitation[5]	35.8	39.6	57.6
D. Land under active rehabilitation[6]	2,797.0	2,876.3	2,914.1
E. Completed rehabilitation[7]	0	0	0

8.2 Key issues that may affect rehabilitation

A broad brush risk assessment which identified the key risks to rehabilitation was conducted in association with development of the HVO MOP documents. The key risks to rehabilitation were identified as:

- **Landform Stability** including the stability of water management structures, internal and external batter slopes and final void batters, and settlement and ponding on final landform surfaces of tailings storage facilities;
- **Spontaneous Combustion** occurring from placement of high risk materials on or near the final surface, or from exposed coal seams;
- **Growth Medium Suitability** issues due to acid rock drainage or atypical soil nutrient and chemical properties impacting vegetation establishment; or establishment of inadequate soil depth during the Growth Medium Establishment phase.

[3] **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/RMP Guidelines). Please note that subsidence remediation areas are excluded.

[4] **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 stockpiles areas, access tracks and haul road, active mining areas, waste emplacements (active/unshaped/in or out-of-pit), and tailings dams (active/unshaped/uncapped).

[5] **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).

[6] **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 sustainability" (revegetation assessed as showing signs of trending towards relinquishment OR infrastructure development).

[7] **Completed rehabilitation** – requires formal sign off by DRE that the area has successfully met the rehabilitation land use objectives and completion criteria.

- **Vegetation Establishment** impacts due to competition from problematic weed species, uncontrolled or inappropriate vehicle or livestock impacts, or resulting in low resilience to bushfire impact; and atypical species diversities, structural densities, growth rates, productivity and recruitment levels when compared with analogue sites.
- **Fauna Recolonisation** impacts due to competition and predation by vertebrate pest species; and
- **Ecosystem Function** issues such that key Landscape Function Analysis (LFA) values for stability, infiltration, nutrient cycling or landscape organisation are trending away from analogue site values.

A Trigger Action Response Plan (TARP) is included in the MOPs and identifies the proposed contingencies strategies in the event of unexpected variations or impacts to rehabilitation outcomes. Weed management continues to be a key issue to manage in order to meet rehabilitation objectives. Management activities for both native and pasture vegetation types are described below.

Native Vegetation Rehabilitation

Since 2011, HVO has increased its focus on re-establishing a diverse native understorey within native vegetation rehabilitation. Experience over this period has shown that weed competition, which includes exotic grasses in the context of native vegetation establishment, is the main limiting factor to the successful establishment of a native understorey. The weed seed source is coming from both historically disturbed areas that are being stripped ahead of mining; and from the cover species on topsoil stockpiles.

HVO has implemented a range of programs to minimise the impact of weeds in rehabilitation, including:

- Prioritising the use of topsoils from good quality native vegetation areas on rehabilitation that is being returned to native vegetation;
- Managing new and old topsoil stockpiles to clean up exotic grass/weed cover and establish a cover of native vegetation;
- Use of spoils and subsoils ameliorated with compost and gypsum as the growth medium for areas being returned to native vegetation. This method avoids the use of “weedy” topsoils and allows native vegetation to become established in the absence of competitive weed species;
- Use of a staged approach to rehabilitation where early sowing of sacrificial cover crops provide opportunities for weed control prior to sowing the native seed mixes;
- Use of a weed wiper and spot spraying to target exotic grasses and weeds in areas that have already been sown with native seed mixes.

Pasture Rehabilitation

HVO has been trialling the use of native grass species in pasture rehabilitation. Where native grass species are being used the limiting factor is weed competition; this is discussed in the section above. In pasture rehabilitation, where exotic pasture species are being used, the desired pasture species are less susceptible to weed competition. The main limiting factor for rehabilitation success in exotic pastures is a lack of diversity which can lead to declining feed quality during the winter periods.

The diversity of exotic pastures in rehabilitation are initially high due to the range of grass and legume species in the seed mixes. However, in the absence of the introduction and management of grazing these sites can become dominated by competitive summer growing species (i.e. Rhodes Grass and Green Panic). During winter these long rank grasses have poor feed quality and tend to shade out the winter growing legumes that would provide good quality feed over this period.

Therefore, to maintain pasture diversity and quality, implementation of grazing management to pasture rehabilitation areas in a timely manner is necessary. Where operational restrictions prevent the introduction of grazing other techniques, such as slashing, can be used to replicate the effect of grazing. HVO has been expanding the areas of pasture rehabilitation that are exposed to grazing through licence agreements over the last couple of years and this is planned to continue.

8.3 Renovations

No renovations or removals to report.

8.4 Rehabilitation Management

Performance criteria for each rehabilitation phase have been detailed in the Mining Operations Plan (MOP) for both HVO North and HVO South. These criteria have been developed so that the rehabilitation success can be quantitatively tracked as it progresses through the phases outlined below:

- Stage 1 – Decommissioning
- Stage 2 – Landform Establishment
- Stage 3 – Growing Media Development
- Stage 4 – Ecosystem and Land use Establishment
- Stage 5 – Ecosystem and Land use Sustainability
- Stage 6 – Rehabilitation Complete

The performance criteria are objective target levels or values that can be measured to quantitatively demonstrate the progress and ultimate success of a biophysical process. A monitoring methodology has been developed to measure the performance criteria outlined in the MOPs utilising a combination of tools that provide quantitative data to assess changes occurring over time.

The target levels or values have been based on monitoring results from reference sites and have been detailed in updated Mining Operations Plans submitted to DRG in December 2017. The results of the rehabilitation monitoring programme for native vegetation areas (presented in Appendix 2) have been compared against the target levels to determine if rehabilitation has been successful or if additional intervention is needed.

The monitoring programme for rehabilitated land returned to native vegetation was commenced by ecologists from Niche Environment and Heritage during 2015. Further monitoring was conducted in early and mid 2017 and a report that details the results of this monitoring programme is presented in Appendix 2. Monitoring was conducted across 12 reference sites within the two target vegetation communities Central Hunter Grey Box-Ironbark Woodland Endangered Ecological Community (EEC), and Ironbark-Spotted Gum-Grey Box Forest EEC. The 2017 monitoring programme revisited 16 of the 18 sites monitored in 2016 to check the consistency of the monitoring results from successive years. The 2017 monitoring programme also established 11 new monitoring sites at HVO.

Additional monitoring methods were incorporated into the 2017 programme to measure the density, health and growth of canopy species. Sites were selected to include rehabilitation of varying ages and different rehabilitation methods.

8.5 Grazing Trail

Monitoring of the grazing trial by DPI personnel was completed during 2017. This trial was initiated by the Upper Hunter Mining Dialogue in 2014 and is designed to test the suitability of rehabilitated mined land for cattle grazing. The grazing trial consists of two trial sites, one on rehabilitated land at HVO, and a control site on neighbouring un-mined land. The trial sites are 40 hectares each, with 10 Angus steers currently being grazed on each site.

The results from the first group of steers that were turned off the trial in April 2016 showed that the cattle grazing on the rehabilitated pastures were on average 764kg per head compared to the cattle on the unmined paddocks which averaged 611 kg per head. The cattle grazing on the rehabilitation paddocks consistently outperformed the cattle on the unmined paddocks during the first trial period.

Based on the condition of the paddocks after the first trial period, it was decided that the rehabilitation paddocks would be able to support higher stocking rates. The number of cattle grazing on the rehabilitated paddocks was therefore increased from 10 to 15 with the introduction of the second lot of steers to the trial. After 9 months on the grazing trial the second group of rehabilitation cattle, on average, weighed 480 kg per head while the cattle on the unmined paddocks average 381 kg per head.

Results from other monitoring undertaken during the trial will be detailed in the grazing trial report which will be finalised in early 2018. The final report will allow comparison between the rehabilitation and unmined areas in the following areas: soil properties, feed quality and quantity, pasture composition and animal health.

8.6 Rehabilitation Performance

A total of 103.2 ha rehabilitation was undertaken during 2017. Details of the rehabilitation areas including the extent of mining, surface contours and rehabilitation vegetation types are provided in Appendix 3. The location of rehabilitation completed in 2017 is shown in Figure 95 and Figure 96.

Table 48 details the amount of rehabilitation and disturbance completed during the reporting period compared with commitments in the respective MOP's. Appendix 4 provides the Annual Rehabilitation Report Form, including rehabilitation progress for each domain through the rehabilitation phases.

Table 48: Summary of rehabilitation and disturbance completed in 2017

MOP	2017 Totals (ha)		Cumulative Totals During Current MOP Period (ha)	
	Actual	MOP Commitment	Actual	MOP Commitment
Rehabilitation				
HVO North	56.3	59.9	140.9	176.3*
HVO South	46.9	139.3	164.8	221.6*
HVO Total	**103.2**	**199.2**	**305.7**	**397.9**
Rehabilitation Disturbance				
HVO North	9.0	0.0	99.1	272.4*
HVO South	6.5	13.4	74.5	93.1*
HVO Total	**15.5**	**13.4**	**173.6**	**365.5**
New Disturbance				
HVO North	41.4	62.5	84.9	296.8*
HVO South	31.5	36.2	151.3	193.3*
HVO Total	**72.9**	**98.7**	**236.2**	**490.1**
Net Rehabilitation (Rehabilitation minus Rehabilitation Disturbance)				
HVO North	47.3	59.9	41.8	-96.1*
HVO South	40.4	125.9	90.3	128.5*
HVO Total	**87.7**	**185.8**	**132.1**	**32.4**

Comparison with HVO North MOP Amendment B 2015 to 2018 approved 8 December 2017) and HVO South MOP Amendment B 2015 to 2018 (approved 8 December 2017);
*Cumulative MOP figures are for periods 2015-2017

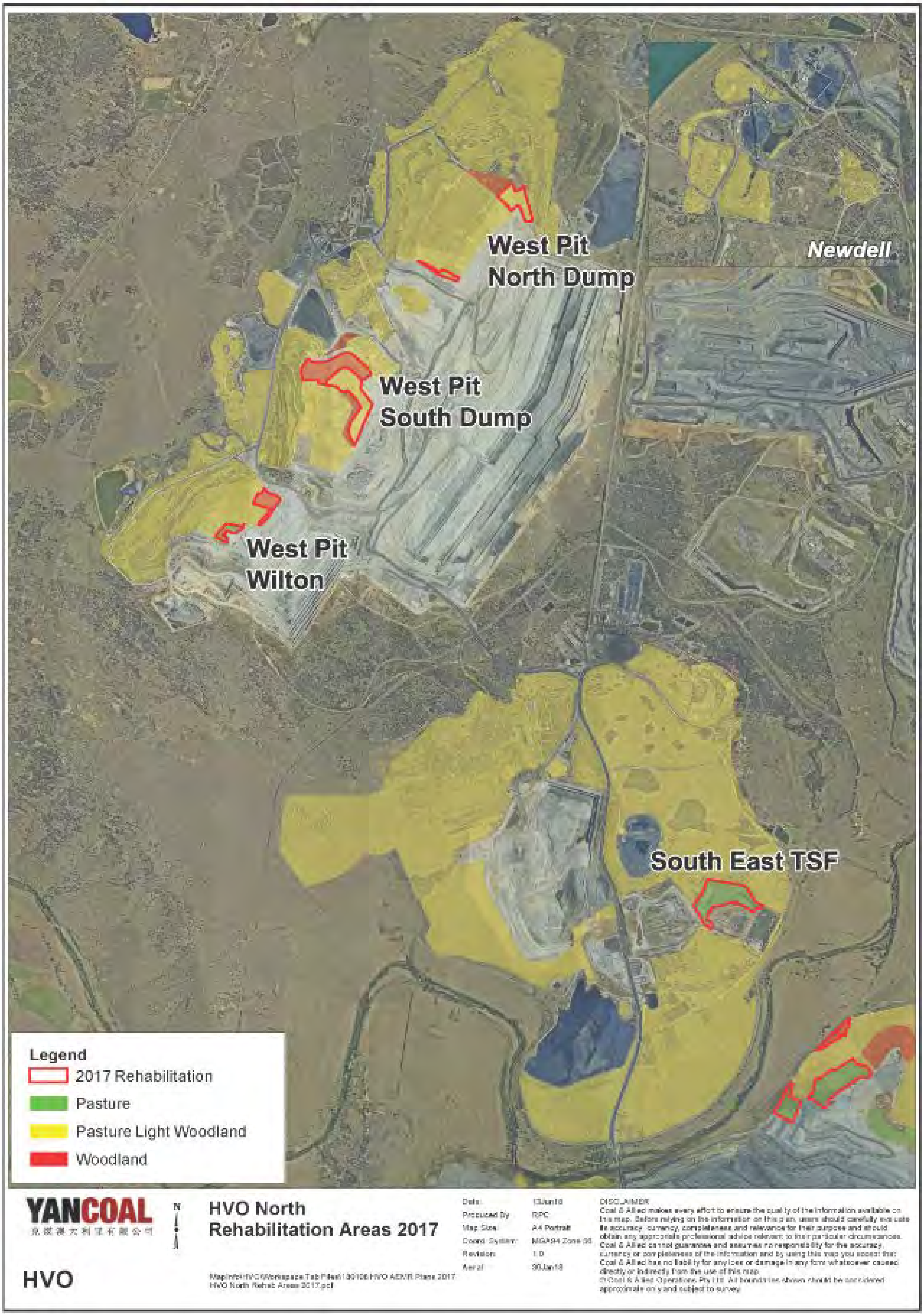


Figure 93: HVO North Rehabilitation Areas 2017

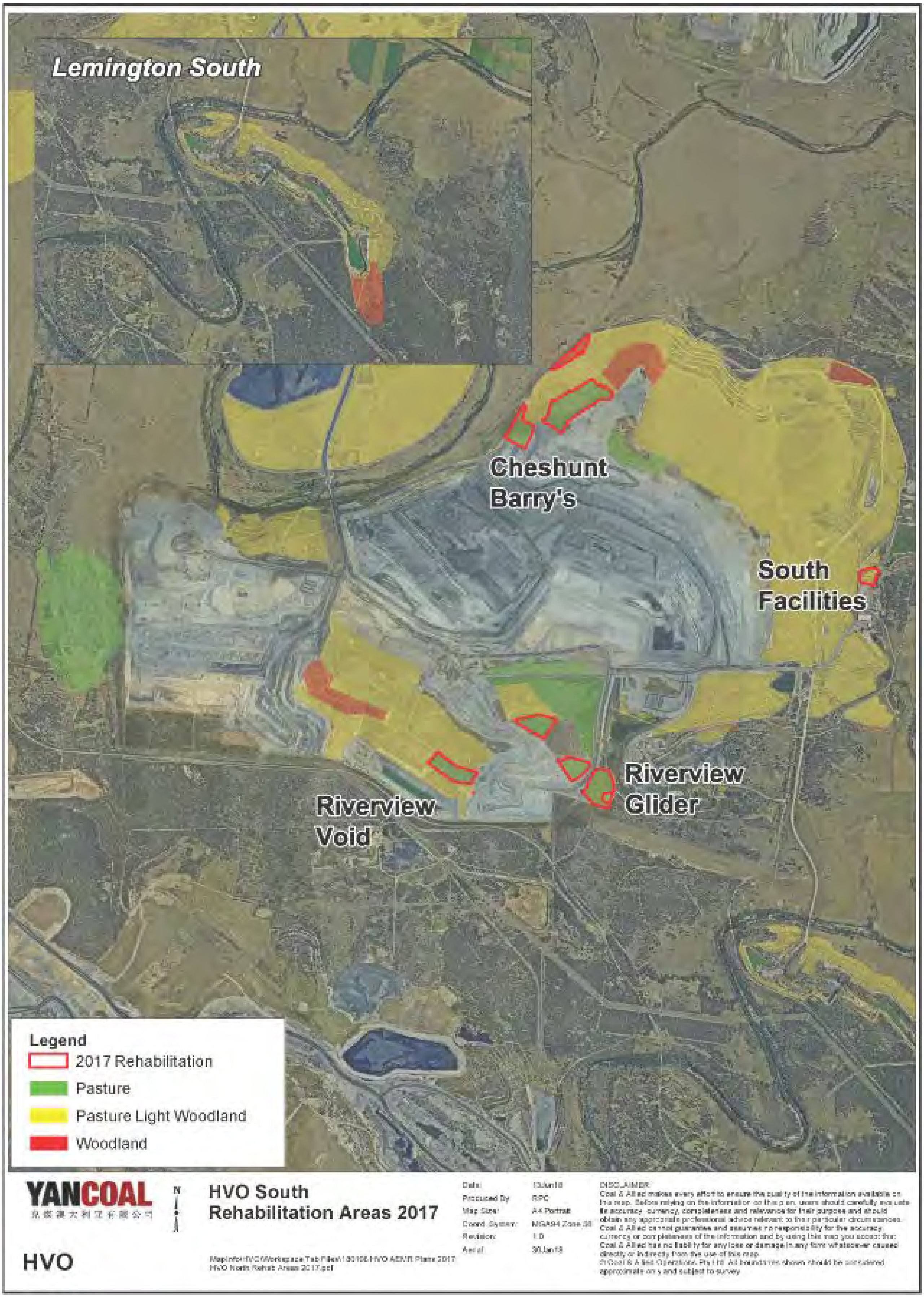


Figure 94: HVO South Rehabilitation Areas 2017

Rehabilitation figures presented relate to areas at or past the phase of Ecosystem and Landuse Establishment.

The area of rehabilitation that was sown during the reporting period was 96 hectares below the MOP commitment. This resulted in the cumulative rehabilitation total for the MOP period (2015 to 2017) also being 92.2 ha below the MOP commitment. The shortfall in rehabilitation completion is offset however by the reduced rehabilitation disturbance over the MOP period. During the MOP period HVO has disturbed 173.6 ha of rehabilitation compared to a MOP projection of 365.5 ha, a reduction of 191.9 ha. In terms of net rehabilitation, HVO is therefore in front of the MOP commitments by 99.7 ha over the MOP period.

The area of new disturbance at HVO during 2017 was 72.9 ha, which was lower than the projected MOP new disturbance of 98.7 ha. The area of new disturbance undertaken over the current MOP period (2015 to 2017) is 236.2ha, which is approximately half the MOP projection of 490.1ha.

A comparison of rehabilitation progression against predictions in the *HVO West Pit Extension and Minor Modifications Environmental Impact Statement (EIS) (October 2003)* and subsequent modifications to the HVO North approval (DA 450-10-2003) indicate that rehabilitation progression is generally consistent with EIS predictions. Planning approval modifications that changed the rate of rehabilitation progression at HVO North include: Carrington East Extension (Modification 2 - 2006); Carrington West Wing (Modification 3 - 2013); Carrington Out-of-Pit TSF (modification 4 - 2014); and Carrington In-Pit TSF (Modification 6 - 2014). When the modifications listed above are taken into account the EIS projection for rehabilitation area at the end of 2018 was 2,075 ha. Actual HVO North rehabilitation area at the end of 2017, totalled 1,840.6 ha which is generally consistent with the EIS projection.

As at the end of 2017, rehabilitation progress for HVO South is ahead of the predictions in the *HVO South Coal Project Environmental Assessment Report (January 2008)*.

Figure 19.3 of the Environmental Assessment Report shows 597.2 ha of rehabilitation completed as at the end of 2007 with a prediction of a further 275.5 ha to be completed in the period 2008 to 2016. The actual rehabilitation area at the end of 2017 is 1,035.7 ha which is ahead of the EA report predictions for the end of 2016 of 872 ha.

8.7 Rehabilitation Programme Variations

The variations to the rehabilitation programme are summarised in Table 49.

Table 49: Variations to the Rehabilitation Programme

Has rehabilitation work proceeded generally in accordance with the conditions of an accepted Mining Operations Plan	**HVO North - Yes (see below)** **HVO South – *Substantially (see below)***
If not please cite any approval granted for variations, or briefly describe the seasonal conditions or other reasons for any changes and the nature of any changes which have been made.	

HVO North net rehabilitation (net rehabilitation = rehabilitation minus – rehabilitation disturbance) completed during period 2015 to 2017: Actual = +41.8 ha vs MOP target = -96.1 ha.

HVO North net rehabilitation progress 137.9 ha ahead of MOP target for period 2015 to 2017.

HVO South net rehabilitation completed during period 2015 to 2017: Actual = +90.3ha vs MOP target = +128.5 ha.

HVO South net rehabilitation progress 38.2 ha behind MOP target for period 2015 to 2017.

HVO South rehabilitation progress delayed due to HVO seeking approval for Cheshunt dumps to be raised to higher level.

8.8 Rehabilitation Monitoring

The 2017 rehab monitoring was the second year of monitoring in rehabilitation areas following commencement during 2016. Monitoring during 2016 addressed 19 sites which had been rehabilitated in the period 2008 to 2014. The 2017 monitoring comprised 29 monitoring sites including 13 new sites which were established on areas that had been rehabilitated during 2015 and 2016 and which have not previously been monitored. Two sites established and monitored during 2016 were not re-visited as native seed mix had not yet been sown (HVOCHES201301 and HVORIV201301). A third site established during 2016 was also not re-visited as it is expected to be re-disturbed during 2018 (HVOCHES201202).

Monitoring was undertaken largely in accordance with the methodology detailed in AECOM (2012) *Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites* as used during the 2016 monitoring event. Two notable amendments to the methodology were employed, based on lessons learnt during the 2016 monitoring period. These amendments include:

- Removal of the 1 x 1 metre pasture/groundcover monitoring and replacement with a BioBanking plot, including a nested 20 x 20 metre plot at each site.
- Introduction of stem density counts along two, 2 metre strips along the length of the 50 metre centre tape.
- Introduction of tree tagging, where endemic trees with a Diametre at Breast Height (DBH) larger than 5 centimetres were marked and numbered, and specific details of each tree was recorded.

8.8.1 Completion criteria trajectory assessment

The monitoring program monitors attributes relevant to assessing the trajectory of rehabilitation areas with respect to the completion criteria detailed in current Mining Operations Plans (HVO North MOP dated 1 June 2017 and HVO South MOP dated 5 June 2017, both submitted on 7 June 2017). Relevant monitoring results with respect to the Growing Media Development phase, Ecosystem and Landuse Establishment phase, and Ecosystem and Landuse Sustainability phase are presented below. Exhaustive consideration of all MOP Completion Criteria has not been undertaken. Criteria associated with the available monitoring data only are detailed in association with discussion of potential performance issues identified by the monitoring data, and relevant associated management actions.

8.8.2 Growing Media Development Phase

In the context of the MOPs Growing Media Development incorporates the processes involved to achieve a soil which is capable of supporting a sustainable plant community. It includes consideration of the chemical, physical and biological properties of the media and takes into account issues such as the specialist requirements, e.g. soil ameliorants aligned to the revegetation of the disturbed areas, whilst also incorporating consideration of landuse that may deviate from the traditional post mining landuse. Soil management is fundamental in successful rehabilitation management at HVO. The key objectives for managing the soil landscape include minimising bare soil patches (which would be affected by wind and water movement and the introduction and transportation of resources into and out of the system), and establishing favourable nutrient, infiltration and stability characteristics.

The Criteria, Performance Measures and Indicators which relate to the growing media development stage is provided in Table 50.

Table 50: Growing Media Development trajectory assessment

Objective	Performance Indicator	Performance Criteria	Trajectory Assessment	Management Actions
Rehabilitation Area – Pasture and Woodland				
Soil properties suitable for the establishment and maintenance of selected vegetation species: NORTH MOP Approximately 70% of mined land re-established as stable, productive pasture areas; Approximately 30% of mined land re-established as woodland areas. SOUTH MOP Returning 60-70% of disturbed mining areas to grazing land; Returning 30-40% of disturbed mining areas to native woodland, but not necessarily conforming to an particular vegetation community.	pH of replaced topsoil to be broadly within the range suitable for targeted species growth.	Pasture - pH >5.5 and <8.5 Woodland - pH >5.5 and <8.5	Generally all sites either fall within the performance criteria for soil stability or are trending towards the target range. All sites are displaying elevated phosphorus levels. Rehab trajectory of the majority of the areas established in Riverview at HVO South during 2014 also requires ongoing monitoring (HVORIV201401, HVORIV201402, HVORIV201403, and HVORIV201404). Soils in these areas are alkaline (pH>8.5) and levels of exchangeable sodium within the upper range of the criteria are generally persisting. Associated CEC is typically above the target range.	Specific management actions are not proposed. A monitoring brief will be maintained over future monitoring events to assess ongoing performance against this criteria.
	Electrical Conductivity of replaced topsoil to be broadly within the range suitable for plant growth.	Pasture - Electrical Conductivity <2 dS/m Woodland - Electrical Conductivity <2 dS/m	All sites were within MOP criteria range.	
	Soil Phosphorous levels (Colwell) to be trending towards the range suitable for plant growth.	Pasture - Phosphorous >40ppm Woodland - Phosphorous within levels in analogue sites by Year 5 Target: 1.2 to	Phosphorus levels were generally elevated variously across all monitoring sites and elevated above analogue site ranges, including for	A monitoring brief will be maintained over future monitoring events to assess ongoing performance against this criteria.

Objective	Performance Indicator	Performance Criteria	Trajectory Assessment	Management Actions
		13.0ppm	sites beyond Year 5.	
	Organic carbon levels are typical of that of the surrounding landscape, increasing or fall within desirable ranges provided by the agricultural industry.	Pasture - Organic Carbon >1.5% Woodland - Organic Carbon within levels in analogue sites by Year 5 Target: 1.6 to 8.7%	All sites were within MOP criteria range.	
	Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry.	Pasture - Cation Exchange Capacity >12 Cmol+/kg Woodland - Cation Exchange Capacity within levels in analogue sites by Year 2 Target: 7.4 to 20.4 Cmol+/kg	Generally sites were within MOP criteria range, steady at values near to criterial or trending towards criteria. . Riverview 2014 sites HVORIV201401 and HVORIV201402 were more elevated although this is likely associated with slightly elevated levels of exchangeable sodium.	A monitoring brief will be maintained over future monitoring events to assess ongoing performance against this criteria, particularly with respect to sites elevated against the criteria range.
	Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry.	Pasture - Exchangeable Sodium Percentage <10% Woodland - Exchangeable Sodium Percentage within levels in analogue sites by Year 2 Target: 0.2 to 8.7%	All sites were within MOP criteria range except sites HVORIV201401 and HVORIV201402, noted above.	
	Calcium/Magnesium ratio is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry.	Pasture - Calcium/magnesium ratio >1 and <10 Woodland - Calcium/magnesium ratio within levels in analogue sites by Year 2 Target: 0.7 to 2.1	Generally sites were within MOP criteria range, or recently completed areas which slightly elevated levels are not of immediate concern.	

8.8.3 Ecosystem and Landuse Establishment Phase

In the context of the MOPs, Ecosystem and Landuse Establishment incorporates the requirements for:

- The management and control of fire, weed and vertebrate pest species;
- Correct flora species selection in terms of the revegetation programmes;
- Suitable Land Capability classes;
- The development of systems to enhance opportunities for nutrient cycling;
- Development and enhancement of habitat for key fauna species; and

- The optimal use of onsite resources, e.g. woody debris, rock, mulch.

Rehabilitation at HVO is generally divided into areas for biodiversity outcomes (woodland) and areas of pasture. The criteria, performance measures and indicators for the Ecosystem and Landuse Establishment phase are provided in Table 51.

Table 51: Ecosystem and Landuse Establishment trajectory assessment

Objective	Performance Indicator	Performance Criteria	Trajectory Assessment	Management Actions
Rehabilitation Area – Pasture and Woodland				
Establishment and germination of selected vegetation species: NORTH MOP - Approximately 70% of mined land re-established as stable, productive pasture areas; - Approximately 30% of mined land re-established as woodland areas. SOUTH MOP - Returning 60-70% of disturbed mining areas to grazing land; - Returning 30-40% of disturbed mining areas to native woodland, but not necessarily conforming to an particular vegetation community.	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Based on key physical, biological and chemical characteristics the LFA Stability Index provides an indication of the site's stability and that it is comparable to or trending towards that of analogue sites (%). Pasture: 63.2% to 69.2%; Woodland: 53.9% to 81.8%.	Stability Index values were wither within or closely located to the criteria range and are reflective of generally stable landforms. Sites with values below criteria are generally reflective of recently completed areas or areas which remain to be progressed to final native cover. Stability at sites HVOCHE201601 and HVOCHE201602 were below criteria reflecting herbicide treatement of sacrificial cover crops in these areas. This site is of concern in current state. It is noted that management practices associated with early stage rehab areas such as herbicide spraying have potential to influence this measure.	Sow further cover crops to Cheshunt 2016 rehab areas or progress to final native seeding (or combination of both).
		Based on key physical, biological and chemical characteristics the LFA Infiltration Index provides an indication of the site's infiltration capacity and that it is comparable to or trending towards that of analogue sites (%). Pasture: 29.4% to 37.3%; Woodland: 48.4% to 73.9%.	Infiltration index scores are generally within or close to criteria range or trending favourably. Lower values are generally associated with early stage establishment and not currently of concern.	Monitor lower values for ongoing trends.

Objective	Performance Indicator	Performance Criteria	Trajectory Assessment	Management Actions
		Based on key physical, biological and chemical characteristics the LFA Nutrient Recycling Index provides an indication of the site's ability to recycle nutrients and that it is comparable to or trending towards that of analogue sites (%). Pasture: 24.1% to 30.7%; Woodland: 38.5% to 79.8%.	Infiltration index scores are generally within or close to criteria range or trending favourably. Lower values are generally associated with early stage establishment and are not currently of concern. Several values are closely located to the lower range limit and although not of immediate concern will be monitored for further drift from the criteria range.	Monitor lower values for ongoing trends.
		The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to or trending towards that of analogue sites. Pasture: 1.00; Woodland: 0.84 to 1.00.	Landscape Organisation Index scores were generally high however with variability across rehabilitation sites. Older sites sown to final native cover generally saw a reduction in value potentially due to dry conditions at the time of monitoring. This potential trend will be monitored over future monitoring events. Initial scores for sites recently sown to native cover are at acceptable levels.	Monitor lower values for ongoing trends.
Rehabilitation Area - Pasture				
NORTH MOP Approximately 70% of mined land re-established as stable, productive pasture areas. SOUTH MOP Returning 60-70% disturbed mining area to grazing land.	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area).	Criteria not yet determined.	Sites sown to native Pasture Light Woodland mixes are generally have species numbers within reference site range values. Key exceptions are areas of Riverview 2014 rehab (HVORIV201403, HVORIV201404, and HVORIV201405) and Cheshunt 2012 rehab (HVOCHE201201) where species presence was low.	Targeted inspection of sites HVORIV201403, HVORIV201404, HVORIV201405, HVOCHE201201, by a suitably qualified person to assess species density across the block compared with monitoring plot results. If needed, development of ongoing action plan based on inspection findings.

Objective	Performance Indicator	Performance Criteria	Trajectory Assessment	Management Actions
Rehabilitation Area - Woodland				
NORTH MOP Approximately 30% of mined land re-established as woodland areas. SOUTH MOP Returning 30-40% disturbed mining area to native woodland, but not necessarily conforming to any particular vegetation community.	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area).	1 to 4 species within a 20m x 20m quadrat.	Tree species numbers in Woodland blocks were generally consistent with analogue sites and within criteria. HVOWES201601 was below criteria however establishing shrubs and grasses were present.	Targeted inspection of sites HVOWES201601 by a suitably qualified person to assess species density across the block compared with monitoring plot results. If needed, development of ongoing action plan based on inspection findings.
	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area).	4 to 9 species within a 20m x 20m quadrat.	Grass species numbers in Woodland community plantings were at or exceeded benchmark counts and performance criteria.	
	The density of trees is comparable to that of analogue sites (no/area).	250 to 3,150 stems per ha	Species densities in Woodland community plantings were generally within benchmark site range and performance criteria. Density in West Pit 2016 site HVOWES201603 is currently below the criteria range and requires ongoing oversight. The trajectory HVOWES201601 is of concern with monitoring indicating nil stems in this plot. An ongoing monitoring brief will remain on this site.	Targeted inspection of sites HVOWES201601 and HVOWES201603 by a suitably qualified person to assess species density across the block compared with monitoring plot results. Development of ongoing action plan based on inspection findings. It is noted that the juvenile stage of many individuals made correct identification problematic and that in recently sown areas full germination may not have occurred. Subsequent monitoring events will provide further guidance on this aspect.

8.8.4 Ecosystem and Landuse Sustainability Phase

In the context of the MOPs, Ecosystem and Landuse Sustainability incorporates the:

- Development of profiles in the growing media;
- Development of land usage which is consistent with surrounding areas;
- Vegetation communities capable of withstanding catastrophic events, e.g. bushfire and extensive drought;
- Nutrient cycling;
- Species diversity and abundance for both flora and fauna;
- Recolonisation of the sites by key indicator species; and
- Suitable Land Capability classes.

The criteria, performance measures and indicators for the Ecosystem and Landuse Sustainability Stage are provided in Table 52.

Table 52: Ecosystem and Landuse Sustainability

Objective	Performance Indicator	Performance Criteria	Trajectory Assessment	Management Actions
Rehabilitation Area - Pasture				
NORTH MOP Approximately 70% of mined land re-established as stable, productive pasture areas. SOUTH MOP Returning 60-70% disturbed mining areas to grazing land.	Weed plant cover (calculated as a percentage of total ground cover) is comparable to that of analogue sites. (% Cover)	Not yet determined	In the absence of criteria for this indicator assessment of pasture areas against the woodland criteria (<33%) has been undertaken. Four of ten sustainability phase pasture blocks are meeting the defacto criteria (<33%). The remaining six blocks have weed percentages in the range 38-78%. HVORIV201402 (38%), HVORIV201403 (52%), HVORIV201501 (76%), HVORIV201503 (56%), HVOWES201604 (38%), HVOLEM201601 (52%)	Targeted inspection of sites with elevated weed cover to confirm that monitoring data is representative of the respective rehab blocks. Development and implementation of targeted weed controls in areas of concern.
Rehabilitation Area – Woodland				
NORTH MOP Approximately 30% of mined land re-established as woodland areas. SOUTH MOP Returning 30-40% disturbed mining area to native woodland, but not necessarily conforming to any particular vegetation community.	Weed plant cover (calculated as a percentage of total ground cover) is comparable to that of analogue sites. (% Cover)	Target: 5% to 33%	Two of five sustainability phase woodland blocks are meeting the criteria. Blocks: HVOCAR200902 (74%), HVORIV201401 (50%), HVOWES201601 (88%) are outside criteria.	Targeted inspection of sites with elevated weed cover to confirm that monitoring data is representative of the rehab block. Development and implementation of targeted weed controls in areas of concern.
	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no./area).	Target: 1 to 4 species within a 20m x 20m quadrat.	Four woodland blocks have trees diameter exceeding 5cm. All blocks are meeting criteria with species numbers in the range 2-3.	
	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no./area).	Target: 50 to 725 stems per ha	All sites to which this criteria apply are meeting criteria.	

Objective	Performance Indicator	Performance Criteria	Trajectory Assessment	Management Actions
	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Target: 10.8cm to 65cm	Sites to which the criteria apply have average width in the range 6.1-10.5cm and are outside the target criteria but trending favourably.	

8.8.5 Overview of rehabilitation trajectory

Based on the current rehabilitation monitoring program the trajectories of rehabiliation completion criteria are generally progressing in an acceptable manner however the monitoring program has identified a number of performance issues which will require additional management actions over the next reporting period. These initial management actions are consistent with the relevant Trigger Action Response Plan items as detailed in the respective Mining Operations Plans and currently broadly comprise investigations to confirm the extent of the identified issues and, where appropriate, development of detailed site specific action plans.

In addition to the identified TARP management responses, an ongoing focus during the next reporting period will be the continued progression of areas which have been initially rehabilitated with sacrificial cover crops to being sown with final-cover seed mixes, and associated supporting management actions to support successful establishment of these areas such as pre-sowing ground preparations, and preparatory and follow-up weed treatments.

8.9 Rehabilitation Maintenance

Management of Rehabilitated Areas is undertaken when required or when issues are identified through monitoring, auditing or inspections.

Broadacre weed treatment within rehabilitation areas is undertaken using agricultural methods comprising boom sprays and wick wipers. In existing rehabilitation areas boom spraying is primarily used to manage cover crop and fallow areas prior to sowing to final native seed mixes. Pre-emergent application of herbicide is occasionally necessary to control emerging weeds in the period between sowing and germination of the desired plants. Wick wiping targets rapidly growing exotic grasses and other erect growing weeds in the period following native germination but while desirable species remain below the wiper target zone. During 2017 areas totalling 370.5 ha of existing rehabilitation received boom and/or wick wiper treatment (Figure 95).

Hand spraying and manual removal of weeds is also undertaken in rehabilitation areas with establishing native vegetation that would be affected by broadacre methods. These activities are described in Section 8.13.

A licence agreement is in place for grazing 719 ha of HVO North rehabilitation area. Temporary grazing licences aimed at reducing fuel loads are in place for a further 212 ha of rehabilitated land across HVO North.

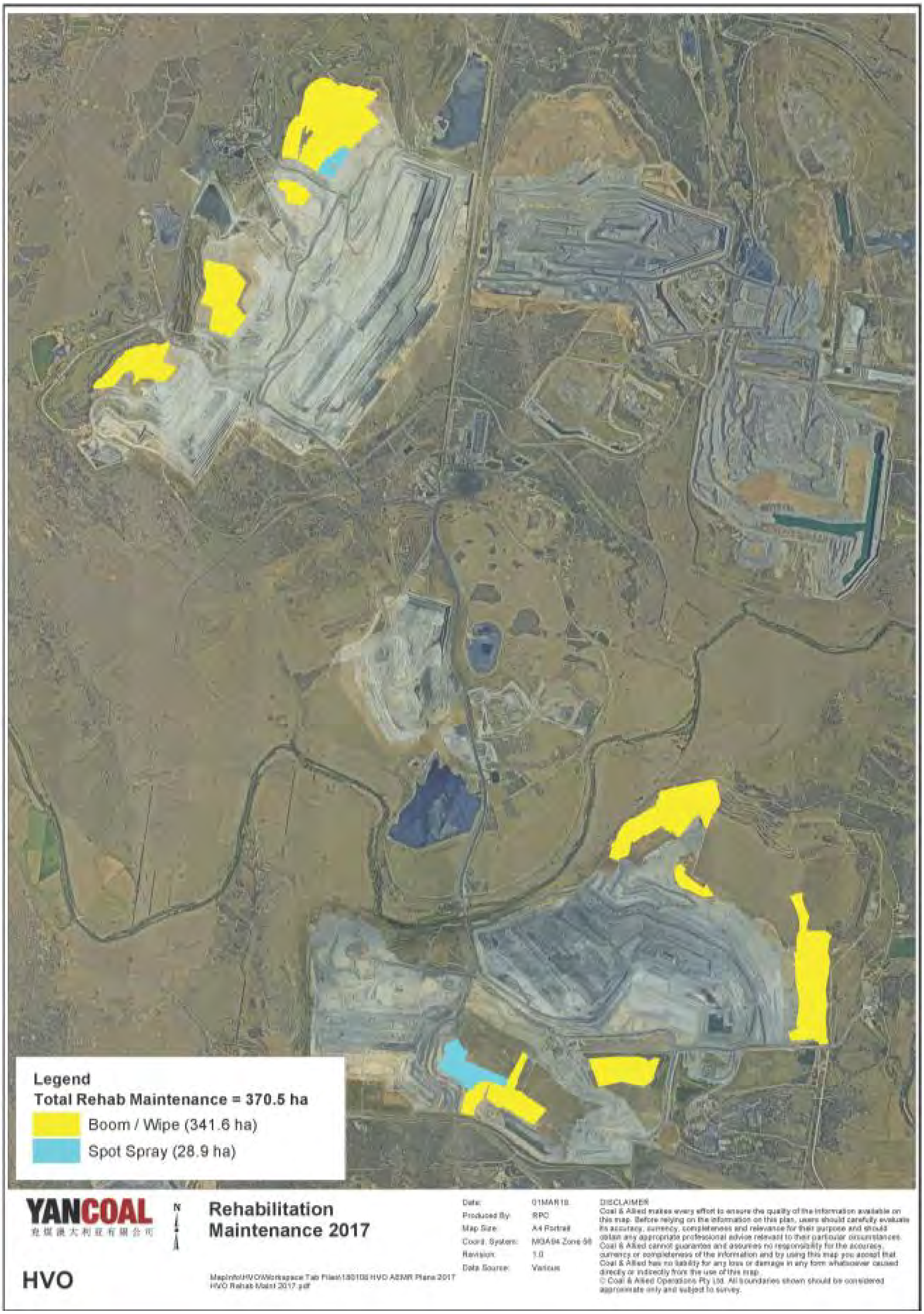


Figure 95: Rehabilitation Maintenance – post-rehabilitation weed control

8.10 Top Soil Management

Topsoil is managed according to the Yancoal Ground Disturbance Permit system and land management procedures. Table 53 outlines the topsoil used and stockpiled during 2017. There were 100.4 ha of rehabilitation top soiled during 2017, using stockpiled and pre-stripped soil resources.

Table 53: Soil Management

Soil Used This Period (m^3)	Soil Prestripped This Period (m^3)	Soil Stockpiled to Date (m^3)	Soil Stockpiled Last Report (m^3)
100,400	88,300	1,863,113	1,875,213

8.11 Tailings Management

A Fine Rejects Management Strategy for HVO has been developed in accordance with the planning approval for HVO North (Clause 28A of DA 450-10-2003 Mod 4). A revised strategy was submitted on 3rd February 2016 to address feedback provided by DP&E and DRE (now DRG). The strategy outlines tailings management for the time horizon spanned by current approvals.

Capping of the Southeast TSF continued, with 15.6 ha of the area rehabilitated during 2017.

Minimising the amount of standing water on tailings storage facilities, by managing the decant water, is important during and post tailings deposition to assist with closure of these facilities. Effective removal of decant water enables better consolidation of the tailings material, which in turn facilitates earlier capping and rehabilitation of the storage facility. Table 54 below outlines the current state of decant water pumping infrastructure across the active and inactive TSF's at HVO.

Table 54: HVO Tailings Storage Facilities

Facility	Status	Decant System
North Void	Active	Decant pumps in place, regular pumping.
Dam 6W	Active	Decant pump in place, regular pumping.
Cumnock Void	Active	Decant pump in place, regular pumping.
Bob's Dump	Inactive	Solar pump in place, pumping as required.
Southeast TSF	Inactive - capping commenced	Diesel pump in place, pumping as required.
Central TSF	Inactive	No pumps required due to rapid drying after rainfall (small catchment reporting to TSF).

8.12 River Red Gum Restoration and Rehabilitation

There are a number of River Red Gum sites (endangered population) across HVO South and North. These are managed under the River Red Gum Restoration and Rehabilitation Strategy. The sites have been categorised into a high level of management at the Carrington Billabong, intermediate level at the priority sites and low level at the low priority sites.

Management activities have included fencing and the removal of cattle grazing to reduce the impact on native vegetation at high priority sites. Weed management activities were implemented in accordance with the Weed Management Plan across all priority sites in 2017 targeting Galenia (*Galenia pubescens*), Tiger Pear (*Opuntia aurantiaca*), Prickly Pear (*Opuntia stricta*), Castor Oil (*Ricinus communis*), Farmer's

Friend (*Bidens pilosa*) and various Thistles (*Onopordum acanthium*), (*Carthamus lanatus*), (*Silybum mariamum*).

Planting programmes to increase the understory diversity of the Carrington Billabong have been undertaken in spring 2015 and autumn 2017. A total of 1,000 plants were planted during each programme and these were broken down into 500 grasses, 250 shrubs and 250 small trees. These were planted into weed mat islands that were fenced off for protection against rabbit and kangaroo browsing. River Red Gum tube stock were also planted into the area. An additional native understorey planting is scheduled to be undertaken in autumn 2018 to add to the diversity of the Carrington Billabong and other priority River Red Gum areas at HVO. Figure 96 shows the new weed mat islands at the Carrington Billabong.

Figure 96: Native tube stock planting at Carrington Billabong

8.13 Weed Control

8.13.1 Weed Treatment

The weeds identified at HVO occur primarily in areas that have been disturbed such as post mining rehabilitation areas, previous civil works areas, soil stockpiles, water management structure surrounds, and general areas of minor ground disturbance. A total of 79 days of weed control work was undertaken on site at HVO during 2017, with 251 ha of land treated, including River Red Gum areas and maintenance of environmental monitoring points. The weeds targeted during the 2017 weed management programme were based on the results of the 2016 weed survey. Figure 97 to Figure 99 illustrate the target species and weed treatment areas across HVO.

The species focussed on during treatment included:

- African Boxthorn (*Lycium ferocissimum*)
- African Olive (*Olea europaea*)
- Balloon Vine (*Cardiospermum grandiflorum*)
- Galenia (*Galenia pubescens*)

- Golden Dodder (*Cuscuta campestris*)
- Green Cestrum (*Cestrum parquii*)
- Mother of Millions (*Bryophyllum delagoense*)
- Farmers Friend (*Bidens pilosa*)
- Mallow (*Malva parviflora*)
- Mustard Weed (Sisymbrium officinale)
- Saligna (Acacia saligna)
- Stinging Nettle (Urtica dioica)
- *Opuntia* (Pear) species (Tiger, Prickly and Creeping pear)
- St John's Wort (*Hypericum perforatum*)
- Thistles: Saffron Thistle (*Carthamus lanatus*), Scotch Thistle (*Onopordum acanthium*), and Variegated Thistle (*Silybum marianum*)

8.13.2 Annual Weed Survey

The management and control of weeds at HVO is governed by the Annual Weed Survey (AWS). The AWS lists Weeds of National Significance (WONS), noxious, environmental and other non-declared weed species identified across HVO, and provides a framework to allow for structured weed management and control across operational and non-operational areas of HVO.

The following summarises the results of the weed survey undertaken during December 2017. From 2018 all reports and surveys will be based upon the NSW Biosecurity Act 2015 which came into force from 1st July 2017 and repealed 14 Acts including the Noxious Weeds Act 1993. The new legislation has resulted in the development of the Hunter Regional Strategic Weed Management Plan 2017-2022 which covers the area occupied by HVO.

Five WONS were identified during the survey, they included:

- African Boxthorn (*Lycium ferocissimum*);
- Blackberry (*Rubus fruticosus*);
- Pear Species, including:
  - Creeping Pear (*Opuntia humifusa*);
  - Prickly Pear (*Opuntia stricta*); and
  - Tiger Pear (*Optunia aurantiaca*).

Five other noxious weeds were identified at HVO during the survey, including:

- Golden Dodder (*Cuscuta campestris*);
- Green cestrum (*Cestrum parqui*);
- Mother-of-Millions (*Bryophyllum delagoense*);
- Xanthium species including:
  - Bathurst burr (*Xanthium spinosum*); and
  - Noogoora burr (*Xanthium occidentale*).

Eleven environmental weed species were identified at HVO during the survey, they included:

- African Olive (*Olea europea subspecies cuspidae*);
- Balloon Vine (*Cardiospermum grandiflorum*);
- Blue helitrope (*Heliotropium amplexicaule*);
- Castor Oil Plant (*Ricinus communis*);

- Cleavers (*Galium aparine*);
- Common Thornapple (*Datura stramonium*);
- Galenia (*Galenia pubescens*);
- Various Thistles including:
  - Scotch Thistle (*Onopordum acanthium*);
  - Saffron Thistle (*Carthamus lanatus*);
  - Variegated Thistle (*Silybum marianum*); and
  - Wandering Jew (*Tradescantia fluminensis*).

Eleven weeds that are not officially declared or listed in NSW were also recorded at HVO including:

- Century Plant (*Agave americana*);
- Fennel (*Foeniculum vulgare*);
- Farmers friends (*Bidens pilosa*);
- Golden Wreath Wattle or Saligna (*Acacia Saligna*);
- Mallow (Small -flowered Mallow) (*Malva parviflora*),;
- Mustard Weed (*Sisymbrium* sp);
- Narrow Leaved cotton bush (*Gomphocarpus fructicosus*);
- Purple Top (*Verbena bonariensis*);
- Spiny Rush (*Juncas acutus*);
- Stinking roger (*Tagetes minuta*); and
- Variegated Geranium (Geranium species).

Species identified during the 2017 survey will form the basis of ongoing weed management works during 2018.

Figure 97: Weed Control Overview for West Pit – 2017

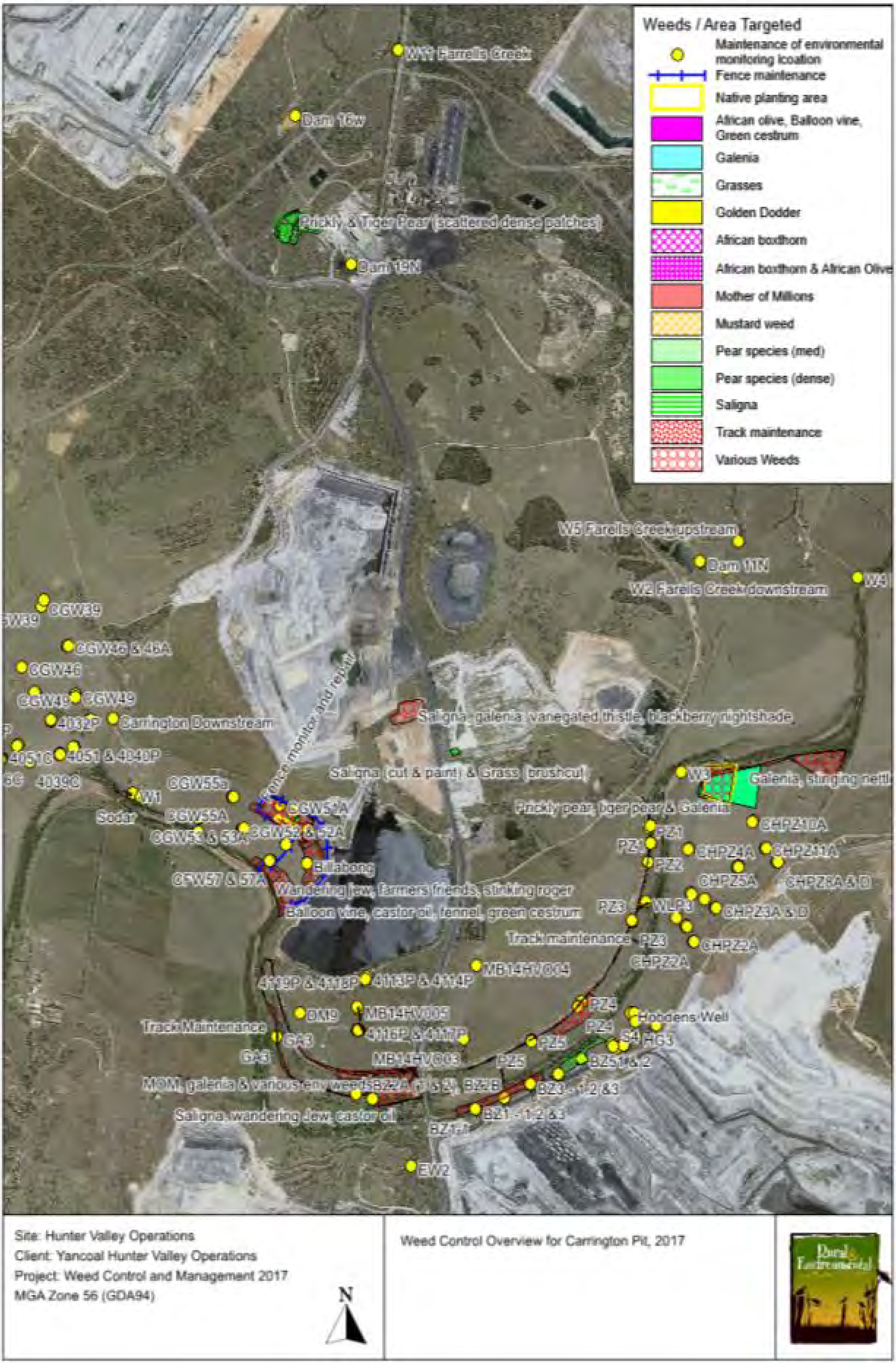


Figure 98: Weed Control Overview for Carrington Pit - 2017

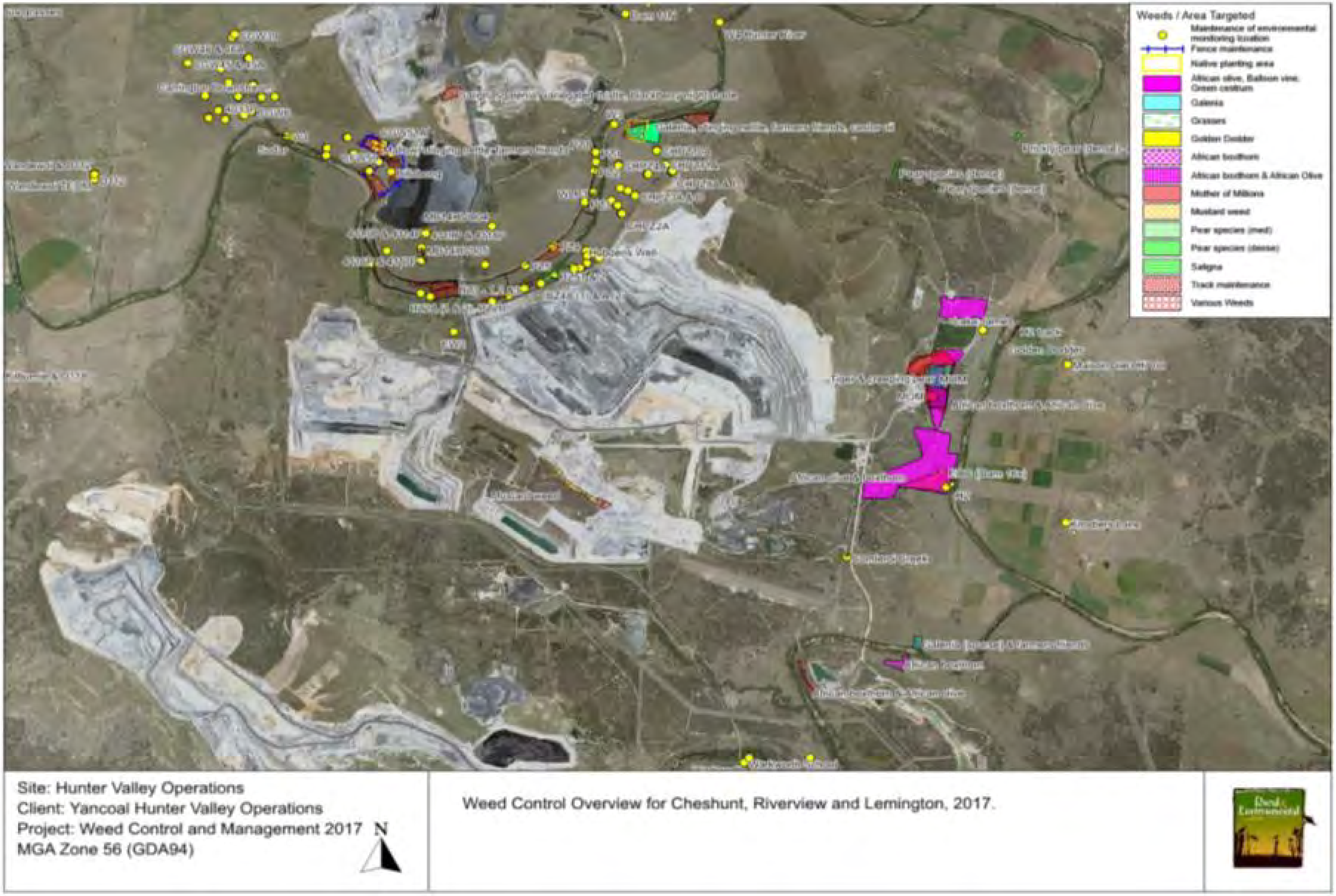


Figure 99: Weed Control Overview for Cheshunt and Riverview Pit - 2017

8.14 Vertebrate Pest management

As part of HVO's Vertebrate Pest Action Plan a control programme is carried out on a seasonal basis within HVO. Three 1080 ground baiting programmes consisting of 60 bait sites utilising meat baits and ejector baits were undertaken during summer, winter and spring to target wild dogs and foxes. Baits were checked over a three week period and replaced each week when taken. Table 55 summarises the results from the programmes carried out at HVO during 2017 with baiting locations and results for the programmes illustrated in Figure 100 to Figure 102.

Table 55: Summary of Vertebrate Pest Management 2017

Season	1080 Baiting			Trapping			Shooting			
	Total Lethal Baits Laid	Takes by Wild Dog	Takes by Fox	Wild Dog	Feral Pig	Fox	Feral Pig	Feral Cat	Hares	Fox
Summer	120	58	7	-	38	-	41		25	2
Autumn - Winter	120	70	4	2	144	2	7	1	14	2
Spring	120	67	3	-	-	-	9		20	5
Total	**360**	**195**	**14**	**2**	**182**	**2**	**57**	**1**	**59**	**9**

Additional pest management programmes included:

- Feral pig trapping was established on HVO owned non-mining land where pig activity and sightings were evident; 182 pigs were trapped and euthanized;
- Soft Jaw trapping across HVO: two wild dogs and two foxes trapped and euthanized;
- Opportunistic shooting of vertebrate pests: 59 hares, one cat, nine foxes and 239 pigs were euthanised;
- Six feral cattle were mustered and removed from the West Pit Rehab area; and
- Rabbit poisoning at the Carrington Billabong: 2900 g out of 3200 g of 1080 poison carrot was consumed.

HVO will continue to carry out seasonal vertebrate pest control programmes during 2018 to limit feral pest impacts on landholdings and surrounding neighbours.

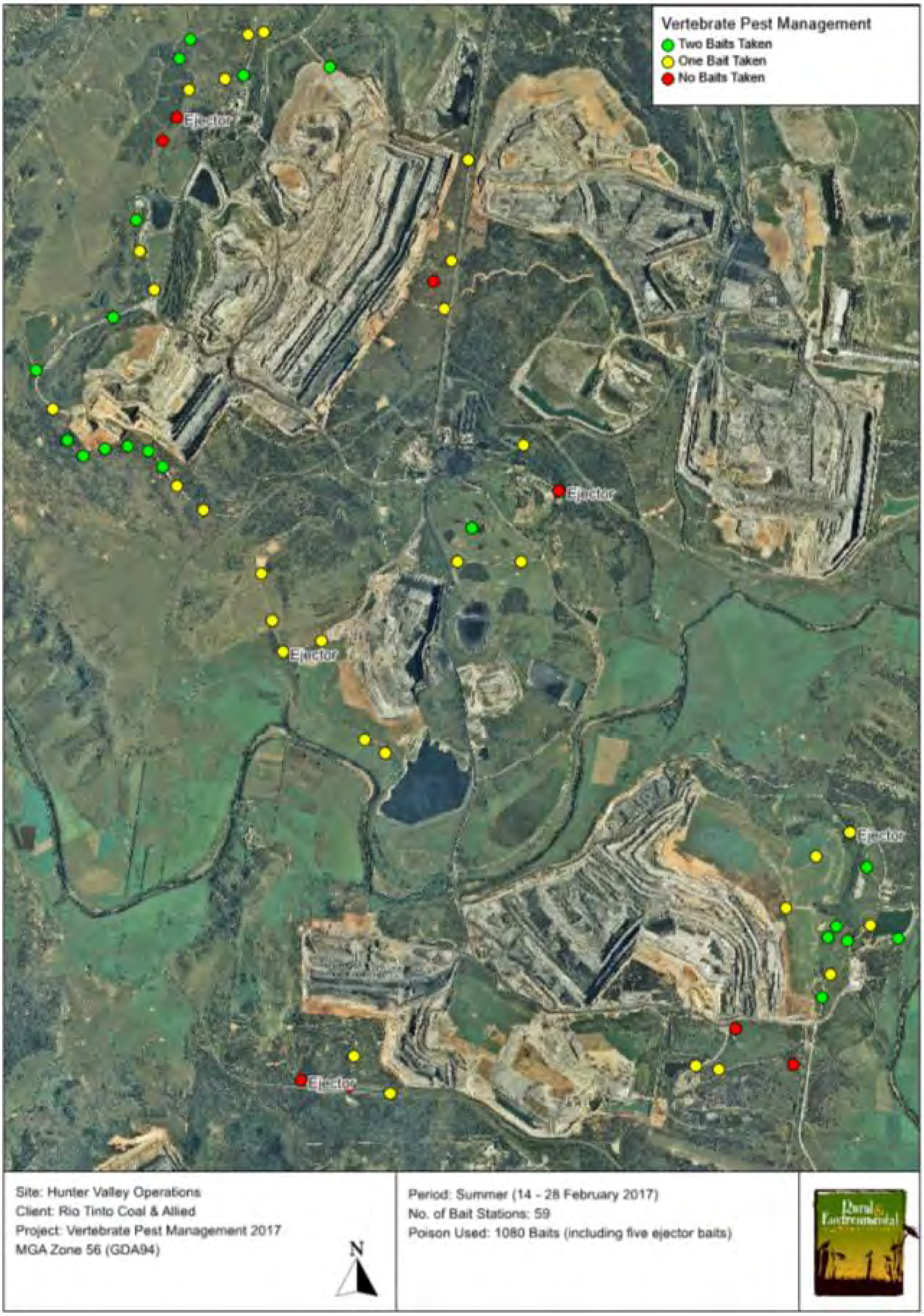


Figure 100: HVO Vertebrate Pest Management Bait Locations – Summer 2017

Figure 101: HVO Vertebrate Pest Management Bait Locations – Autumn 2017

Figure 102: HVO Vertebrate Pest Management Bait Locations – Spring 2017

8.15 Biodiversity Offsets

8.15.1 Management

The Hunter Valley Operation Mine's impacts on biodiversity values are offset through the protection and management of Biodiversity Areas (BAs). The BA's that are related to HVO are listed in Table 56.

Table 56: HVO Biodiversity Areas

Biodiversity Area	Offset Area (ha)	State Govt. Approvals	Federal Govt. Approvals		Offset Feature/s
		PA 06_0261	EPBC 2016/7640	HVO Enforceable Undertaking	
Goulburn River (HVO Portion)	140	140			Narrow-leaved Ironbark Woodland
Condon View (HVO Portion)	168		168		Regent Honeyeater Habitat
Wandewoi	405.8		405.8		Central Hunter Valley Eucalypt Forest (CHVEF); and Swift Parrot Habitat
Mitchel Hill	312.7		132	180.7	CHVEF; Swift Parrot Habitat; and Regent Honeyeater Habitat
Crescent Head	190.4		190.4		Green and Golden Bell Frog Habitat

BA's are managed in accordance with the Regional Offset Management Plan (OMP). This Offset Management Plan was superseded with new site specific plans in 2017.

The OMP provides the management framework for the entire BAs and their Offset Areas, as in some cases the entire BA is not an Offset Area, to enhance the biodiversity values through the implementation of conservation management strategies. All of the OMPs are available on the Yancoal Portal.

8.15.2 Biodiversity Area Management Activities

The OMP describes the Conservation Management Strategies. The following are the key actions completed throughout 2017.

8.15.2.1 Weed Control

Weed control at Condon View and Goulburn River targeted Blackberry, Willows, St John's Wort, Varigated Thistle, Prickly Pear, Tree of Heaven, Deadly Nightshade, Paddy Melons and Nagoora Burr.

8.15.2.2 Infrastructure Management and Improvement

Track, fence and waste audits were undertaken within the HVO BAs. Fence repairs, including the installation of new sections of boundary fence, were undertaken on the Wandewoi BA to exclude grazing from neighbouring stock. The access track into Wandewoi BA was upgraded to provide all weather access. New Biodiversity Area signs were installed and property inspections were undertaken at all HVO BAs.

8.15.2.3 Fire Management

The Regional Offset Bushfire Management Plan and the HVO Bushfire Management Plan were reviewed and updated. In December a bushfire that started in the neighbouring Limeburners Creek National Park, burnt through the Crescent Head South BA. A property inspection, undertaken two weeks after the fire, indicated that the vegetation was burnt to varying degrees across the Biodiversity Area. There was evidence of grasses already recovering from the bushfire and banksias and other heath species had released seeds. Figure 103 and Figure 104 show the Biodiversity Area after the fire.

Figure 103: Damage to vegetation

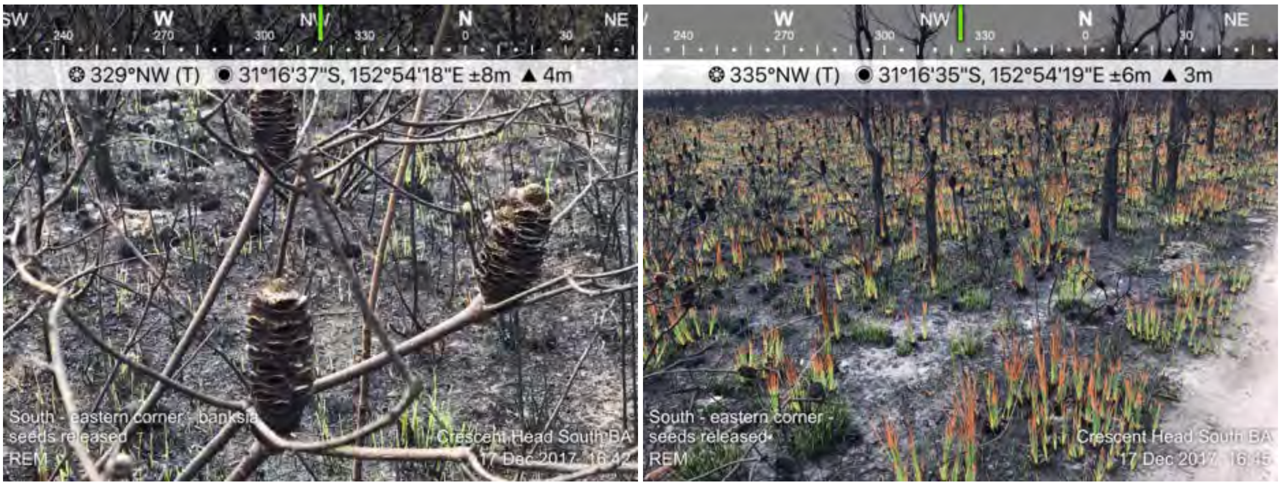


Figure 104: Seeds released after the fire and grass recovering

8.15.2.4 Strategic Grazing

All livestock has been removed from BA's in line with the management plan procedures hence there strategic grazing activities did not take place during the 2017 reporting period.

8.15.2.5 Vertebrate Pest Management

The 1080 ground baiting programmes were undertaken in autumn at Condon View BA and spring at Condon View and Goulburn River BAs targeting wild dogs and foxes. Baits were checked over a three week period and replaced each week when taken. Table 57 summarises the results from the programmes carried out on the BA's during 2017.

Table 57: Summary of Vertebrate Pest Management 2017

Season	1080 Baiting			Trapping		Shooting					
	Total Lethal Baits Laid	Takes by Wild Dog	Takes by Fox	Wild Dog	Fox	Feral Pig	Feral Cat	Fox	Deer	Hares	Rabbit
Summer	-	-	-	-	-	-	1	2	-	6	7
Autumn - Winter	22	11	-	6	2	8	-	1	-	-	-
Spring	72	29	12	-		1	-	-	4	4	-
Total	**94**	**40**	**12**	**6**	**2**	**9**	**1**	**3**	**4**	**10**	**7**

Additional pest management programmes included:

- Soft Jaw trapping across Wandewoi and Goulburn River BA: six wild dogs and two foxes trapped and euthanised;
- Sixty Five feral cattle were mustered and removed from the Goulburn River BA;
- Noisy Miner ground shoot at the Goulburn River BA to assist the survivability of the Regent Honeyeater: 350 Noisy Miners controlled under NPWS Section 120/121; and
- Opportunistic shooting of other vertebrate pests.

Vertebrate pest management programmes will continue to be carried out during 2018 to limit feral pest impacts on landholdings and surrounding neighbours.

9 COMMUNITY

9.1 Complaints

A total of 39 complaints were received by HVO during 2017 (Figure 105). This represents an increase of 13 community complaints from the previous year but is consistent with historical trends. Complaints were received in relation to noise, dust and blasting and water quality.

Yancoal provides a 24 hour Community Complaints Hotline (telephone: 1800 656 892) for community members to comment on concerns relating to its operations. All complaint details are recorded in accordance with Condition M4.2 of Environmental Protection Licence 640.

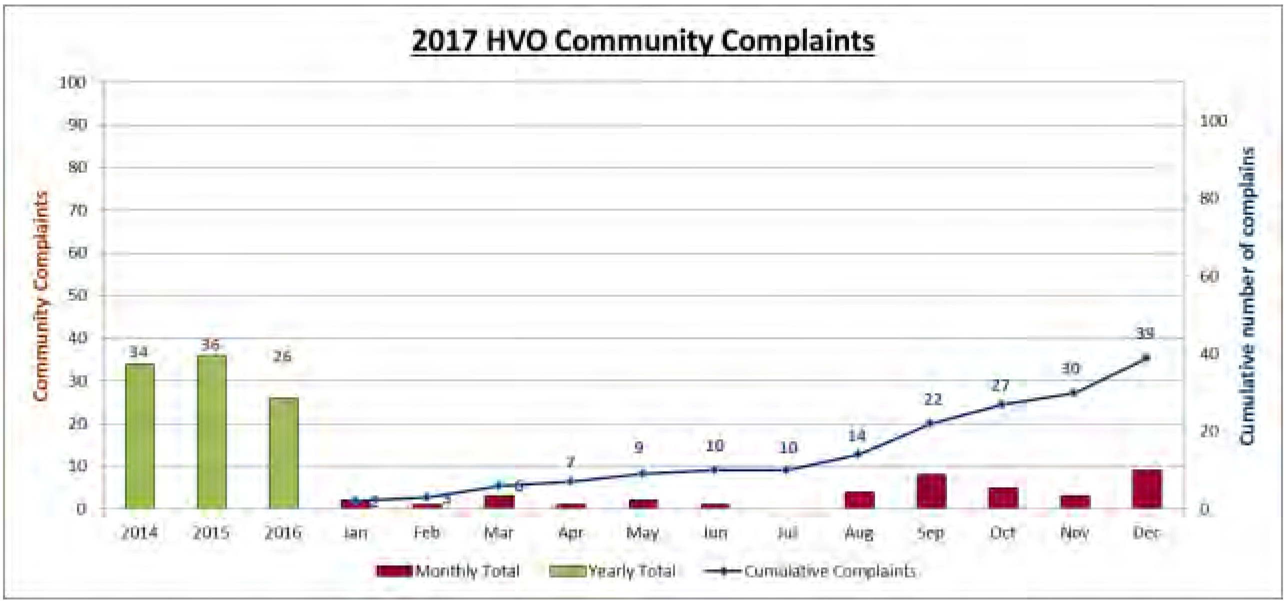


Figure 105 Community Complaints

9.1.1 Noise complaints

Eighteen noise complaints were received in 2017 compared to seventeen in 2016. Distribution of noise complaints received is as follows:

- Jerrys Plains residents – nine complaints; and
- Maison Dieu residents – nine complaints.

9.1.2 Blasting

HVO received thirteen complaints regarding blasting activities 2017 compared to 8 in 2016. The majority of complaints related to overpressure/vibration and dust, a small proportion related to odour. The majority of complaints originated from Maison Dieu (seven complaints) as well as three complaints from both Long Point and Jerrys Plains.

9.1.3 Dust

Four dust complaints were received during 2017 compared to three in 2016 divided evenly between Maison Dieu and Jerrys plains.

9.2 Review of Community Engagement

9.2.1 Communication

Quarterly letters were sent to HVO's near neighbours to provide an overview of current and future mining operations and other relevant activities, as well as inform residents about how impacts are being managed. In addition, HVO issues correspondence to specific near neighbours who may be affected by certain changes, to inform of upcoming consultation activities and as a feedback mechanism. In 2017, this included communication relating to:

- HVO South modification 5 project;
- Operational updates;
- Environmental activities such as aerial seeding activities, feral pest management programme;
- Community initiatives such as near neighbour first aid training, donation and sponsorship programme;
- HVO Community Consultative Committee meeting updates; and
- Communication tools – InSite, environmental monitoring public reporting website and the blast notification SMS alert system.

In February and December, HVO hosted community information sessions for near neighbours at Jerry's Plains, Long Point and Maison Dieu. The sessions were aimed at providing community members with an opportunity to speak with HVO representatives about current operations and future plans, HVO South Modification 5 project and environmental and community programmes. The sessions were attended by more than 70 residents from Jerry's Plains, Maison Dieu, Long Point and surrounding areas, as well as HVO staff members. Details of these sessions are included in regular near neighbour communications.

A range of consultation and engagement activities were also completed, including:

- Proactive near neighbour visits for residents living in the HVO area to discuss current operations and future plans for near neighbour engagement, as well as consultation to provide project updates at key project milestones and activities, and to respond to concerns/queries raised by individual near neighbours
- Local Council and Business Chamber briefings
- Participation in the Upper Hunter Mining Dialogue - a programme coordinated by the NSW Minerals Council to engage the community across the Hunter Valley
- Committee representation on the Singleton Business Chamber Board and the NSW Minerals Council's Health, Safety, Environment and Community Conference
- Hosted mine tours
- School engagement - working with teachers and students to assist and enhance learning outcomes and build relationships
- Participation in various community events and committees, which have been supported through Yancoal's community investment programmes.

HVO continued to encourage the community to contact the company in a way that suits the individual community members.

9.2.2 Community Consultation Committee (CCC)

The HVO CCC meetings were held in March, July and November 2017. The HVO CCC meet to discuss operations, projects and mine activities. The Committee is comprised of HVO representatives, community members and other key external stakeholders, including Council. The HVO CCC minutes are available on the Yancoal website (www.insite.yancoal.com.au). The community is invited to visit the website(s) to learn more about the HVO CCC.

Following CCC meetings a letter is mailed to HVO near neighbours to provide an update on matters which were discussed at the meeting and any additional information about HVO's plans and activities. In 2017 CCC members included:

- Dr Colin Gellatly (Independent chairperson);
- Cr Hollee Jenkins;
- Dr Neville Hodkinson;
- Mr Charlie Shearer;
- Mr David Love;
- Mr Brian Atfield;
- Mrs Di Gee;
- HVO General Manager – Mr Jason McCallum; and
- Manager Environment & Community – Mr Andrew Speechly.

9.3 Community Development

In 2017, HVO continued its focus on ensuring the long term sustainability of the communities in which it operates, through the facilitation of community development programmes such as:

- Coal & Allied Community Development Fund (CDF);
- HVO's Site Donations Committee; and
- Community partnership with Westpac Rescue Helicopter Service.

9.3.1 Community Development Fund

The year 2017 marked 19 years of operation of the CDF, which has invested over $15 million to support over 120 community projects in the Hunter Valley since its establishment in 1999, across the areas of health, education, environment and economic development.

In 2014, Coal & Allied announced that a further $3 million[8] would be made available to the CDF over a three year period (2015 – 2017) for projects in the Singleton, Muswellbrook and Upper Hunter LGAs. Strategic priority areas were refined for the 2015-2017 funding cycle to enable a more targeted approach to addressing identified community need and to leverage other resources Coal and Allied may be able to offer to strengthen community partnerships.

Priority areas for the 2015-2017 funding cycle include (See Figure 106 for allocations):

- Economic Development: encouraging the diversity and competitiveness of the Upper Hunter economy;

[8] With the sale of Bengalla Mine and the Mount Pleasant project the total available funding was revised to reflect the reduced footprint. The revised allocation was $2,166,000

- Community Health: Supporting projects which target health, safety and social wellbeing of the community;
- Education: Promoting the value of education and building skills within our community; and
- Environment and Land Management: Supporting projects that can make a difference on a greater scale. For example, beyond Coal & Allied mining operations.

In 2017, the CDF contributed more than $800,000 to 14 programmes (Table 58) aimed at delivering long term benefits for communities in the CDF catchment, which include the Singleton, Muswellbrook and Upper Hunter LGAs. Across the 2015 – 2017 funding cycle the CDF contributed more than $2.1 million to community development programmes.

Table 58: Coal & Allied Community Development Fund projects supported in 2017

Partner	Programme	Value
Sirolli Institute	Enterprise Facilitation	$45,000
Upper Hunter Where There's A Will Foundation	Positive Education Programme	$80,000
University of Newcastle	Science and Engineering Challenge, and SMART Programme (2015-2019)	$138,493
Upper Hunter Education Fund	HSC Study Camps and Upper Hunter Education Fund Scholarships (2015-2017)	$84,000
Singleton Business Chamber	Business Development Officer	$72,000
University of Newcastle	University of Newcastle Scholarships	$80,000
Outward Bound Australia	Youth Leadership Programme (2015-2017)	$245,332
Singleton Council	Singleton Economic Development and Funding Coordinator (2015-2017)	$100,000
Ungooroo Aboriginal Corporation	Health Services Programme (2017-2018)	$110,000
Bulga Rural Fire Service	Electronic Datasign	$24,500
Australian Christian College Singleton	STEM Lego Robotics Programme	$10,420
Jerrys Plains Public School	Ready 4 School Programme (2017-2018)	$58,000
Tocal College	Tocal Steers Challenge (2015-2017)	$25,725
Milbrodale Public School	Early Learning Programme (2017-2018)	$64,000

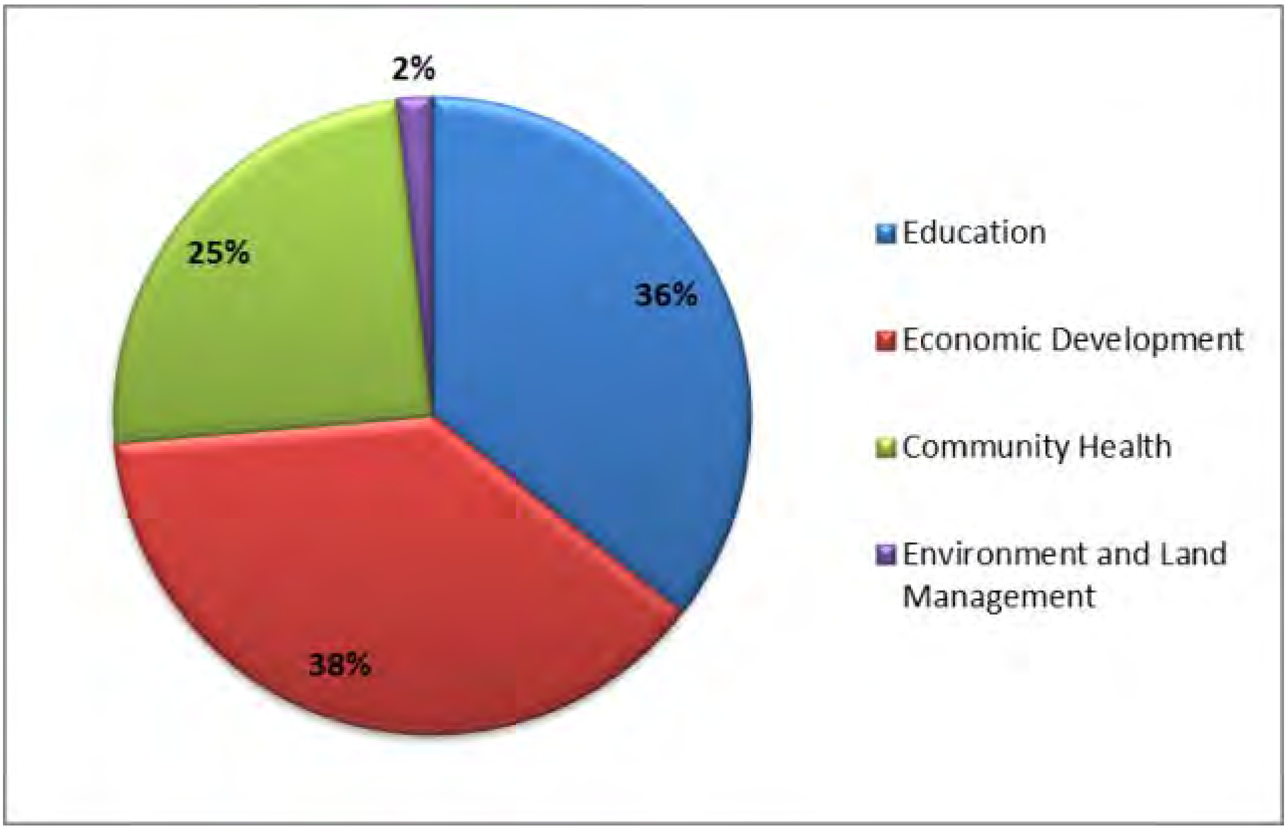


Figure 106: Distribution of Community Development Fund by category (2015 – 2017)

9.3.2 Site Donations

Coal & Allied supports applications for local donations and sponsorships that have a clear community benefit. In 2017, HVO provided $45,812 to 23 local projects and initiatives, including:

1. Rotary Club of Singleton on Hunter - Singleton Art Prize
2. Australian Families of the Military – Mental Health Retreat
3. Wildlife Aid Inc. – Injured Wildlife rescue
4. Singleton Business Chamber – International Women's Day event
5. NSW Cancer Council – Singleton Relay for Life
6. Singleton Junior Rugby League – Sporting equipment
7. Singleton Junior Rugby League – 2017 season sponsorship
8. Northern Agricultural Association Inc – 2017 Singleton Show
9. Glendonbrook Hall Inc – Safety fencing for children's play area
10. Singleton Pony Club – Repairs/upgrades to clubrooms
11. Singleton Theatrical Society – 2017 production of 'Oliver Twist'
12. Singleton Historical Society and Museum – Copier and printing consumables
13. Singleton Hospital Community Trust – Holes 4 Hospital Charity Golf Day 2017
14. Singleton Council – Christmas on John Street Fireworks
15. Greta Branxton Wildcats Football Club – Jerseys for junior football teams
16. Australian Stockhorse Eastern Branch – Championships
17. Jerrys Plains School of Arts Hall Committee – Community Christmas Event 2017
18. NSW Cancer Council – Transport for Treatment programme 2018
19. Singleton Australian Football Club – Strapping Tape for 2018 season
20. Salvation Army Singleton – Children's Christmas Party

21. Singleton Fire Brigade Social Club – Santa’s Lolly Run
22. Singleton Red Cross – promotional signage
23. Singleton Business Chamber – Coal Festival 2018

10 INDEPENDENT AUDIT

The most recent independent compliance audit was undertaken in October 2016. Outcomes of the audit including subsequent action plan was submitted to the Department in December 2016 with Department Approval of the audit and action plan received in February 2017. During 2017 HVO worked to progress the status of subsequent actions. **Error! Reference source not found.**6 below presents the status of these actions as at 31 December 2017. The next audit is due in 2019.

Table 59: IEA Action Status

Action Ref.	Action Description	Status
Environment Protection Licence - 640		
A1.1	Ensure that records of volume of crushed aggregate are maintained.	Ongoing
L2.4	Clarification should be obtained as to whether conductivity should be reported for Point 8 (EPL Annual Return reporting requirements).	Complete
M2.2	Clarification should be obtained as to the definition of continuous monitoring and period of time permissible for outage.	Complete
R2.2	Maintain records of process for incident reporting. Keep a record of initial phone call notification and following up email.	Ongoing
U1.1	Obtain confirmation from the NSW EPA as to next steps required to close out this requirement.	Ongoing
Hunter Valley Operations South Coal Project Approval (PA 06_0261)		
Sch. 3 Cond. 8	Review location of Archerfield Vibration monitor.	Complete
Sch. 3 Cond. 18	Review road closure plan to make sure it is correct and current.	Complete
Sch. 3 Cond. 27	Review Appendix headings against references in Table 1 of the HVO WMP, i.e. Sch. 3 Cond. 27(c) (on page 12, last row) references Appendix D – Groundwater Monitoring Programme, where it should reference Appendix C – Surface Water Monitoring Programme.	Complete
Sch. 3 Cond. 31	Clarification should be sought to ensure protections are to the satisfaction of the Director-General.	Complete
Sch. 3 Cond. 34	Observation was made that areas shown in the MOP as pasture were sown with a native woodland mix. Opportunity exists to clarify and make consistent the proposed rehabilitated vegetation types across all plans.	Ongoing
Sch. 3 Cond. 40	Consider whether the current inspection regime is sufficiently meeting the intent of the ACHMP and this condition and seek clarification from DPE as to the adequacy of same.	Complete
Sch. 3 Cond. 50	As there have been complaints during the reporting period, combined with the auditor's observation in the field, it would be advisable to review the Australian Standard AS4282 (INT) 1995 – Control of Obtrusive Effects of Outdoor Lighting to ensure all practicable measures to mitigate off-site lighting impacts are implemented.	Complete
Sch. 3 Cond. 52	Follow-up is recommended to confirm formal feedback from DP&E once the MOD is updated.	In Progress

Sch. 3 Cond. 57	Confirm with DP&E the current status of approval with regard to disposal of heavy earthmoving tyres. Confirm EPA expectations and/or approach to disposal of used tyres in mine voids. Consider need for inclusion of waste tyres in the EPL.	In Progress
Sch. 3 Cond. 58	Communicate appropriate storage and segregation rules for dangerous goods to maintenance teams, particularly with respect to segregation of incompatible Dangerous Goods i.e. Class 2 and Class 3.	Ongoing
Sch. 3 Cond. 60	The Bushfire Management Plan on the HVO website is dated June 2007. It is recommended the current plan is added to the website.	Complete
Sch. 4 Cond. 4	Consideration should be given to addressing wording in consent when updating the DA to reflect an appropriate timeframe for reporting.	Complete
Sch. 4 Cond. 5	Obtain notification from the DG that the Independent Review demonstrates compliance with noise criteria and that the review may be discontinued.	Complete
Sch. 5 Cond. 4A	Review performance of system introduced in March 2016. If the review indicates this condition is not being met, revise as appropriate.	Ongoing
Hunter Valley Operations South Coal Project Approval (PA 06_0261) – Statement of Commitments		
Blast and Vibration	Consider updating the BMP to address the specific requirements of this commitment.	Complete
Ecology	Collect River Red Gum seed from existing stands	Ongoing
Mine Landscape Planning	Identify opportunities to monitor vegetation within the Project Application area but outside the proposed disturbance area. Incorporate more log re-use in rehabilitation areas for habitat creation and enhancement for common and threatened species.	Complete/Ongoing
Hunter Valley Operations North Development Consent (DA 450-10-2003)		
Sch. 4 Cond. 6	Confirm relevance of the commitments made in the Monitoring Program and implement monitoring of PM2.5 if deemed necessary.	Complete
Sch. 4 Cond. 9	Continue to manage noise attenuation via campaign use of haul truck and/or upgrade fleet to meet improved operation noise attenuation. Finalise options for coordination of noise management with adjoining Wambo mine and update NMP accordingly.	Complete
Sch. 4 Cond. 16B	It is recommended that the intent of the condition is confirmed with Director-General with consideration given to modification of the wording of the condition.	Complete

Sch. 4 Cond. 35	Provide details regarding relocation of bat roosts or salvaging habitat resources.	Ongoing
Sch. 4 Cond. 54	Review the relevance for requirement for any further tree planting and bund, and report findings to DRE and DG.	In progress
Sch. 4 Cond. 56	Review the Australian Standard AS4282 (INT) 1995 – Control of Obtrusive Effects of Outdoor Lighting to ensure all practicable measures to mitigate off-site lighting impacts are implemented.	Complete
Sch. 6 Cond. 2	Once the revised EMS is approved by the DG, issue copies to Council and the CCC.	In progress
Hunter Valley Operation North Statement of Commitments (Carrington West Wing)		
Groundwater	Correct the title of Table 8 in future version	Complete
Visual Amenity	Complete annual visual assessments	In Plan
Hunter Valley Operation North Statement of Commitments (Carrington Pit Extended)		
Ecology	Future monitoring to ensure access to all required stands is available well in advance.	Ongoing

Hunter Valley Operations was audited in November 2016 as part of the cross agency environmental compliance audit program, focusing on dam compliance. The outcomes of this audit were released in 2017 with the only non-compliance noted during the audit being related to recommendations from dam surveillance reports not always actioned in a timely manner. Other actions from the report recommendations and their current status are presented in Table 60.

Table 60: EPA/DP&E Audit Actions

EPA Item	Action Description	Due Date	Completion Date
1	Divert surface water runoff from the north of the North Void TSF away from the tailings dam.	30/6/2017	29/09/17
2	Confirm plant and equipment maintenance issues identified at Parnells Dam on 4 November 2016 have been resolved.	30/3/2017	21/03/17
3	Confirm all sampling analyses are undertaken by NATA certified bodies.	30/3/2017	31/03/17
4	Review and if necessary update the map within the PIRMP with all stormwater diversion drains/channels installed onsite.	20/4/2017	3/05/17
5	Update the PIRMP to include the nature and objectives of any staff training programme in relation to the plan.	30/4/2017	20/04/17
6	The relevant pollutant limits imposed by conditions of an EPL (including HRSTS limits) must be published in the monthly meaningful summary.	9/4/2017 (to commence in March reports)	7/04/17

7	The date when the data was obtained by the licensee must be published with the data in the monthly meaningful and monthly obtained reports. Obtained can be defined as when the results are received by RTCA from the lab or sampling provider, or when data has been processed into a format required by the monitoring condition.	9/4/2017 (to commence in March reports)	29/03/17

11 INCIDENTS AND NON-COMPLIANCES

11.1 Noise

There were no noise non-compliances during 2017. One measurement exceeded criteria but did not constitute non-compliance as the noise was promptly addressed (within 75 minutes of detection, per approved Noise Management Plan). Non-compliance is determined with reference to the applicable conditions of consent and the NSW Industrial Noise Policy. Noise measurements which exceeded criteria are presented in Table 61 below.

Table 61: Noise measurements which exceeded noise criteria during 2017

Date/Time	Monitoring Location	Criteria	Criteria (dB)	Measured Noise (dB)	Criteria Exceeded by (dB)
6/07/2017 21:33	Maison Dieu	HVO South $L_{Aeq\ 15min}$	37	41	4

11.2 Blasting

There were no exceedances of the 5 mm/s or 10 mm/s ground vibration criteria at any residence on privately-owned land.

There were a total of nine blasts that recorded an initial overpressure reading greater than 115dB(L) during the reporting period. Upon investigation, five blasts were found to be due to wind reinforcement and as such are not considered to constitute non-compliance with HVO's conditions of approval.

The resulting four readings over 115dB(L) limit have been assessed for comparison against the 5% of the total number of blasts over a 12 month period these results are shown in Table 62

Table 62: HVO airblast overpressure allowable exceedance summary

Monitoring Location	Allowable Exceedance over 115dB(L) of time over 12 months (%)	Percentage of blasts over 115dB(L)
Moses Crossing	5	0.00
Jerrys Plains	5	0.00
Warkworth	5	0.00
Maison Dieu	5	1.06
Knodlers Lane	5	0.35

11.3 Air Quality

During 2017 HVO conducted investigations into 34 High Volume Air Sampler measurements and 24 TEOM PM10 measurements exceeded the 24hr short term impact assessment criteria. The results of these investigations showed that HVO complied with all air quality criteria; with the exception of one exceedance of short term PM10 criteria measured at the Hunter Valley Glider Club on 29th July 2017. Details of the non-compliance is presented in Table 63.

Table 63: Air Quality Non-compliance – 2017

Date	Site	24hr result (μg/m^3)	Estimated max. contribution from HVO (μg/m^3)	Estimated max. contribution (%)
29/07/2017	Gliding Club PM10 (HVAS)	58	49	85

An external consultant was engaged to conduct an investigation which determined maximum potential HVO contribution to be 49µg/m3 or 85% of the measured result based on prevailing wind conditions and upwind monitoring results. The Hunter Valley Glider Club was operating on this day with several flights being conducted from the runway which is positioned between the monitoring location and HVO. As such, it's assumed that a portion of this maximum contribution is also influenced by the glider clubs activities. The contribution of this activity is impossible to estimate because the High Volume Air Sampler only takes an aggregated sample in the 24 hour monitoring period.

The result was reported to the Hunter Valley Glider Club and the DP&E.

11.4 Water

During 2017 there was one non-compliance related to water summarised below.

11.4.1 Incident 30 March 2017

On 30th March 2016 at approximately 15:25 a sediment sump at the Hunter Valley Load Point (HVLP) was observed to be overtopping via the sump spillway into Bayswater Creek, following a high intensity, short duration rainfall event.

The duration of discharge from the sump is unknown; however, on a worst case scenario it would have been no greater than 3.5 hours. This has been determined by the start time of the high-intensity rainfall at 13:00, as recorded from the site weather station and a subsequent inspection at 16:30, where the sump level was observed below the spillway and was not overtopping. The high intensity rainfall recorded between 13:00 and 13:10 (12 mm total) was equivalent to between a 2- and 5-year Average Recurrence Interval (ARI) IFD.

Any water that overtopped from the sediment sump was caused by the rainfall runoff volumes exceeding the capacity of the sump. The water level in the sump is managed via an automated electric pump (level sensor control), which was operating at the time of the discharge. Water is pumped to the nearby Dam 33N (Bayswater Dam). A conservative duty rate for the pump is 30 m^3/hr, but may have been operating at up to 80 m^3/hr (based on pump operating curves).

Sampling of the sump water and receiving waters in Bayswater Creek was undertaken on 30th March 2017 (follow-up sampling completed on 31st March 2017). The sampled water was analysed for a comprehensive suite of analytes including electrical conductivity, total suspended solids major cations and anions, and total metals.

An existing improvement project is underway to increase the size and pumping capacity of the HVLP sediment sump; work was due for completion in 2016, however DP&E advised that to proceed a Modification to Development Consent was required, which was subsequently granted in December 2016.These works have commenced and are scheduled for completion in 2018. Repairs to the spillway, which was damaged as a result of the event, have also been undertaken.

The following notifications were submitted in accordance with the HVO Pollution Incident Response Management Plan between 3:55pm and 4:40 pm:

- Singleton Council;
- The NSW Department of Health ;
- Fire and Rescue;
- Muswellbrook council; and
- DP&E.

No complaints were received in relation to his event.

HVO was issued a $15,000 penalty notice from the EPA in relation to this incident.

12 ACTIVITIES TO BE COMPLETED IN 2018

12.1 Noise

Noise management improvements identified for implementation in 2018 include:

- Noise attenuation of up to 31 rear dump trucks
- Implementation of an Environmental Noise Compass (directional noise monitor) in Maison Dieu, and associated revision to the Trigger, Action, Response Plan (TARP); and
- Revision of the HVO Noise Management Plan.

12.2 Blasting

Blasting management improvements identified for implementation in 2018 include:

- Revision of the HVO Blast Management Plan; and
- Hardware upgrades to ground units to allow for longer storage of blast data

12.3 Air Quality

Air Quality management improvements identified for implementation in 2018 include:

- Relocation of relevant near field air quality monitors to account for pit progression;
- Revision of the HVO Air Quality & Greenhouse Gas Management Plan.
- Aerial seeding of overburden that is temporarily unavailable for rehabilitation.

12.4 Cultural Heritage

12.4.1 Aboriginal Cultural heritage

Ongoing Aboriginal archaeological and cultural heritage management activities will occur in 2018 at HVO in accordance with the ACHMPs, to inform ongoing land management and development planning. This will include the assessment for cultural heritage values of any unassessed lands required for development associated with the operation of HVO mine. Condition monitoring of those sites both within and peripheral to authorised disturbance areas will be conducted at regular intervals to ensure operational compliance with the ACHMPs.

12.4.2 Historic Heritage

Yancoal will continue to consult with the neighbouring Liddell Coal Operations on any future mining plans that may interact with the Chain of Ponds Inn complex to ensure appropriate protective management measures are implemented where required. Consultation with the CHAG will also continue to discuss and manage any areas or sites of historical interest on HVO owned lands.

12.5 Water

Improvements to mine water management in 2018 will focus on mine water containment. This includes:

- Commissioning of the augmented stormwater containment basin at the Hunter Valley Load Point;
- Commissioning of the secondary containment dam downstream of the Parnells Dam with an automatic pump-back arrangement;
- Relocation of the Riverveiw Pit Ring Main pipeline.

The Water Management Plan will be reviewed in 2018, as a result of Modifications to Consent being granted, and to reflect updated water quality triggers incorporating 2017 data for the surface water and groundwater monitoring programmes.

12.6 Rehabilitation

12.6.1 Performance Criteria

The rehabilitation monitoring programme will continue in 2018 for both grazing and native vegetation rehabilitation areas.

12.6.2 Rehabilitation Maintenance

During 2018, maintenance activities are planned to result in approximately 150ha of rehabilitation, currently in the initial stage of cover cropping, being seeded with the full native seed mixes. Weed spraying (boom and spot spraying) and weed wiping will be conducted in establishing rehabilitation areas as required to control both noxious and environmental weeds that are likely to impact on successful rehabilitation being achieved.

The amount of new rehabilitation that is planned to be undertaken at HVO during 2018 is 100ha.

Rehabilitation monitoring conducted in early 2017 has indicated that the density of canopy species in some rehabilitation areas is much higher than what would be required in mature vegetation communities. Sites with high numbers of canopy species will be thinned to reduce the risk of overcrowding causing understorey species to drop out.

12.6.3 Habitat Augmentation

Habitat augmentation measures, such as the construction of habitat ponds and the placement of salvaged logs in rehabilitation areas, have been undertaken during 2016 and will continue in 2018.

12.6.4 Stage 2 Rehabilitation Methods Trials

HVO has experienced inconsistent results in relation to the germination of native species sown into areas that have been initially stabilised with cover crops. Various methods of soil preparation will be investigated to determine effective methods for transitioning areas from the initial clean-up stage, involving cover crops, to the establishment of native vegetation. The use of inoculants containing soil-based bacteria and fungi will also be assessed as a stimulant for the germination and early establishment of native species.

12.6.5 Tailing Storage Facility Capping

Capping activities on Southeast TSF will continue during 2018 to progress rehabilitation of the remaining surface.

12.7 Community Development

Priority areas for community development in 2017 included education, economic development, community health, environment and land management. Yancoal currently support numerous programmes and scholarships in relation to these priority areas with continuation and commencement of these into 2018.

12.8 Timeline for implementation of improvement projects

A proposed timeline for the improvement projects mentioned in Section 12 is shown below in Figure 107.

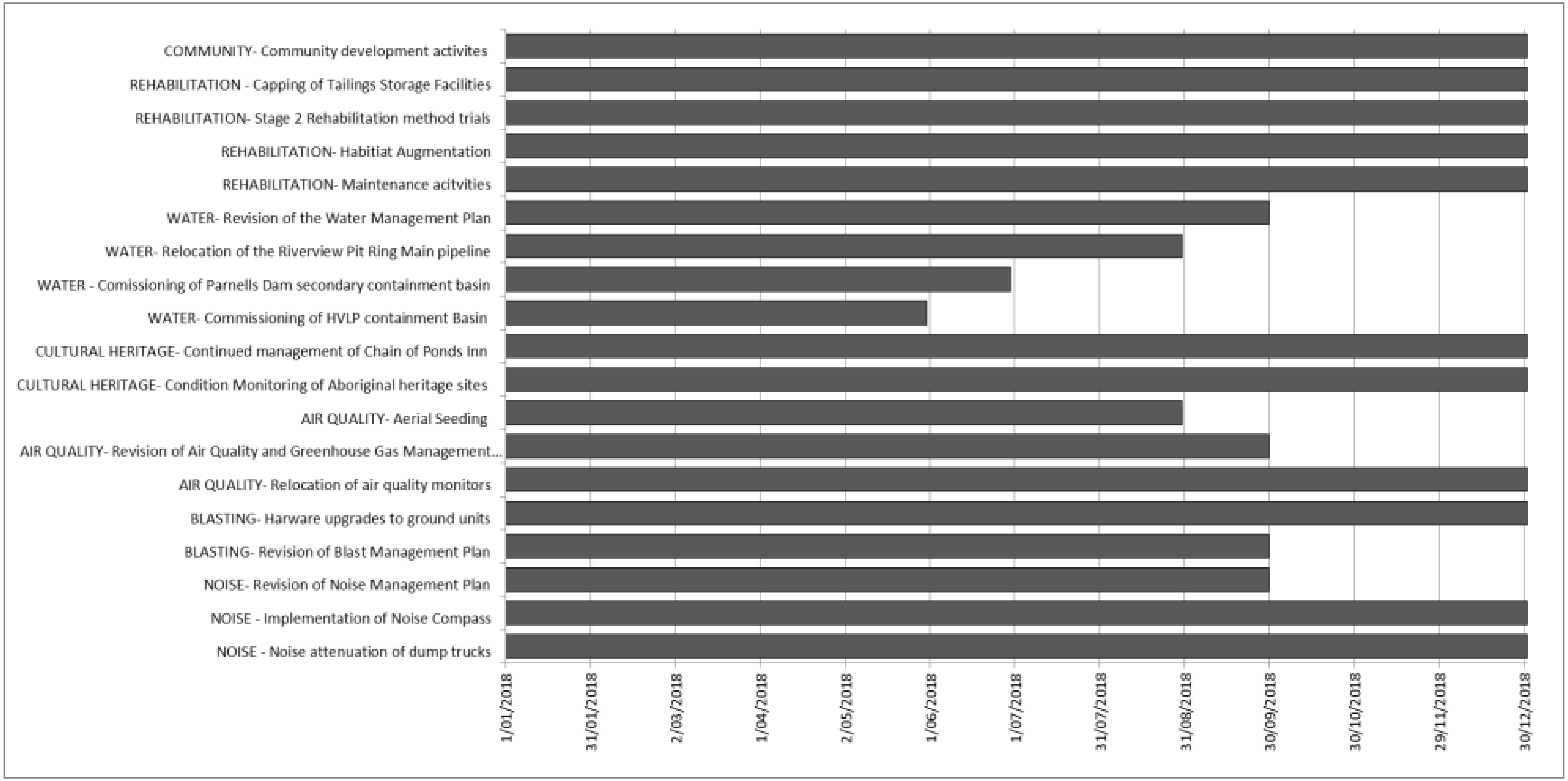


Figure 107: Proposed Timeline for Implementation of 2018 Improvement Projects

Appendix 1: Annual Ground Water Report

29 March 2018

620.12182-L01-v1.1.docx

Yancoal

Attention: Andrew Hodge

Dear Andrew

Hunter Valley Operations
2017 Predicted Groundwater Take

1 Introduction

The Hunter Valley Operations (HVO) mining complex is located approximately 20 km north-west of Singleton, NSW. As part of compliance with mine approval conditions, routine groundwater monitoring is conducted across HVO, and an annual review undertaken of groundwater take. An annual review is required for:

- HVO South in accordance with Condition 28 of the Project Approval (PA 06 0261 24) and licence conditions for Lemington Underground (LUG) Bore (20BL173392); and
- Individual bore license conditions (20BL173587-89, 20BL173847 and 20BL173392).

1.1 Scope of Work

SLR Consulting (SLR) have been engaged by Yancoal to estimate the amount of groundwater directly and indirectly intercepted as part of operations across HVO North and South for 2017. This report presents the estimated volumes and data sources, and also includes details on groundwater level changes surrounding the LUG Bore.

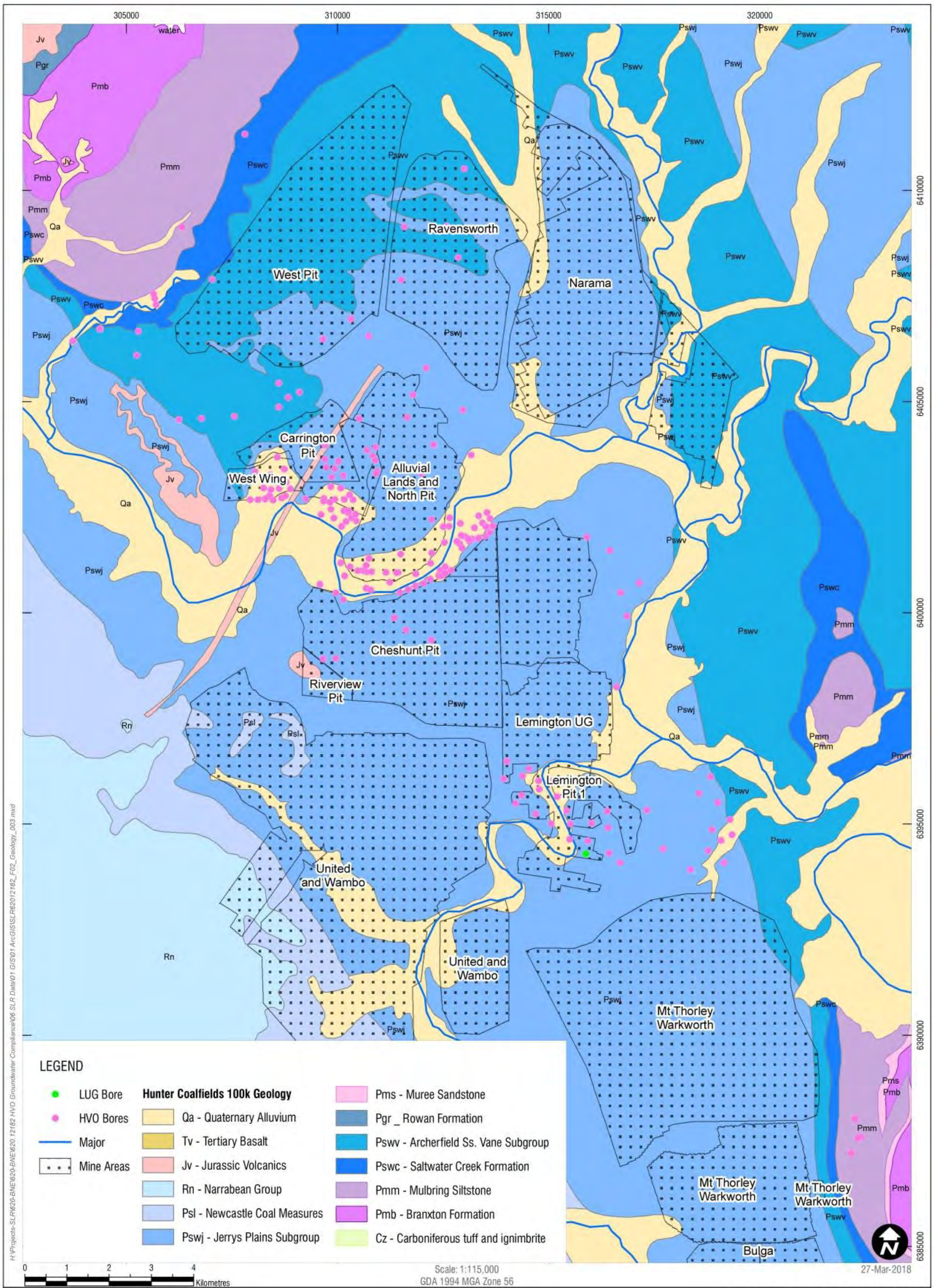
1.2 Hydrogeological Background

This section provides a brief summary of the hydrogeological regime at HVO, and what licensed water source each of the key groundwater bearing units relates to. **Figure 1-1** presents a map of the geology of the HVO site and surrounds.

HVO lies within the Hunter Coalfields, which are dominated by the Permian-aged Whittingham Coal Measures of the Sydney Basin. The Whittingham Coal Measures are made up of the Jerrys Plains Sub-group and Van Sub-group. These units comprise economic coal seams along with overburden and interburden consisting of sandstone, siltstone, tuffaceous mudstone and conglomerate. The Whittingham Coal Measures occur at HVO as stratified (layered) sequences that dip at a shallow angle (2^0 to 5^0) to the south-west. The coal seams sub-crop to the north and east of HVO. Groundwater associated with the Whittingham Coal Measures is captured under the North Coast Fractured and Porous Rock Water Source.

Along the Hunter River and Wollombi Brook thin Quaternary alluvial deposits unconformably overlie the Permian strata. The alluvial deposits comprise surficial fine grained and low permeability sediments (i.e. silts and clays). Along major watercourses the surficial sediments overly highly productive basal sands and gravels that are between 7 m to 20 m thick.

Groundwater within alluvial sediments along Wollombi Brook, and low permeability units along the Hunter River are captured under the Hunter Unregulated and Alluvial Water Source. Groundwater within the highly productive alluvium connected to the Hunter River is captured under the Hunter Regulated River Water Source.



Hunter Valley Operations
2017 Predicted Groundwater Take
Site Geology

Figure 1-1

1.3 Groundwater Licenses

Under the *Water Act 1912* and *Water Management Act 2000*, water licences associated with the take of groundwater by mining activities are required for approval of the mine developments. Groundwater licenses held for HVO are outlined in **Table 1-1**. Water licence details have been obtained from the 2016 Annual Environmental Review.

Table 1-1 HVO Groundwater Licenses

License Number	Description	WSP	Water Source - Management Zone	Approved Extraction (ML)
WAL 40462	HVO Pit Excavations – Alluvial Lands Bores	North Coast Fractured and Porous Rock	Permian Coal Seams	2,400
WAL 40463				180
WAL 40466				460
TBA 20BL167860	HVO North – Carrington Pit			220
TBA 20BL170000	HVO North Pit Excavation			20
WAL39798	Lemington Underground (LUG) Bore			1,800
WAL18127	Carrington BB1	Hunter Unregulated and Alluvial Water Sources	Hunter Regulated River Alluvial Water Source – Upstream Glennies Creek Management zone	383
WAL18158	Ollenberry			65
WAL18307	HVO West – Parnells Creek Dam (Diversion Works Bywash)		Jerrys Management Zone Jerrys Management Zone	500
WAL18327	HV Loading Point Pump Bayswater Creek (Diversion Works)			150
WAL36190	HVO North, old farm bore			120
WAL23889	Greenleek		Lower Wollombi Brook Water Source	144
WAL962 (20AL201237)	Surface water access – West Pit area	Hunter Regulated River Water Source	Hunter River (Zone 1b) between Goulburn River junction and Glennies Creek junction.	3,165
WAL970, WAL1006 & WAL1070 (20AL201256, 20AL201337 & 20AL201500)	Surface water access – HVO North and HVO South areas		Hunter River (Zone 2a) between Glennies Creek junction and Wollombi Brook junction.	1,500 (500 each)

2 Groundwater Take

Interception of groundwater occurs at site due to a range of activities, including direct interception of groundwater with mining activities and abstraction from water supply bores, and indirect interception via induced inter-formation flows due to depressurisation of the Permian coal measures. Each activity is discussed below and the estimated groundwater take for the various water sources outlined in **Section 1**.

2.1 Groundwater Inflows to Mine Operations

The most recent groundwater assessment that captures operations across HVO North and HVO South was the HVO South Modification 5, which was granted consent by the Planning Assessment Commission on 28th February 2018. The groundwater assessment for Modification 5 was completed by AGE (2017)[1], and included development of a numerical groundwater model to represent groundwater response to approved mine activities and the proposed modification. AGE (2017) reported on predicted impacts associated with approved operations over 2017 (model Year 2). The approved operations included mining at Cheshunt Pit, Riverview Pit, Glider Pit and West Pit, as well as surrounding non-HVO mining operations (i.e. Ravensworth, Mt Thorley Warkworth etc) and abstraction from the LUG Bore.

The model was calibrated up to December 2015 and replicates mine progression on a quarterly basis to the year 2039. Year 2 model results (predictive model) represent predicted groundwater conditions and take for the 2017 reporting period for inclusion in this report. Where available, predicted take for 2017 was utilised where reported within the AGE (2017) Modification 5 report. Where predicted take was not reported (i.e. West Pit), the results were extracted from the existing numerical groundwater model.

To extract the results, Yancoal provided SLR with the calibrated numerical groundwater model. SLR re-ran the model to replicate the results reported within the HVO South Modification 5 groundwater impact assessment report (AGE 2017) to ensure consistency. Budget zones were then developed to quantify the predicted groundwater inflows relating to West Pit from the various water sources.

Based on the model results, the predicted total direct interception of groundwater form the North Coast Fractured and Porous Rock Water Source was estimated at 928 ML for HVO over 2017. It should be noted that this includes water held within the rock material and lost to evaporation. The predicted indirect interception of water, via inter-formational flows due to depressurisation of the Permian coal measures, was estimated for 2017 to be:

- 39 ML from the Hunter River Regulated Water Source; and
- 358 ML from the Hunter Unregulated and Alluvial Water Sources.

[1] Australasian Groundwater and Environmental Consultants 2017, *HVO South Modification 5 Groundwater Study*, prepared for EMM Consulting for Coal & Allied Operations Pty Ltd, January 2017.

2.2 LUG Bore Abstraction

2.2.1 Metered Abstraction Volumes

Lemington Underground (LUG) bore is an abstraction bore constructed into the abandoned LUG mine void underlying HVO. The bore is licensed to take up to 1,800 ML of water from the North Coast Fractured and Porous Rock aquifer (20BL173392) per water year. The bore is equipped with a flow meter, with total monthly abstraction is documented. Based on the flow volumes recorded, from July 2016 to June 2017 901 ML of water was abstracted from the LUG bore, which is within the licensed allocation of 1,800 ML/year. From June 2017 to December 2017 826 ML of water was abstracted.

As the bore intersects LUG that mined the Permian coal measures, groundwater levels within bores intersecting the coal measures around the bore have been reviewed to identify the extent of groundwater drawdown.

2.2.2 Groundwater Level Change

Routine groundwater level monitoring is conducted across HVO, including a series of bores located near South Lemington Pit and the LUG Bore. This section presents a review of groundwater level changes at the bores around the LUG Bore, in order to identify any changes in groundwater levels over 2017 that may relate to the bore abstraction. The results are presented for the alluvium and each of the main Permian coal seams, and discussion of the results is presented in Section

Groundwater levels within the Bowfield Seam of the Permian coal measures around South Lemington have declined by up to 12.2 m to a distance of 1.3 km from LUG Bore. However, only limited drawdown (maximum 0.4 m decline) was recorded for bores within the shallower coal measures surrounding LUG Bore. In addition, no clear impacts related to groundwater abstraction from the historical underground mine were observed for nearby alluvial bore Appleyard Farm.

2.2.2.1 Alluvium

Time series groundwater levels for three bores within the alluvium at Lemington South, along the Wollombi Brook, are shown in **Figure 2-1**. As shown in **Figure 2-1**, groundwater levels fluctuated the most within bore Appleyard Farm, which is located over 1.2 km upstream of Lemington South Pit and within 50 m of Wollombi Brook. These fluctuations show close correlation with stream flow levels as recorded stream gauge Wollombi Brook at Warkworth, which is located approximately 350 m upstream of the bore. Bores C919(ALL) and PB01(ALL) are located approximately 150 m from Wollombi Brook and show a more muted response to stream flow. Bore D317(ALL) is located adjacent to the Lemington South Pit, approximately 190 m from Wollombi Brook.

Over 2017 groundwater elevations within the alluvial bores Appleyard Farm, PB01(ALL) and C919(ALL) ranged between 45.9 mAHD and 48.6 mAHD. Groundwater levels fluctuated over 2017 but generally showed a decline in line with declining stream flow and rainfall. An exception to this spike in groundwater levels in April that appears to correspond with the peak stream flow and rainfall event in March.

Groundwater levels remained stable within bore D317(ALL) at around 44.4 mAHD, and have been relatively stable since 2012. Historical data indicates groundwater is present at around 15 m depth; however, available bore details indicate the bore is screened from 9.2 m to 12.2 m. It is therefore anticipated that bore D317(ALL) is dry.

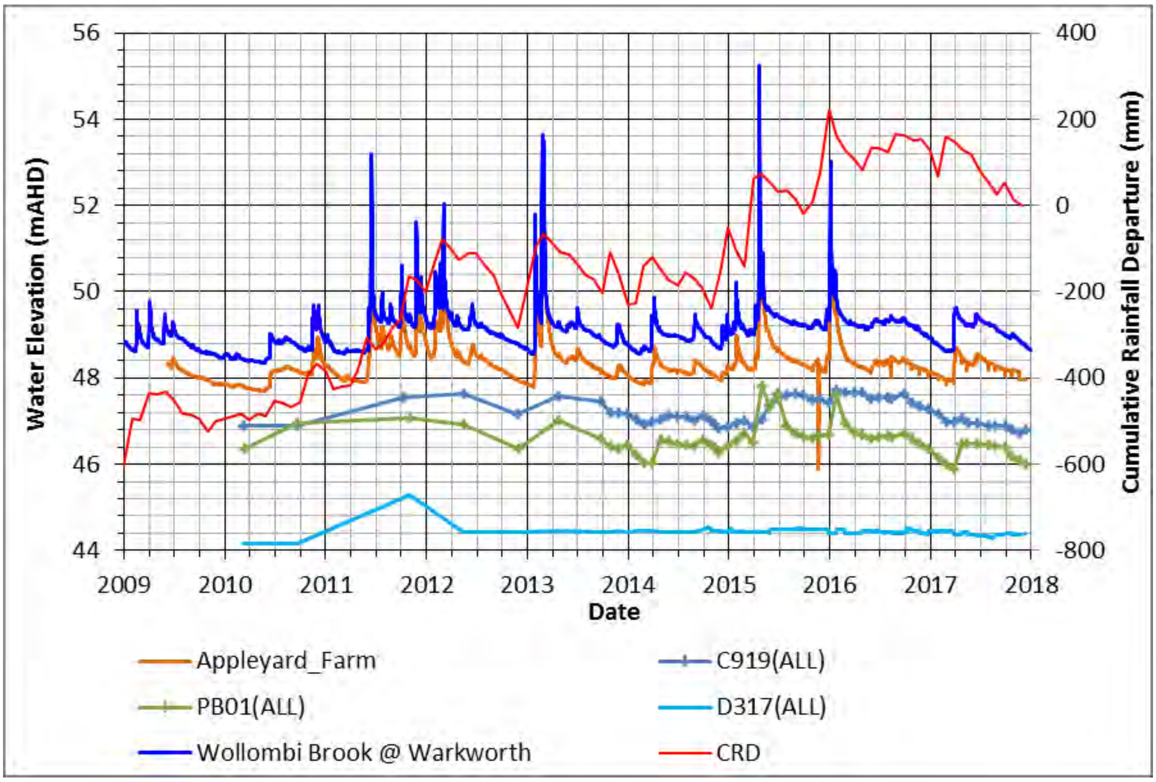


Figure 2-1 Hydrograph of Alluvial Bores – Lemington South and LUG Bore

2.2.2.2 Permian Coal Measures

Groundwater monitoring bores around Lemington South Pit and LUG Bore intersect various units of the Permian coal measures, including (in stratigraphic order) the Arrowfield Seam, Woodlands Hill Seam/Glen Munro Seam and Bowfield Seam. Groundwater level trends for each of these seams are included below.

Time series data for bores targeting the Arrowfield Seam are presented in **Figure 2-2**. As shown in **Figure 2-2**, all Arrowfield Seam bores recorded relatively stable to slightly declining groundwater levels over 2017, consistent with climate trends.

Time series data for bores targeting the shallow interburden, Woodlands Hill Seam and Glen Munro Seam are presented in **Figure 2-3**. As shown in **Figure 2-3**, groundwater elevations for all bores except B425(WDH) ranged between 46.1 mAHD and 49.1 mAHD. Over 2017 the groundwater levels declined slightly, by between 0.1 m (C130(WDH)) and 0.5 m (D010(GM)). An exception to this is bore C809(WDH), which declined by 2.4 m over 2017. This bore is located furthest west away from Lemington South Pit, compared to the other bores. These trends may therefore reflect cumulative drawdown impacts from surrounding operations.

Bore B425(WDH) recorded groundwater elevations unique to the other bores, at around 22.3 mAHD and 30.2 mAHD over 2017. The bore recorded a 7.9 m decline in groundwater levels over 2017. These elevations and trends correspond more closely with trends observed for the Bowfield Seam bores discussed below and likely intersects the deeper unit.

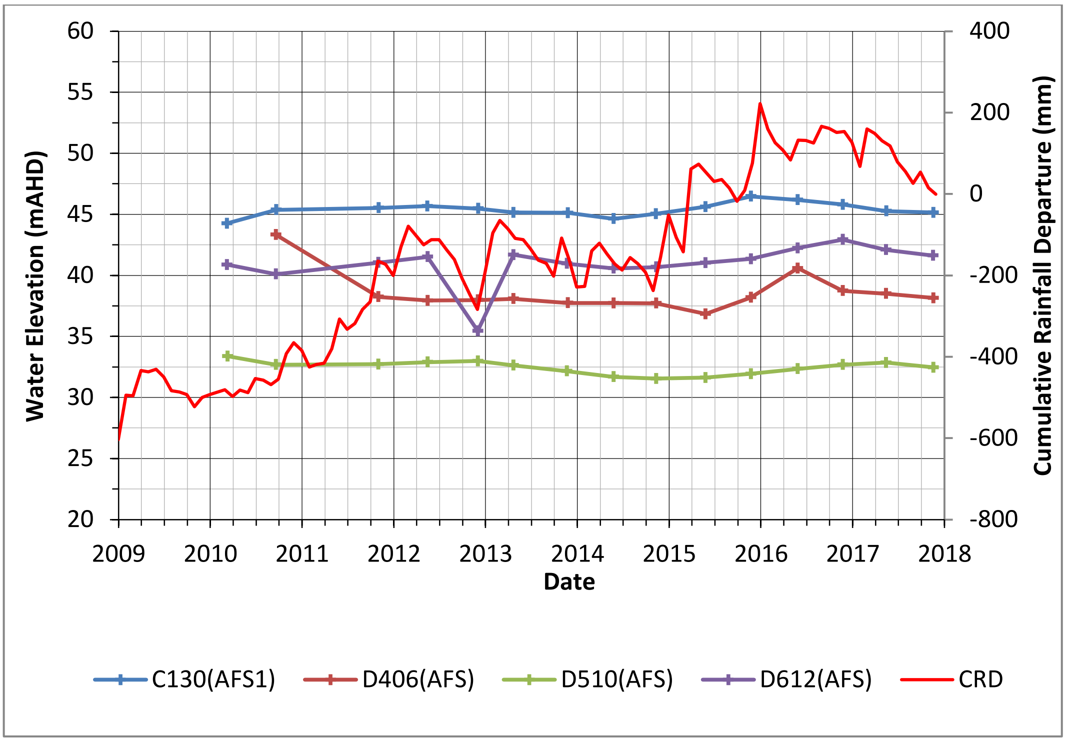


Figure 2-2 Hydrograph of Arrowfield Seam – Lemington South and LUG Bore

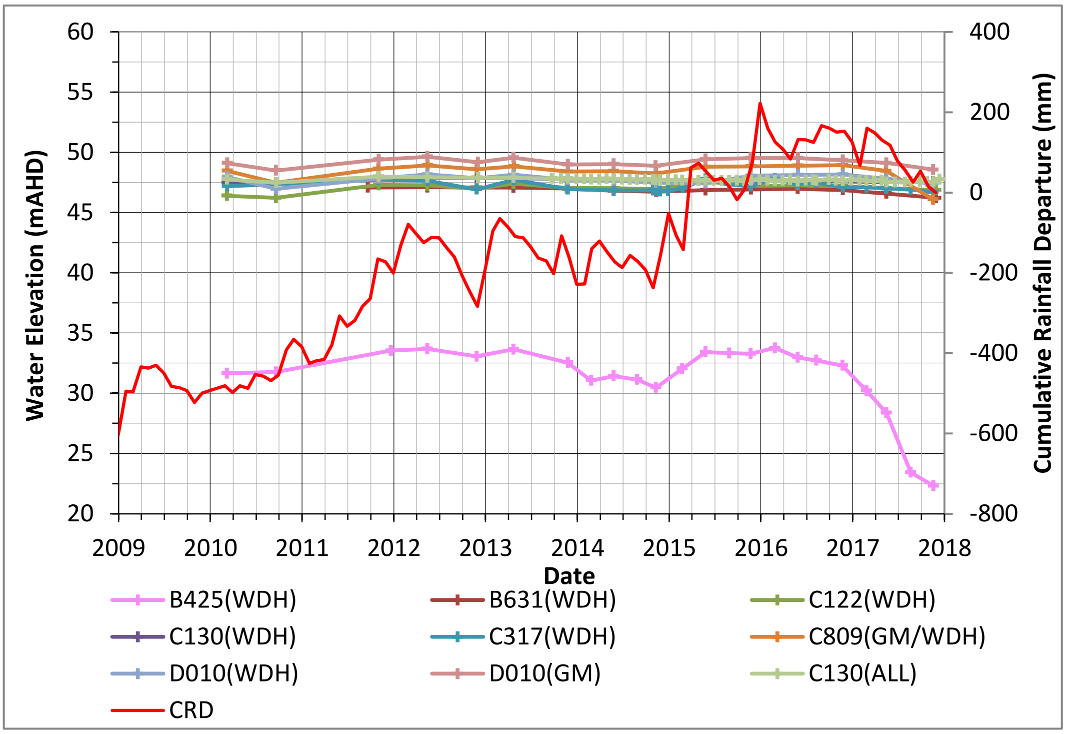


Figure 2-3 Hydrograph of Woodlands Hill and Glen Munro Seam – Lemington South and LUG Bore

Time series data for bores targeting the Bowfield Seam are presented in **Figure 2-4**. As shown in **Figure 2-4**, groundwater elevations ranged between 13.8 mAHD and 43.1 mAHD. Interpolated groundwater elevation contours for the Bowfield Seam are presented in **Figure 2-5**, based on December 2017 readings.

Over 2017 the groundwater levels remained relatively stable to slightly declining within bores D010(BFS), D406(BFS), D510(BFS), D612(BFS) and D807(BFS). Bores D214(BFS), D317(BFS) and D613(BFS) also recorded relatively stable groundwater levels until Q3, between Q3 and Q4 the bores recorded a 2.4 m to 3.4 m decline in groundwater levels.

In contrast, bores B334(BFS), B631(BFS), B925(BFS), C130(BFS), C317(BFS), C621(BFS) and C630(BFS) recorded a more visible decline in groundwater level, by between 6.6 m (C630(BFS)) and 12.2 m (B925(BFS)) over 2017. The bores are located between 300 m (B925(BFS)) and 1.3 km (C630(BFS)) of LUG Bore. The LUG bore intersects the historical Lemington Underground workings, which mined through the Bowfield Seam. Over 2017 (calendar year) 1567 ML of water was abstracted from the bore. The groundwater level drawdown is therefore likely related to abstraction from the bore. This is shown in **Figure 2-5**, which illustrates groundwater flow towards LUG Bore to the southwest.

Bores targeting the shallower coal seams are also located within 1.3 km of the LUG Bore, these include (B631(WDH), C122(WDH), C130(AFS), C130(ALL), C130(WDH) and C317(WDH). As outlined above, these bores recorded relatively stable to slightly declining (maximum 0.4 m decline) groundwater levels over 2017. This highlights that the drawdown impacts are largely localised to the Bowfield Seam, due to the low permeability of the interburden units (i.e. siltstone and sandstone) overlying the seam. Alluvial bore Appleyard Farm is the closest alluvial bore to the LUG Bore. As discussed in **Section 2.2.2.1** groundwater trends within the bore reflect rainfall and stream flow trends. The bore shows no clear impacts related to groundwater abstraction from the historical underground mine.

It is noted that bore C122(BFS) is also within proximity to LUG Bore, but records unique groundwater water levels that indicate the bore may be damaged or the water level sits at the base of the bore (i.e. the bore is effectively dry).

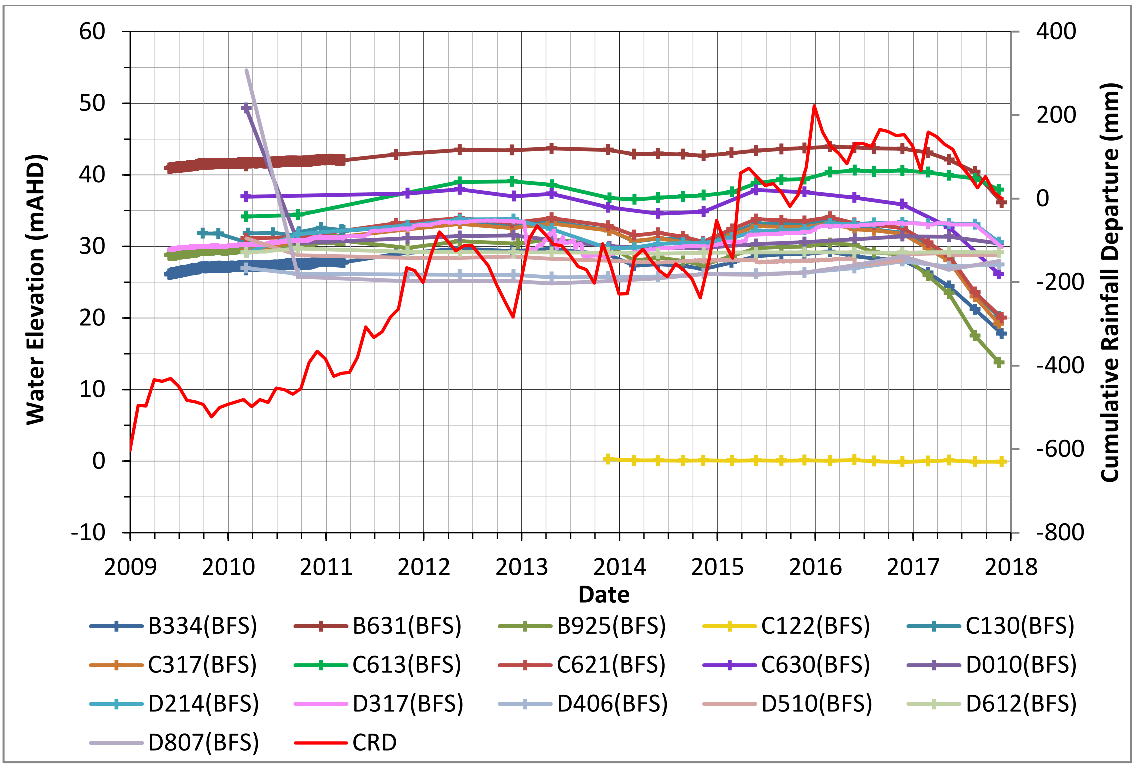


Figure 2-4 Hydrograph of Bowfield Seam – Lemington South and LUG Bore

Figure 2-5 Interpolated LUG Bore Groundwater Drawdown – Bowfield Seam

2.3 Summary of Groundwater Take For 2017

The predicted take of groundwater from the various groundwater sources associated with HVO is presented in **Table 2-1**.

Table 2-1 Predicted Groundwater Take for 2017

	Hunter Regulated	Hunter Unregulated	North Coast Fractured and Porous Rock
HVO Mine Operations	159	358	928
LUG Bore Abstraction	-	-	901*
Total	**159**	**358**	**1829**

***Note:** * take over water year (July 2016 to end of June 2017)*

As shown in **Table 2-1**, over the 2017 reporting year the total take under the Hunter Regulated water source was estimated at 159 ML, total take from Hunter Unregulated water source was estimated at 358 ML and 1,829 ML from the North Coast Fractured and Porous Rock water source. These volumes are within the licensed take for each groundwater source; however these values do not include water abstracted from surface water (i.e. Hunter River).

3 Conclusions

Over 2017 operations across HVO included active mining at West Pit, Cheshunt Pit, Riverview Pit and Glider Pit and groundwater was abstracted from LUG Bore. Quantification of groundwater take was undertaken based on reported volumes estimated for approved operations as part of Modification 5 (AGE 2017), extraction of model estimates from the Modification 5 Model for areas not previously reported (i.e. West Pit) and metered abstraction volumes from LUG Bore. Based on this, over the 2017 reporting year the total take under the Hunter Regulated water source was estimated at 159 ML, total take from Hunter Unregulated water source was estimated at 358 ML and 1,829 ML from the North Coast Fractured and Porous Rock water source. These volumes are within the licensed take for each groundwater source; however these values do not include water abstracted from surface water (i.e. Hunter River).

Groundwater abstracted from the licensed LUG Bore was measured at 901 ML from July 2016 to June 2017, which is within the licensed allocation of 1,800 ML/year. Review of groundwater level data around LUG Bore for 2017 identified a decline in groundwater level within the Bowfield Seam, which appears to relate to bore abstraction. These trends appear restricted to the Bowfield Seam, with shallower units showing little to no response to the abstraction.

Yours sincerely

CLAIRE STEPHENSON
Associate

Checked/
Authorised by: DL

Appendix 2: Rehabilitation Monitoring Report

Native Vegetation Rehabilitation Monitoring 2017 – New Sites

Mount Thorley Warkworth and Hunter Valley Operations

Prepared for Coal & Allied

13 March 2018

Document control

Project no.: 3417

Project client: Coal & Allied Operations Pty Ltd

Project office: Mudgee

Document description: Monitoring of new native vegetation within rehabilitation areas at Mt Thorley Warkworth Operations (MTW) and Hunter Valley Operations (HVO) as part of the annual Rehabilitation Monitoring Program.

Project Director: Rhidian Harrington

Project Manager: Vivien Howard

Authors: Vivien Howard and Alex Christie

Internal review: Rhidian Harrington

Document status: Rev1

Document address: P:\Projects\3000s\3400s\3417 RTCA Rehabilitation Monitoring\Report\Final\New Sites 2017

Author	Revision number	Internal review	Date issued
Vivien Howard Alex Christie	Rev 0	R. Harrington	27/07/17
Alex Christie	Rev 1	L. Carter	14/03/18

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box W36
Parramatta NSW 2150
Email: info@niche-eh.com
All mail correspondence should be through our Head Office.

Sydney
0488 224 888

Central Coast
0488 224 999

Illawarra
0488 224 777

Armidale
0488 224 094

Newcastle
0488 224 160

Mudgee
0488 224 025

Port Macquarie
0488 774 081

Brisbane
0488 224 036

Cairns
0488 284 743

Cover photograph: Native rehabilitation at monitoring site

Executive summary

Context

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Coal & Allied Operations Pty Ltd (C&A) to undertake monitoring of native rehabilitation post-mining at the Mt Thorley Warkworth (MTW) and Hunter Valley Operations (HVO) mine sites. The monitoring forms part of the MTW and HVO monitoring program, which aims to assess the recovery of native rehabilitation within the HVO and MTW rehabilitation areas. The monitoring follows on from the first round monitoring undertaken by Niche in February and March 2016 at the same sites (Niche 2016), but also inludes a number of new sites. This report presents the findings from monitoring undertaken at 25 MTW sites and 29 HVO sites.

Methods

This monitoring report provides the results of the progress of the native vegetation rehabilitation and was undertaken largely in accordance with the methodology detailed in AECOM (2012) *Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites*. Two notable amendments to the methodology were employed, based on lessons learnt during the 2016 monitoring period. These amendments include:

- Removal of the 1 x 1 metre pasture/groundcover monitoring and replacement with a BioBanking plot, including a nested 20 x 20 metre plot at each site.
- Introduction of stem density counts along two, 2 metre strips along the length of the 50 metre centre tape.
- Introduction of tree tagging, where endemic trees with a Diametre at Breast Height (DBH) larger than 5 centimetres were marked and numbered, and specific details of each tree was recorded.

These surveys also included the set-up of monitoing plots at 12 reference sites established at Belford National Park and within biodiversity offset areas owned by Rio Tinto and Peabody Energy. The reference sites have been selected to target Biometric Vegetation Types (BVTs) specified in the respective Mining Operations Plans (MOP) for MTW and HVO, these being:

1. HU701 Central Hunter Grey Box-Ironbark Woodland.
2. HU632 Central Hunter Ironbark-Spotted Gum-Grey Box Forest.

The data obtained during the monitoring has been presented in this report and compared with baseline data collected during the 2016 monitoring period and the reference sites established.

Aims

The aim of the monitoring program is to monitor vegetation attributes at rehabilitation sites established in 2016 and reference sites to determine the success of the rehabilitation within the HVO and MTW post-mine areas.

Results

This report compares the data from 2016 with the data collected at the 12 reference sites and 54 monitoring sites in 2017.

Key findings include:

- There is significant variation in the types and ages of the rehabilitation sites that were part of the monitoring project, and therefore there is a high degree of variability in monitoring results including native plant species richness, exotic cover, percentage cover, and projected cover of all strata.
- Rehabilitation sites fall within the reference site soil property ranges and therefore meet the MOP performance criteria.
- Generally the Landscape Organisation Index (LOI) at the reference and rehabilitation sites was high, with an average LOI of 0.98 for the reference sites and 0.9, 0.7 and 0.8 for HVO and MTW woodland – other and MTW woodland – EEC sites respectivly.
- The average infiltration scores for rehabilitation sites overall has increased from 42.4 to 51.1 for HVO sites and 37.4 to 41.6 for MTW woodland – other sites. MTW woodland – EEC has dropped slightly from 47.8 to 43.7. This is likely due to the addition of new sites to this domain type.
- All rehabilitation sites fall below benchmark in at least one attribute.
- Due to the density of regenerating shrub species, a number of sites exceed the upper benchmark for Native Ground Cover – Shrubs (NGCS). This is likely a result of the combination of exceptional germination and juvenile canopy and mid-storey species contributing towards NGCS.
- Only one MTW woodland – EEC site is meeting the MOP performance criteria target for Native Overstorey Cover (NOS).
- All other MTW woodland – EEC sites have very low to no NOS. This is due to juvenile trees not occurring in the canopy stratum.
- Eight MTW woodland – EEC rehabilitation sites were within the reference site range values for native mid-storey cover (NMS). Part of the contribution to mid-storey cover however might be due to the presence of juvenile overstorey species which are not yet mature enough to be included in the overstorey and are included as mid-storey.
- Results for woodland – other rehabilitation sites are indicating that the current target for Exotic Plant Cover (EPC) of 0% will be very difficult to achieve. Only two woodland – other rehabilitation sites across HVO and MTW sites met this reference site benchmark level and in both cases these sites had no vegetative cover at all due to a recent knockdown herbicide spray.
- In comparison, the MOP performance criteria target for exotic plant cover for woodland – EEC rehabilitation sites has been set at a more realistic level of 5-33%. Nine of the MTW woodland – EEC rehabilitation sites met this target level. High exotic plant cover scores that exceed the benchmark at new rehabilitation sites are primarily due to the use of cover crops early during the rehabilitation works.
- Most MTW Woodland – EEC rehabilitation sites were not meeting the target levels for total native plant species richness (NPS). Although sites were generally meeting species richness targets for native trees, shrubs and grasses, they were achieving low results for species richness of ‘other species’ (i.e. herbs, forbs and monocots other than grasses etc.). The category of ‘other species’ is where most of the native plant species diversity is found in the reference sites, with results from reference sites showing they contain 10-20 species in this category.
- In relation to NPS, there is not necessarily a correlation between age of the rehabilitation and species richness. Older rehabilitation sites do not necessarily have a greater number of plant species. This is likely to reflect that seed mixes being used since 2011 have had a much higher diversity of species than earlier seed mixes.

- Due to the age of the rehabilitation sites, only eight of the 54 rehabilitation sites had trees with a DBH greater than five centimetres. However, the canopy species diversity at these sites were generally good, with all of these sites falling within the benchmark range.
- No fallen logs or large rocks were recorded at any of the rehabilitation sites.
- The 2017 reference site benchmarks vary from 2016, likely due to seasonal differences. While field surveys were conducted during the same time of the year as the 2016 surveys, many benchmark values are lower. This is likely a result of extended periods of extremely hot weather prior to the 2017 surveys, which is likely to have killed sensitive herbs and forbs compared to the previous year.

Table of Contents

List of Figures

List of Tables

List of Appendices

Abbreviations

Acronym	Term/Definition
BBAM	BioBanking Assessment Methodology
BVT	Biometric Vegetation Type
C&A	Coal & Allied Operations
Dbh	Diameter at breast height
EEC	Endangered Ecological Community
EPC	Exotic Plant Cover
FL	Fallen logs
ha	Hectare/s
HVO	Hunter Valley Operations
Km	Kilometre
LFA	Landscape Function Analysis
LFI	Landscape Function Index
LOI	Land Organisation Index
MOP	Mining Operations Plan
MTW	Mount Thorley Warkworth
NGCG	Native ground cover grasses
NGCO	Native ground cover other
NGCS	Native ground cover shrubs
NMS	Native midstorey
NOS	Native overstorey
NPS	Native plant species
NTH	Number of trees with hollows
NPWS	National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage (formerly DECCW, DECC, DEC)
OR	Overstorey regeneration
PCT	Plant Community Type
SSCI	Soil Surface Condition Indicators
TSC Act	*Threatened Species Conservation Act 1995* (NSW)

1. Introduction

1.1 Overview

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Coal & Allied Operations Pty Ltd (C&A) to undertake the first year of native rehabilitation post-mining monitoring at the Mt Thorley Warkworth (MTW) and Hunter Valley Operations (HVO) mine sites (Figure 1Figure 12). The monitoring forms part of the MTW and HVO monitoring program, which aims to assess the recovery of native rehabilitation across all 29 HVO and 25 MTW sites. This includes an additional 13 new HVO rehabilitation monitoring sites and 8 new MTW rehabilitation monitoring sites. This document outlines the 2017 monitoring results in isolation, but also compares these results with the data collected during the baseline surveys undertaken during 2016 (Niche 2016).

The monitoring methods implemented were largely consistent with the methodology detailed in Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites (AECOM 2012).

Information available from the relevant BioBanking benchmark sites and monitoring data from the reference sites have been used to inform the performance criteria targets for native vegetation rehabilitation in the Mining Operations Plan (MOP) for MTW, HVO North and HVO South. The results of monitoring in these new rehabilitation areas have been assessed against the MOP performance criteria in this report.

It should be noted, that monitoring of native vegetation rehabilitation was generally not undertaken prior to 2015 and was first undertaken in 2016 and then subsequently in 2017. The results of these other monitoring periods are presented in a separate report, Native Vegetation Rehabilitation Monitoring 2016 – Mount Thorley Warkworth and Hunter Valley Operations (Niche 2016).

1.2 Background to the rehabilitation monitoring

Rehabilitation monitoring at MTW and HVO is undertaken to satisfy the following regulatory obligations:

- Schedule 3 – Condition 58(i) of Development Consent SSD-6464 (Warkworth Mine)
- Schedule 3 – Condition 36(h) of Development Consent SSD-6465 (Mt Thorley Mine)
- Schedule 4 – Condition 62C(j) of Development Consent DA 450-10-2003 (HVO North)
- Schedule 3 – Condition 36(e) of Project Application PA 06_0261 (HVO South)
- Commitments made in respective Mining Operations Plans (MOPs) for MTW, HVO North and HVO South.

Rehabilitation activities at MTW and HVO involve areas of post-mined lands being returned to either a native ecosystem or a grazing pasture (or grassland). C&A has committed to recreating Endangered Ecological Communities (EEC) to a standard comparable to similar reference EECs. The EECs include Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest, which are both listed as EECs under the NSW *Threatened Species Conservation Act 1995* (TSC Act). The area of rehabilitation that is proposed to be returned to EEC communities is 2,114 hectares at MTW and 4 hectares at HVO.

1.3 Project scope and objectives

This rehabilitation monitoring report documents the 2017 monitoring survey results and provides comparisons with reference site data and published OEH benchmark data. Further to the existing rehabilitation sites, this report includes new monitoring data for an additional 21 new rehabilitation sites that had not been surveyed prior to 2017.

The monitoring involved the following key objectives:

- Establish permanent monitoring sites within each of the new rehabilitation areas (13 at HVO and eight at MTW)
- Complete Landscape Function Analysis (LFA) at all monitoring sites
- Complete visual monitoring at all monitoring sites
- Complete soil analysis at all monitoring sites
- Complete photographic monitoring at all monitoring sites
- Complete tree health characteristic at all monitoring sites
- Provide an analysis of results against reference sites
- Provide recommendations to assist with the improvement of future monitoring and performance indicators.

Based on learnings from monitoring in 2016 at older monitoring sites, the methodology outlined in AECOM (2012) was amended in the following ways:

- Removal of the 1 x 1 metre pasture/groundcover monitoring and replacement with a BioBanking plot, including a nested 20 x 20 metre plot at each site.
- Introduction of stem density counts along two, 2 metre strips along the length of the 50 metre centre tape. The data from these will be compared separately to gauge consistency and determine if this level of collection is required in the future. Sensitivity analysis will aslo be undertaken to determine if this level of data collection is adequate for this purpose.
- The methodology for the collection of information pertaining to endemic canopy was made a little more prescriptive, where each canopy tree (endemic) with a Diametre at Breast Height (DBH) larger than 5 centimetres was marked with a metal tree tag or similar. Each tree was given a unique number and details including canopy health and reproductive status (flowers/fruit) was recorded.

Given the young age of the rehabilitation monitored as part of these works, some details of the health of the endemic canopy were not collected because individuals that may make up the canopy in the future were not currently developed enough (i.e. they all have a DBH less than 5 centimetres).

1.4 Monitoring team

Data collection for the 2017 monitoring period was undertaken between the 7th and 15th February 2017 with addional monitoring of new sites between the 1st and 3rd May 2017. Ecologists involved with the completion of field monitoring tasks and reporting are listed as follows:

Vivien Howard	Senior Ecologist (Field survey and reporting)
Alex Christie	Ecologist (Field survey and reporting)

2. Monitoring Sites

2.1 HVO rehabilitation areas

Monitoring has been conducted within 29 individual rehabilitation areas across HVO (see Figure 2 to Figure 6), comprised of different rehabilitation establishment conditions. The desired outcome of the rehabilitation is to achieve a native woodland community. Details regarding the establishment and treatment for each site, including the target domain type are provided in Table 1. It is worthwhile to note that two monitoring sites established during the 2016 monitoring period were not revisited as the native seed mixes had not been sown. Locations of the monitoring sites are provided in Appendix 3.

Table 1. HVO rehabilitation areas, establishment conditions and size – Woodland - other domain type

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
HVOWES200801	3.4	2008	Topsoil, native seed broadcasted in 2008	Woodland - other
HVOWES201101	4.4	2011	Compost (with spoil), native seed hydroseeded in 2011	Woodland - other
HVOWES201301	3.7	2013	Compost (with spoil), native seed drilled in 2013	Woodland - other
HVOWES201302	12.7	2013	Topsoil/Compost, native seed drilled in 2016	Woodland - other
HVOCAR200901	14.2	2009	Topsoil, native seed broadcast in 2009	Woodland - other
HVOCAR200902	7.7	2009	Topsoil, native seed broadcast in 2009	Woodland - other
HVOCAR201401	25.6	2014	Compost (with topsoil), natives not sown	Woodland - other
HVORIV201406	3.1	2014	Topsoil/Compost, native seed drilled in 2016	Woodland - other
HVORIV201405	14.3	2014	Compost (with subsoil), native seed drilled in 2014	Woodland - other
HVORIV201404	8.4	2014	Compost (with subsoil), native seed drilled in 2014	Woodland - other
HVORIV201403	4.8	2014	Compost (with subsoil), native seed drilled in 2015	Woodland - other
HVORIV201402	10	2014	Compost (with subsoil), native seed drilled in 2014	Woodland - other
HVORIV201401	5.8	2014	Compost (with spoil), native seed drilled in 2014	Woodland - other
HVOCHE201201	20.8	2012	Compost (with topsoil), native seed drilled in 2013	Woodland - other
HVOCHE201203	26.6	2012	Compost (with topsoil), natives not sown	Woodland - other
HVOCHE201401	9.8	2014	Compost (with topsoil), natives not sown	Woodland - other
HVORIV201502	6.8	2015	Topsoil/compost, natives not	Woodland - other

[1] Soil and seeding information provided by Bill Baxter (C&A)

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
			sown	
HVORIV201503	6.2	2015	Topsoil/compost, second application of gypsum and compost, natives drilled 2016	Woodland - other
HVORIV201501	2.4	2015	Topsoil/compost, natives drilled 2016	Woodland - other
HVOLEM201501	13.4	2015	Topsoil/compost, natives sown first	Woodland - other
HVOCHE201501	24.4	2015	Topsoil/compost, natives not sown	Woodland - other
HVORIV201601	7.9	2016	Topsoil/compost, natives not sown	Woodland - other
HVOWES201602	4.0	2016	Topsoil/compost, natives sown first	Woodland - other
HVOWES201601	6.2	2016	Topsoil/compost, natives sown first	Woodland - other
HVOWES201603	8.1	2016	Topsoil/Composted green waste trial, native sown first	Woodland - other
HVOWES201604	5.0	2016	Topsoil/Composted green waste trial, native sown first.	Woodland - other
HVOCHE201601	21.5	2016	Topsoil/compost, natives not sown	Woodland - other
HVOCHE201602	10.2	2016	Topsoil/compost, natives not sown	Woodland - other
HVOLEM201601	5.0	2016	Topsoil/Composted green waste trial, native sown first (after delay)	Woodland - other

2.2 MTW rehabilitation areas

Monitoring has been conducted within 25 individual rehabilitation areas across MTW (see Figure 10 to Figure 15), comprised of different rehabilitation establishment conditions. These are listed in Table 2 and Table 3 below.

Table 2. MTW rehabilitation areas, establishment conditions, and size – Woodland – EEC domain type

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
MTWNPN201301	23.1	2013	Compost (with topsoil), natives drilled Winter 2015	Woodland -EEC
MTWNPN201401	7.1	2014	Topsoil/compost, natives drilled in 2014	Woodland -EEC
MTWNPN201402	1.9	2014	Compost (with fresh sand topsoil), natives drilled 2014	Woodland -EEC
MTWNPN201403	5.5	2014	Compost (with subsoil), natives drilled 2014	Woodland -EEC
MTWNPN201101	43.3	2011	Topsoil, natives hydroseeded 2011	Woodland -EEC

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
MTWNPN200901	21.8	2009	Topsoil, native seed broadcasted in 2009	Woodland -EEC
MTWCDD201101	8.1	2011	Topsoil, native seed hydroseeded	Woodland -EEC
MTWCDD201301	9.1	2013	Compost (with topsoil), natives not sown	Woodland -EEC
MTWCDD201501	6.4	2015	Compost (with spoil), natives drilled	Woodland -EEC
MTWSPN201401	37.7	2014	Compost (with topsoil), natives not sown	Woodland -EEC
MTWWDL201401	4.7	2014	Compost (with topsoil), natives drilled 2015	Woodland -EEC
MTWWDL201402	8.9	2014	Topsoil/compost, natives drilled in 2016	Woodland -EEC
MTWTD1201501	20.6	2015	Compost (with spoil), native seed drilled 2015	Woodland -EEC
MTWMTO200503	11.7	2005	Topsoil, native seed broadcasted in 2005	Woodland -EEC
MTWSPS201601	5	2016	Topsoil/compost, natives not sown	Woodland -EEC
MTWSPN201602	1.4	2016	Topsoil/compost, natives hydroseeded 1st	Woodland -EEC
MTWSPN201601	8.1	2016	Topsoil/compost, natives not sown	Woodland -EEC
MTWSPN201501	12.2	2015	Topsoil/compost, natives not sown	Woodland -EEC
MTWSPS201602	13	2016	Topsoil/compost, natives not sown	Woodland -EEC
MTWNOO201501	3.7	2015	Topsoil/compost, natives drilled 2016	Woodland -EEC

Table 3. MTW rehabilitation areas, establishment conditions and size - Woodland - EEC domain type

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
MTWMTO200001	6.3	2000	Topsoil, native seed broadcasted in 2000	Woodland - other
MTWNPN200501	13.2	2005	Topsoil, native seed broadcasted in 2005	Woodland - other
MTWNPN200502	4.8	2005	Topsoil, native seed broadcasted in 2005	Woodland - other
MTWMTO201501	8.1	2015	Topsoil, natives not sown	Woodland - other
MTWMTO201601	28.4	2016	Topsoil/compost, natives not sown	Woodland - other

2.3 Native rehabilitation performance criteria, measures and associated indicators

As previously discussed in Section 1.2, performance criteria for the native rehabilitation areas have been detailed in the MOP's (Coal & Allied 2015, 2016a and 2016b), and target values for the criteria have been developed based on reference site monitoring data and information available from OEH BioBanking benchmarks. This monitoring report provides a comparison of results for rehabilitation sites against reference sites, BioBanking benchmark values (where available) and the relevant performance criteria. The results section of this report has been divided based on the MOP performance criteria, with the relevant criteria displayed above the relevant results.

3. Monitoring methodology

3.1 Monitoring dates

Monitoring was undertaken during two distinct periods, including seven days between 7th and 15th February 2017 and three days between 1st and 3rd May 2017. Details regarding the dates, personnel and sites completed for each day during the monitoring is provided in Appendix 2.

3.2 Design

Monitoring was undertaken in accordance with AECOM's (2012) Monitoring Methodology. Niche has summarised the techniques used from AECOM's Monitoring Methodology below.

3.2.1 Rehabilitation monitoring sites

A total of 54 rehabilitation monitoring sites have been established in rehabilitation areas being returned to woodland/forest vegetation, including:

- 29 monitoring sites at HVO (Figure 2, and Figure 3Figure 9)
- 25 monitoring sites at MTW (Figure 2, and Figure 10Figure 15).

For each monitoring site, a marker-post was placed at the start and end point, with the end point established downslope. Waypoints were taken at the start and end point for each monitoring site location (Appendix 3).

Monitoring at each rehabilitation site included the collection of the following data: photo points, visual assessment, Landscape Function Analysis (LFA), soil analysis, and the collection of BioBanking data.

The locations of the monitoring sites, along with their associated descriptions and coordinates have been provided in Appendix 3.

3.2.2 Reference monitoring sites

As part of the monitoring undertaken during 2016, 12 reference monitoring sites were established. These aimed at capturing data around two BVTs specified in the MOP. Six sites were established at each of two vegetation communities:

1. HU701 Central Hunter Grey Box-Ironbark Woodland
2. HU632 Central Hunter Ironbark-Spotted Gum-Grey Box Forest.

Two of the Central Hunter Grey Box-Ironbark Woodland reference sites were established within land managed by Wambo Coal Mine (Figure 18), with another four established in land managed by C&A (Figure 16 and Figure 17).

The coordinates for the location of each reference site is provided in Appendix 3.

BioBanking data collected at each of the reference sites was input into the OEH BioBanking Benchmark Calculator to provide the lower and upper benchmark ranges for each attribute. The reference site ranges were then compared to the OEH benchmarks for both BVTs.

Follow-up monitoring at these reference sites was undertaken during February 2017.

3.3 Sampling techniques

3.3.3 Landscape Function Analysis (LFA)

LFA is a monitoring procedure developed by the CSIRO (Tongway and Hindley, 1997, last revised in 2004) that uses rapidly acquired field-assessed indicators to assess the biogeochemical functioning of landscapes at the hillslope scale. It provides a rapid, reliable, and easily applied method for assessing and monitoring landscape restoration or rehabilitation projects. LFA examines the way physical and biological resources are acquired, used, cycled and lost from a landscape.

Eleven Soil Surface Condition Indicators (SSCIs) (Table 4), each focusing on the measurement of specific biological and/or physical processes, are used to calculate three LFA indices; soil stability, soil infiltration and nutrient cycling. The three indices have scores of 0 to 100, which represent the ecosystem function of the area. These scores provide quantitative measures that may be used to compare rehabilitated areas with reference sites throughout the course of a monitoring program.

An LFA plot and transect was completed at each rehabilitation and reference site.

Table 4. Soil Surface Condition Indicators (SSCI) used to assess the effect of biological and physical processes on ecosystem function

Indicator	Related process
Rainsplash Protection	Rainsplash erosion
Perennial Vegetation Cover	Below ground biomass
Litter	Nutrient cycling of organic matter
Cryptogam Cover	Indication of soil stability and presence of nutrients
Crust Brokenness	Potential for wind and water erosion
Soil Erosion Type and Severity	Type and severity of existing soil erosion
Deposited Materials	Soil stability upslope
Soil Surface Roughness	Water infiltration and retention
Surface Resistance to Disturbance	Effect of mechanical disturbance
Slake Test	Soil stability when wet
Texture	Soil permeability and water storage

3.3.4 BioBanking – site value scores

The NSW Biodiversity Banking and Offsets Scheme – known as 'BioBanking', was introduced by the NSW government in 2008. The BioBanking Assessment Methodology (BBAM) assesses biodiversity values as defined by the TSC Act. These values include the composition, structure and function of ecosystems. They also include (but are not limited to) threatened species, threatened populations and threatened ecological communities, and their habitats.

AECOM (2012) refers to the use of 'site value' to provide a quantitative measure of the condition of the vegetation within each rehabilitation area. The site value for a particular zone is calculated based on quantitative measures of ten site attributes which are measured along a transect and within a survey plot, and assessed against benchmarks values (Table 5). A minimum number of plots are required based on the area of the site being assessed. It was thought to be more valuable to present results for each of the BioBanking criteria rather than just the site value score. In accordance with the relevant MOP performance criteria, the results for the Woodland - Other rehabilitation areas have been compared to the reference site benchmarks.

BioBanking plots were undertaken at all reference sites and all rehabilitation sites as identified in Appendix 4.

Table 5. The ten site value scores recorded as part the BioBanking assessment

Attribute	Explanation
Native plant species richness (NPS)	Number of native species recorded within a nested 20 x 20 m quadrat.
Native over-storey % cover (NOS)	Recorded at 5 m intervals along a 50 m tape
Native mid-storey % cover NMS)	Recorded at 5 m intervals along a 50 m tape
Native ground cover (grass) % cover (NGCG)	Recorded at 1 m intervals along a 50 m tape
Native ground cover (other) % cover (NGCO)	Recorded at 1 m intervals along a 50 m tape
Native ground cover (shrubs) % cover NGCS)	Recorded at 1 m intervals along a 50 m tape
Exotic plant cover % cover (EPC)	Recorded at 1 m intervals along a 50 m tap
Overstorey regeneration	Regeneration is measured as the proportion of over-storey species present in the zone that are regenerating (i.e. with diameter at breast height < 5 cm). For example, if there are three tree species present in the zone but only one of these species is regenerating, then the value is 0.33. The maximum value for this measure is 1.
Fallen logs (m) Length of logs (m) (FL)	Total length of logs recorded within the 20 x 50 m quadrat. To be eligible for inclusion, logs must be >10 cm diameter and longer than 50 cm.
Number of trees with hollows (NTH)	Number of trees with hollows within the 20 x 50 m quadrat.

3.3.5 Visual monitoring

Species composition

The dominant species present in the monitoring area were identified to obtain a 'picture' of the species composition. In rehabilitation areas, this allowed confirmation that the species establishing conformed to the target vegetation types being re-established.

Additionally, notes were made on the general health and sustainability of vegetation as indicated by presence/absence of flowering/fruiting adult plants. The presence of plants at reproductive stage is an indication that the ecosystem is recruiting and, as such, capable of self-regeneration. Given the young age of the rehabilitation sites where monitoring was undertaken, minimal details around canopy health and maturity were collected during the 2017 monitoring period.

Habitat and fauna monitoring

Artificial habitat features installed throughout the site as part of the rehabilitation activities (e.g. stag trees) were recorded.

Notes were also made on the presence and extent of habitat features such as free standing water, coarse woody debris, rocks, mistletoes and whether plants were flowering or fruiting.

Disturbance monitoring

Disturbance monitoring was undertaken using the visual monitoring tool developed by AECOM (2012). This technique is a field-based, rapid assessment tool to visually assess and award a score to various contributors. The objective of this monitoring is to identify factors and processes that occur at the landscape/catchment scale and have the potential to impact on the monitoring site. The disturbance monitoring aims to cover those aspects that are not adequately covered in the BioBanking and LFA monitoring tools. The following disturbance categories (and associated disturbance factors) were monitored and assessed at each site:

- Disturbance related to mining activities, including:
  - Evidence of wheeled vehicles, tracked vehicles and foot disturbance
  - Excavation
  - Presence of mine rubbish
- Disturbance related to non-mining activities, including:
  - Evidence of grazing
  - Presence of animal pads
- Presence of exotic weeds and feral animal species
- Presence of domestic litter / rubbish
- Fire disturbance
- Evidence of nearby maintenance activities (i.e. chemical treatments, fencing, earthworks)
- Surface stability and erosion issues, including:
  - Eroding factor (i.e. wind, water).
  - Erosion type (i.e. sheet, rill/gully, pedestal, terracette, scalding (Tongway & Hindley 2004)).

3.3.6 Canopy development and over-storey regeneration

In order to understand the adequacy of canopy development at rehabilitation sites in terms of species diversity, stem density, size and habitat values, two additional assessment techniques were introduced. One captures the adequacy of canopy recruitment, whilst the other captures canopy development and maturity:

- Introduction of stem density counts along two, 2 metre strips along the length of the 50 metre centre tape. The number and species of each individual canopy tree was counted. Where individuals could not be identified to species level, they were identified to genus.
- Information pertaining to canopy development; diversity and density, average trunk diameter, condition of the tree population, and percent of the endemic canopy with reproductive structures. This was undertaken in the nested 20 x 20 metre plot and each tree labelled with a metal tree tag or flagging tape with an ID number to allow for follow-up monitoring. Trees with a DBH less than five centimetres were not included in the count.

3.3.7 Soil analyses

Soil characterisation and analyses were performed to determine the physical and chemical properties of the growing media. Soil samples were collected from all monitoring sites (rehabilitation and reference sites). A composite sample, consisting of a minimum of nine sub-samples collected 10 to 15 metres apart, was collected within a 20 metre radius. The radius was based on a central point five metres in from the 20 metre quadrat tape. All samples were placed in a bucket, and were mixed. The sample was then placed in a plastic bag, labelled, and sent to the Environmental Analysis Laboratory (EAL) and Sydney Environmental & Soil Laboratory (SESL) Australia for analysis.

The following soil parameters were determined:

- pH
- Electrical conductivity (EC)
- Cation balance
- Sodicity
- Soil organic matter content
- Soil texture including clay content.

3.3.8 Photographic monitoring

Photographic monitoring is a simple and useful tool that allows for direct visual comparison of a specific site between monitoring events. Digital photographs were taken at the start and finish transect points at each monitoring site. This included:

- A photograph with the tape (and star picket) in the centre of the frame
- Photograph to the left and right of the centre tape.

3.3.9 Rill survey

In accordance with the LFA methodology (Tongway and Hindley 2004), rill surveys are to be carried out where rills are observed at less than 30 metre spacing across the slope.

None of the monitoring sites were impacted by rill erosion at the time of the 2017 monitoring survey, and therefore no rill surveys were undertaken.

3.3.10 Weather

Temperatures and rainfall in the months preceding the field monitoring period during both 2017 and 2016 are listed below in Table 6 and Table 7.

Conditions during the first round of the 2017 field surveys were dry and hot, with low rainfall recorded. When comparing results between 2016 and 2017 it should be noted that the weather preceding the 2017 surveys had considerably higher temperatures and lower rainfall than historical averages, with the rainfall being notably less than the rainfall which preceded the 2016 surveys. Daily maximum temperatures ranged from 29°C to 45°C.

Table 6. Weather conditions preceding and during the 2017 monitoring period (BoM Station # 061397)

	Monthly mean and total			Historical average (2002-2016)		
Month	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)
October 2016	10.4	25.1	52.2	14.1	26.4	44.7
November 2016	12.7	30.7	52.2	17.8	28.8	83.6
December 2016	17.2	33.0	75	19.4	29.9	70.5
January 2017	19.1	34.4	48.4	20.2	31.5	69.9
February 2017	19.4	36.2	8.1	18.6	32.7	91.9
March 2017	17.7	28.5	129.7	15.1	28.2	64.2
April 2017	10.8	24.1	37.6	11.1	24.7	60.8
May 2017	7.3	21.7	24.6	6.9	21.5	29.3

Table 7. Weather conditions preceding and during the 2016 monitoring period (BOM Station #061397)

	Monthly mean and total			Historical average (2002-2016)		
Month	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)
October 2015	10.0	26.8	42.6	14.1	26.4	44.7
November 2015	14.0	28.8	83.9	17.8	28.8	83.6
December 2015	15.8	29.9	73.9	19.4	29.9	70.5
January 2016	17.7	29.3	208.8	20.2	31.5	69.9
February 2016	17.6	29.0	10.0	18.6	32.7	91.9

3.4 Limitations

Many of the flora recorded in the rehabilitation monitoring sites were in a juvenile or seedling state and could not always be identified confidently. As such, identification may need to be updated in later monitoring years and analyses corrected.

Whilst the reference sites were located within BVTs that were in good condition and within the general region of the study area, they had been impacted by historic clearing, and thus old growth forms of these BVTs were not able to be sampled as reference sites. Considering this disturbance history, the reference sites represent recovering vegetation communities and therefore are useful to compare with the rehabilitation sites during the establishment phase.

Data analysis was limited to a comparison of rehabilitation site, (split by domain type) and reference sites, and to areas of different soil treatment. Details regarding weed management history and seeding rates were not available so data analysis based on these parameters was not undertaken. It was evident during the field visits in January that weather had created sub-optimal conditions for plant growth with the hot dry conditions resulting in stress to many individual plants, including individuals within mature rehabilitation areas and at reference sites in remnant vegetation. This was particularly evident for groundcovers species.

As some of the assessment methods changed between the 2016 baseline and 2017 monitoring periods, not all the key parameters were directly comparable. The ground-cover assessment was not replicated during 2017, therefore this data is not available for comparison. Similarly, new data collected, including details around canopy maturity and overstorey regeneration cannot be compared at this stage as baseline data is not available.

3.1 Compliance with the performance criteria outlined in the Mining Operations Plan.

The MOP provides a range of performance criteria to assess the native rehabilitation, in terms of establishment and sustainability. Due to the number of sites and the breadth and number of performance criteria, it is difficult to assess the performance of sites against the criteria in one Table. Table 8 provides a list of each of the criteria and provides the table number where it's addressed for each of the sites.

Table 8. MOP Performance Criteria – MTW and HVO rehabilitation sites

Performance Criteria – Growth Medium Development		Subheading	Domain Type	Table Number
1	pH >5.5 and <8.5	Soil Analysis	All Woodland	Table 10 to Table 13
2	Electrical Conductivity <2 dS/m	Soil Analysis	All Woodland	Table 10 to Table 13
3	Phosphorous within levels in analogue sites by Year 5	Soil Analysis	All Woodland	Table 10 to Table 13
4	Organic Carbon within levels in analogue sites by Year 5	Soil Analysis	All Woodland	Table 10 to Table 13
5	Cation Exchange Capacity within levels in analogue sites by Year 2	Soil Analysis	All Woodland	Table 10 to Table 13
6	Exchangeable Sodium Percentage within levels in analogue sites by Year 2	Soil Analysis	All Woodland	Table 10 to Table 13
7	Calcium/magnesium ratio within levels in analogue sites by Year 2	Soil Analysis	All Woodland	Table 10 to Table 13
Performance Criteria – Ecosystem and Landuse Establishment		**Subheading**	**Domain Type**	**Table Number**
1	Based on key physical, biological and chemical characteristics the LFA Stability Index provides an indication of the site's stability and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
2	Based on key physical, biological and chemical characteristics the LFA Infiltration Index provides an indication of the site's infiltration capacity and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
3	Based on key physical, biological and chemical characteristics the LFA Nutrient Recycling Index provides an indication of the site's ability to recycle nutrients and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
4	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
5	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland - Other	Table 29 and Table 31
6	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland - Other	Table 24 and Table 26
7	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland - Other	Table 29 and Table 31
8	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland EEC	Table 30

9	The number of shrub species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
10	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
11	The number of subshrub species and understorey species (other than grasses) comprising the vegetation community is comparable to that of analogue sites (no. species/area).	Species Richness	Woodland EEC	Table 25
12	The native plant species richness is within 50-100% or exceeds that of analogue sites (no. species/area). (Use OEH benchmark values)	Species Richness	Woodland EEC	Table 25
13	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland EEC	Table 30
Performance Criteria – Ecosystem and Landuse Sustainability		**Subheading**	**Domain Type**	**Table Number**
1	Weed plant cover (calculated as a percentage of total ground cover) is comparable to that of analogue sites. (% Cover)	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
2	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover)	Habitat Features	Woodland - Other	Table 16 and Table 17
3	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no./area).	Vegetation Health	Woodland - Other	Table 42
4	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
5	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no./area).	Vegetation Health	Woodland - Other	Table 42
6	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - Other	Table 42
7	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
8	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
9	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
10	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - Other	Table 42
11	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites.	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
12	The percentage of native over storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
13	The percentage of native mid storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39

14	The percentage of native ground cover (grasses) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
15	The percentage of native ground cover (shrubs) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
16	The percentage of native ground cover (other) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
17	Exotic plant cover (calculated as a percentage of total ground cover and mid storey cover) is within 5-33% or less than that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
18	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover).	Habitat Features	Woodland - EEC	Table 18
19	The abundance of native understorey species per square metre, averaged across the site, provides an indication of the heterogeneity of the site and that the number of native species is comparable to analogue sites (no. species/m^2).	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
20	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no. /area).	Vegetation Health	Woodland - EEC	Table 42
21	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
22	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no./area).	Vegetation Health	Woodland - EEC	Table 42
23	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - EEC	Table 42
24	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
25	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
26	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
27	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - EEC	Table 42
28	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
29	The total length of fallen logs is within 50- <100% or exceeds that of analogue sites. (Use OEH benchmark values)	Habitat Features	Woodland - EEC	Table 39
30	The number of hollows / nesting sites is within 50- <100% or exceeds that of analogue sites. (Use OEH benchmark values)	Habitat Features	Woodland - EEC	Table 39

4. Results

4.1 Growth Medium Development

Table 9 outlines the MOP performance criteria that are relevant to growth medium development. They are applicable to all the rehabilitation sites, regardless of the domain type.

Table 9. Growth Medium Development MOP Performance Criteria

Performance Criteria – Growth Medium Development		Subheading	Domain Type
1	pH >5.5 and <8.5	Soil Analysis	All Woodland
2	Electrical Conductivity <2 dS/m	Soil Analysis	All Woodland
3	Phosphorous within levels in analogue sites by Year 5	Soil Analysis	All Woodland
4	Organic Carbon within levels in analogue sites by Year 5	Soil Analysis	All Woodland
5	Cation Exchange Capacity within levels in analogue sites by Year 2	Soil Analysis	All Woodland
6	Exchangeable Sodium Percentage within levels in analogue sites by Year 2	Soil Analysis	All Woodland
7	Calcium/magnesium ratio within levels in analogue sites by Year 2	Soil Analysis	All Woodland

4.1.1 Soil Analysis

The results of the soil analyses by EAL Australia for key soil chemistry parameters for the HVO and MTW sites are detailed in Appendix 7.

Some of the results for soil properties outlined in the MOP Performance criteria have been compared with data from the reference sites. Data from the reference sites is provided in Table 10. The comparison of rehabilitation site data against the reference site ranges can be seen in Table 11, Table 12 and Table 13.

Table 10. Reference site soil results 2017

Site Name	pH >5.5 and <8.5	EC (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	CEC (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
WamboSpot1	6.28	0.06	4.73	5.02	8.26	1.16	2.14
WamboSpot2	6.41	0.05	5.94	6.23	14.88	1.53	1.94
WamboSpot3	6.19	0.06	5.28	4.74	8.59	2.17	1.87
WamboGB01	5.76	0.06	9.01	5.87	12.07	3.64	0.8
WamboGB02	6.69	0.1	7.73	7.67	20.44	1.74	2.02
WARKGB01	5.42	0.05	3.36	3.43	7.97	3.27	1.56
WARKGB02	6.03	0.06	5.41	4.97	8.16	2.63	1.99
WARKGB04	5.71	0.09	9.44	8.72	8.25	5.54	1
BEL1	5.44	0.05	5.19	7.05	7.44	4.18	0.65
BEL2	5.93	0.05	3.2	3.69	7.66	2.84	1.66
BEL3	5.69	0.1	5.19	8.17	11.26	4.43	1.28
Range	**5.42-6.69**	**0.05-0.10**	**3.19-9.44**	**3.43-8.72**	**7.44-20.44**	**1.16-5.54**	**0.65-2.14**
Average	**5.96**	**0.07**	**5.86**	**5.96**	**10.45**	**3.01**	**1.54**

Table 11. HVO Rehabilitation site soil results compared to MOP target/reference site range values (woodland – other domain type)

Site Name	pH >5.5 and <8.5	Electrical Conductivity (EC) (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	Cation Exchange Capacity (CEC) (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
Reference Site Average	**5.96**	**0.07**	**5.86**	**5.96**	**10.45**	**3.01**	**1.54**
Reference Site Range	**5.42-6.69**	**0.05-0.10**	**3.19-9.44**	**3.43-8.72**	**7.44-20.44**	**1.16-5.54**	**0.65-2.14**
HVO WES200801	7.24	0.11	17.17	4.43	13.76	2.02	1.10
HVO WES201101	8.44	0.16	87.55	5.64	20.09	2.05	1.48
HVO WES201301	8.37	0.18	146.20	4.36	18.96	1.27	2.24
HVO WES201302	7.81	0.54	186.15	8.84	23.81	1.65	2.74
HVO CAR200901	7.60	0.12	14.96	4.06	17.46	5.53	0.75
HVO CAR200902	7.70	0.08	11.65	2.73	23.27	3.01	1.16
HVO CAR201401	8.03	0.15	48.37	4.80	23.68	3.03	1.85
HVO RIV201406	7.78	0.17	55.85	6.41	22.01	4.98	1.20
HVO RIV201405	8.46	0.12	149.60	3.48	13.50	3.65	2.67
HVO RIV201404	8.80	0.20	101.15	5.29	20.66	6.02	2.30
HVO RIV201403	8.51	0.17	64.77	3.82	21.87	5.43	0.91
HVO RIV201402	8.72	0.48	215.05	8.28	30.22	9.32	1.58
HVO RIV201401	8.80	0.45	243.95	7.67	30.27	9.96	1.07
HVO CHE201201	8.13	0.16	249.90	9.57	23.32	4.04	2.69
HVO CHE201401 - A	7.69	0.13	77.18	4.97	18.25	2.53	1.71
HVO CHE201401 - B	8.14	0.17	244.80	6.27	16.47	3.44	3.95
HVO CHE201203	5.53	0.05	9.52	2.84	4.32	7.06	1.25
HVOCHE201601	8.07	0.52	43.30	6.69	17.75	4.20	1.74
HVOCHE201602	7.77	0.73	71.11	5.58	25.00	4.22	2.15
HVOLEM201501	6.98	0.06	50.64	3.62	7.19	1.70	3.41
HVOLEM201601	6.16	0.07	11.28	1.08	3.55	4.19	1.65
HVORIV201501	8.36	0.15	54.84	3.78	16.59	5.41	1.98
HVORIV201502	8.21	0.14	49.59	4.97	18.85	3.93	1.38
HVORIV201503	7.54	1.69	212.54	7.70	27.52	3.94	5.44
HVORIV201601	7.75	0.55	80.29	7.30	20.22	3.76	1.16
HVOWES201601	7.58	0.75	117.82	6.88	19.48	3.26	4.07
HVOWES201602	7.48	0.40	57.73	7.18	17.53	3.29	3.30
HVOWES201603	7.24	0.44	58.78	5.79	15.50	6.19	1.33
HVOWES201604	7.76	0.44	32.54	3.64	17.68	1.85	2.67

	outside reference site range values
	within reference site range values

Notes: pH and EC are compared against the target set within the MOP performance criteria rather than compared to reference site range values.

Table 12. MTW Rehabilitation site soil results compared to MOP target/reference site range values (woodland – EEC domain type)

Site Name	pH >5.5 and <8.5	Electrical Conductivity (EC) (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	Cation Exchange Capacity (CEC) (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
Reference Site Average	**5.96**	**0.07**	**5.86**	**5.96**	**10.45**	**3.01**	**1.54**
Reference Site Range	**5.42-6.69**	**0.05-0.10**	**3.19-9.44**	**3.43-8.72**	**7.44-20.44**	**1.16-5.54**	**0.65-2.14**
MTWNPN201301	6.87	0.08	24.57	2.64	8.04	1.37	2.43
MTWNPN201401	6.84	0.1	36.3	5.32	13.33	3.61	1.43
MTWNPN201403	8.28	0.2	121.55	4.94	17.27	6.1	1.54
MTWNPN201101	8.14	0.07	25.67	3.4	14.09	0.84	1.92
MTWNPN200901 - A	6.41	0.15	7.89	4.87	14.24	1.85	1.15
MTWNPN200901-B	8.02	0.16	81.43	5.2	18.25	1.23	2.4
MTWCDD201101	6.95	0.1	8.84	3.82	13.86	6.31	1.27
MTWCDD201301	8.31	0.14	133.45	5.99	16.31	4.44	2.64
MTWCDD201501	8.81	0.19	147.05	5.25	13.02	6.13	1.82
MTWWDL201401	7.41	0.17	86.7	6.74	15.17	8.68	1.53
MTWWDL201402	8.11	0.35	119.85	5.81	20.08	7.59	1.56
MTWTDI201501	9.19	0.8	89.25	10.94	19.61	36.74	1.14
MTWMTO200503	7.71	0.19	11.14	4.94	13.69	4.78	1.11
MTWSPN201401	8.32	0.16	38.42	5.29	15.49	4.04	2.04
MTWNOO201501	7.62	0.13	48.02	4.97	16.96	3.02	1.68
MTWNPN201402	6.32	0.03	30.96	4.4625	4.76	0.86	6.78
MTWSPN201501	8.07	0.32	186.04	7.2625	19.72	1.72	4.24
MTWSPN201601	7.04	0.68	112.83	8.085	20.84	4.31	2.85
MTWSPN201602	7.06	0.39	93.94	5.1625	13.59	7.4	1.92
MTWSPS201601	8.23	0.53	103.91	7.6825	20.42	4.88	2.65
MTWSPS201602	7.89	0.67	81.34	4.9525	20.07	4.68	2.24

(light grey)	outside reference site range values
(green)	within reference site range values

Notes: pH and EC are compared against the targets set within the MOP performance criteria rather than compared to reference site range values.

Table 13. MTW Rehabilitation site soil results compared to MOP target/reference site range values (woodland – other domain type)

Site Name	pH >5.5 and <8.5	Electrical Conductivity (EC) (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	Cation Exchange Capacity (CEC) (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
Reference Site Average	**5.96**	**0.07**	**5.86**	**5.96**	**10.45**	**3.01**	**1.54**
Reference Site Range	**5.42-6.69**	**0.05-0.10**	**3.19-9.44**	**3.43-8.72**	**7.44-20.44**	**1.16-5.54**	**0.65-2.14**
MTWMTO200001	7.55	0.15	15.64	2.47	12.43	13.55	0.73
MTWNPN200501	7.48	0.09	19.98	3.89	11.66	2.83	1.08
MTWNPN200502	7.31	0.09	22.44	5.97	13.07	1.43	1
MTWMTO201501	9.07	0.23	10.5	3.7625	12.69	9.71	1.62
MTWMTO201601	8.49	0.63	53.53	5.215	15.99	10.9	2.01

	outside reference site range values
	within reference site range values

Notes: pH and EC are compared against the target set within the MOP performance criteria rather than compared to reference site range values.

The above soil analysis shows results from HVO and MTW monitoring sites broken into domain type. The key results include:

- All sites, apart from HVO RIV201404, HVO RIV201403, HVO RIV201402, HVO RIV201401, MTWCDD201501, MTWTD1201501 and MTWMTO201501, fell within the MOP target levels for soil pH. The listed sites that did not fall within the target levels exhibited high alkalinity.
- Only two sites MTWNPN200901 – A, and MTWCDD201101 fell within the reference site range for Phosphorous levels. All other rehabilitation sites had higher Phosphorous levels than the reference sites.
- All sites, excluding HVOCAR200902 and HVOCHE201203 meet reference site levels for organic carbon.

4.2 Ecosystem and Landuse Establishment

4.2.1 Landscape Function Analysis

The following MOP performance criteria are relevant to LFA. The results are provided in Table 15 - Table 21. The relevant MOP performance criteria are provided in Table 14. These criteria relate to all sites, regardless of the domain type.

Table 14. Landscape Function Analysis MOP performance criteria

Performance Criteria – Ecosystem and Landuse Establishment		Subheading	Domain Type	Table Number
1	Based on key physical, biological and chemical characteristics the LFA Stability Index provides an indication of the site's stability and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
2	Based on key physical, biological and chemical characteristics the LFA Infiltration Index provides an indication of the site's infiltration capacity and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
3	Based on key physical, biological and chemical characteristics the LFA Nutrient Recycling Index provides an indication of the site's ability to recycle nutrients and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21

4	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21

Reference Sites

The LFA scores for the Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest reference sites were tabulated and are provided in Table 15. It also provides the results and data from the 2016 baseline. Key results include the following:

- Most sites scored an Landscape Organisation Index (LOI) of 1.0
- Most LOI scores were largely consistent, with only minor variation between 2016 and 2017
- WAMBOSPOT2 had the lowest LOI (0.95) across all reference sites
- The average LOI for Ironbark-Spotted Gum-Grey Box Forest was similar to the average for Grey Box-Ironbark Woodland
- The stability scores achieved at many sites reduced overall between 2016 and 2017
- Stability ranged from 53.9 to 68.9 for Grey Box-Ironbark Woodland with WAMBOSPOT2 having the highest stability score of 68.9
- There has been some variation in the LFA scores between 2016 and 2017 at reference sites.

Table 15. LFA data for Reference sites

	Landscape Organisation Index		**Stability**		**Infiltration**		**Nutrient cycling**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Central Hunter Grey Box-Ironbark Woodland								
WARKGB01	1	1	69.8	53.9	49.7	65.2	43.2	42.9
WARKGB02	1	0.98	70	59.8	57.6	59	52.1	51.6
WARKGB03	0.84	0.99	57.9	55	49.8	55	38.7	38.5
WARKGB04	0.97	0.98	72.5	58.9	48.4	52.1	48.4	60.6
WAMBOGB1	1	1	58.3	63.5	56.2	57.4	46.3	56.9
WAMBOGB2	1	1	72.5	61.1	48.4	55.5	48.4	50.8
Range	**0.84 - 1**	**0.98 - 1**	**57.9- 72.5**	**53.9 - 63.5**	**48.4 - 57.6**	**52.1 - 65.2**	**38.7 - 52.1**	**38.5 - 60.6**
Average	**1.0**	**1.0**	**66.8**	**58.7**	**51.7**	**57.4**	**46.2**	**50.2**
Central Hunter Ironbark-Spotted Gum-Grey Box Forest								
BELLSPOT1	1	1	66.7	56.9	51.6	70.4	43.6	41.4
BELLSPOT2	0.94	0.98	81.8	66.7	69.9	61.1	54.2	70.3
BELLSPOT3	1	1	63.9	55.2	65.3	61.8	54.9	64.4
WAMBOSPOT1	1	1	62.5	66.9	74	60.4	65.6	55.6
WAMBOSPOT2	0.96	0.95	72.7	68.9	64.2	58.1	62.1	79.8
WAMBOSPOT3	1	1	69.7	62.2	67.2	73.9	59.7	53.8
Range	**0.94 - 1**	**0.98 - 1**	**62.5- 81.8**	**55.2 - 68.9**	**51.6 - 74**	**58.1 - 73.9**	**43.6 - 65.6**	**41.4 - 79.8**
Average	**1.0**	**1.0**	**69.6**	**62.8**	**65.4**	**64.3**	**56.7**	**60.9**
Total Range	**0.84 - 1**	**0.98 - 1**	**57.9-81.8**	**53.9 - 68.9**	**48.4 - 74**	**52.1 - 73.9**	**38.7 - 65.6**	**38.5 - 79.8**
Total Average	**1.0**	**1.0**	**68.2**	**60.8**	**58.5**	**60.8**	**51.4**	**55.6**

The 2016 and 2017 raw data, ranges and average LFA scores for all the HVO and MTW sites broken by domain type is provided in Table 16-Table 21. A summary of the key outcome is provided below.

HVO rehabilitation sites – Woodland other

The raw data, ranges and average LFA scores for HVO - woodland other sites from 2016 and 2017 is provided in Table 16 and Table 19. The comparison columns for each of the four indices are based on the reference site range values for each of these indices.

Based on the data, LFA scores across all indices were fairly consistent for all sites, with no conspicuous outliers. The average LOI score was 0.9 across all sites. High LOI scores, particularly at younger rehabilitation sites, were generally driven by extensive grass cover, rather than development of leaf litter or shrub species.

MTW rehabilitation sites – woodland other

The raw data, ranges and average LFA scores for MTW - woodland other sites from 2016 and 2017 is provided in Table 17 and Table 20. The comparison columns for each of the four indices are based on the reference site range values for each of these indices.

Key results are as follows:

- LOI ranged from 0.41 to 0.96
- Stability ranged from 39.5 to 56.1
- Infiltration was variable and ranged from 28.7 to 56.4
- Nutrient cycling was variable and ranged from 10.3 to 77.8
- MTWCDD201501 had the lowest LFA score.

MTW rehabilitation sites – woodland EEC

The raw data, ranges and average LFA scores for MTW – woodland EEC sites from 2016 and 2017 is provided in Table 18 and Table 21. The comparison columns for each of the four indices is based on the reference site range values for each of these indices.

Key results are as follows:

- LOI ranged from 0.21 to 1.0
- Stability ranged from 44.2 to 73.2
- Infiltration was highly variable and ranged from 8.2 to 65.4
- Nutrient cycling was variable and ranged from 12.3 to 43.1.

Table 16. Landscape Function Analysis scores HVO- woodland other domain type (2017 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**0.98**	**60.75**	**60.75**	**55.5**
Reference Site Range	**0.98 - 1**	**53.9 - 68.9**	**52.1 - 73.9**	**38.5 - 79.8**
HVOCAR200901	0.59	59.4	35.8	39.7
HVOCAR200902	0.93	63	75	61.5
HVOCAR201401	0.75	50.9	59.6	49.9
HVOCHE201201	0.84	56.1	54	47.7
HVOCHE201203	0.96	62.8	58.4	47.7
HVOCHE201401	0.99	51.1	47.9	36.2
HVORIV201401	0.94	67.1	60.5	58.3
HVORIV201402	0.84	53.5	51.6	43.4
HVORIV201403	0.91	53.4	33.1	36.3
HVORIV201404	0.87	55.6	43.2	32.1
HVORIV201405	1	56.7	46.9	32.3
HVORIV201406	0.95	51.6	70.5	15.3
HVOWES200801	0.84	69.6	43.5	72.1
HVOWES201101	0.73	63.8	53.2	54.4
HVOWES201301	0.67	61.9	50	42.9
HVOWES201302	0.96	62	58	47
HVOCHE201501	1	59	57	44.6
HVOCHE201601	1	45	27.6	13
HVOCHE201602	1	44.4	30.9	11.6
HVOLEM201501	1	57.9	75.7	69.2
HVOLEM201601	0.98	59.5	56.7	47.7
HVORIV201501	1	51.1	65.9	47.7
HVORIV201502	1	69	43	47
HVORIV201503	1	61.5	61.9	64.6
HVORIV201601	0.92	67.4	57.4	42.8
HVOWES201601	1	53.3	35.8	23.8
HVOWES201602	0.92	55.1	26.2	17.9
HVOWES201603	0.96	56.1	53.4	49.1
HVOWES201604	0.89	54.6	40.7	30.7
Rehabilitation Site Average	**0.9**	**57.8**	**51.1**	**42.7**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 17. Landscape Function Analysis scores for MTW - woodland other domain type (2017 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**0.98**	**60.75**	**60.75**	**55.5**
Reference Site Range	**0.98 - 1**	**53.9 - 68.9**	**52.1 - 73.9**	**38.5 - 79.8**
MTWMTO200001	0.96	56.1	56.4	41.5
MTWNPN200501	0.58	51.3	50.1	43.1
MTWNPN200502	0.67	39.5	41.1	34
MTWMTO201501	0.41	54.4	31.6	31.5
MTWMTO201601	0.69	50.7	28.7	12.3
Rehabilitation Site Average	**0.7**	**50.4**	**41.6**	**32.5**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 18. Landscape Function Analysis results for MTW - woodland EEC domain type (2017 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**0.98**	**60.75**	**60.75**	**55.5**
Reference Site Range	**0.98 - 1**	**53.9 - 68.9**	**52.1 - 73.9**	**38.5 - 79.8**
MTWCDD201101	0.71	69.3	49.6	61.5
MTWCDD201301	0.97	60	48	49
MTWCDD201501	0.28	13.3	8.2	5.7
MTWMTO200503	0.35	56.1	45.3	33.5
MTWNPN200901	0.89	73.2	54.1	58.5
MTWNPN201101	0.21	69.3	49.6	61.5
MTWNPN201301	0.61	49.9	29.4	30.8
MTWNPN201402	0.55	53	51.6	44.8
MTWNPN201403	0.95	51.5	39	38.3
MTWSPN201401	0.94	45.2	65.4	49.5
MTWTD1201501	0.64	58.9	22.8	18.6
MTWWDL201401	0.68	44.2	32.5	35.9
MTWWDL201402	0.94	64.5	43.7	46.4
MTWNOO201501	1	52.8	27.5	20.9
MTWNPN201402	1	54.5	53.6	40.2
MTWSPN201501	0.01	57.5	53	38.5
MTWSPN201601	0	55.6	33.4	20.1
MTWSPN201602	0.85	57.6	66	60.1
MTWSPS201601	0.79	50.2	53.2	44.6
MTWSPS201602	0.75	53.9	31.8	20.8
Rehabilitation Site Average	**0.8**	**54.8**	**43.7**	**39.7**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 19. Landscape Function Analysis scores HVO- woodland other domain type (2016 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**1.0**	**68.2**	**58.5**	**51.4**
Reference Site Range	**0.84 - 1**	**57.9 - 81.8**	**48.4 - 74**	**38.7 - 65.6**
HVO CAR200901	0.83	66.5	47.4	44.2
HVO CAR200902	0.99	68	46.2	40.1
HVO CAR201401	0.86	61.4	43.3	50.2
HVO CHE201201	0.98	65.4	56.1	76.5
HVO CHE201203	0.91	64.3	57.3	57.5
HVO CHE201301	1	64.2	46.3	67
HVO CHE201401	0.82	55.6	40.2	34.1
HVO RIV201301	0.94	73.1	48.7	52.4
HVO RIV201401	0.69	49	33.2	22.6
HVO RIV201402	0.77	53.9	22.1	13.5
HVO RIV201403	0.86	50.8	22	16
HVO RIV201404	0.96	56	21.3	15.9
HVO RIV201405	1	73.1	64.1	77.8
HVO RIV201406	1	74.4	63.3	75.6
HVO WES200801	0.61	58.8	47.1	46
HVO WES201101	0.95	61.4	35.9	25.7
HVO WES201301	0.88	50.4	27	18.8
Rehabilitation Site Average	**0.9**	**61.5**	**42.4**	**43.2**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 20. Landscape Function Analysis scores for MTW - woodland other domain type (2016 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**1.0**	**68.2**	**58.5**	**51.4**
Reference Site Range	**0.84 - 1**	**57.9 - 81.8**	**48.4 - 74**	**38.7 - 65.6**
MTWMTO200001	0.89	58.2	31.8	33.9
MTWNPN200501	0.92	63.3	43.3	39.9
MTWNPN200502	0.95	61.3	37	32.4
Rehabilitation Site Average	**0.9**	**60.9**	**37.4**	**35.4**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 21. Landscape Function Analysis scores for MTW - woodland EEC domain type (2016 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**1.0**	**68.2**	**58.5**	**51.4**
Reference Site Range	**0.84 - 1**	**57.9 - 81.8**	**48.4 - 74**	**38.7 - 65.6**
MTWCDD201101	0.98	85.4	65.2	72.1
MTWCDD201301	1	78.7	77.8	64.6
MTWCDD201501	0.14	47.8	10.3	10.3
MTWMTO200503	0.54	54	28.5	21.4
MTWNPN200901	0.93	66.2	40.5	45.8
MTWNPN201101	1	58.7	57.1	53.5
MTWNPN201301	1	63.5	57.1	53.3
MTWNPN201401	0.67	61.9	32.8	21.4
MTWNPN201402	0.96	59.8	39.5	47
MTWNPN201403	0.98	74.6	66.8	65.5
MTWSPN201401	1	73.7	40.7	37.2
MTWTD1201501	0.61	54.4	24	22
MTWWDL201401	0.97	63.7	40.6	36.8
MTWWDL201401	0.97	63.7	40.6	36.8
MTWWDL201402	0.98	66.5	71.4	67.2
MTWWDL201402	0.98	66.5	71.4	67.2
Rehabilitation Site Average	**0.9**	**64.9**	**47.8**	**45.1**

lower than reference site range values

within reference site range values

exceeds reference site range values

4.2.2 Species Richness

Table 23 to Table 26 below provide species counts of the reference and rehabilitation sites. These tables also highlight the rehabilitation sites that have achieved species richness comparable to the reference sites.

The following MOP performance criteria in Table 22 show performance criteria relevant to species richness. Some of these performance criteria only apply to particular domain types. A comparison of total native plant species richness for rehabilitation and reference sites is presented in Table 24 to Table 26 for information purposes. This measure is only a MOP performance criteria for Woodland – EEC domains and the target relates to species richness in OEH benchmark sites for Central Hunter Grey Box-Ironbark Woodland. A comparison of total native species richness for Woodland – EEC rehabilitation sites against the OEH benchmarks is presented in the Native Plant Species (NPS) column of Table 39.

Table 22. Species richness MOP performance criteria

Performance Criteria – Ecosystem and Landuse Establishment		Subheading	Domain Type	Table Number
6	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland - Other	Table 24 and Table 26
9	The number of shrub species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
10	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
11	The number of subshrub species and understorey species (other than grasses) comprising the vegetation community is comparable to that of analogue sites (no. species/area).	Species Richness	Woodland EEC	Table 25
12	The native plant species richness is within 50-100% or exceeds that of analogue sites (no. species/area). (Use benchmark values)	Species Richness	Woodland EEC	Table 39

Table 23. 2017 Reference site native species count

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Sites					
BEL1	2	6	4	12	24
BEL2	2	4	4	12	22
BEL3	4	4	6	12	26
WAMBOG1	2	4	5	12	23
WAMBOGB2	1	6	9	12	28
WAMBOSPOT1	4	9	4	13	30
WAMBOSPOT2	4	7	8	12	31
WAMBOSPOT3	3	7	6	13	29
WARKGB01	2	5	5	14	26
WARKGB02	2	6	7	20	35
WARKGB03	3	6	6	11	26
WARKGB04	2	5	6	10	23
Reference Site Average	**3**	**6**	**6**	**13**	**28**
Reference Site Range	**1 - 4**	**4 - 9**	**4 - 9**	**10 - 20**	**22 - 35**

Table 24. 2017 HVO Rehabilitation sites native species count (Woodland – other domain type)

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Site Average	3	6	6	13	28
Reference Site Range	1 - 4	4 - 9	4 - 9	10 - 20	22 - 35
HVOCAR200901	3	4	1	0	8
HVOCAR200902	3	3	2	0	8
HVOCAR201401*	0	0	2	2	4
HVOCHE201201	0	0	2	3	5
HVOCHE201203*	0	0	2	1	3
HVOCHE201401*	0	0	3	0	3
HVORIV201401	3	5	6	6	20
HVORIV201402	1	1	4	2	8
HVORIV201403	0	2	5	3	10
HVORIV201404	0	2	3	4	9
HVORIV201405	0	0	1	0	1
HVORIV201406	0	0	5	4	9
HVOWES200801	4	6	7	2	19
HVOWES201101	6	7	5	3	21
HVOWES201301	4	2	6	2	14
HVOWES201302*	0	0	4	2	6
HVOCHE201501	0	0	0	3	3
HVOCHE201601	0	0	2	1	3
HVOCHE201602	0	0	1	1	2
HVOLEM201501	1	2	7	3	13
HVOLEM201601	1	5	3	5	14
HVORIV201501	0	0	11	2	13
HVORIV201502	0	0	2	5	7
HVORIV201503	4	4	10	4	22
HVORIV201601	0	0	1	1	2
HVOWES201601	0	3	5	4	12
HVOWES201602	3	11	12	11	37
HVOWES201603	4	6	11	5	26
HVOWES201604	0	6	8	6	20
HVO Average	1.3	2.5	4.6	3.3	11.7

lower than reference site range values

within reference site range values

exceeds reference site range values

not a MOP performance criteria for this domain type

Notes: * = sites that have not yet been sown with native seed mixes and therefore excluded from site averages.

Table 25. 2017 MTW Rehabilitation sites native species count (Woodland EEC domain type)

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Site Average	3	6	6	13	28
Reference Site Range	1 - 4	4 - 9	4 - 9	10 - 20	22 - 35
MTWCDD201101	4	10	5	6	25
MTWCDD201301*	0	0	0	0	0
MTWCDD201501	3	7	13	3	26
MTWMTO200503	2	0	6	12	20
MTWNPN200901	4	6	2	1	13
MTWNPN201101	2	9	2	3	16
MTWNPN201301	0	7	5	3	15
MTWNPN201401	0	12	9	3	24
MTWNPN201403	1	3	3	2	9
MTWSPN201401*	0	0	4	0	4
MTWTDI201501	1	2	8	1	12
MTWWDL201401	3	8	6	6	23
MTWWDL201402*	0	0	5	2	7
MTWNOO201501	0	3	7	3	13
MTWSPN201501	0	0	1	0	1
MTWSPN201601	0	0	0	0	0
MTWSPN201602	0	2	6	5	13
MTWSPS201601	0	0	2	4	6
MTWSPS201602	0	0	0	0	0
MTWNPN201402	0	10	5	7	22
MTW Average	1.1	3.6	4.4	2.8	11.9

lower than reference site range values

within reference site range values

exceeds reference site range values

MOP performance criteria for this domain relates to comparison with OEH benchmark (see Table 39)

Notes: * = sites that have not yet been sown with native seed mixes and therefore excluded from site averages.

Table 26. 2017 MTW rehabilitation sites native species count (Woodland – other domain type)

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Site Average	3	6	6	13	28
Reference Site Range	1 - 4	4 - 9	4 - 9	10 - 20	22 - 35
MTWMTO200001	2	2	0	9	13
MTWNPN200501	1	2	4	6	13
MTWNPN200502	2	4	2	2	10
MTWMTO201501	0	0	0	0	0

MTWMTO201601	0	0	2	1	3
MTW Average	**1.0**	**1.6**	**1.6**	**3.6**	**7.8**

	lower than reference site range values
	within reference site range values
	exceeds reference site range values
	not a MOP performance criteria for this domain type

Notes: * = sites that have not yet been sown with native seed mixes and therefore excluded from site averages

4.2.3 Canopy Development

Table 27. Tree species and canopy development MOP performance criteria

Performance Criteria – Ecosystem and Landuse Establishment		Subheading	Domain Type	Table Number
5	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland - Other	Table 29 and Table 31
7	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland - Other	Table 29 and Table 31
8	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland EEC	Table 30
13	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland EEC	Table 30

Reference site stem density counts

At each rehabilitation and reference site the stem density of canopy species was recorded within two 50 metre x 2 metre quadrats, running along either side of the 50 metre tape. The number of each different kind of over-storey species was recorded and the results are summarised in Table 28 - Table 31, with full results provided in Appendix 6.

Table 28. Details of canopy regeneration at reference sites

Site	Number of species	Stems per hectare (ha)
WAMBOGB1	2	950
WAMBOGB2	1	250
WARKGB01	2	3150
WARKGB02	2	1050
WARKGB03	3	2750
WARKGB04	2	500
Average	**2**	**1442**
BELLSPOT1	2	300
BELLSPOT2	2	850
BELLSPOT3	4	1000
WAMBOSPOT1	4	1650
WAMBOSPOT2	4	950
WAMBOSPOT3	3	800
Average	**3.2**	**925**
Total Average	**3**	**1183**
Range	**1 - 4**	**250 - 3150**

Table 29. Details of canopy regeneration at HVO rehabilitation sites 2017 (Woodland – other)

Site	Number of species	Stems per hectare (ha)	Natives sown (Y/N)
Reference Site Range	**1 - 4**	**250 - 3150**	
HVOCAR200901	3	1900	Y
HVOCAR200902	3	2400	Y
HVOCAR201401	0	0	N
HVOCHE201201	0	0	Y
HVOCHE201203	0	0	N
HVOCHE201401	0	0	N
HVORIV201401	3	350	Y
HVORIV201402	1	50	Y
HVORIV201403	0	0	Y
HVORIV201404	0	0	Y
HVORIV201405	0	0	Y
HVORIV201406	0	0	Y
HVOWES200801	4	4250	Y
HVOWES201101	6	4650	Y
HVOWES201301	4	600	Y
HVOWES201302	0	0	N
HVOLEM201501	1	100	Y
HVORIV201501	1	50	Y
HVORIV201503	1	50	Y

HVOWES201602	4	1000	Y
HVOWES201603	1	50	Y
HVOCHE201501	0	0	N
HVOCHE201601	0	0	N
HVOCHE201602	0	0	N
HVOLEM201601	0	0	N
HVORIV201502	0	0	N
HVORIV201601	0	0	N
HVOWES201601	0	0	N
HVOWES201604	0	0	N
Average	**1.9**	**908.8**	

	lower than reference site range values
	within reference site range values
	exceeds reference site range values

Notes: Sites which have not yet been sown with native seed mixes have been excluded from site averages.

Table 30. Details of canopy regeneration at MTW rehabilitation sites 2017 (Woodland – EEC)

Site	Number of species	Stems per hectare (ha)	Natives sown (Y/N)
Reference Site Range	**1 - 4**	**250 - 3150**	
MTWCDD201101	4	1750	Y
MTWCDD201301	0	0	N
MTWCDD201501	3	4850	Y
MTWMTO200503	2	1150	Y
MTWNPN200901	4	3500	Y
MTWNPN201101	2	600	Y
MTWNPN201301	0	0	Y
MTWNPN201401	0	0	Y
MTWNPN201402	0	0	Y
MTWNPN201403	1	100	Y
MTWSPN201401	0	0	N
MTWTDI201501	1	50	Y
MTWWDL201401	3	750	Y
MTWWDL201402	0	0	N
MTWNOO201501	0	0	N
MTWSPN201501	0	0	N
MTWSPN201601	0	0	N
MTWSPN201602	0	0	N
MTWSPS201601	0	0	N
MTWSPS201602	0	0	N
Average	**2.0**	**1159.1**	

lower than reference site range values

within reference site range values

exceeds reference site range values

Notes: Sites which have not yet been sown with native seed mixes have been excluded from site averages.

Table 31. Details of canopy regeneration at MTW rehab sites 2017 (Woodland – other)

Site	Number of species	Stems per hectare (ha)	Natives sown (Y/N)
Reference Site Range	**1 - 4**	**250 - 3150**	
MTWMTO200001	2	850	Y
MTWNPN200501	1	100	Y
MTWNPN200502	2	1500	Y
MTWMTO201501	0	0	N
MTWMTO201601	0	0	N
Average	**1.7**	**816.7**	

lower than reference site range values

within reference site range values

exceeds reference site range values

Notes: Sites which have not yet been sown with native seed mixes have been excluded from site averages.

4.3 Ecosystem and Landuse Sustainability

4.3.1 Vegetation Structure and Species Richness

Results for vegetation structure and species richness for both reference and rehabilitation sites are displayed in Table 37 to Table 41 below. Both OEH and the calculated reference site benchmark values are also shown.

Table 32. Vegetation Structure and Species Richness MOP performance criteria

Performance Criteria – Ecosystem and Landuse Sustainability		Subheading	Domain Type	Table Number
1	Weed plant cover (calculated as a percentage of total ground cover) is comparable to that of analogue sites. (% Cover)	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
11	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites.	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
12	The percentage of native over storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
13	The percentage of native mid storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
14	The percentage of native ground cover (grasses) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
15	The percentage of native ground cover (shrubs) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
16	The percentage of native ground cover (other) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
17	Exotic plant cover (calculated as a percentage of total ground cover and mid storey cover) is within 5-33% or less than that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
19	The abundance of native understorey species per square metre, averaged across the site, provides an indication of the heterogeneity of the site and that the number of native species is comparable to analogue sites (no. species/m^2).	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
28	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39

Reference sites

OEH Benchmark values

The OEH Benchmark Values for both Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest are provided in Table 33.

Based on a comparison of the OEH benchmark values for the two communities the following can be concluded:

- Grey-Box Ironbark Woodland has a higher NPS compared to Ironbark Spotted Gum-Grey Box Forest
- Spotted Gum – Grey Box Forest has a greater NOS range compared to Grey-Box Ironbark Woodland
- Spotted Gum – Grey Box Forest has a greater NMS range compared to Grey-Box Ironbark Woodland
- Ironbark Spotted Gum-Grey Box Forest has a greater NGCG and a greater NGCG range compared to Grey-Box Ironbark Woodland
- Grey-Box Ironbark Woodland has the same NGCS range as Ironbark Spotted Gum – Grey Box Forest
- Grey-Box Ironbark Woodland has a greater NGCO compared to Ironbark Spotted Gum-Grey Box Forest
- NTH is greater in Grey-Box Ironbark Woodland
- FL is far greater within Ironbark Spotted Gum – Grey Box Forest.

Table 33. OEH Benchmark values for Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest

Plot name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Grey-Box Ironbark Woodland OEH Benchmark Upper and Lower Limits	≥41	15	40	5	20	30	50	5	10	20	40	0	3	1	≥5
Spotted Gum – Grey Box Forest OEH Benchmark Upper and Lower Limits	≥25	20	50	10	60	5	16	5	10	5	15	0	1	1	≥66

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.

4.3.2 Reference sites against OEH Benchmark values

BioBanking data collected at each of the reference sites was input into the OEH BioBanking Benchmark Calculator to provide the lower and upper benchmark ranges for each attribute. The OEH benchmarks values have been compared to the reference site benchmark values below in Table 34 and Table 35.

Table 34. OEH benchmarks and 2017 reference site benchmarks

Reference site name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Central Hunter Grey Box-Ironbark Woodland															
WamboGB01	25	9.5		0.5		40		2		2		0	0	1	11
WamboGB02	28	13.5		0		32		6		6		0	0	1	22
WARKGB01	25	11.5		8		20		8		2		2	1	1	26
WARKGB02	37	21.5		1		66		0		8		0	0	1	60
WarkGB03	25	7.5		1		32		0		2		0	0	1	15
WarkGB04	22	6		0		26		10		14		0	1	1	10
Reference Site Benchmark Upper and Lower Limits	≥27	13.3	22.8	0.0	10.0	18.0	33.0	1.0	11.0	3.0	26.0	0	≥1	1	≥21
OEH Benchmark Upper and Lower Limits	≥41	15	40	5	20	30	50	5	10	20	40	0	3	1	≥5
Central Hunter Ironbark-Spotted Gum-Grey Box Forest															
BEL1	25	13		0		38		0		14		0	0	1	17
BEL2	22	19.5		0		22		2		36		6	0	1	24
BEL3	25	17		0		14		4		16		4	0	1	27
WamboSpot1	28	14		14.5		28		8		2		0	4	1	82
WamboSpot2	29	13.5		0		24		12		4		0	1	1	15
WamboSpot3	29	26		5.5		22		10		4		0	2	1	12
Reference Site Benchmark Upper and Lower Limits	≥25	6.8	17.5	0.0	4.5	23.0	53.0	0.0	9.0	2.0	11.0	0	≥0	1	≥19
OEH Benchmark Upper and Lower Limits	≥25	20	50	10	60	5	16	5	10	5	15	0	≥1	1	≥66

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.

Table 35. OEH benchmarks and 2016 reference site benchmarks

Reference site name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Central Hunter Grey Box-Ironbark Woodland															
WamboGB01	34	13		7		50		6		32		0	0	1	7
WamboGB02	35	19		0		62		12		12		0	0	1	23
WARKGB01	28	15		23		38		0		38		2	0	1	4.5
WARKGB02	31	14.5		1		70		0		62		0	0	1	22
WarkGB03	31	18.5		0		54		0		16		0	0	1	27
WarkGB04	29	2		0		64		28		16		4	1	1	3
Reference Site Benchmark Upper and Lower Limits	≥31	7.5	18.8	0	15.0	44.0	67.0	0	20.0	14.0	50.0	0	≥0	1	≥15
OEH Benchmark Upper and Lower Limits	≥41	15	40	5	20	30	50	5	10	20	40	0	3	1	≥5
Central Hunter Ironbark-Spotted Gum-Grey Box Forest															
BEL1	34	10.5		0		56		2		22		0	0	1	60
BEL2	35	38		2		56		6		50		0	0	1	13.5
BEL3	33	26.5		0		36		2		50		0	0	1	64
WamboSpot1	32	27		14		38		4		12		0	4	1	74
WamboSpot2	27	21		7.5		40		6		12		0	0	1	12
WamboSpot3	34	29		15		30		8		16		0	4	1	13
Reference Site Benchmark Upper and Lower Limits	≥34	15.8	33.5	0.0	14.5	33.0	56.0	2.0	7.0	12.0	50.0	0	≥0	1	≥37
OEH Benchmark Upper and Lower Limits	≥25	20	50	10	60	5	16	5	10	5	15	0	1	1	≥66

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.

Table 36. Combined reference site benchmarks using combined data from all reference sites and from both 2016 and 2017 monitoring

Reference site name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Reference Site Benchmark Upper and Lower Limits	≥28	7.4	26.6	0.0	14.6	21.8	64.2	0	10.2	2.0	39.2	0	≥1	1	≥20

Based on a comparison of the reference site benchmarks to the OEH benchmarks of Central Hunter Grey Box-Ironbark Woodland, the following conclusions can be made:

- Reference sites have a lower limit for most attributes, except NGCG and FL
- NPS for the reference site benchmark had a total of 14 species less than the OEH benchmark
- NOS for reference site benchmark has a smaller range than the OEH benchmark and this may be attributed to the historic clearing of the reference sites
- NMS for the reference site benchmark has a lower value of zero, whilst the OEH benchmark has a lower value of five percent
- NGCG for the reference site benchmark has a small range compared to the OEH benchmark
- NGCS for the reference site benchmark has a lower value of one and a higher upper value compared to the OEH benchmark
- NGCO for the reference site benchmark has a lower value of three, whilst the OEH benchmark has a lower value of 20 percent
- FL is higher for the reference site benchmark than the OEH benchmark.

Based on a comparison of the local benchmarks to the OEH benchmarks of Central Hunter Ironbark-Spotted Gum-Grey Box Forest, the following conclusions can be made:

- NPS was the same for the local benchmark and OEH benchmark
- NOS for reference site benchmark has a smaller range than the OEH benchmark and this may be attributed to the historic clearing of the reference sites
- NMS for the reference site benchmark has a lower benchmark value of zero compared to a lower OEH benchmark of ten and the reference site benchmark also has a significantly lower upper value compared to the OEH benchmark
- NGCG for the reference site benchmark is significantly higher compared to the the OEH benchmark
- NGCS for the reference site benchmark has a greater range compared to OEH benchmark
- NGCO for the reference site benchmark has a slightly lower range compared to OEH benchmark
- FL has a lower reference site benchmark than the OEH benchmark.

Considerable variation can be seen between the 2016 and 2017 local benchmark data (Table 34 and Table 35):

- NPS, NMS and NGCG decreased in both vegetation types in 2017 compared with 2016
- NOS has increased slightly in Central Hunter Grey Box-Ironbark Woodland, although it has decreased in Central Hunter Ironbark-Spotted Gum-Grey Box Forest in 2017
- NGCS has decreased for Central Hunter Grey Box-Ironbark Woodland while the range for Central Hunter Ironbark-Spotted Gum-Grey Box Forest in 2017 has increased
- NGCO has reduced substantially over both vegetation from 2016 to 2017
- Another hollow was recorded in Central Hunter Grey Box-Ironbark Woodland bringing the benchmark up to ≥1 from ≥0 the previous year
- FL has decreased substantially for Central Hunter Ironbark-Spotted Gum-Grey Box Forest in 2017, while the range for Central Hunter Grey Box-Ironbark Woodland has increased slightly.

A combined reference site benchmark has been established utilising data from both Central Hunter Ironbark-Spotted Gum-Grey Box Forest and Central Hunter Grey Box-Ironbark Woodland (Table 36). This benchmark calculation includes data from both 2016 and 2017 and aims to provide a representative benchmark of general vegetation within the region.

4.3.3 Biobanking values for rehabilitation sites against OEH benchmarks and reference site benchmarks.

The MOP performance criteria for Woodland – Other domains require analysis of biometric data against reference sites benchmark values (see Table 37 - Table 38). The MOP performance criteria for Woodland – EEC domains require analysis of biometric data against OEH benchmark values (see Table 39). The data has been tabulated based on site and domain type.

Table 37. HVO Woodland – other rehabilitation sites compared to the combined reference site benchmarks

Plot name	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL
Combined Benchmark	≥28	7.4 26.6	0.0 14.6	21.8 64.2	0 10.2	2.0 39.2	0	≥1	1	≥20
HVOCAR200901	9	0	13	0	4	2	30	0	0	0
HVOCAR200902	10	8	0	0	0	0	74	0	0	0
HVOCAR201401*	4	0	0	0	0	0	74	0	0	0
HVOCHE201201	5	0	0	0	0	18	14	0	0	0
HVOCHE201203*	3	0	0	20	0	0	64	0	0	0
HVOCHE201401*	3	0	0	28	0	0	42	0	0	0
HVORIV201401	18	0	0	4	4	20	50	0	0	0
HVORIV201402	7	0	0	14	0	4	38	0	0	0
HVORIV201403	11	0	0	24	0	2	52	0	0	0
HVORIV201404	10	0	0	16	4	10	10	0	0	0
HVORIV201405	1	0	0	0	0	0	60	0	0	0
HVORIV201406	9	0	0	0	2	4	34	0	0	0
HVOWES200801	16	11	2	16	0	2	10	0	0	0
HVOWES201101	21	8	0	12	2	24	10	0	0	0
HVOWES201301	14	0	0	30	0	8	30	0	0	0
HVOWES201302*	0	0	0	50	0	8	30	0	0	0
HVOCHE201501	0	0	0	0	0	0	80	0	0	0
HVOCHE201601	0	0	0	0	0	0	0	0	0	0
HVOCHE201602	0	0	0	2	0	0	0	0	0	0
HVOLEM201501	0	0	0	94	0	0	18	0	0	0
HVOLEM201601	0	0	0	14	4	2	52	0	0	0
HVORIV201501	13	0	0	52	0	0	76	0	0	0
HVORIV201502	7	0	0	0	0	16	100	0	0	0
HVORIV201503	22	0	0	32	4	10	66	0	0	0
HVORIV201601	2	0	0	0	0	0	92	0	0	0
HVOWES201601	12	0	0	64	0	0	88	0	0	0
HVOWES201602	37	0	0	62	24	4	18	0	0	0
HVOWES201603	26	0	0	40	0	0	74	0	0	0
HVOWES201604	20	0	0	42	0	4	38	0	0	0

lower than reference site benchmark

within reference site benchmark

exceeds reference site benchmark

not a MOP performance criteria for this domain type

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.
Notes: 1. * = Sites which have not yet been sown with native seed mixes; 2. A low value for Exotic Plant Cover (EPC) is the desired result.

Table 38. MTW Woodland – other rehabilitation sites compared to the combined reference site benchmarks

Plot name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Combined Benchmark	≥28	7.4	26.6	0.0	14.6	21.8	64.2	0	10.2	2.0	39.2	0	≥1	1	≥20
MTWMTO200001	12	0.5		0		0		0		40		18	0	0	0
MTWNPN200501	12	0		3.5		12		0		0		22	0	0	0
MTWNPN200502	11	16.5		12		0		4		0		34	0	0	0
MTWMTO201501	4	0		0		0		0		2		72	0	0	0
MTWMTO201601	0	0		0		10		0		0		34	0	0	0

	lower than reference site benchmark
	within reference site benchmark
	exceeds reference site benchmark
	not a MOP performance criteria for this domain type

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.
Notes: 1. * = Sites which have not yet been sown with native seed mixes; 2. A low value for Exotic Plant Cover (EPC) is the desired result.

Table 39. MTW Woodland – EEC rehabilitation sites compared to the Central Hunter Grey Box – Ironbark Woodland OEH benchmarks

Plot name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Central Hunter Grey Box-Ironbark Woodland OEH benchmark	≥41	15	40	5	20	30	50	5	10	20	40	5-33%	3	1	≥5
MTWCDD201101	24	3		6		18		48		12		2	0	0	0
MTWCDD201301*	0	0		0		0		0		0		90	0	0	0
MTWCDD201501	24	0		5		26		24		10		16	0	0	0
MTWMTO200503	19	0.5		0		10		0		6		78	0	0	0
MTWNPN200901	13	17		2.5		2		18		2		2	0	0	0
MTWNPN201101	16	0		5.5		12		26		0		46	0	0	0
MTWNPN201301	16	0		0		12		6		16		28	0	0	0
MTWNPN201401	24	0		8.3		30		22		4		26	0	0	0
MTWNPN201403	10	0		0		6		2		10		66	0	0	0
MTWSPN201401*	4	0		0		16		0		0		10	0	0	0
MTWTDI201501	13	0		0		34		0		50		20	0	0	0
MTWWDL201401	23	0		1.5		20		26		16		16	0	0	0
MTWWDL201402*	7	0		0		10		0		0		80	0	0	0
MTWNOO201501	0	0		0		40		0		2		56	0	0	0
MTWSPN201501	1	0		0		0		0		0		0	0	0	0
MTWSPN201601	0	0		0		0		0		0		0	0	0	0
MTWSPN201602	13	0		0		32		0		0		38	0	0	0
MTWSPS201601	6	0		0		0		0		4		58	0	0	0
MTWSPS201602	0	0		0		0		0		0		34	0	0	0
MTWNPN201402	22	4.9		11.6		54		46		8		8	0	0	0

	lower than 50% of OEH benchmark
	within 50 – 100% of OEH benchmark
	exceeds OEH benchmark

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.
Notes: 1. * = Sites which have not yet been sown with native seed mixes; 2. A low value for Exotic Plant Cover (EPC) is the desired result; 3. MOP Performance Criteria target of 5-33% used for comparison for EPC.

4.3.4 Vegetation Health

Results of vegetation health for reference and rehabilitation sites can be seen in Table 41 and Table 42 below.

Table 40. Vegetation Health MOP performance criteria

Performance Criteria – Ecosystem and Landuse Sustainability		Subheading	Domain Type	Table Number
3	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no. /area).	Vegetation Health	Woodland - Other	Table 42
4	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
5	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no. /area).	Vegetation Health	Woodland - Other	Table 42
6	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - Other	Table 42
7	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
8	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
9	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
10	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - Other	Table 42
20	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no. /area).	Vegetation Health	Woodland - EEC	Table 42
21	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
22	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no. /area).	Vegetation Health	Woodland - EEC	Table 42
23	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - EEC	Table 42
24	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
25	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
26	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
27	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - EEC	Table 42

Reference site canopy maturity and habitat values

At each reference site, individual canopy tree species with a DBH greater than five centimetres were marked with a metal tree tag or flagging tape and were numbered. This will allow future monitoring to identify trees that were included in counts and DBH measurements. Whether an individual had flowers or fruit was determined by whether there was evidence of these structures on the tree at the time of survey. Therefore, this is likely to under-estimate the maturity of the tree canopy. The results are provided below in Table 41. Full data is provided in Appendix 6.

Table 41. Details of canopy maturity at reference sites

Site name	Average tree width (cm)	Native trees >5cm DBH (20x20 plot)	Native trees >5cm DBH per hectare	Native tree species >5cm DBH	Native trees with fruit/flowers
WAMBOGB1	11.5	22	550	4	0
WAMBOGB2	22	4	100	2	0
WARKGB1	14.8	25	625	2	0
WARKGB2	14	24	600	2	0
WARKGB3	14.5	28	700	3	0
WARKGB4	65	2	50	1	0
BELLSPOT1	18.7	20	500	2	0
BELLSPOT2	19	13	325	2	0
BELLSPOT3	15	21	525	3	0
WAMBOSPOT1	22.5	8	200	3	0
WAMBOSPOT2	10.75	29	725	2	2
WAMBOSPOT3	22	9	225	3	0
Total Average	**20.8**	**17**	**427.1**	**2.4**	**0.16**
Reference Site Range	**11.5 - 65**	**2 - 29**	**50 - 725**	**1 - 4**	**0 - 2**

Rehabilitation site canopy maturity and habitat values

As for reference sites, each individual canopy tree at rehabilitation sites with a DBH greater than five centimetres were marked with a metal tree tag or flagging tape and numbered. Only a limited number of rehabilitation sites had canopy trees with a DBH greater than five centimetres. Whether an individual had flowers or fruit was determined by whether there was evidence of these structures on the tree at the time of survey. This technique is also likely to under-estimate the maturity of the tree canopy for rehabilitation sites but the same method has been applied at reference sites to provide an equal comparison. The canopy maturity results are provided in Table 42. Full data is provided in Appendix 6.

Table 42. Details of canopy maturity at all rehabilitation sites – split by location and domain type

Site name	Average tree width (cm)	Native trees >5cm DBH (20x20 plot)	Native trees >5cm DBH per hectare	Native tree species >5cm DBH	Native trees with fruit/flowers
Reference Site Range	**11.5 - 65**	**2 - 29**	**50 - 725**	**1 - 4**	**0 - 2**
HVOCAR200901	10.5	25	625	3	0
HVOCAR200902	6.5	4	100	3	0
HVOWES200801	6.1	38	950	2	0
HVOWES201101	6.2	17	425	2	0
Average	**7.3**	**21**	**525**	**2.5**	**0**
MTWCDD201101	5.8	17	425	2	2
Average	**5.8**	**17.0**	**425.0**	**2.0**	**2.0**
MTWMTO200001	7.1	6	150	1	0
MTWNPN200501	15	2	50	1	0
MTWNPN200502	9.1	30	750	3	0
Average	**10.4**	**12.7**	**316.7**	**1.7**	**0.0**
Total Average	**8.2**	**17.37**	**434.4**	**2.13**	**0.16**

	lower than reference site range values
	within reference site range values
	exceeds reference site range values

4.3.5 Habitat Features

Habitat features such as fallen logs and number of hollow bearing trees were recorded using the BioBanking methodology. The results for these performance criteria are presented in Table 39 of the BioBanking data. The total groundcover components (dead and live plant material, rocks and logs) can be seen in the Stability column of the LFA results in Table 16 to Table 18.

Table 43. Habitat Features MOP performance criteria

Performance Criteria – Ecosystem and Landuse Sustainability		Subheading	Domain Type	Table Number
2	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover)	Habitat Features	Woodland - Other	Table 16 and Table 17
18	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover).	Habitat Features	Woodland - EEC	Table 18
29	The total length of fallen logs is within 50-100% or exceeds that of analogue sites. (Use benchmark values)	Habitat Features	Woodland - EEC	Table 39
30	The number of hollows / nesting sites is within 50-100% or exceeds that of analogue sites. (Use benchmark values)	Habitat Features	Woodland - EEC	Table 39

All rehabilitation sites were recorded as having no fallen logs, therefore, not within the 2017 reference site range values (for Woodland – Other domains) or within 50-100% of OEH benchmark levels (for Woodland – EEC domains).

The results in Table 39 of the BioBanking data show zero hollow bearing trees recoded across all rehabilitation sites.

Total groundcover at the rehabilitation sites, including protective ground cover components such as dead and live plant material, rocks and logs, has been compared to the reference sites using the LFA data. This can be seen in Table 16, Table 17, and Table 18 of Section 4.2.1 within the LOI column of the LFA results where total groundcover percentage for rehabilitation sites from the 2017 monitoring is compared with the reference site range values.

4.3.6 Visual and Photo Monitoring (Appendix)

The results of the visual monitoring, and photo monitoring are provided in Appendix 5.

5. Discussion

5.1 Growth Medium Development

5.1.1 Soil Analysis

Overall, many of the rehabilitation sites fall within the MOP performance criteria targets or reference site soil property range values and therefore meet the MOP performance criteria. The following conclusions can be made from comparing rehabilitation sites against reference site range values (where applicable) or the target specified in the MOP performance criteria:

- pH falls between the target values specified in the MOP at all sites except HVORIV201404, HVORIV201403, HVORIV201402, HVORIV201401, MTWCDD201501, MTWTDI201501 and MTWMTO201501. These sites have only recently been established and it may take some time for the pH to reduce and become less alkaline, as is seen in older sites. While most sites fall between the values specified in the MOP, many rehabilitation sites show higher levels of pH than that of the reference sites.
- Electrical Conductivity (EC) falls within the required target of <2dS/m as outlined in the MOP for all sites, however the rehabilitation sites are generally higher than the reference site range.
- Phosphorous levels only meet benchmark at two sites, MTWNPN200901-A and MTWCDD201101. Levels of phosphorus at rehabilitation sites were markedly higher than those recorded at reference sites. Many of the older sites do not meet the performance criteria of being within analogue levels within five years of establishment.
- Organic Carbon has met benchmark for all sites excluding HVOCAR200902 and HVOCHE201203. This is likely due to compost being added and the organic matter from short-lived annuals. Sites with a higher number of exotic cover tended to have higher Organic Carbon. These higher Organic Carbon levels may also make it difficult for native species to compete on sites with higher densities of exotic species.
- Cation Exchange Capacity (CEC) falls between benchmark for approximately 70 percent of sites.
- Approximatly 46 percent of rehabilitation sites did not meet benchmark for sodium levels.
- Half of the HVO rehabilitation sites and the MTW woodland – other domain sites did not meet the reference site benchmark for Calcium / Magnesium Ratio. MTW woodland – EEC rehabilitation sites all fell within benchmark levels for Calcium / Magnesium Ratio.

5.2 Ecosystem and Landuse Establishment

5.2.1 Landscape Function Analysis (LFA)

LFA data was used to help understand landscapes stability, infiltration and Nutrient cycling capacity. These characteristics are discussed seperatly below.

5.2.2 Landscape Organisation Index (LOI)

In general the LOI at the reference and rehabilitation sites was high, with an average LOI of 0.98 for the reference sites and 0.9, 0.8 and 0.7 for the rehabilitation sites for HVO – woodland other, MTW – woodland other and MTW – woodland EEC respectively (see Table 15 - Table 21). The variability in the range of scores however, was greater at the rehabilitation sites than the reference sites. The variability in values at the rehabilitation sites is likely to be influenced by the seed treatments applied to those sites and the age of the rehabilitation. For example, many of the rehabilitation sites with a LOI of 1 achieved this result due to the high density of grass species (whether native or exotic). An example of one of these sites with a high density of exotic grasses is HVORIV201405, which is similar to that observed in 2016. This result highlights that LOI does not determine native cover per se, rather it’s a determination of site stability. Conversely, sites that achieved relatively low LOI indices were typically spoil/compost sites that had only recently been established and exhibited little grass or plant cover (i.e. MTWSPN201501 and MTWSPN201601). Changes in the LOI between 2016 and 2017 can be seen in Table 16 - Table 21.

5.2.3 Soil surface condition

Stability

There's some level of consistency between the average stability index for reference and rehabilitation sites, with the reference sites obtaining an average index of 60.75 and the rehabilitation sites obtaining an average scores of 57.8 for HVO woodland – other, 50.4 MTW woodland – other, and 54.8 MTW woodland – EEC sites. As with the results from the LOI (above), stability indicators across the reference sites show greater consistency than the stability indicators for the rehabilitation sites. One of the indicators of stability is vegetation cover, which due to weed treatment (herbicide spray) at some rehabilitation sites, had reduced. This may have contributed to a reduction in the average score at rehabilitation sites. Changes in scores for stability between 2016 and 2017 for reference sites at HVO and MTW can be found in Table 16 - Table 21.

Infiltration

The average infiltration scores for rehabilitation sites overall from 2016 to 2017 has increased from 42.4 to 51.1 for HVO for woodland - other and 37.4 to 41.6 for MTW woodland – other sites. MTW woodland – EEC has dropped slightly from 47.8 to 43.7. This is likely due to the addition of new sites to this domain type. The range of scores was greater for the rehabilitation scores than for the reference sites. This may be due to an increase in the litter component at most rehabilitation sites. Under the methodology, dead and decaying vegetation forms litter and this probably contributed to the higher infiltration scores.

Nutrient cycling

Nutrient enrichment values between 2016 and 2017 showed no obvious trend with the average difference for the reference sites increasing from 51.43 to 55.5, while the average for the rehabilitation sites has decreased from 43.2 to 42.7 for HVO for woodland - other, 35.4 to 32.5 for MTW woodland – other and 45.1 to 39.7 for MTW woodland – EEC site in 2016 to 2017. This is likely due to the addition of new monitoring sites.

5.2.4 Species Richness

Tree species

The results of the native species counts for tree species are discussed in Section 5.2.5 Canopy Development.

Grass species

The reference sites recorded a range between 4 and 9, averaging six grass species overall. Rehabilitation sites were lower recording averages of 4.6 for HVO woodland – other, 4.4 for MTW woodland – EEC and 1.6 for woodland – other sites. At HVO, eleven sites met benchmark for this criteria with four exceeding the benchmark range. Eleven MTW woodland – EEC sites met the benchmark, with one exceeding the benchmark range. Only one of the woodland other domain types at MTW met benchmark for this criteria.

Shrub Species

MTW woodland – EEC domain contained sixteen sites that fell within or exceeded the reference site range, with an average of 3.6 shrub species for MTW woodland - EEC. This average was bought down by the inclusion of the younger sites, none of which meet the local benchmark for number of shrub species.

Other Species

MTW woodland – EEC domain contained only one site each that met the reference site range The average for these sites was 2.8 which is low in comparison with the reference sites average of 13 species. This may indicate that rehabilitation sites require a greater diversity or higher rate of herbs and forbs added to the seeding mix.

Native plant species richness

MTW woodland – EEC had five sites that were within the MOP target of 50-100% of the OEH benchmark value for native plant species richness. Most sites contain adequate numbers of tree, shrub and grass species, however, they lacked other species such as herbs and forbs which has reduced the overall number of native plant species per site.

The current diversity targets that are in place to guide seed mix formulation require 10 species of herbs and forbs to be included in each seed mix for planting of MTW Woodland – EEC areas. Given the low rates of establishment of herbs and forbs in rehabilitation areas, further investigation of the suitability of the species being included in seed mixes to rehabilitation areas may be warranted. If species currently being used in seed mixes are found to be problematic to germinate or establish in rehabilitation areas then other species that are more suited to rehabilitation areas should be investigated. To achieve higher diversity of herbs and forbs in rehabilitation areas it may also be necessary to increase the sowing rate of herbs and forbes that are added to seed mixes. Low rates of herb and forb establishment may also be due to these species not having enough over-storey protection which may require enrichment planting of herbs and forbs into established rehabilitation areas to address this issue.

5.2.5 Canopy Development

Number of tree species

HVO woodland – other sites contained 12 sites that was within or exceeded the reference site range of 1 to 4 species. These sites recorded an average score of 1.9. MTW woodland – other sites contained three sites that were within the reference site range, with an average score of 1.7.

MTW woodland – EEC contained eight sites that fell within the reference site range. The average value recorded for these sites was 2. Many of the rehabilitation sites had not been broadcast with native seed at time of recording, and as such have not been included in the average.

Many of the tree species recorded over the sites were still at a juvenile stage which made it difficult to correctly identify all individuals to a species level. Furthermore, some seeds may not have germinated at this early stage. Overstorey species richness should continue to be monitored and dependant on the results some site may require additional seeding or enrichment planting in the future to promote the number of overstorey species.

Canopy density

Six HVO woodland – other domain type sites met the reference site range of 250 to 3150 stems per hectare. Two sites HVOWES200801 and HVOWES201101 exceeded the benchmark range. These eight sites recorded an average score of 908.8 stems per hectare. Of the HVO woodland - other sites HVOCHE201201, HVORIV201403, HVORIV201404, HVORIV201405 and HVORIV201406 have previously been sown to natives but have no overstorey species recoded.

The MTW woodland – other sites contained two sites that met the benchmark range, with sites recording an average score of 816.7. All sites that had been sown to natives had overstorey species germinate.

MTW woodland – EEC sites contained four sites that fell within the local benchmark. Two sites MTWCDD201501 and MTWNPN200901 exceeded this benchmark. The average value recorded for these sites was 1,159.1 stems per hectare. MTWNPN201301, MTWNPN201401 and MTWNPN201402 had been previously sown to natives, however, showed no sign of overstorey species germinating.

All the domain types show a large range of variation between sites, in particular MTW woodland – EEC, has sites ranging from 0 to a density up to 4,850 stems per hectare which exceeded the benchmark. Some sites may require tree thinning in the future to more closely align with reference site range values. Thinning will allow understory species to compete for light and help them establish. It will also increase the number of fallen logs on the ground, helping to improve performance criteria for length of fallen logs with that of the reference sites.

The new method of monitoring the stem density of canopy species by counting individuals along the transect, within 2 meters either side of the 50 metre tape and extrapolating to stems per hectare worked well. This method of collecting stem density should continue to be used in future monitoring.

5.3 Ecosystem and Landuse Sustainability

5.3.6 Vegetation Structure and Species Richness

Exotic plant cover

At HVO, two sites fell within benchmark for exotic plant cover HVOCHE201601 and HVOCHE201602. However, these sites actually contained no vegetative cover at all. HVORIV201502 had 100 percent exotic plant cover. The high percentage of exotic cover at some of the rehabilitation sites is due to the use of cover crops which were seeded to stabilise and add nitrogen to the soil.

The MTW woodland – other domain type, did not have any sites which met benchmark levels. The site which contained the highest percentage of exotic cover in this domain was MTWMTO201501 with 72 percent cover.

MTW woodland – EEC contained two sites which fell within benchmark, these were MTWSPN201501 and MTWSPN201601. Again these sites also contained no vegetative cover. The site that contained the highest percentage of exotic cover was MTWCDD201301 with 90 percent cover.

It will be difficult to lower exotic plant cover to a level similar to that of the reference sites, as most of these exotic species have established a large seed bank which may last for many years before germinating. The best way to reduce exotic cover is to establish the native overstorey species, allowing them to shade out the exotic understory species.

Native over-storey cover (NOS)

Only one MTW Woodland – EEC rehabilitation site was within the 50-100% of the OEH benchmark target for this criteria. This is due to the young age of the rehabilitation sites, meaning that establishing overstorey trees are not yet large enough to contribute to the measured overstorey cover. The generally adequate overstorey stem densities in rehabilitation areas, as seen in Table 30, provide confidence that the rehabilitation sites will achieve the target levels for NOS when the trees grow to a sufficient height.

Native mid-storey cover

Six of the MTW Woodland – EEC rehabilitation sites were within the 50-100% of the OEH benchmark target for this criteria. Due to the young nature of the rehabilitation sites, this mid-storey cover may consist of over-storey species that haven’t reached maturity and are still growing within the mid-storey stratum.

Native ground cover (grasses)

Nine of the MTW woodland – EEC rehabilitation sites were within the 50-100% of the OEH benchmark target for this criteria, with one site MTWNPN201402 exceeding the OEH upper benchmark. Two of the sites that did not achieve the benchmark levels were established pre-2011 prior to the use of native grass seed in the rehabilitation seed mixes. One of these sites MTWNPN200901 also has a very high overstorey stem density (3,500 stems/ha) which would be causing shading and competition for grass species. The remaining MTW woodland – EEC rehabilitation sites that have been sown to native seed mixes but are not yet achieving the benchmark level for native grass cover are mainly new sites experiencing delayed germination due to dry weather.

Native ground cover (shrubs)

MTW woodland – EEC contains eight sites which met MOP performance criteria target levels, of which seven sites exceeded the OEH upper benchmark. This is likely a result of the combination of exceptional germination combined with juvenile canopy and mid-storey species contributing towards NGCS.

Native ground cover (other)

MTW woodland- EEC had six sites meet benchmark and one site exceed the OEH benchmark range for Central Hunter Grey Box-Ironbark Woodland. The low results for native plant species richness for 'other species' in MTW woodland – EEC rehabilitation sites (Table 25) indicate that a small number of herbs and forbs are contributing to the measured cover for 'other species'.

5.3.7 Vegetation Health

Tree Diversity (DBH >5cm)

Rehabilitation sites containing tree species with a DBH >5 cm fell between the benchmark range of 1 to 4 species of maturing trees. HVO had an average of 2.5 species of maturing trees at sites which contained trees >5cm DBH, and this was slightly above the reference site average of 2.4 species per site. MTW woodland – other had a single site which contained two species of trees with a >5cm DBH. MTW woodland – EEC supported three sites of mature trees, which produced an average of 1.7 tree species per site. Overall these sites had an average of 2.13 species of tree per site containing trees >5cm DBH (Table 42). While this is a reasonable number of species per site, only eight of the 54 rehabilitation sites recorded trees with a DBH >5cm. No new rehabilitation sites contained trees >5cm DBH which was to be expected. This performance criteria will only improve with time once trees on younger sites have matured and have a larger DBH.

Tree Density (DBH >5cm)

All rehabilitation sites containing tree species with a DBH >5 cm fell between or exceeded the benchmark range of 50 – 725 stems per hectare. HVO sites recorded an average of 525 trees per hectare which was moderately denser than the reference site average of 427.1 trees per hectare. HVO site HVOWES200801 also exceeded the benchmark range with 950 trees per hectare. The MTW woodland – other site produced a score of 425 trees per hectare, which is slightly lower than the reference site average. MTW woodland – EEC produced a score of 316.7 trees per hectare with one site (MTWNPN200502) exceeding the benchmark range. Together all sites containing trees averaged an above benchmark score of 434.4 trees per hectare (Table 42).

These sites would also contain trees that fell below the 5 centimetre DBH cut off, meaning many of these sites may produce higher densities of trees >5 centimetre DBH in the future, as smaller trees mature. If this is the case, management of tree densities will be required into the future to bring numbers down to within benchmark levels. As mentioned previously, thinning may also be required to improve light penetration in order to improve growth and establishment of ground-storey species.

Tree Health

No quantitative data was collected for tree health, however, visual analysis of sites in the field allowed us tree health at rehabilitation sites to be noted. All trees appeared to be in a healthy to moderate condition, even in the dry conditions in which the rehabilitation sites were recoded. No trees were viewed as being in a state of advanced dieback.

Reproductive Structures

All sites meet benchmark range, however, it should be noted the range begins at zero automatically qualifying sites as reaching the benchmark. Table 42 shows one site within the MTW woodland – other domain containing two trees that had buds or were flowering. This has brought the average for all rehabilitation site domain types up to be comparable to the average achieved by the reference sites. This shows that some of the rehabilitation sites are possibly becoming capable of recruitment.

5.3.8 Habitat Features

Percentage Groundcover (dead and live plant material, rocks and logs)

Total groundcover including protective ground cover components such as dead and live plant material, rocks, and logs at the rehabilitation sites have been compared to the reference sites in Table 15 of the LFA data. LOI represents percentage cover (dead and live plant material, rocks and logs) along the transect. As mentioned above in Section 5.2.2 LOI, was relatively high for both reference and rehabilitation sites. This was a result of the high density of dead or live vegetation, mostly in the form of cover crops.

Rehabilitation sites did not contain any logs or large rocks. Sites contained uniform sized rocks from overburden, but lacked larger boulders and flat habitat rocks that would otherwise naturally occur, and can been seen at some of the reference sites.

Length of fallen logs

No fallen logs where recorded at any of the rehabilitation sites. This performance criteria is something that will develop with time. However, improvement against this criteria could be fast-tracked with the introduction of such features as ‘habitat furniture’. As mentioned above in Sections 5.2.5 and 5.3.7 trees will require thinning in the future and this should be done at such a time and in such a way so that it contributes towards improving performance levels for rehabilitation sites with regard to fallen logs.

No hollow trees were recorded at any of the rehabilitation sites. Hollows would not be expected to develop in any of the rehabilitation sites for many years. Habitat for hollow dependant birds may be improved by the installation of next boxes in the future.

5.3.9 Visual and Photo Monitoring (Appendix)

The results of the visual monitoring and photo monitoring are provided in Appendix 5.

6. Conclusions

6.1 Conclusions

There is significant variation in the types and ages of the rehabilitation sites which formed part of this monitoring project and thus there is a high degree of variability in the results, particularly for native plant species richness, exotic cover, percentage cover, LOI and projected cover of all strata. Weather conditions varied greatly between the 2016 and 2017 monitoring seasons, which affected the degree of native cover and diversity at both the rehabilitation sites and at the reference sites. Provided below are some of the core outcomes of the BioBanking assessment, LFA, the assessment of tree canopy and over-storey regeneration.

6.2 Growth Medium Development

Generally speaking, many of the rehabilitation sites fall within the MOP performance criteria targets or reference site soil property range values and therefore meet the MOP performance criteria. Most rehabilitation sites met the MOP performance criteria targets for pH, EC, Organic Carbon and Cation Exchange Capacity. Phosphorous levels in rehabilitation sites were generally significantly higher than the reference site range values. High levels of available major nutrients such as Phosphorous will be useful for the re-establishment of vegetation communities in rehabilitation areas. However, there is a risk that high nutrient levels may stimulate weed growth that can compete with the native plants and prevent establishment of the desired vegetation communities. Weed management will therefore be an important intervention to ensure rehabilitation areas continue on the desired trajectory.

6.3 Ecosystem and Landuse Establishment

6.3.1 Landscape Function Analysis

Landscape Function Analysis was undertaken at all rehabilitation sites and reference sites. Generally the LOI at the reference and rehabilitation sites was high, with an average LOI of 0.98 for the reference sites and 0.9, 0.8 and 0.7 for the rehabilitation sites (see Table 16 to Table 21). However, the variability in the range of scores was greater at the rehabilitation sites than at the reference sites. This variability is likely to be influenced by rehabilitation management, with sites with a high degree of herbaceous cover returning a high LOI score and sites that had recently been sprayed and had limited live cover returning a low LOI score.

Three other attributes are measured through LFA, including stability, infiltration and nutrient cycling. Like with the LOI score, there was some consistency between the stability score achieved at the rehabilitation sites and the reference sites. The reference sites obtained an average index of 60.75 and the rehabilitation sites obtaining average scores of 57.8 for HVO sites, 50.4 for MTW woodland – other, 54.8 for MTW woodland – EEC. As vegetation cover is a core component of the stability score, individual site management practises (including high herbaceous cover or conversely herbicide spraying) can dictate this indicator.

The average infiltration scores for rehabilitation sites overall has increased from 42.4 for HVO sites, 37.4 for MTW woodland – other and 47.8 for MTW woodland – EEC to 51.1, 41.6, and 43.7 respectively. MTW woodland – EEC has dropped slightly from 47.8 to 43.7. This is likely due to the addition of new sites to this domain type.

Nutrient enrichment values between 2016 and 2017 showed no obvious trend with average differences for the reference sites increasing from 51.43 to 55.5 and the average for the rehabilitation sites having decreased from 43.2 for HVO sites, 35.4 for MTW woodland - other and 45.1 for MTW woodland – EEC in 2016 to 42.7, 32.5 and 39.7 in 2017 respectively. This is likely due to the addition of new monitoring sites.

6.3.2 Species Richness

Measures of species richness for trees and grasses are used as MOP performance criteria for all Woodland domain types. Of the rehabilitation sites that had been planted with native seed mixes, 48% of the HVO woodland – other; 60% of the MTW woodland – other; and 47% of the MTW woodland – EEC sites were within or exceeded the reference site range values for native tree species richness. Similarly, 60% of the HVO woodland – other; 20% of the MTW woodland – other; and 71% of the MTW woodland – EEC rehabilitation sites that had been sown with native seed mixes met or exceeded the reference site range values for native grass species richness. These results are expected to improve with future monitoring because many of the sites that didn't achieve the reference site range values were new sites that were experiencing delayed germination due to dry weather conditions.

Additional MOP performance criteria for species richness related to shrubs, other groundcover (i.e. not grasses) and total native plant species apply to woodland – EEC domains. The reference site range for shrub species richness was 4 to 9, and a total of eight MTW woodland – EEC rehabilitation sites met or exceeded the reference site range values for this criteria. Species richness data collected for 'other species' (including herbs and forbs) indicated that in comparison to reference site range values, MTW woodland – EEC rehabilitation sites do not score as well for this attribute. The reference site range is 10 to 20 species, and only one of the MTW woodland – EEC rehabilitation sites fell within this range.

The relatively poor species richness result for 'other species' also impacted on the performance of MTW woodland – EEC rehabilitation sites in terms of total native plant species richness. Only five of the 17 MTW woodland – EEC rehabilitation sites that had been sown to native seed mixes achieved the total native plant species target of 50-100% of the OEH Benchmark for Central Hunter Grey Box – Ironbark Woodland. While many sites meet the canopy, grass and shrub targets, the comparative number of species of herbs and forbs is often too low. This may be due to such species germinating later than other species or not having enough overstorey protection to establish.

6.4 Ecosystem and Landuse Sustainability

6.4.3 Vegetation structure and species richness

Results were generally positive when comparing rehabilitation sites with benchmark ranges, with some sites falling within the reference site benchmark for some of the ten attributes. Given the relatively young age of some of the rehabilitation sites, it is inherent that these sites would not meet benchmark for these attributes. Core outcomes include:

- All rehabilitation sites fall below benchmark in at least one attribute.
- Due to the density of regenerating shrub species, a number of sites exceed the upper benchmark for NGCS. This is likely a result of the combination of exceptional germination and juvenile canopy and mid-storey species contributing towards NGCS.
- Only one MTW woodland – EEC site is meeting the MOP performance criteria target for NOS.
- All other MTW woodland – EEC sites have very low to no NOS. This is due to juvenile trees not occurring in the canopy stratum.
- The 2017 reference site benchmarks vary from 2016, likely due to seasonal differences. While field surveys were conducted during the same time of the year as the 2016 surveys, many benchmark values are lower. This is likely a result of extended periods of extremely hot weather prior to the 2017 surveys, which is likely to have killed sensitive herbs and forbs compared to the previous year.

- The MOP performance criteria for exotic plant cover for woodland – other rehabilitation sites has a target level of 'comparable to reference site values'. As all of the reference sites had exotic plant cover levels of 0-6%, the reference site benchmark value was calculated to be 0%. Only two woodland – other rehabilitation sites across HVO and MTW sites met this reference site benchmark level and in both cases these sites had no vegetative cover at all due to a recent knockdown herbicide spray. A target level of 0% exotic plant cover is going to be very difficult to achieve in rehabilitation areas due to high weed seed loads present in topsoil.
- In comparison, the MOP performance criteria target for exotic plant cover for woodland – EEC rehabilitation sites has been set at 5-33%. Nine of the MTW woodland – EEC rehabilitation sites met this target level. High exotic plant cover scores that exceed the benchmark at new rehabilitation sites are primarily due to the use of cover crops early during the rehabilitation works.
- MTW Woodland – EEC rehabilitation sites were generally not meeting the target levels for total native plant species richness (NPS). Although sites were generally meeting species richness targets for native trees, shrubs and grasses, they were achieving low results for species richness of 'other species' (i.e. herbs, forbs and monocots other than grasses etc.). The category of 'other species' is where most of the native plant species diversity is found in the reference sites, with results from reference sites showing they contain 10-20 species in this category.
- In relation to NPS, there is not necessarily a correlation between age of the rehabilitation and species richness. Older rehabilitation sites do not necessarily have a greater number of plant species. This is likely to reflect that seed mixes being used since 2011 have had a much higher diversity of species than earlier seed mixes.
- Eight MTW woodland – EEC rehabilitation sites were within the reference site range values for native mid-storey cover. Part of the contribution to mid-storey cover however might be due to the presence of juvenile overstorey species which are not yet mature enough to be included in the overstorey and are included as mid-storey.
- Due to the age of the rehabilitation sites, only eight of the 54 rehabilitation sites had trees with a DBH greater than five centimetres. However, the canopy species diversity at these sites were generally good, with all of these sites falling within the benchmark range.
- No fallen logs or large rocks were recorded at any of the rehabilitation sites.

7. References

AECOM (2012) Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites. Prepared for Coal & Allied.

Coal and Allied (2015) Mining Operations Plan – HVO South.

Coal and Allied (2016a) Mining Operations Plan – HVO North.

Coal and Allied (2016b) Mining Operations Plan - Mount Thorley Warkworth.

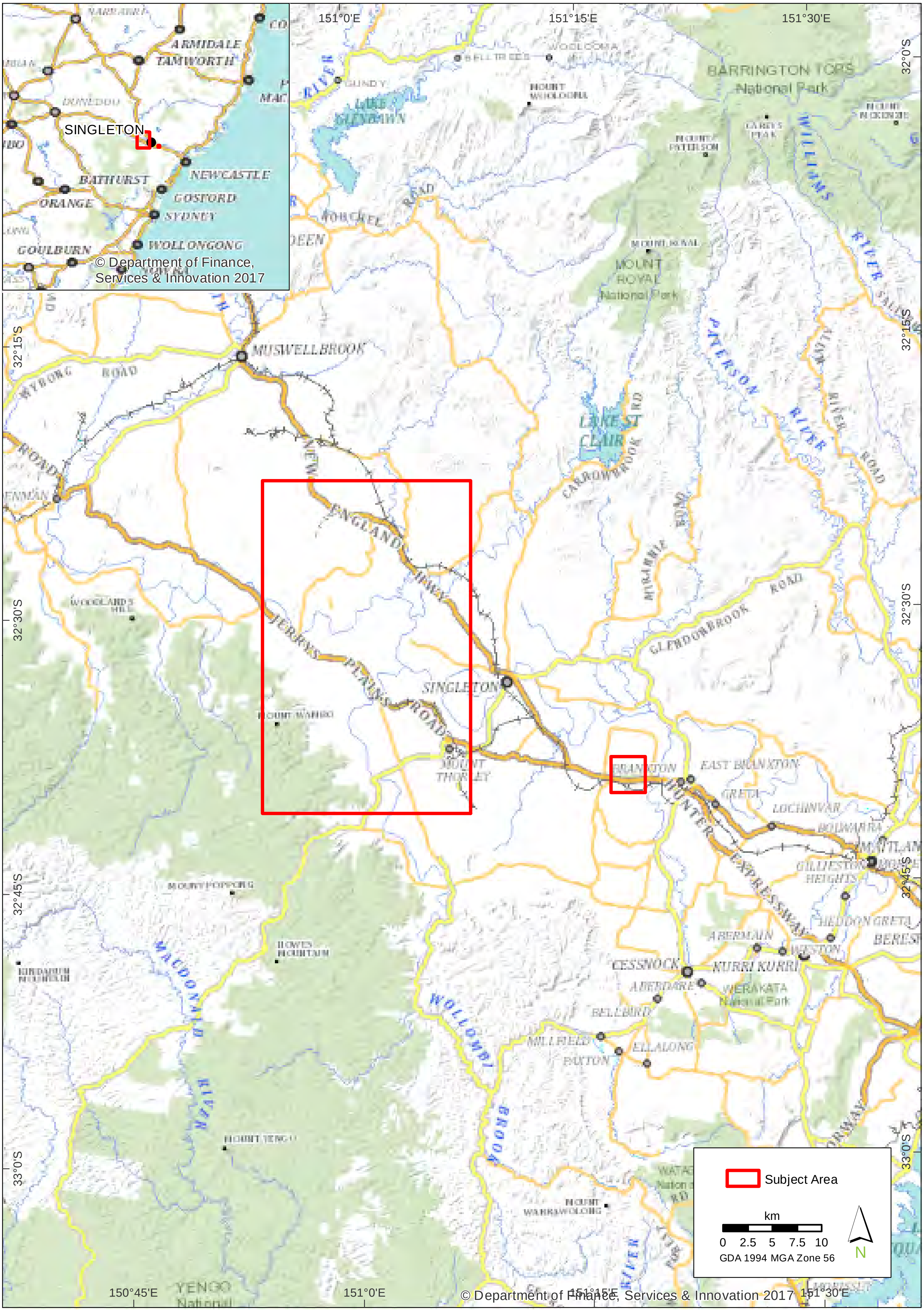
DECCW (2010) Belford National Park: plan of management / NSW National Parks and Wildlife Service, part of the Department of Environment, Climate Change and Water.

Niche (2016) Native Vegetation Rehabilitation Monitoring 2016 - Mount Thorley Warkworth and Hunter Valley Operations. Prepared for Coal & Allied.

Niche (2017) Native Vegetation Rehabilitation Monitoring 2017 - Mount Thorley Warkworth and Hunter Valley Operations. Prepared for Coal & Allied.

Tongway, D. and Hindley, N. (2004) Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes with Special References to Mine sites and Rangelands. CSIRO Sustainable Ecosystems, Canberra.

Appendix 1 – Figures



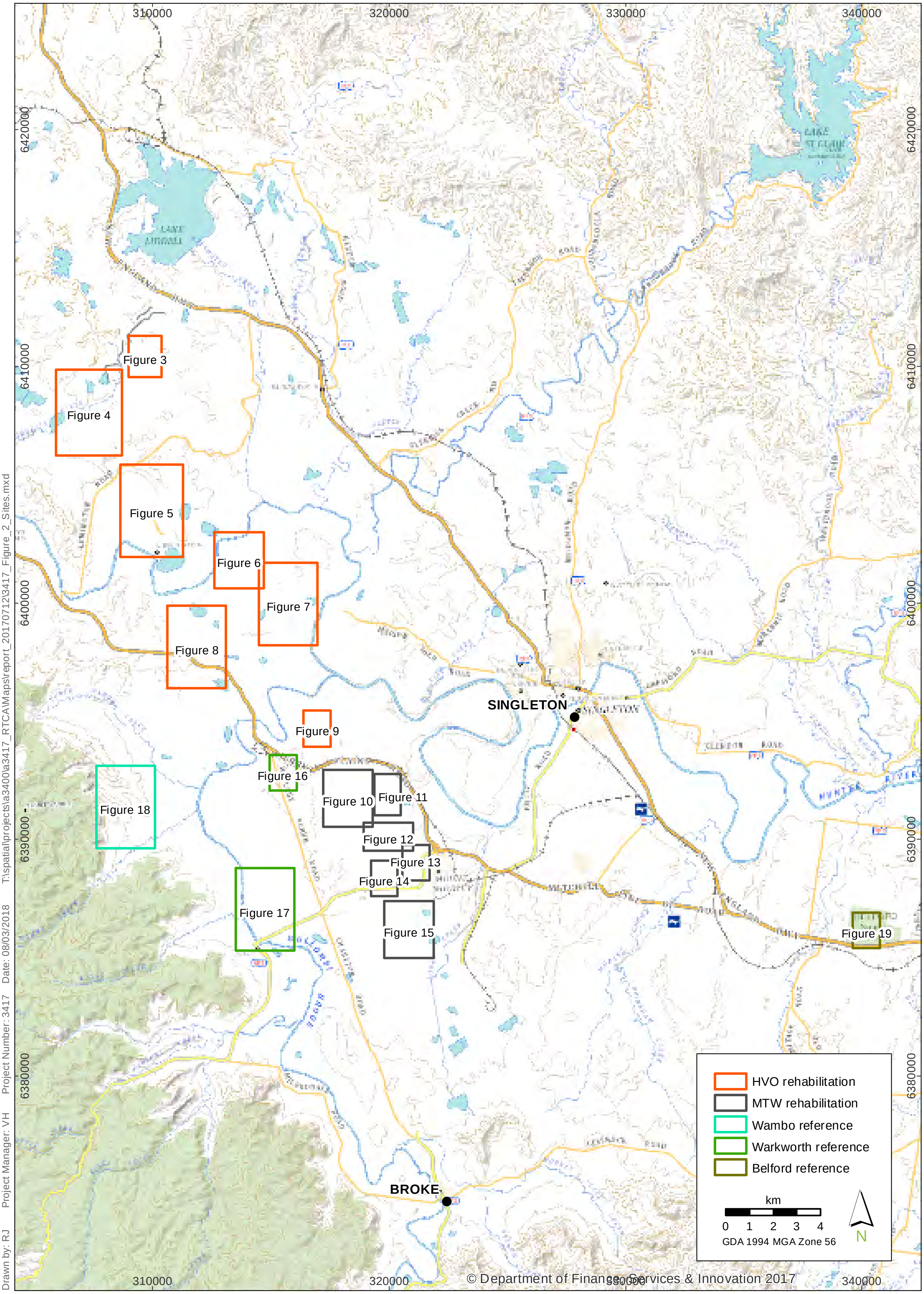
Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_1_Location.mxd

Location map

Native Vegetation Rehabilitation Monitoring

FIGURE 1

niche Environment and Heritage



Site locations overview

Native Vegetation Rehabilitation Monitoring

FIGURE 2

niche Environment and Heritage

HVO survey locations - map 1 (HVOWES)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 3

Imagery: (c) Nearmap 2018-02-07

HVO survey locations - map 2 (HVOWES)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 4

Imagery: (c) Nearmap 2015-03-06

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_5_HVOCAR.mxd

HVO survey locations - map 3 (HVOCAR)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 5

Imagery: (c) Nearmap 2015 - 2018

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_6_HVOCHE.mxd

HVO survey locations - map 4 (HVOCHE)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 6

Imagery: (c) Nearmap 2017-11-03

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_7_HVOCHE.mxd

HVO survey locations - map 5 (HVOCHE)

Native Vegetation Rehabilitation Monitoring

FIGURE 7

Imagery: (c) Nearmap 2017-11-03

niche Environment and Heritage

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_8_HVORIV.mxd

niche Environment and Heritage

HVO survey locations - map 6 (HVORIV)

Native Vegetation Rehabilitation Monitoring

FIGURE 8

Imagery: (c) Nearmap 2017-11-03

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_9_HVOLEM.mxd

HVO survey locations - map 7 (HVOLEM)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 9

Imagery: (c) Nearmap 2017-11-03

niche Environment and Heritage

MTW survey locations - map 1 (MTWNPN)

Native Vegetation Rehabilitation Monitoring

FIGURE 10

Imagery: (c) Nearmap 2017-11-03

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_11_MTWNPN_NOO.mxd

MTW survey locations - map 2 (MTWNPN-NOO)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 11

Imagery: (c) Nearmap 2017-11-03

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_12_MTW_NPN_SPN.mxd

MTW survey location - map 3 (MTWCDD-SPN)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 12

Imagery: (c) Nearmap 2018-01-05

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_13_MTWSPS.mxd

MTW survey location - map 4 (MTWSPS)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 13

Imagery: (c) Nearmap 2018-01-05

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_14_MTWWDL.mxd

MTW survey location - map 5 (MTWWDL)

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 14

Imagery: (c) Nearmap 2018-01-05

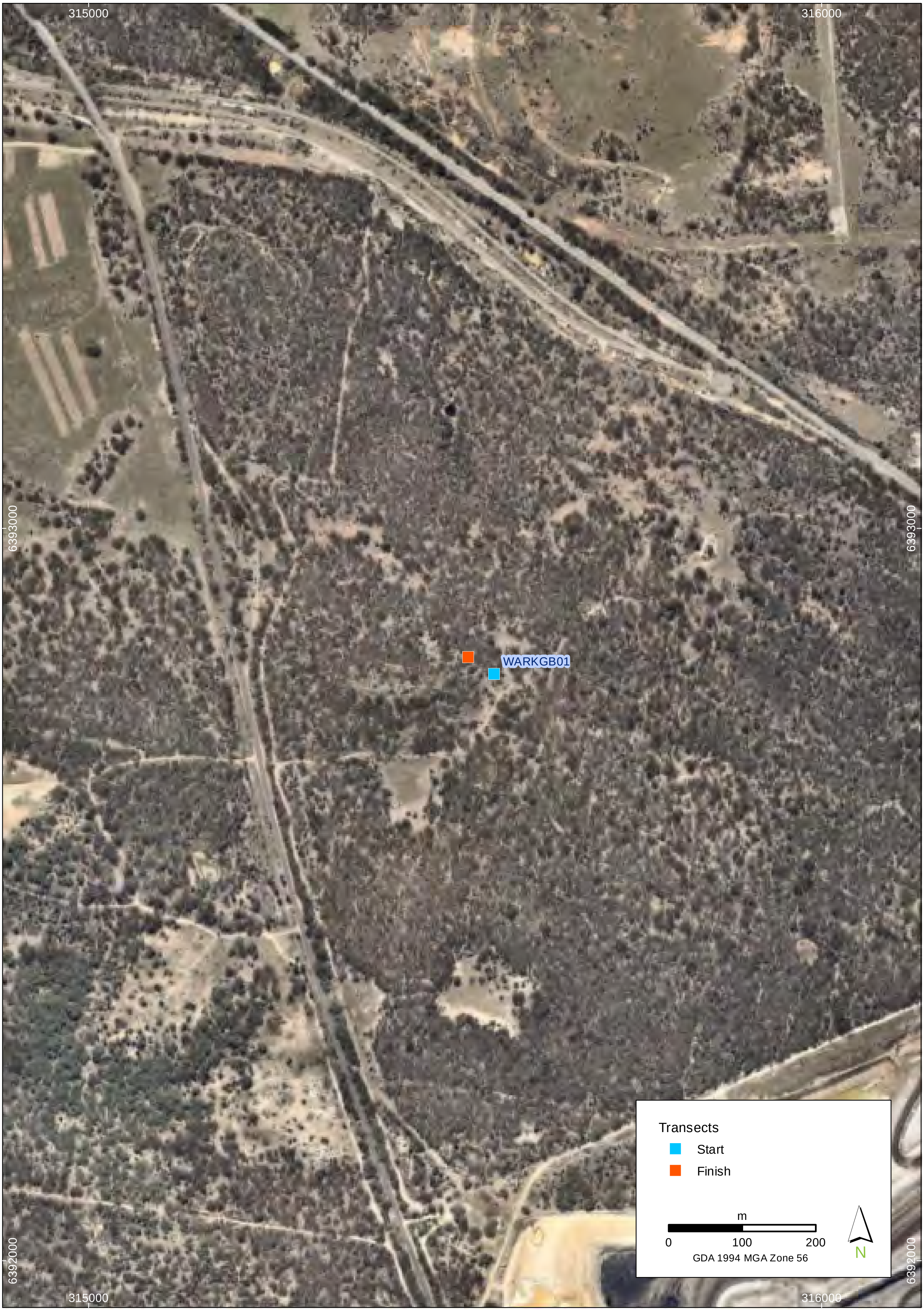
niche Environment and Heritage

MTW survey location - map 6 (MTWMTO)

Native Vegetation Rehabilitation Monitoring

FIGURE 15

Imagery: (c) Nearmap 2018-01-05



Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_16_WARKGB01.mxd

niche Environment and Heritage

Warkworth reference sites (WARKGB01)

Native Vegetation Rehabilitation Monitoring

FIGURE 16

Imagery: (c) Nearmap 2017-11-03

Warkworth reference sites (WARKGB02-03-04

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 17

Imagery: (c) Nearmap 2018-01-05

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_18_Wambo GB01-GB02-Spot1-Spot2-Spot3.mxd

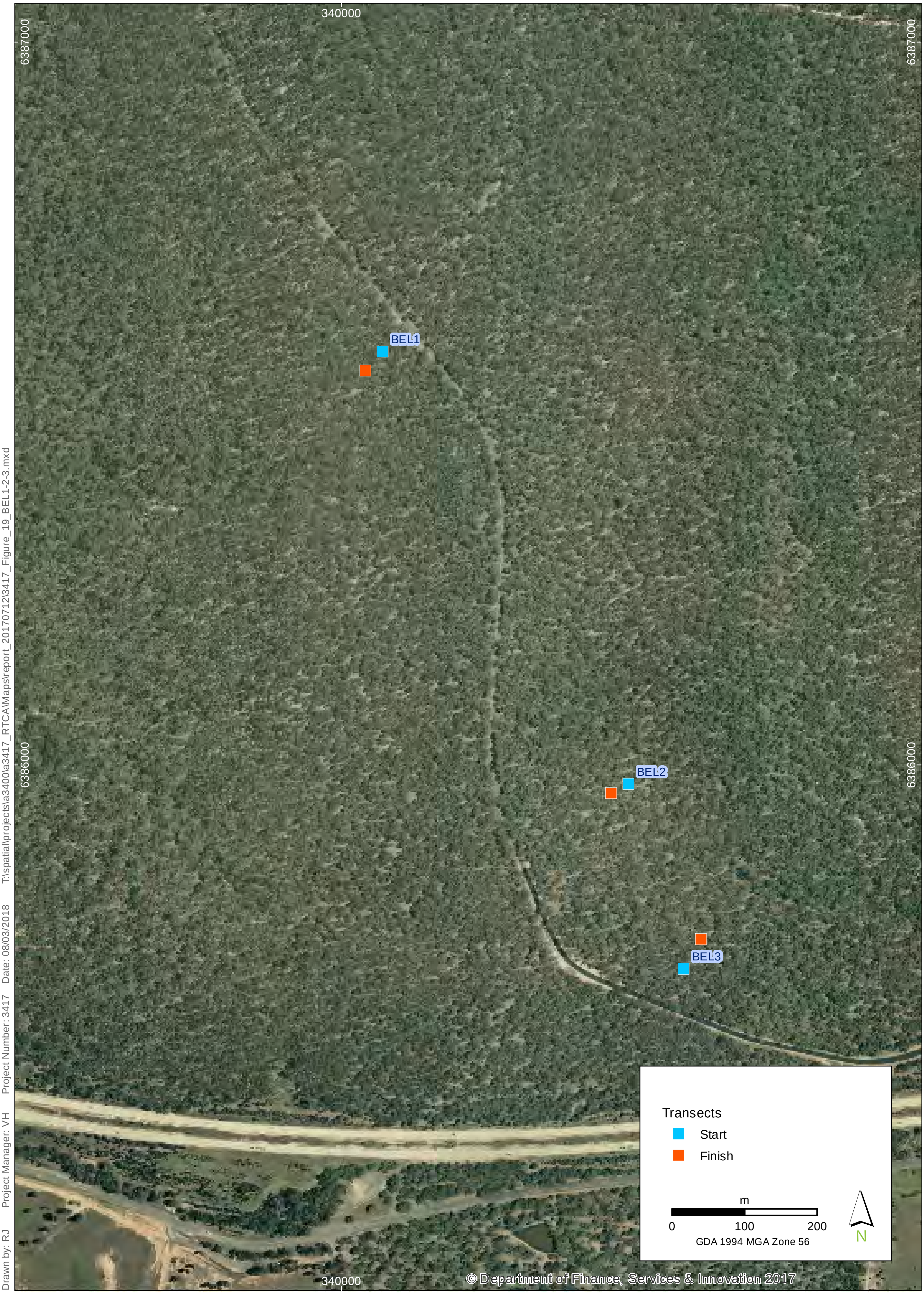
Wambo reference sites

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 18

Imagery: (c) LPI 2008-12-17



Belford reference sites

Native Vegetation Rehabilitation Monitoring

niche Environment and Heritage

FIGURE 19

Imagery: (c) LPI 2008-12-17

Appendix 2 – Monitoring dates

Location	Survey personnel	Date
HVO CAR200901	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	13/02/2017
HVO CAR200902	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	13/02/2017
HVO CAR201401	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	13/02/2017
HVO CHE201201	Alex Christie, Vivien Howard and Jess Blair	09/02/2017
HVO CHE201203	Alex Christie, Vivien Howard and Jess Blair	09/02/2017
HVO CHE201401	Alex Christie, Vivien Howard and Jess Blair	09/02/2017
HVO RIV201401	Alex Christie, Vivien Howard and Bill Baxter	13/02/2017
HVO RIV201402	Alex Christie, Vivien Howard and Bill Baxter	13/02/2017
HVO RIV201403	Alex Christie, Vivien Howard and Bill Baxter	13/02/2017
HVO RIV201404	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
HVO RIV201405	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
HVO RIV201406	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
HVO WES200801	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVO WES201101	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVO WES201301	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVO WES201302	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVOCHE201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOCHE201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOCHE201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOLEM201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOLEM201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVORIV201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVORIV201502	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVORIV201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOWES201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOWES201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOWES201603	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWCDD201101	Alex Christie, Vivien Howard and Jess Blair	08/02/2017
MTWCDD201301	Alex Christie, Vivien Howard and Jess Blair	08/02/2017
MTWCDD201501	Alex Christie, Vivien Howard and Jess Blair	08/02/2017
MTWMTO200001	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
MTWMTO200503	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
MTWMTO201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWMTO201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWNOO201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWNPN200501	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017

Location	Survey personnel	Date
MTWNPN200502	Alex Christie, Vivien Howard and Bill Baxter	08/02/2017
MTWNPN200901	Alex Christie, Vivien Howard and Jess Blair	15/02/2017
MTWNPN201101	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWNPN201301	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWNPN201402	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWNPN201403	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWSPN201401	Alex Christie, Vivien Howard and Bill Baxter	08/02/2017
MTWSPN201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPN201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPN201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPS201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPS201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWTD1201501	Luke Baker, Vivien Howard and Bill Baxter	08/02/2017
MTWWDL201401	Alex Christie, Vivien Howard and Bill Baxter	08/02/2017
MTWWDL201402	Alex Christie, Vivien Howard and Bill Baxter	15/02/2017
BELLSPOT1	Alex Christie and Vivien Howard	06/02/2017
BELSPOT2	Alex Christie and Vivien Howard	14/02/2017
BELSPOT3	Alex Christie and Vivien Howard	14/02/2017
WAMBOGB1	Alex Christie and Vivien Howard	16/02/2017
WAMBOGB2	Alex Christie and Vivien Howard	16/02/2017
WAMBOSPOT1	Alex Christie and Vivien Howard	16/02/2017
WAMBOSPOT2	Alex Christie and Vivien Howard	16/02/2017
WAMBOSPOT3	Alex Christie and Vivien Howard	16/02/2017
WARKGB1	Alex Christie and Vivien Howard	15/02/2017
WARKGB2	Alex Christie and Vivien Howard	10/02/2017
WARKGB3	Alex Christie and Vivien Howard	10/02/2017
WARKGB4	Alex Christie and Vivien Howard	10/02/2017

Appendix 3 – Monitoring locations

Hunter Valley Operations monitoring sites and locations

Monitoring site	Position on transection	Northing	Easting
HVO CAR200901	Start	6405168	310358
HVO CAR200901	Finish	6405171	310311
HVO CAR200902	Start	6403453	309114
HVO CAR200902	Finish	6403430	309076
HVO CAR201401	Start	6403057	309832
HVO CAR201401	Finish	6403083	309872
HVO CHE201201	Start	6400898	315694
HVO CHE201201	Finish	6400937	315660
HVO CHE201301	Start	6400040	315617
HVO CHE201301	Finish	6400044	315667
HVO CHE201401	Start	6399065	315541
HVO CHE201401	Finish	6399040	315582
HVO RIV201401	Start	6398663	311033
HVO RIV201401	Finish	6398633	310994
HVO RIV201402	Start	6398476	311320
HVO RIV201402	Finish	6398516	311293
HVO RIV201403	Start	6398539	311901
HVO RIV201403	Finish	6398558	311854
HVO RIV201404	Start	6398524	312023
HVO RIV201404	Finish	6398476	312029
HVO RIV201405	Start	6398089	312243
HVO RIV201405	Finish	6398114	312269
HVO RIV201406	Start	6397946	312522
HVO RIV201406	Finish	6397895	312522
HVO WES200801	Start	6406920	306340
HVO WES200801	Finish	6406877	306364
HVO WES201101	Start	6409164	308265

Monitoring site	Position on transection	Northing	Easting
HVO WES201101	Finish	6409172	308223
HVO WES201301	Start	6407223	306899
HVO WES201301	Finish	6407251	306859
HVO WES201302	Start	6407365	306889
HVO WES201302	Finish	6407409	306878
HVORIV201502	Start	6398308	311543
HVORIV201502	Finish	6398260	311526
HVORIV201501	Start	6398020	312211
HVORIV201501	Finish	6397998	312256
HVOLEM201501	Start	6394462	316910
HVOLEM201501	Finish	Not recorded	Not recorded
HVOCHE201501	Start	6402006	313968
HVOCHE201501	Finish	6402056	313952
HVORIV201601	Start	6398284	311284
HVORIV201601	Finish	6398245	311314
HVOWES201602	Start	6408560	308357
HVOWES201602	Finish	6408597	308323
HVOWES201601	Start	6410903	309820
HVOWES201601	Finish	Not recorded	Not recorded
HVOWES201603	Start	6409944	309354
HVOWES201603	Finish	6409903	309385
HVOCHE201601	Start	6401634	313555
HVOCHE201601	Finish	6401683	313541
HVOCHE201602	Start	6401299	313072
HVOCHE201602	Finish	6401346	313057
HVOLEM201601	Start	6394768	317039
HVOLEM201601	Finish	6394760	316990
HVORIV201503	Start	311249	6398378
HVORIV201503	Finish	311216	6398340
HVOWES201604	Start	307372	6407327

Monitoring site	Position on transection	Northing	Easting
HVOWES201604	Finish	307394	6407374

Mount Thorley Warkworth monitoring sites and locations

Monitoring site	Position on transection	Northing	Easting
MTWCDC201101	Start	6390304	319599
MTWCDC201101	Finish	6390312	319552
MTWCDD201301	Start	6390165	319516
MTWCDD201301	Finish	6390212	319535
MTWCDD201501	Start	6390074	319049
MTWCDD201501	Finish	6390034	319081
MTWNPN201401	Start	6392128	317619
MTWNPN201401	Finish	Not recorded	Not recorded
MTWMTO200001	Start	6386940	320551
MTWMTO200001	Finish	6386982	320531
MTWMTO200503	Start	6385782	320678
MTWMTO200503	Finish	6385756	320640
MTWNPN200501	Start	6391225	319816
MTWNPN200501	Finish	6391183	319842
MTWNPN200502	Start	6391981	319682
MTWNPN200502	Finish	Not recorded	Not recorded
MTWNPN200901	Start	6391524	319069
MTWNPN200901	Finish	6391535	319027
MTWNPN201101	Start	6392138	318166
MTWNPN201301	Finish	6391519	317995
MTWNPN201301	Start	6391551	318047
MTWNPN201402	Start	6392086	317658
MTWNPN201402	Finish	6392120	317620
MTWNPN201403	Start	6391271	318089
MTWNPN201403	Finish	6391236	318060
MTWSPN201401	Start	6390161	320170

Monitoring site	Position on transection	Northing	Easting
MTWSPN201401	Finish	Not recorded	Not recorded
MTWTDI201501	Start	6392186	319688
MTWTDI201501	Finish	6392236	319692
MTWWDL201401	Start	6388508	319805
MTWWDL201401	Finish	6388526	319849
MTWWDL201402	Start	6388357	319636
MTWWDL201402	Finish	6388309	319624
MTWMTO201501	Start	6385357	321386
MTWMTO201501	Finish	6385331	321427
MTWSPS201601	Start	6389384	320910
MTWSPS201601	Finish	6389413	320949
MTWSPN201602	Start	6389769	320444
MTWSPN201602	Finish	6389775	320494
MTWSPN201601	Start	6390589	320130
MTWSPN201601	Finish	6390630	320158
MTWSPN201501	Start	6390291	319956
MTWSPN201501	Finish	6390332	319984
MTWSPS201602	Start	6388963	320830
MTWSPS201602	Finish	6388975	320879
MTWMTO201601	Start	6385308	320667
MTWMTO201601	Finish	6385305	320718
MTWNOO201501	Start	6391940	320406
MTWNOO201501	Finish	6391979	320438

Reference monitoring sites and locations

Monitoring site	Position on transection	Northing	Easting
BEL1	Start	6386547	340083
BEL1	Finish	6386546	340033
BEL2	Start	6386551	340072
BEL2	Finish	6385962	340373

Monitoring site	Position on transection	Northing	Easting
BEL3	Start	6385719	340474
BEL3	Finish	6385760	340498
WamboGB01	Start	6392661	309215
WamboGB01	Finish	6392618	309194
WamboGB02	Start	6391965	309539
WamboGB02	Finish	6392010	309561
WamboSpot1	Start	6390324	308275
WamboSpot1	Finish	6390355	308311
WamboSpot2	Start	6390550	308504
WamboSpot2	Finish	6390593	308522
WamboSpot3	Start	6390200	308276
WamboSpot3	Finish	6390185	308238
WARKGB01	Start	6392801	315553
WARKGB01	Finish	6392824	315517
WARKGB02	Start	6387985	314002
WARKGB02	Finish	6387939	313998
WARKGB03	Start	6386859	314917
WARKGB03	Finish	6386864	314960
WARKGB04	Start	6386046	315336
WARKGB04	Finish	6386087	315316

Appendix 4 – Flora species list

Flora two-way table: MTW Sites

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Aizoaceae	*Galenia pubescens*	Galenia	X	2			3	2		2	3	2		2
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X	1				2			2	1		2
Asteraceae	*Arctotheca calendula*	Capeweed	X						3					
Asteraceae	*Aster* spp.		X	2	3					2				
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X	1				2	2					2
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy						2			2			1
Asteraceae	*Centaurea solstitialis*	St Barnabys Thistle	X		1									
Asteraceae	*Cichorium intybus*	Chicory	X						2					
Asteraceae	*Cirsium vulgare*	Spear Thistle	X						2					
Asteraceae	*Conyza* spp.	A Fleabane	X	2	3	2	1	2			2			2
Asteraceae	Gnaphalium spp.	Cudweed						2						
Asteraceae	*Senecio madagascariensis*	Fireweed	X	2		2			2			1	1	
Asteraceae	*Sonchus* spp.	Sowthistle	X		1				2					

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Asteraceae	*Tagetes minuta*	Stinking Roger	X								1			
Asteraceae	*Vittadinia cuneata*	A Fuzzweed					2	2			2			
Asteraceae	*Vittadinia sulcata*						2	1				2		
Boraginaceae	*Echium* spp.		X				5	5				2		
Brassicaceae	*Brassica rapa*		X							2		1		
Brassicaceae	*Lepidium campestre*	Field Cress	X			1	1							
Brassicaceae	*Lepidium spp.*	A Peppercress	X		2									
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	X				2	1						
Caryophyllaceae	*Petrorhagia prolifera*	Proliferous Pink	X	1	1	2								
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush		2		2	2	2						
Chenopodiaceae	*Chenopodium album*	Fat Hen	X						2					1
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush						3			1			
Chenopodiaceae	*Einadia trigonos*	Fishweed				2	2							
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush		2			3	3			1			2
Commelinaceae	*Commelina cyanea*	Native Wandering					2							

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
		Jew												
Convolvulaceae	*Dichondra repens*	Kidney Weed						1		2				
Cyperaceae	*Carex appressa*	Tall Sedge						1						
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea												2
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine		2			2	2		2	1		1	
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla												1
Fabaceae (Faboideae)	*Macroptilium atropurpureum*	Siratro	X						1					
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X						2					
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle		3		2					2	2	3	4
Fabaceae (Mimosoideae)	*Acacia binervata*	Two-veined Hickory				2								
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle		2		2				3				4
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle		2		2				2			2	3
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle		2									3	
Fabaceae (Mimosoideae)	*Acacia falcata*			3									1	3

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Fabaceae (Mimosoideae)	*Acacia filicifolia*	Fern-leaved Wattle								1				
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle		2		2					2	1	2	3
Fabaceae (Mimosoideae)	*Acacia longifolia*			2								2		
Fabaceae (Mimosoideae)	*Acacia mearnsii*	Black Wattle												2
Fabaceae (Mimosoideae)	*Acacia parvipinnula*	Silver-stemmed Wattle										4		
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba		2		2							2	
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	X					2			4	1		3
Fabaceae (Mimosoideae)	*Acacia spectabilis*	Mudgee Wattle		2		2								
Fabaceae (Mimosoideae)	*Acacia* spp.	Wattle					2							
Gentianaceae	*Centaurium spicatum*	Spike Centaury				2								
Geraniaceae	*Geranium* spp.		X							2				
Malvaceae	*Malva* spp.	Mallow	X						2					
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X							2				

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Malvaceae	*Sida corrugata*	Corrugated Sida		2			2							1
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X	2				2	2	3	3		2	
Myoporaceae	*Eremophila debilis*	Amulla		2			2	1			2	2		
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X							2				
Myrtaceae	*Corymbia citriodora*	Lemon-scented Gum	X								4			
Myrtaceae	*Corymbia maculata*	Spotted Gum		3		3						5	6	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark		2									3	2
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark										3	3	1
Myrtaceae	*Eucalyptus moluccana*	Grey Box		3			3	1				3	3	
Oxalidaceae	*Oxalis perennans*									2				
Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge						2						
Phytolaccaceae	*Phytolacca octandra*	Inkweed	X			1								
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X			2		1	2	2			1	2
Poaceae	*Austrostipa aristiglumis*	Plains Grass				1								

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Poaceae	*Austrostipa scabra*	Speargrass				2								
Poaceae	*Bothriochloa macra*	Red Grass		2		2		2		4	1			1
Poaceae	*Capillipedium spicigerum*	Scented-top Grass				1								
Poaceae	*Chloris gayana*	Rhodes Grass	X	2	5	1					4	1	3	4
Poaceae	*Chloris truncata*	Windmill Grass				2		2		3	1			
Poaceae	*Chloris ventricosa*	Tall Chloris		2		3					1			
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass				2		4			3		2	
Poaceae	*Cynodon dactylon*	Common Couch		1		2		2	3			1		
Poaceae	*Digitaria divaricatissima*	Umbrella Grass				1								
Poaceae	*Entolasia marginata*	Bordered Panic										1		
Poaceae	*Entolasia stricta*	Wiry Panic								2				
Poaceae	*Eragrostis brownii*	Brown's Lovegrass				1				3				
Poaceae	*Eragrostis curvula*	African Lovegrass	X					2			2	2		1
Poaceae	*Eriochloa* spp.	A Cupgrass							2	2				
Poaceae	*Panicum effusum*	Hairy Panic				2				2				

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Poaceae	*Panicum maximum*	Guinea Grass	X							4				
Poaceae	Paspalum dilatatum	Paspalum	X	2								2		
Poaceae	Pennisetum clandestinum	Kikuyu Grass	X											2
Poaceae	Pennisetum glaucum	Pearl Millet	X						4					
Poaceae	Rytidosperma spp.			2		2		2					2	
Poaceae	Setaria gracilis	Slender Pigeon Grass	X	1							1			
Poaceae	Setaria parviflora		X							2		2		
Poaceae	Sporobolus creber	Slender Rat's Tail Grass				2		2		2				
Poaceae	Themeda triandra			2										2
Poaceae	Urochloa spp.		X							2				
Portulacaceae	Portulaca spp.		X						3					
Sapindaceae	Dodonaea viscosa	Sticky Hop-bush												2
Solanaceae	Solanum nigrum	Black-berry Nightshade	X			1								
Solanaceae	Solanum prinophyllum	Forest Nightshade					1		1					
Verbenaceae	Verbena bonariensis	Purpletop	X	2			1				2	1		2

Flora two-way table: MTW Sites

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Aizoaceae	*Galenia pubescens*	Galenia	X	2	1		1	2	2			1	1	1	3
Aizoaceae	*Galenia* spp.		X			4									
Amaranthaceae	*Alternanthera* spp.	Joyweed						1							
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily				1									
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X		1					1		1			1
Asteraceae	*Aster* spp.		X	2	2						2				
Asteraceae	*Aster subulatus*	Wild Aster	X												2
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X	4	3	3				1				1	2
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy		2								2		2	
Asteraceae	*Centaurea solstitialis*	St Barnabys Thistle	X								1	1	1		
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting						1							
Asteraceae	*Cichorium intybus*	Chicory	X						3	3					
Asteraceae	*Cirsium vulgare*	Spear Thistle	X	2	2	1				1	1		1		1
Asteraceae	*Conyza* spp.	A Fleabane	X	2	3	1			2		1		2		
Asteraceae	*Hypochaeris radicata*	Catsear	X											2	
Asteraceae	*Senecio madagascariensis*	Fireweed	X		2			1	2	2	1		2	1	2
Asteraceae	*Sonchus oleraceus*	Common Sowthistle	X							3					2
Asteraceae	*Sonchus* spp.	Sowthistle	X	2		2		1	2		1		2		

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Asteraceae	*Tagetes minuta*	Stinking Roger	X											1	
Asteraceae	*Vittadinia cuneata*	A Fuzzweed			2									2	
Brassicaceae	*Brassica rapa*		X	4		3		2	3	4			5	1	
Brassicaceae	*Lepidium spp.*	A Peppercress	X	2		1					1				2
Cactaceae	*Opuntia stricta*	Common Prickly Pear, Smooth Pest Pear	X	2											
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush		2								2	2		
Chenopodiaceae	*Atriplex* spp.	A Saltbush						1							
Chenopodiaceae	*Chenopodium album*	Fat Hen	X									1			
Chenopodiaceae	*Chenopodium pumilio*	Small Crumbweed												1	
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush				2						2			
Chenopodiaceae	*Einadia trigonos*	Fishweed										3			
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush									2	1			1
Commelinaceae	*Commelina cyanea*	Native Wandering Jew												1	
Convolvulaceae	*Dichondra repens*	Kidney Weed						1							1
Euphorbiaceae	*Euphorbia* spp.		X					2							
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea			2									1	
Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil												1	

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine						1	2						
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla			3							2		2	
Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo		2	2			1				1		2	
Fabaceae (Faboideae)	*Macroptilium atropurpureum*	Siratro	X						1	4					
Fabaceae (Faboideae)	*Medicago polymorpha*	Burr Medic	X												2
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X						2	4		1			
Fabaceae (Faboideae)	*Swainsona galegifolia*	Smooth Darling Pea			1										
Fabaceae (Mimosoidea e)	*Acacia amblygona*	Fan Wattle		3	4							3			
Fabaceae (Mimosoidea e)	*Acacia binervata*	Two-veined Hickory			4										
Fabaceae (Mimosoidea e)	*Acacia cultriformis*	Knife-leaved Wattle		3	4	2		1						2	
Fabaceae (Mimosoidea e)	*Acacia decora*	Western Silver Wattle		3	3	2						2		3	
Fabaceae (Mimosoidea e)	*Acacia falcata*			3	2							3		3	
Fabaceae (Mimosoidea e)	*Acacia implexa*	Hickory Wattle				2						3			
Fabaceae (Mimosoidea	*Acacia leiocalyx*													5	

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
e)															
Fabaceae (Mimosoidea e)	*Acacia longifolia*			2	3							1		3	
Fabaceae (Mimosoidea e)	*Acacia paradoxa*	Kangaroo Thorn		3	2							1		2	
Fabaceae (Mimosoidea e)	*Acacia parvipinnula*	Silver-stemmed Wattle			2									2	
Fabaceae (Mimosoidea e)	*Acacia salicina*	Cooba									1	2			
Fabaceae (Mimosoidea e)	*Acacia saligna*	Golden Wreath Wattle	X	2		1							1	1	
Fabaceae (Mimosoidea e)	*Acacia spectabilis*	Mudgee Wattle									1				
Fumariaceae	*Fumaria* spp.	Fumitory	X												1
Gentianaceae	*Centaurium* spp.		X										3		
Geraniaceae	*Geranium homeanum*								1						
Lycopodiacea e	*Phylloglossum drummondii*	Pigmy Clubmoss							2						
Malvaceae	*Malva* spp.	Mallow	X												
Malvaceae	*Malva sylvestris*	Tall Mallow	X				1								
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X	2				2							
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X	4	1	3		2		2		2		1	2
Myoporaceae	*Eremophila*	Amulla											2		

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
	debilis														
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X					1	2	2				1	
Myrtaceae	*Corymbia maculata*	Spotted Gum		1							2	2			
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark										2			
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark				1									
Myrtaceae	*Eucalyptus moluccana*	Grey Box				1									
Myrtaceae	*Eucalyptus spp.*										1	2			
Phyllanthaceae	*Breynia* spp.													2	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X									1	2		2
Poaceae	*Austrostipa scabra*	Speargrass			3						2			2	
Poaceae	*Bothriochloa macra*	Red Grass		2	2			2			1		3	1	
Poaceae	*Chloris gayana*	Rhodes Grass	X	3	2	5	2		2		4	2	2		3
Poaceae	*Chloris truncata*	Windmill Grass		2				6			4	3	2		
Poaceae	*Chloris ventricosa*	Tall Chloris			3		2				2	3	2		
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass			2										
Poaceae	*Cynodon dactylon*	Common Couch		3	4	2		2	3			2	3	2	2
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass		2							2				
Poaceae	*Eragrostis brownii*	Brown's Lovegrass						4						1	

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Poaceae	*Eragrostis curvula*	African Lovegrass	X		2	1								1	
Poaceae	*Eriochloa procera*	Spring Grass													2
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass		3	2	2						3	5		
Poaceae	*Eriochloa* spp.	A Cupgrass							2						
Poaceae	*Heteropogon contortus*	Bunch Speargrass			3										
Poaceae	*Lolium perenne*	Perennial Ryegrass	X										3		
Poaceae	*Melinis repens*	Red Natal Grass	X											2	
Poaceae	*Panicum effusum*	Hairy Panic				1		2			2	1			
Poaceae	*Panicum maximum*	Guinea Grass	X						2	4	1		2		2
Poaceae	Paspalidium spp.							1			2				
Poaceae	Paspalum dilatatum	Paspalum	X	2											2
Poaceae	Pennisetum clandestinum	Kikuyu Grass	X		1										1
Poaceae	Pennisetum glaucum	Pearl Millet	X										5		
Poaceae	Rytidosperma spp.				2							2			
Poaceae	Setaria gracilis	Slender Pigeon Grass	X	2								3	2		
Poaceae	Setaria italica	Foxtail Millet	X							2					
Poaceae	Setaria parviflora		X					3							
Poaceae	Sporobolus	Slender Rat's Tail									2				

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
	creber	Grass													
Poaceae	Themeda australis	Kangaroo Grass												1	
Poaceae	Themeda triandra				3										
Poaceae	Urochloa panicoides	Urochloa Grass	X										2		
Portulacacea e	Portulaca spp.		X				1	2		1					
Rubiaceae	Cyclophyllum longipetalum	Coast Canthium		2											
Sapindaceae	Dodonaea viscosa	Sticky Hop-bush			2										
Solanaceae	Solanum nigrum	Black-berry Nightshade	X					2	2	3		1		1	
Thymelaeace ae	Pimelea linifolia	Slender Rice Flower			2									1	
Verbenaceae	Verbena bonariensis	Purpletop	X		2							2			2
Zygophyllace ae	Tribulus spp.	Cat-head, Caltrop							1						

Flora two-way table: HVO Sites

Family	Species	Common Name	Exotic	HVOCAR200901	HVOCAR200902	HVOCAR201401	HVOCHE201201	HVOCHE201301	HVOCHE201401	HVOCHE201501	HVOCHE201601	HVOCHE201602	HVOLEM201501	HVOLEM201601	HVORIV201401
Aizoaceae	*Galenia pubescens*	Galenia	X	3		3	2	2	2		1	1			3
Apiaceae	*Cyclospermum leptophyllum*	Slender Celery	X								1				
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X	2		2		1							2
Apocynaceae	*Gomphocarpus spp.*		X									1			
Asteraceae	*Arctotheca calendula*	Capeweed	X								1				
Asteraceae	*Aster spp.*		X										2		4
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy											2		
Asteraceae	*Cassinia arcuata*	Sifton Bush					1								
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting											2		
Asteraceae	*Cichorium intybus*	Chicory	X									2			
Asteraceae	*Cirsium vulgare*	Spear Thistle	X			2								2	2
Asteraceae	*Conyza spp.*	A Fleabane	X		2	2		2					3	2	3
Asteraceae	*Hypochaeris radicata*	Catsear	X							2	1		2	2	
Asteraceae	*Senecio madagascariensis*	Fireweed	X	2	3	2				2	1		2	4	3
Asteraceae	*Senecio spp.*	Groundsel, Fireweed	X						1						

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Asteraceae	*Silybum marianum*	Variegated Thistle	X							1	1			2	
Asteraceae	*Sonchus oleraceus*	Common Sowthistle	X								1				
Asteraceae	*Sonchus spp.*	Sowthistle	X									1	2	4	2
Asteraceae	*Tagetes minuta*	Stinking Roger	X											2	
Asteraceae	*Vittadinia sulcata*						1								
Brassicaceae	*Brassica rapa*		X			4			3						2
Brassicaceae	*Lepidium spp.*	A Peppercress	X					2	1						
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	X				1								
Campanulaceae	*Wahlenbergia spp.*	Bluebell												2	
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush					2								3
Chenopodiaceae	*Chenopodium album*	Fat Hen	X											4	
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush													4
Chenopodiaceae	*Salsola spp.*														4
Convolvulaceae	*Dichondra repens*	Kidney Weed										1			
Cucurbitaceae	*Citrullus lanatus*	Camel Melon	X											3	
Cyperaceae	*Carex inversa*	Knob Sedge			2										
Cyperaceae	*Cyperus spp.*									2				2	
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine				1									
Fabaceae	*Hardenbergia*	False												2	2

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
(Faboideae)	*violacea*	Sarsaparilla													
Fabaceae (Faboideae)	*Macroptilium atropurpureum*	Siratro	X								1	1			
Fabaceae (Faboideae)	*Medicago polymorpha*	Burr Medic	X								1				
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X								1				
Fabaceae (Faboideae)	*Medicago spp.*	A Medic	X									1			
Fabaceae (Faboideae)	*Trifolium spp.*	A Clover	X			2					1				
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle		3										2	
Fabaceae (Mimosoideae)	*Acacia binervata*	Two-veined Hickory												2	2
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle		4	4										3
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle											2	2	3
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle		4	4										
Fabaceae (Mimosoideae)	*Acacia falcata*												1		3
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle		4	3										
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba			5									2	3
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	X	4		3					1		1		3
Gentianaceae	*Centaurium spp.*		X		3	2									

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Geraniaceae	*Erodium cicutarium*	Common Crowfoot	X									1			
Geraniaceae	*Geranium solanderi*	Native Geranium								1					
Geraniaceae	*Geranium spp.*		X								1	1			
Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort									1				
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X			2						1			
Malvaceae	*Sida corrugata*	Corrugated Sida		1											
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X			2	1				1	1		2	
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X							2	1	1	2	5	
Myrtaceae	*Corymbia maculata*	Spotted Gum		5	5									1	
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark		2	1										
Myrtaceae	*Eucalyptus moluccana*	Grey Box		5	2								2		4
Oxalidaceae	*Oxalis perennans*									2				2	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X		3	2			1		1				3
Poaceae	*Austrostipa scabra*	Speargrass													3
Poaceae	*Avena spp.*	Oats	X						1						
Poaceae	*Bothriochloa macra*	Red Grass											2		
Poaceae	*Capillipedium spicigerum*	Scented-top Grass											2		

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Poaceae	*Chloris gayana*	Rhodes Grass	X	5	5	5	2	4	2						5
Poaceae	*Chloris truncata*	Windmill Grass				3							3		4
Poaceae	*Chloris ventricosa*	Tall Chloris							2						
Poaceae	*Cynodon dactylon*	Common Couch		3		3		3			1	1	6	2	3
Poaceae	*Dichanthium sericeum*	Queensland Bluegrass												2	
Poaceae	*Dichanthium setosum*	Bluegrass											2		
Poaceae	*Eragrostis brownii*	Brown's Lovegrass											2		
Poaceae	*Eragrostis spp.*	A Lovegrass	X						1						
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass					2	4	5						
Poaceae	*Melinus repens*	Red Natal Grass	X											3	
Poaceae	*Panicum capillare*	Witchgrass	X								1				
Poaceae	*Panicum effusum*	Hairy Panic			2		1				1			2	4
Poaceae	*Panicum maximum*	Guinea Grass	X	2	2	3								3	
Poaceae	*Pennisetum glaucum*	Pearl Millet	X							2	1	2		2	
Poaceae	*Rytidosperma spp.*								1						3
Poaceae	*Setaria gracilis*	Slender Pigeon Grass	X						3						3

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Poaceae	*Setaria parviflora*		X										2	4	
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass			2								3		
Poaceae	*Themeda triandra*														2
Poaceae	*Urochloa panicoides*	Urochloa Grass	X						2						
Portulacaceae	*Portulaca oleracea*	Pigweed						2							
Portulacaceae	*Portulaca spp.*		X				2				1			2	
Rubiaceae	*Pomax umbellata*	Pomax											2		
Sapindaceae	*Dodonaea viscosa*	Sticky Hop-bush												2	
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	X			1								2	
Solanaceae	*Solanum prinophyllum*	Forest Nightshade				2									2
Solanaceae	*Solanum spp.*		X									1			
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower												3	
Verbenaceae	*Verbena bonariensis*	Purpletop	X			2		2							

Flora two-way table: HVO Sites

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
Aizoaceae	*Galenia pubescens*	Galenia	X		3	2	2	3	2			2	3	3	3
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X		2				2	2	2				
Asteraceae	*Aster spp.*		X	2	2		2		2	3	2				3
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X					1	2	5	3	2			
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy						1							
Asteraceae	*Carthamus lanatus*	Saffron Thistle	X	2											2
Asteraceae	*Centaurea solstitialis*	St Barnabys Thistle	X		3	2									2
Asteraceae	*Cichorium intybus*	Chicory	X						3		3	2			
Asteraceae	*Cirsium vulgare*	Spear Thistle	X	3	3						2	1			1
Asteraceae	*Conyza spp.*	A Fleabane	X	3	2		2	4	2	2	2		1		
Asteraceae	*Senecio madagascariensis*	Fireweed	X	3	3	1	2	2	2	2	2	2			2
Asteraceae	*Silybum marianum*	Variegated Thistle	X								2	1			
Asteraceae	*Sonchus oleraceus*	Common Sowthistle	X						2						
Asteraceae	*Sonchus spp.*	Sowthistle	X	3	2						3	2			
Asteraceae	*Tagetes minuta*	Stinking Roger	X						2			1			
Asteraceae	*Taraxacum officinale*	Dandelion	X									1			
Asteraceae	*Vittadinia*	A Fuzzweed													1

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
	muelleri														
Brassicaceae	*Brassica rapa*		X	2	2				2	2	2	3			4
Brassicaceae	*Hirschfeldia incana*	Buchan Weed	X												1
Brassicaceae	*Lepidium spp.*	A Peppercress	X									2			
Cactaceae	*Opuntia stricta*	Common Prickly Pear, Smooth Pest Pear	X				2								
Campanulaceae	*Wahlenbergia spp.*	Bluebell						1		2					
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak												3	
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush				2									
Chenopodiaceae	*Chenopodium album*	Fat Hen	X			2	3		2						
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush				2				2	3				
Chenopodiaceae	*Einadia trigonos*	Fishweed			3						2			4	
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush		4	4									4	4
Chenopodiaceae	*Salsola spp.*			3	3	2			2	2	2				
Chenopodiaceae	*Sclerolaena spp.*	Copperburr, Poverty-bush						2							
Commelinaceae	*Commelina cyanea*	Native Wandering Jew				1		1		3					
Convolvulaceae	*Dichondra repens*	Kidney Weed								2					
Fabaceae	*Glycine*	Twining									1				

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
(Faboideae)	*clandestina*	glycine													
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla												1	
Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo												4	
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X								3	5			
Fabaceae (Faboideae)	*Trifolium spp.*	A Clover	X								2				
Fabaceae (Faboideae)	*Vicia spp.*	Vetch	X									2			
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle									2		4		
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle			3										
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle				1					2		3		3
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle											5	3	
Fabaceae (Mimosoideae)	*Acacia falcata*		X								2			2	
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle									3			3	3
Fabaceae (Mimosoideae)	*Acacia longifolia*													3	
Fabaceae (Mimosoideae	*Acacia paradoxa*	Kangaroo Thorn											1		

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
)															
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba		1	2	1					3		4	4	1
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	X	3	3	1			1		2	1			
Geraniaceae	*Geranium spp.*		X									1			
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush											2		
Malvaceae	*Malva spp.*	Mallow	X				2								
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X		2										
Malvaceae	*Modiola spp.*		X						1						
Malvaceae	*Sida corrugata*	Corrugated Sida											2		
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X						2		1		3		
Malvaceae	*Sida spp.*		X						2						
Myoporaceae	*Eremophila debilis*	Amulla											3		
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X								2	1			
Myrtaceae	*Corymbia maculata*	Spotted Gum									2		5	5	3
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark									1			4	
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark												3	3
Myrtaceae	*Eucalyptus moluccana*	Grey Box			4	2					1			3	3

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
Oleaceae	*Notelaea microcarpa*	Native Olive												1	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X		2				2	2	2	2	1		2
Poaceae	*Aristida spp.*	A Wiregrass							1						
Poaceae	*Aristida vagans*	Threeawn Speargrass											2		
Poaceae	*Austrostipa bigeniculata*	Yanganbil									3				
Poaceae	*Austrostipa spp.*	A Speargrass							2						
Poaceae	*Austrostipa verticillata*	Slender Bamboo Grass									2		4	3	3
Poaceae	*Avena spp.*	Oats	X				1		2						
Poaceae	*Bothriochloa macra*	Red Grass		2					3		4			2	4
Poaceae	*Bromus spp.*	A Brome	X												2
Poaceae	*Capillipedium spicigerum*	Scented-top Grass									3				
Poaceae	*Chloris gayana*	Rhodes Grass	X	3	5				2		3	1	3	2	3
Poaceae	*Chloris truncata*	Windmill Grass		2				2	2		3				2
Poaceae	*Chloris ventricosa*	Tall Chloris							2						
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass							2				2	2	
Poaceae	*Cynodon dactylon*	Common Couch		2	3	2					3				
Poaceae	*Digitaria brownii*	Cotton Panic Grass							2						
Poaceae	*Digitaria*	Umbrella					4								

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
	divaricatissima	Grass													
Poaceae	*Digitaria spp.*	A Finger Grass	X						2						
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass						3		2					
Poaceae	*Echinochloa spp.*		X	2			2				2				
Poaceae	*Eragrostis curvula*	African Lovegrass	X											3	2
Poaceae	*Eragrostis leptostachya*	Paddock Lovegrass			2								1		
Poaceae	*Eragrostis spp.*	A Lovegrass	X						2						
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass				2		2							
Poaceae	*Eriochloa spp.*	A Cupgrass							2	2	2	2			
Poaceae	*Lachnagrostis spp.*							2							
Poaceae	*Lolium perenne*	Perennial Ryegrass	X				1								
Poaceae	*Lolium spp.*	A Ryegrass	X						2						
Poaceae	*Panicum effusum*	Hairy Panic		4	4	2		2	2		2		1		2
Poaceae	*Panicum maximum*	Guinea Grass	X									2			
Poaceae	*Paspalidium spp.*								2		1				
Poaceae	*Paspalum dilatatum*	Paspalum	X						2						
Poaceae	*Pennisetum glaucum*	Pearl Millet	X	2				2		2	3				
Poaceae	*Rytidosperma*				3				2		2		2	3	4

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
	spp.														
Poaceae	*Setaria parviflora*		X					2	2	4	4				
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass											1		3
Poaceae	*Themeda triandra*													3	
Poaceae	*Triticum spp.*		X									3			
Poaceae	*Urochloa panicoides*	Urochloa Grass	X					1							
Poaceae	*Urochloa spp.*		X						2						
Polygonaceae	*Rumex crispus*	Curled Dock	X		1										
Portulacaceae	*Portulaca spp.*		X			1									
Proteaceae	*Hakea sericea*	Needlebush												2	
Rosaceae	*Rubus fruticosus*	Blackberry complex	X						2						
Rubiaceae	*Pomax umbellata*	Pomax							2						
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	X		2				2	3	3	1			2
Solanaceae	*Solanum prinophyllum*	Forest Nightshade										1			
Verbenaceae	*Verbena bonariensis*	Purpletop	X	1		2			2						2

Flora two-way table: HVO Sites

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Aizoaceae	*Galenia pubescens*	Galenia	X	2	2	2	5	2
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X		1	2	1	3
Asteraceae	*Aster* spp.		X	2			2	
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X		2	2	5	
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy				1		
Asteraceae	*Carthamus lanatus*	Saffron Thistle	X					2
Asteraceae	*Cichorium intybus*	Chicory	X		2			
Asteraceae	*Cirsium vulgare*	Spear Thistle	X			2	1	1
Asteraceae	*Conyza* spp.	A Fleabane	X	3		2	2	
Asteraceae	*Senecio madagascariensis*	Fireweed	X1		2		1	
Asteraceae	*Sonchus* spp.	Sowthistle	X					2
Asteraceae	*Tagetes minuta*	Stinking Roger	X		2	1	1	
Asteraceae	*Taraxacum officinale*	Dandelion	X			1		
Asteraceae	*Vittadinia cuneata*	A Fuzzweed				1		
Asteraceae	*Xanthium occidentale*	Noogoora Burr	X		2	3		
Asteraceae	*Xanthium spinosum*	Bathurst Burr	X				1	
Boraginaceae	*Heliotropium amplexicaule*	Blue Heliotrope	X					3
Brassicaceae	*Brassica rapa*		X	4	1			4

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell				2		
Chenopodiaceae	*Atriplex* spp.	A Saltbush			1	2		
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush		2			3	2
Chenopodiaceae	*Einadia trigonos*	Fishweed		2	1			
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush		4				
Chenopodiaceae	*Salsola* spp.					2		2
Convolvulaceae	*Dichondra repens*	Kidney Weed				1		2
Euphorbiaceae	*Ricinus communis*	Castor Oil Plant	X					2
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea				2		
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea				1		
Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil				1		
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine				1		
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla				1	1	1
Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo				2	2	
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X					1
Fabaceae (Faboideae)	*Trifolium repens*	White Clover	X				2	1
Fabaceae	*Acacia*	Fan Wattle			1	2	2	2

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
(Mimosoideae)	*amblygona*							
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle				2		
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle			1	2	3	2
Fabaceae (Mimosoideae)	*Acacia falcata*					2	2	
Fabaceae (Mimosoideae)	*Acacia filicifolia*	Fern-leaved Wattle					2	3
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle					1	
Fabaceae (Mimosoideae)	*Acacia longifolia*					1		
Fabaceae (Mimosoideae)	*Acacia paradoxa*	Kangaroo Thorn				2		
Fabaceae (Mimosoideae)	*Acacia parvipinnula*	Silver-stemmed Wattle				2		
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba						1
Fabaceae (Mimosoideae)	*Acacia spectabilis*	Mudgee Wattle			2	2	2	3
Gentianaceae	*Centaurium* spp.		X	2				
Geraniaceae	*Erodium cicutarium*	Common Crowfoot	X			2		

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Geraniaceae	*Erodium crinitum*	Blue Crowfoot						4
Geraniaceae	*Erodium spp.*	Crowfoot	X		1			
Geraniaceae	*Geranium solanderi*	Native Geranium					1	
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X		1		2	2
Malvaceae	*Sida cardiophylla*							1
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X		2		2	4
Myoporaceae	*Eremophila debilis*	Amulla				1		
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X		2	2	2	3
Myrtaceae	*Angophora floribunda*	Rough-barked Apple				1		
Myrtaceae	*Corymbia maculata*	Spotted Gum				2	2	
Myrtaceae	*Eucalyptus moluccana*	Grey Box				2	1	
Myrtaceae	*Eucalyptus spp.*						1	
Oxalidaceae	*Oxalis perennans*				1		1	
Phytolaccaceae	*Phytolacca octandra*	Inkweed	X				1	1
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X	3	1	2	2	2
Poaceae	*Aira cupaniana*	Silvery Hairgrass	X		2			
Poaceae	*Aristida ramosa*	Purple Wiregrass					1	

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Poaceae	*Austrostipa bigeniculata*	Yanganbil				2	2	
Poaceae	*Austrostipa scabra*	Speargrass				2	3	
Poaceae	*Bothriochloa macra*	Red Grass				2	2	2
Poaceae	*Capillipedium spicigerum*	Scented-top Grass			2	3	2	
Poaceae	*Chloris gayana*	Rhodes Grass	X	4	3	2	2	2
Poaceae	*Chloris truncata*	Windmill Grass		4	2	2	3	2
Poaceae	*Chloris ventricosa*	Tall Chloris		3		2		
Poaceae	*Chloris virgata*	Feathertop Rhodes Grass	X		2		2	
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass				2		1
Poaceae	*Cynodon dactylon*	Common Couch				1	3	
Poaceae	*Dichanthium sericeum*	Queensland Bluegrass			3		4	
Poaceae	*Dichanthium setosum*	Bluegrass						4
Poaceae	*Digitaria* spp.	A Finger Grass	X		2			
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass			2			
Poaceae	*Eleusine* spp.		X				1	
Poaceae	*Eragrostis brownii*	Brown's Lovegrass						2
Poaceae	*Eragrostis* spp.	A Lovegrass	X			2		
Poaceae	*Eriochloa*	Early Spring		6				

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
	pseudoacrotricha	Grass						
Poaceae	*Eriochloa* spp.	A Cupgrass			2	2		2
Poaceae	*Melinis repens*	Red Natal Grass	X			1		
Poaceae	*Panicum capillare*	Witchgrass	X			2		
Poaceae	*Panicum effusum*	Hairy Panic					2	2
Poaceae	*Panicum maximum*	Guinea Grass		2	3		1	4
Poaceae	*Paspalidium distans*					2		
Poaceae	Paspalidium spp.							2
Poaceae	Paspalum dilatatum	Paspalum				1	2	2
Poaceae	Paspalum quadrifarium	Tussock Paspalum			2			
Poaceae	Pennisetum clandestinum	Kikuyu Grass			2		2	2
Poaceae	Pennisetum glaucum	Pearl Millet	X			1	2	
Poaceae	Rytidosperma spp.					2	3	
Poaceae	Setaria parviflora		X		3		5	
Poaceae	Sporobolus creber	Slender Rat's Tail Grass		4				
Poaceae	Themeda avenacea	Native Oatgrass				1	1	
Poaceae	Urochloa spp.		X				2	2

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Solanaceae	Solanum nigrum	Black-berry Nightshade	X			2	2	2
Solanaceae	Solanum prinophyllum	Forest Nightshade			2	2	3	3
Verbenaceae	Verbena bonariensis	Purpletop	X	2		2	2	

Flora two-way table: Reference sites

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower		1			2								
Adiantaceae	*Cheilanthes sieberi*	Rock Fern			1	1	2						2		
Aizoaceae	*Galenia pubescens*	Galenia	*												3
Amaranthaceae	*Alternanthera spp.*	Joyweed											1		3
Anthericaceae	*Dichopogon spp.*	Chocolate Lily					2			1			3		
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily		2										3	
Asteraceae	*Calotis cuneifolia*	Purple Burr-Daisy				2						2			
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy			3								2		
Asteraceae	*Cassinia uncata*	Sticky Cassinia										2	1		
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting						2					1		
Asteraceae	*Olearia elliptica*	Sticky Daisy-bush		4			4	1	3	5	3		1		
Asteraceae	*Ozothamnus diosmifolius*	White Dogwood													1
Asteraceae	*Senecio madagascariensis*	Fireweed	*		1		2	2				2	2	2	3
Asteraceae	*Senecio sp. E*				2							2			
Asteraceae	*Vittadinia cuneata*	A Fuzzweed		2			2					2	2		
Asteraceae	*Vittadinia sulcata*				3										2
Bignoniaceae	*Pandorea pandorana*	Wonga Vine								1					
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	*										2	2	2
Cactaceae	*Opuntia stricta*	Common Prickly Pear, Smooth Pest Pear	*				2	2	2			4	1		
Campanulaceae	*Wahlenbergia spp.*	Bluebell					2	2			1		2		
Casuarinaceae	*Allocasuarina luehmannii*	Bulloak					5					4	5	5	3
Chenopodiaceae	*Einadia hastata*	Berry Saltbush										1			
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush											1		
Chenopodiaceae	*Einadia trigonos*	Fishweed										2			

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush													1
Clusiaceae	*Hypericum gramineum*	Small St John's Wort											1		
Commelinaceae	*Commelina cyanea*	Native Wandering Jew								2	1		3	3	3
Convolvulaceae	*Dichondra repens*	Kidney Weed											1		
Cyperaceae	*Carex inversa*	Knob Sedge					2						2		
Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge												1	
Cyperaceae	*Gahnia aspera*	Rough Saw-sedge		2	3	3		2	2		2		1		
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge		3	4										
Dilleniaceae	*Hibbertia spp.*								2						
Ericaceae	*Lissanthe strigosa*	Peach Heath		3	3	2									
Euphorbiaceae	*Amperea xiphoclada*										3	4			
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea												2	
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea												2	3
Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil					2	2	2	3					
Fabaceae (Faboideae)	*Desmodium varians*	Slender Tick-trefoil		2		3	2	2	2	3	2	2	2	3	
Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine									2	1	3		
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine		2	3	3			2			2	3	3	
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla		3											
Fabaceae (Faboideae)	*Hovea linearis*								1						
Fabaceae (Faboideae)	*Pultenaea spinosa*	A Bush Pea		3	3										
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle		3				3		3				3	5
Fabaceae (Mimosoideae)	*Acacia bulgaensis*	Bulga Wattle							4						
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle						2							
Fabaceae	*Acacia decurrens*	Black Wattle											1		

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
(Mimosoideae)															
Fabaceae (Mimosoideae)	*Acacia falcata*			3	4	2		3							2
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle					2		3		4	3			
Fabaceae (Mimosoideae)	*Acacia mearnsii*	Black Wattle		3	4	2									
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba													1
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	*				2	2				1			
Goodeniaceae	*Goodenia rotundifolia*			1											
Juncaceae	*Juncus prismatocarpus*						1	2							
Lauraceae	*Cassytha pubescens*	Downy Dodder-laurel									2				
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush			4	5	2	2		2			2		2
Lomandraceae	*Lomandra filiformis subsp. filiformis*							2	2	2					
Lomandraceae	*Lomandra glauca*	Pale Mat-rush												2	3
Lomandraceae	*Lomandra multiflora*	Many-flowered Mat-rush			2			2	2		2	2			
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily								2					
Malvaceae	*Sida corrugata*	Corrugated Sida					3	2	2	2		3	2		
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	*												2
Myoporaceae	*Eremophila debilis*	Amulla				1						3	2		2
Myrsinaceae	*Rapanea howittiana*	Brush Muttonwood									2				
Myrtaceae	*Corymbia maculata*	Spotted Gum		5	5	5				5	4				
Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum												5	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark		4			2		4		4	5	5	4	4
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark				4	4								
Myrtaceae	*Eucalyptus moluccana*	Grey Box		3	4	5	3	5		5					
Myrtaceae	*Eucalyptus punctata*	Grey Gum							5		3				

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Myrtaceae	*Melaleuca decora*													4	
Oleaceae	*Notelaea longifolia*	Large Mock-olive						2	3	2	2	3			
Oleaceae	*Notelaea microcarpa*	Native Olive						4							
Oleaceae	*Olea europaea*	Common Olive	*	3	3	5									
Oxalidaceae	*Oxalis perennans*													1	
Phormiaceae	*Dianella longifolia*	Blueberry Lily			1										
Phormiaceae	*Dianella longifolia var. longifolia*	A Blue Flax Lily				2	2			2			1		
Phormiaceae	*Dianella revoluta*	Blueberry Lily		3	3	4	2				2			2	3
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			4	3			2		2	3	2	2	
Phyllanthaceae	*Phyllanthus gunnii*														1
Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge											1	1	
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn		4		3			4	4	4		3	3	
Plantaginaceae	*Veronica plebeia*	Trailing Speedwell					2							2	
Poaceae	*Aristida ramosa*	Purple Wiregrass			2	3	4	3		2			4		
Poaceae	*Aristida vagans*	Threeawn Speargrass		3	1	2		2	3	3	3	4	4	5	4
Poaceae	*Austrostipa scabra*	Speargrass		2			4	2		2		3	3		
Poaceae	*Austrostipa verticillata*	Slender Bamboo Grass						2	4		4				
Poaceae	*Chloris truncata*	Windmill Grass								2					3
Poaceae	*Chloris ventricosa*	Tall Chloris						2		2					
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass		3	4	3	4	3	4	4	3	4	3	5	5
Poaceae	*Cynodon dactylon*	Common Couch												3	
Poaceae	*Entolasia marginata*	Bordered Panic		2											
Poaceae	*Entolasia stricta*	Wiry Panic			4	4	2				2		5	4	
Poaceae	*Eragrostis brownii*	Brown's Lovegrass						2						3	3
Poaceae	*Microlaena stipoides*	Weeping Grass				2									
Poaceae	*Oplismenus aemulus*										1				
Poaceae	*Panicum effusum*	Hairy Panic						2		2					

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Poaceae	*Rytidosperma spp.*					2	4	3	2	4	2	3	4	3	3
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass													3
Poaceae	*Themeda triandra*											2	4		
Proteaceae	*Grevillea mucronulata*									2					
Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung							3		3				
Ranunculaceae	*Clematis aristata*	Old Man's Beard									1				
Rubiaceae	*Pomax umbellata*	Pomax		2		2									
Rutaceae	*Boronia pinnata*									1					
Santalaceae	*Exocarpos cupressiformis*	Cherry Ballart							4			3	1		
Sapindaceae	*Dodonaea viscosa*	Sticky Hop-bush						2	3	2	4				
Solanaceae	*Solanum prinophyllum*	Forest Nightshade				1			2			2	1		
Sterculiaceae	*Brachychiton populneus*	Kurrajong						1	1	1	1				
Sterculiaceae	*Lasiopetalum spp.*								1						
Verbenaceae	*Lantana camara*	Lantana	*									1			
Zamiaceae	*Macrozamia flexuosa*								3	3	4				

Appendix 5 – Visual and Photo Monitoring

HVORIV201503

HVORIV201503	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	311249	6398378
End transect:	311216	6398340

Description:

The HVORIV201503 rehabilitation area occurs on imported topsoil and compost with a second application of gypsum and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Aster sp., Chloris gayana, Pennisetum glaucum, Sonchus spp., Setaria parviflora, Cichorium intybus, Solanum nigrum* and *Bidens pilosa.*

Table. Dominant species and structure at HVORIV201503

Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia amblygona, Acacia decora, Corymbia maculata, Acacia implexa, Acacia falcata*
Ground layer	1	30	*Bothriochloa macra, Rytidosperma spp., Chloris truncata, Austrostipa bigeniculata, Einadia nutans, Cynodon dactylon, Capillipedium spicigerum*

*Projected foliage cover

Site photographs at HVORIV201503

Start position 2017

End position 2017

HVORIV201502

HVORIV201502	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	311543	6398308
End transect:	311526	6398260

Description:

The HVORIV201502 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been weed wiped to kill weeds and reduce competition with natives sown in 2016.

Common weeds recorded at the site included *Aster sp., Solanum nigrum, Plantago lanceolata, Conyza bonariensis* and *Bidens pilosa.*

Table. Dominant species and structure at HVORIV201502

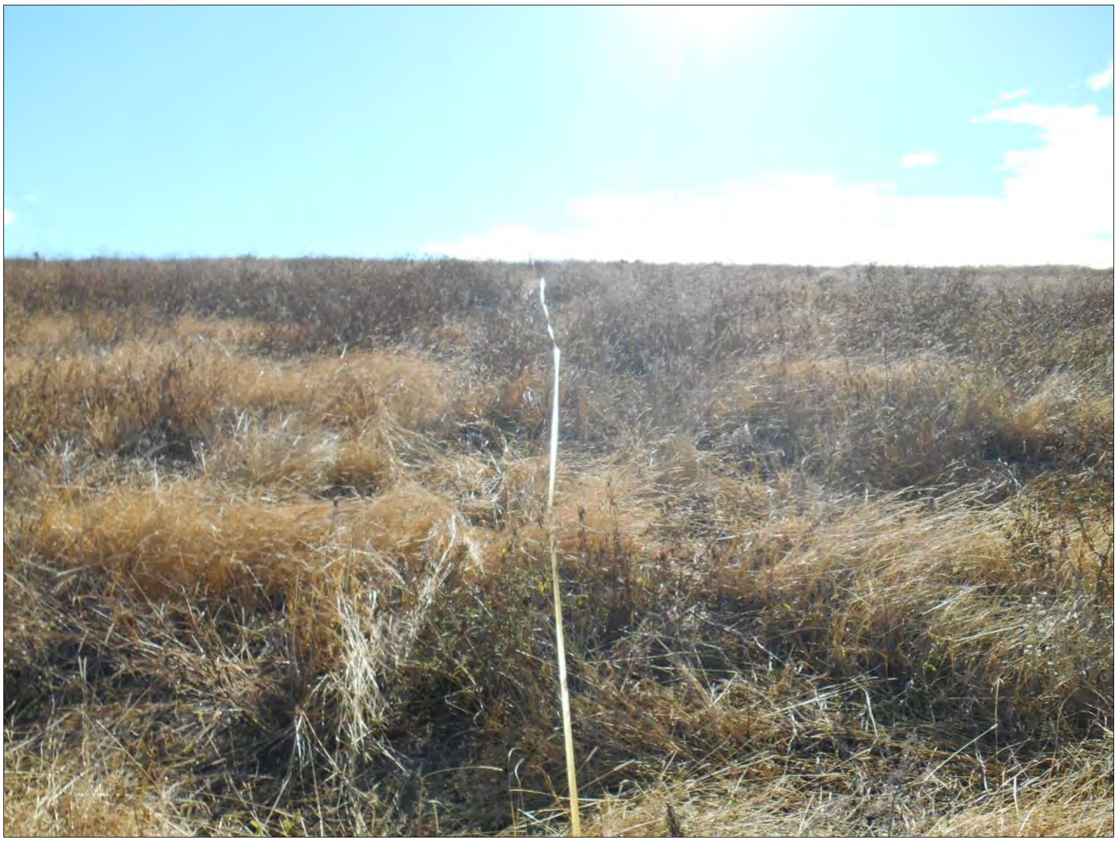
Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	15	*Commelina cyanea, Dichondra repens, Einadia nutans*

*Projected foliage cover

Site photographs at HVORIV201502

Start position 2017

End position 2017



HVORIV201501

HVORIV201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	312211	6398020
End transect:	312256	6397998

Description:

HVORIV201501 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consists mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Acacia saligna*, *Galenia pubescens, Plantago lanceolata, Conyza bonariensis, Senecio madagascariensis* and *Chloris gayana*.

Table. Dominant species and structure at HVORIV201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	40	*Bothriochloa macra, Panicum effusum*, *Austrostipa sp.*

*Projected foliage cover

Site photographs at HVORIV201501

Start position 2017

End position 2017

HVOLEM201501

HVOLEM201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	6394462	316910
End transect:	-	-

Description:

HVOLEM201501 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOLEM201501 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Senecio madagascariensis, Conyza bonariensis* and *Aster spp*.

Table. Dominant species and structure at HVOLEM201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Eucalyptus moluccana*
Ground layer	1	75	*Cynodon dactylon, Bothriochloa macra, Capillipedium spicigerum, Dichanthium sericeum, Sporobolus creber, Chloris truncata*

*Projected foliage cover

Site photographs at HVOLEM201501

Start position 2017

End position 2017

HVOCHE201501

HVOCHE201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	313968	6402006
End transect:	313952	6402056

Description:

HVOCHE201501rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOCHE201501consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Common weeds recorded at the site included *Senecio madagascariensis, Anagallis arvensis* and *Hypochaeris radicata.*

Table. Dominant species and structure at HVOCHE201501

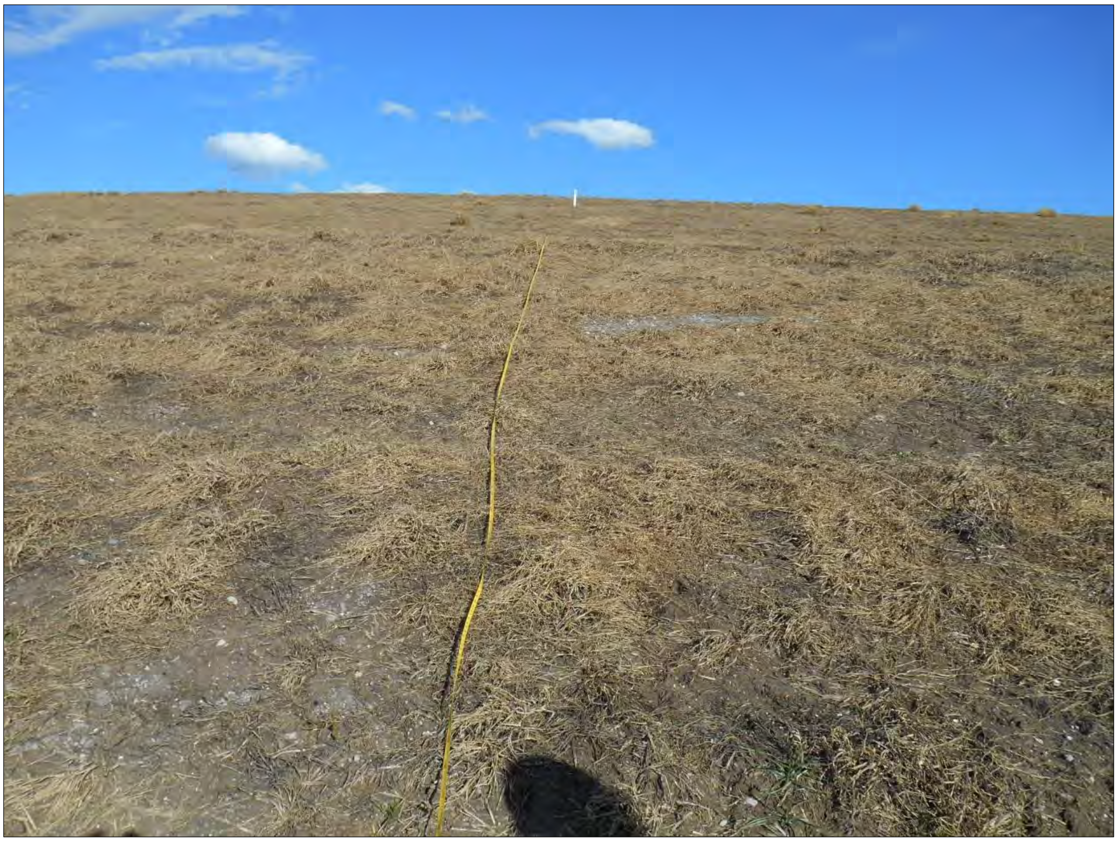
Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	
Ground layer	0.5	<5	*Oxalis perennans*, *Geranium solanderi*

*Projected foliage cover

Site photographs at HVOCHE201501

Start position 2017

End position 2017



HVORIV201601

HVORIV201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	311284	6398284
End transect:	311314	6398245

Description:

HVORIV201601 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVORIV201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Medicago sativa, Bidens pilosa, Senecio madagascariensis, Sonchus sp.* and *Brassica spp*..

Table. Dominant species and structure at HVORIV201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	<5	*Solanum prinophyllum, Echinochloa colona, Geranium solanderi*

*Projected foliage cover

Site photographs at HVORIV201601

Start position 2017

End position 2017

HVOWES201602

HVOWES201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	308357	6408560
End transect:	308323	6408597

Description:

HVOWES201602 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted that a number of regenerating eucalypts and small acacias were recorded in the plot.

Disturbance:

Disturbance present at rehabilitation site HVOWES201602 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Galenia pubescens, Plantago lanceolata, Senecio mada gascariensis, Gomphocarpous fruiticosis, Melinis repens, Pennisetum glaucum* and *Solanum nigrum.*

Table. Dominant species and structure at HVOWES201602

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	30	*Acacia falcata, acacia cultriformis, Acacia paradoxa, Eucalyptus moluccana, Corymbia maculate, Acacia decora*
Ground layer	1	50	*Capillipedium spicigerum, Dichondra repens, Wahlenbergia communis, Austrostipa scabra, Themeda avenacea*

*Projected foliage cover

Site photographs at HVOWES201602

Start position 2017

End position 2017

HVOWES201601

HVOWES201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	309820	6410903
End transect:	-	-

Description:

HVOWES201601 rehabilitation area occurs on a combination of spoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted that a number of acacias were also recorded regenerating in the plot.

Disturbance:

Disturbance present at rehabilitation site HVOWES201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Chloris gayana, Galenia pubescens, Bidens pilosa, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Sida rhombifolia* and *Solanum nigrum.*

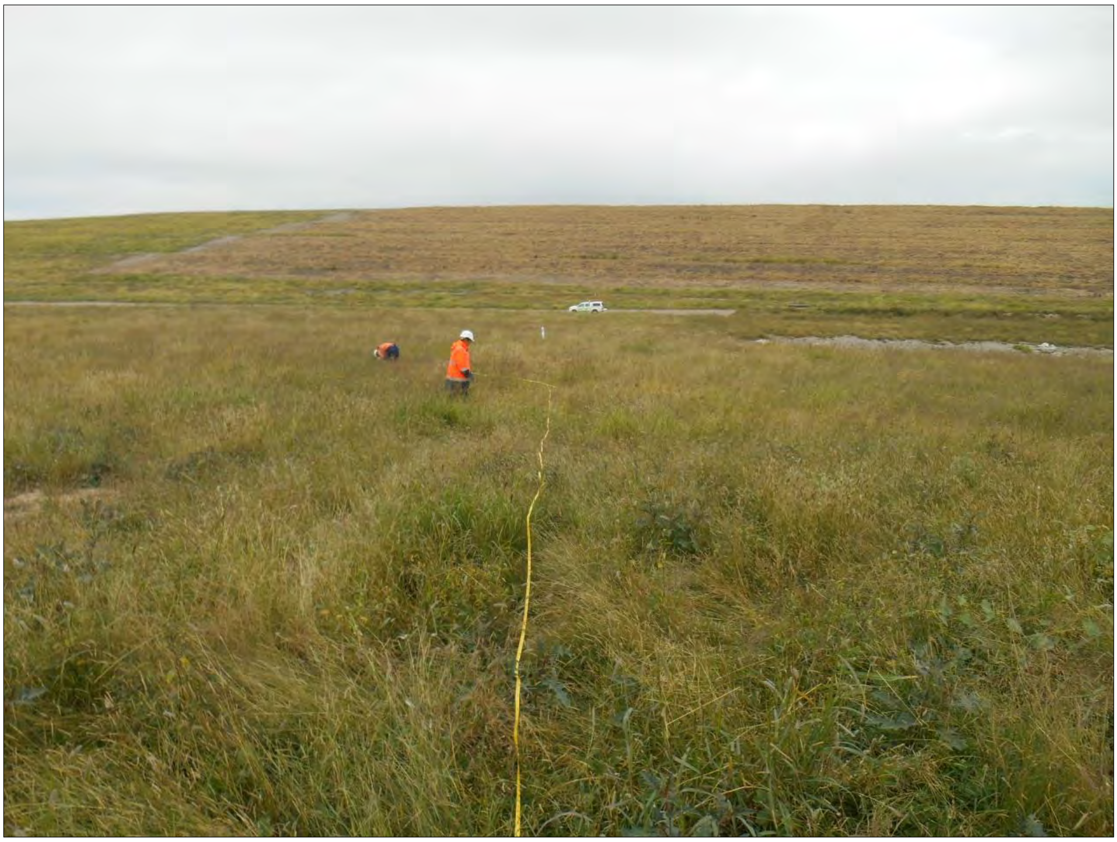
Table. Dominant species and structure at HVOWES201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia spectabilis, Acacia decora, Acacia amblygona*
Ground layer	1	25	*Capillipedium spicigerum, Solanum prinophyllum, Chloris truncata, Eriochloa pseudoacrotricha, Atriplex semibaccata*

*Projected foliage cover

Site photographs at HVOWES201601

Start position 2017



End position 2017

HVOWES201603

HVOWES201603	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	309354	6409944
End transect:	309385	6409903

Description:

HVOWES201603 rehabilitation area occurs on a combination of topsoil and compost. The compost that was applied to this area is a composted green waste rather than the mixed source compost typically used in rehabilitation at HVO.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOWES201603 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Conyza bonariensis, Chloris gayana, Setaria parviflora, Verbena bonariensis, Galenia pubescens, Bidens pilosa, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Plantago lanceolata, Sida rhombifolia* and *Solanum nigrum.*

Table. Dominant species and structure at HVOWES201603

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia decora, Acacia falcata, Acacia filicifolia, Acacia amblygona*
Ground layer	1	30	*Einadia nutans, Austrostipa bigeniculata, Austrostipa scabra Chloris truncata, Rytidosperma spp., Cynodon dactylon, Dichanthium sericeum*

*Projected foliage cover

Site photographs at HVOWES201603

Start position 2017

End position 2017

HVOWES201604

HVOWES201604	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	307372	6407327
End transect:	307394	6407374

Description:

HVOWES201604 rehabilitation area occurs on a combination of topsoil, compost and trail of composted green waste.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOWES201604 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Chloris gayana, Anagallis arvensis, Galenia pubescens, Gomphocarpous fruiticosis, Panicum maximum, Heliotropium amplexicaule, Sida rhombifolia, Brassica rapa* and *Erodium cicutarium.*

Table. Dominant species and structure at HVOWES201604

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia decora, Acacia filicifolia, Acacia amblygona, Acacia spectabilis*
Ground layer	1	30	*Solanum prinophyllum, Einadia nutans, Dichondra repens, Chloris truncata, Dichanthium sericeum*

*Projected foliage cover

Site photographs at HVOWES201604

Start position 2017

End position 2017

HVOCHE201601

HVOCHE201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	313555	6401634
End transect:	313541	6401683

Description:

HVOCHE201601 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOCHE201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Common weeds recorded at the site included *Conyza bonariensis*, *Galenia pubescens, Senecio madagascariensis* and *Sida rhombifolia.*

Table. Dominant species and structure at HVOCHE201601

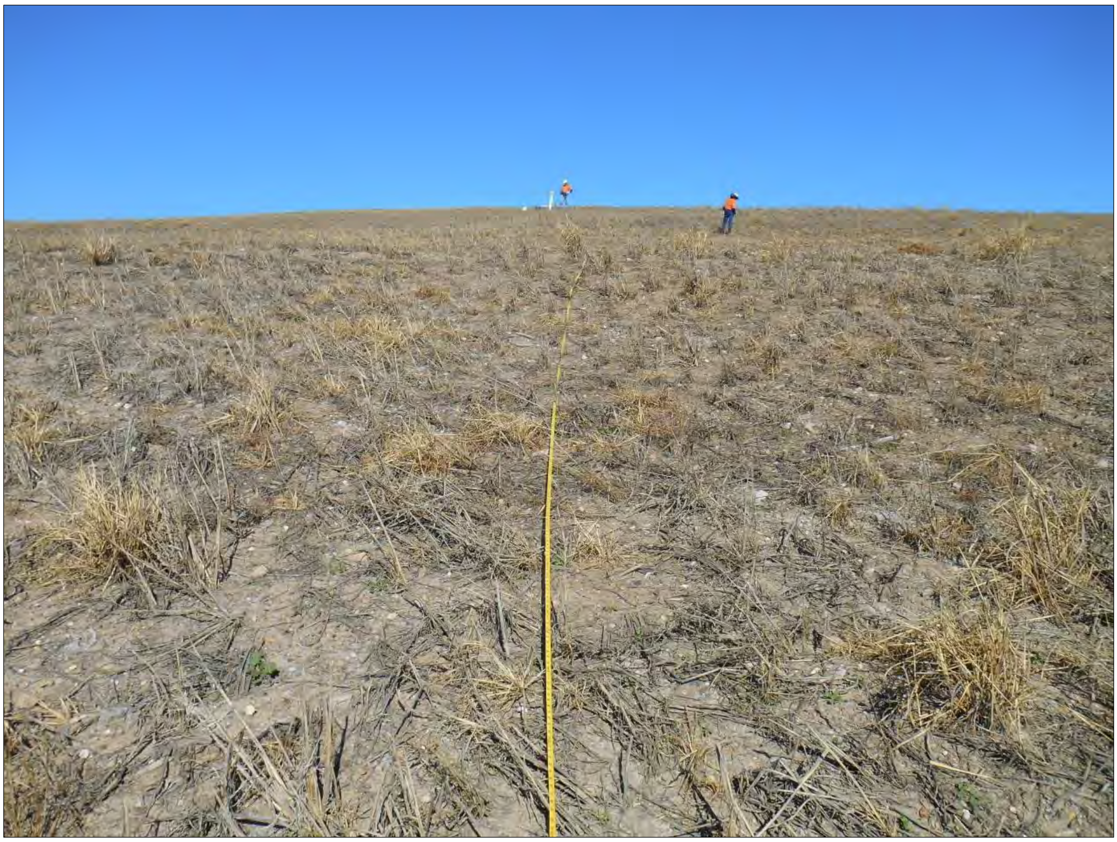
Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	<5	*Panicum effusum, Cynodon dactylon*

*Projected foliage cover

Site photographs at HVOCHE201601

Start position 2017

End position 2017



HVOCHE201602

HVOCHE201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	313072	6401299
End transect:	313057	6401346

Description:

HVOCHE201602 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOCHE201602 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Common weeds recorded at the site included *Pennisetum glaucum, Macroptilium atropurpureum* and *Galenia pubescens.*

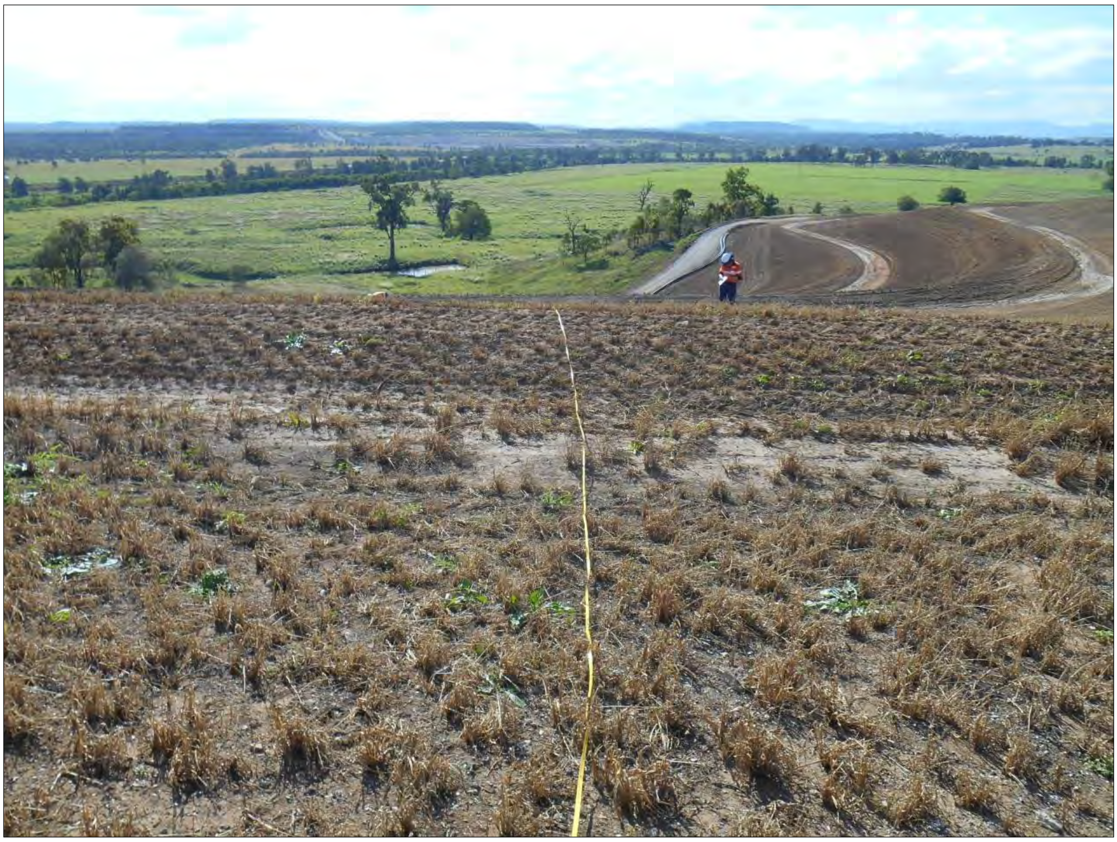
Table. Dominant species and structure at HVOCHE201602

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	<5	*Dichondra repens, Cynodon dactylon*

*Projected foliage cover

Site photographs at HVOCHE201602

Start position 2017



End position 2017

HVOLEM201601

HVOLEM201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	317039	6394768
End transect:	316990	6394760

Description:

HVOLEM201601 is rehabilitation area occurs on a combination of topsoil, compost and trial of composted green waste.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOLEM201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Conyza bonariensis*, *Setaria parviflora, Galenia pubescens, Senecio mada gascariensis, Panicum maximum* and *Anagallis arvensis.*

Table. Dominant species and structure at HVOLEM201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1	<5	*Corymbia maculata, Acacia binervata, Dodonaea viscosa, Acacia salicina, Acacia amblygona*
Ground layer	0.5	10	*Dysphania pumilio, Pimelea linifolia, Dichanthium sericeum, wahlenbergia communis, Hardenbergia violacea*

*Projected foliage cover

Site photographs at HVOLEM201601

Start position 2017

End position 2017

MTWSPS201601

MTWSPS201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320910	6389384
End transect:	320949	6389413

Description:

MTWSPS201601 rehabilitation area occurs on topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site MTWSPS201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Chloris gayana, Cichorium intybus* and *Conyza spp..*

Table. Dominant species and structure at MTWSPS201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	10	*Cynodon dactylon, Glycine tabacina, Phylon sp., Eriochloa pseudoacrotricha*

*Projected foliage cover

Site photographs at MTWSPS201601

Start position 2017

End position 2017

MTWSPN201602

MTWSPN201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320444	6389769
End transect:	320494	6389775

Description:

MTWSPN201602 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site MTWSPN201602 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Setaria parviflora, Cichorium intybus, Brassica rapa* and *Solanum nigrum.*

Table. Dominant species and structure at MTWSPN201602

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	30	*Chloris truncata, Panicum effusum, Bothriochloa macra, Eragrostis brownii*

*Projected foliage cover

Site photographs at MTWSPN201602

Start position 2017

End position 2017

MTWSPN201601

MTWSPN201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320130	6390589
End transect:	320158	6390630

Description:

The MTWSPN201601 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted no natives or exotic species were recorded at MTWSPN201601.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Table. Dominant species and structure at MTWSPN201601

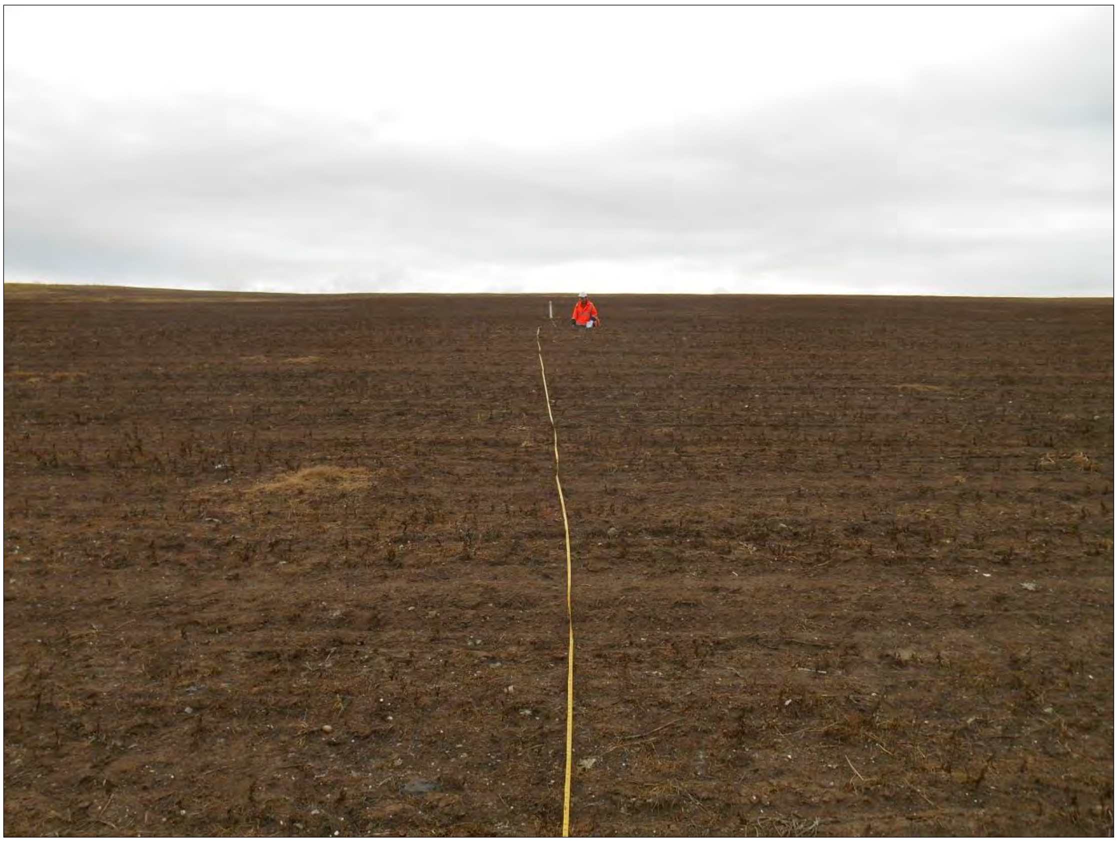
Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

*Projected foliage cover

Site photographs at MTWSPN201601

Start position 2017

End position 2017



MTWSPN201501

MTWSPN201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	319956	6390291
End transect:	319984	6390332

Description:

The MTWSPN201501 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted no native species were recorded at MTWSPN201501. One native species, *Chloris ventricosa,* was recorded which had been sprayed and was dead.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Portulaca spp., Galenia pubescens* and *Chloris gayana.*

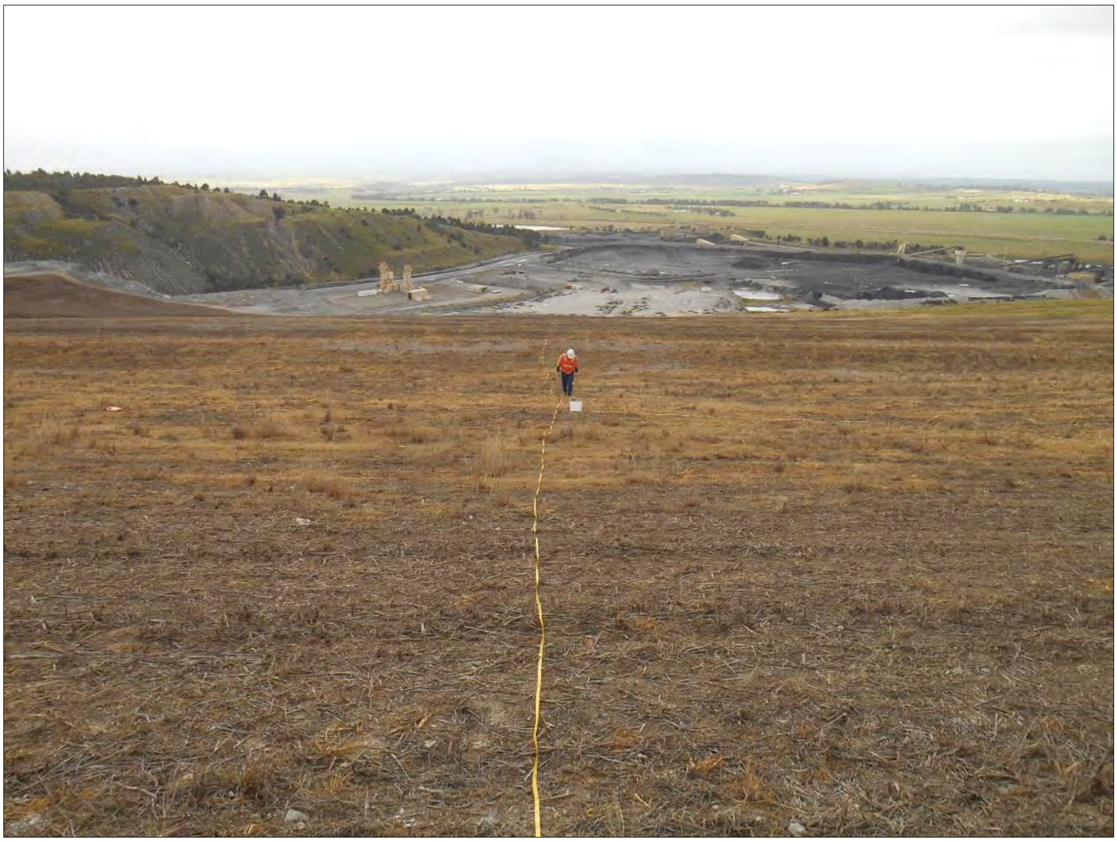
Table. Dominant species and structure at MTWSPN201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

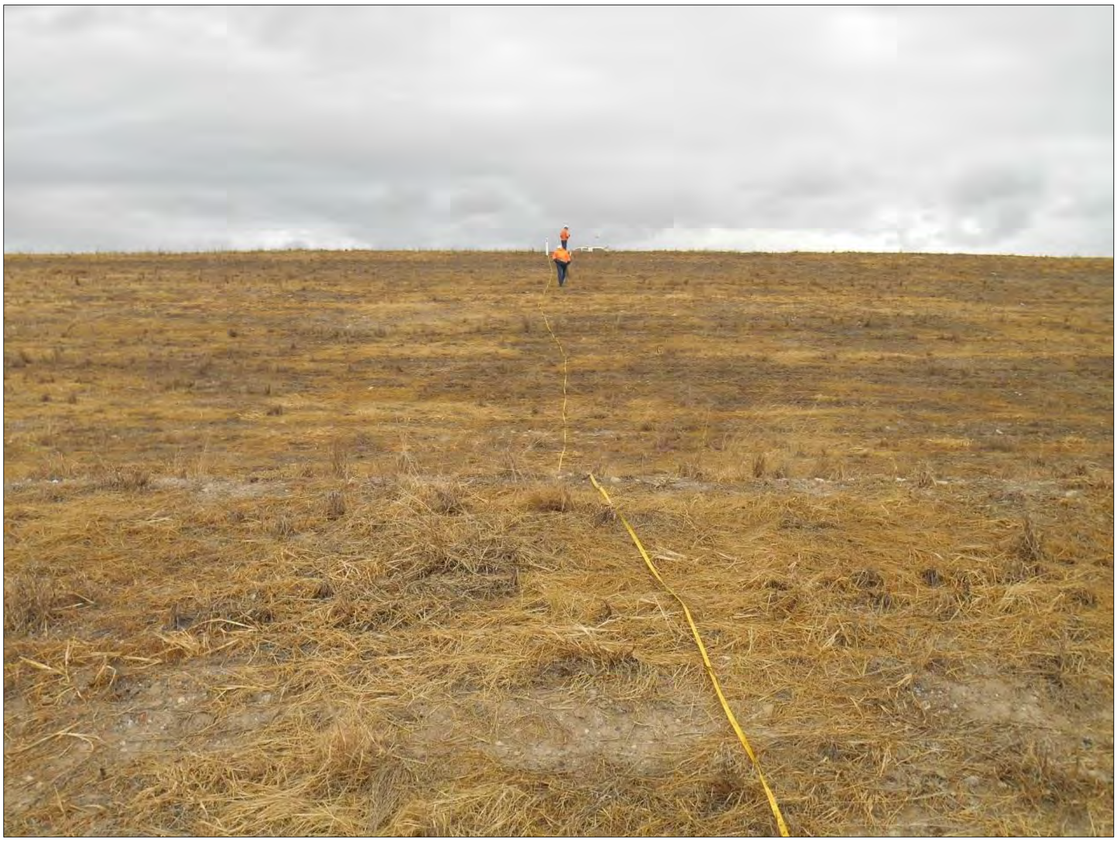
*Projected foliage cover

Site photographs at MTWSPN201501

Start position 2017



End position 2017



MTWSPS201602

MTWSPS201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320830	6388963
End transect:	320879	6388975

Description:

The MTWSPS201602 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Macroptilium bracteatum* , *Medicago sativa, Brassica rapa* and *Panicum maximum.*

Table. Dominant species and structure at MTWSPS201602

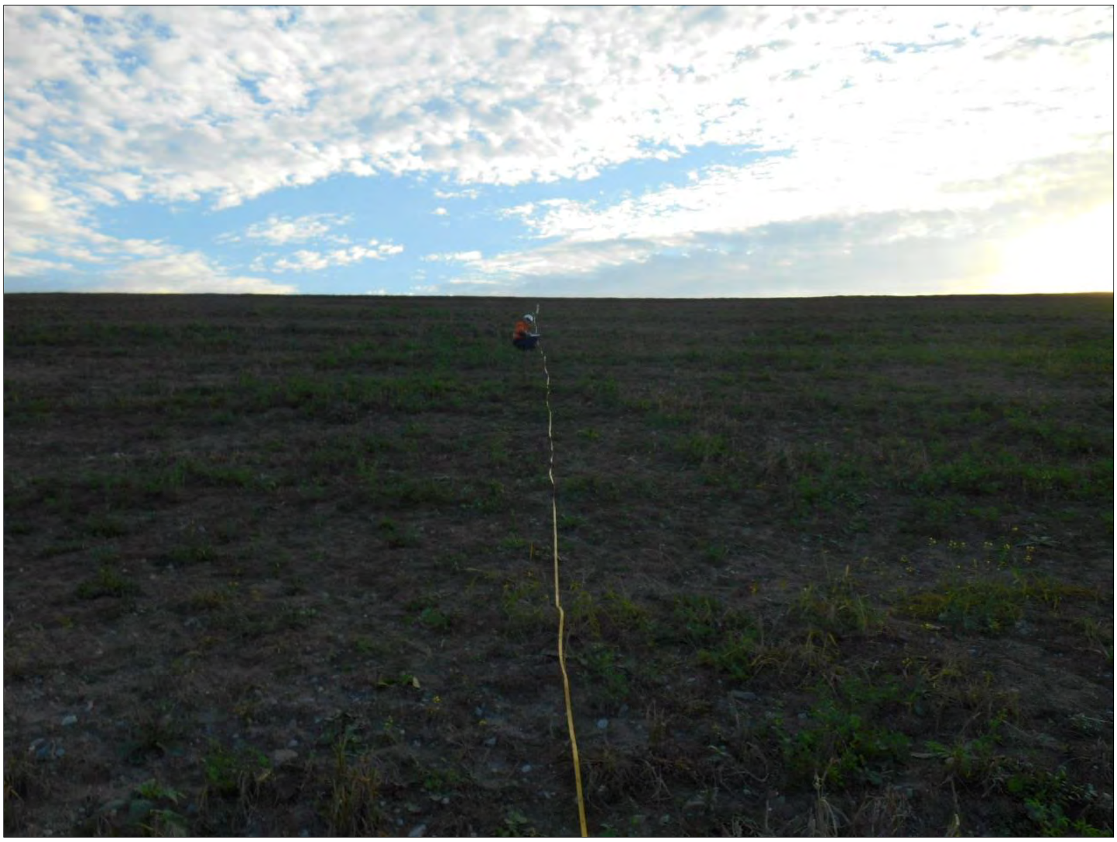
Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

*Projected foliage cover

Site photographs at MTWSPS201602

Start position 2017

End position 2017



MTWNOO201501

MTWNOO201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320406	6391940
End transect:	320438	6391979

Description:

The MTWNOO201501 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Panicum maximum, Plantago lanceolata, Chloris gayana, Sida rhombifolia* and *Brassica rapa.*

Table. Dominant species and structure at MTWNOO201501

Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia cultriformis, Acacia decora*
Ground layer	1	40	*Sporobolus creber, Chloris truncata, Bothriochloa macra, Dichondra repens, Oxalis perennans, Eragrostis brownii, Panicum effusum, Glycine tabacina, Geranium solanderi, Entolasia stricta*

*Projected foliage cover

Site photographs at MTWNOO201501

Start position 2016

End position 2017

MTWMTO201501

MTWMTO201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	321386	6385357
End transect:	321427	6385331

Description:

The MTWMTO201501 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Bidens pilosa, Setaria italica, Galea pubescens, Plantago lanceolata, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis.*

Table. Dominant species and structure at MTWMTO201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	<5	*Dichondra repens, Enchylaena tomentosa, Cynodon dactylon, Eriochloa pseudoacrotricha*

*Projected foliage cover

Site photographs at MTWMTO201501

Start position 2017

End position 2017

MTWMTO201601

MTWMTO201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320667	6385308
End transect:	320718	6385305

Description:

The MTWMTO201601 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Pennisetum glaucum, Solanum nigrum, Portulaca spp.* and *Arctotheca calendula.*

Table. Dominant species and structure at MTWMTO201601

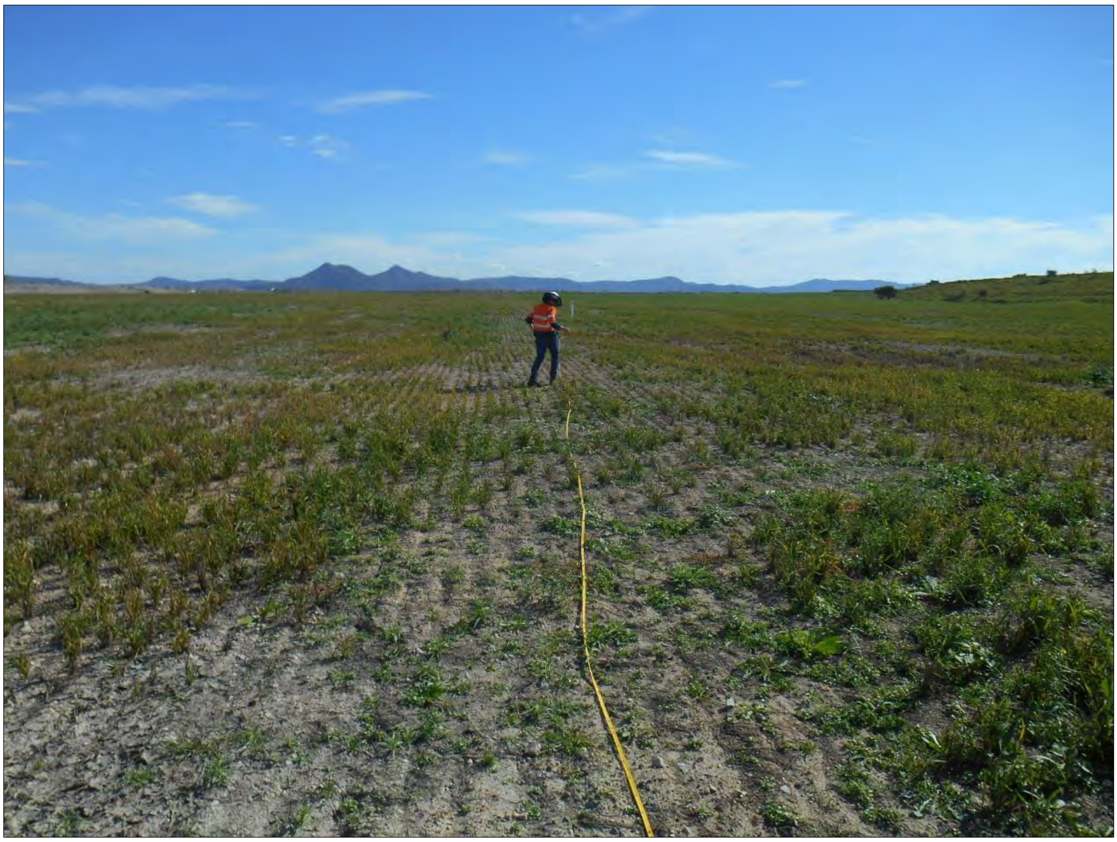
Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

*Projected foliage cover

Site photographs at MTWMTO201601

Start position 2017

End position 2017



Appendix 6 – Tree and canopy data

Bell 1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		20	
2	*E. crebra*		30	
3	*C. maculata*		13	
4	*C. maculata*		16	
5	*E. crebra*		15	
6	*E. crebra*		30	
7	*C. maculata*		12	
8	*C. maculata*		20	
9	*C. maculata*		18	
10	*E. crebra*		28	
11	*C. maculata*		15	
12	*E. crebra*		25	
13	*E. crebra*		12	
14	*E. crebra*		10	
15	*E. crebra*		10	
16	*E. crebra*		10	
17	*E. crebra*		25	
18	*E. crebra*		25	
19	*E. crebra*		30	
20	*E. crebra*		10	

Bell 2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		20	
2	*E. moluccana*		16	
3	*C. maculata*		22	
4	*C. maculata*		21	
5	*C. maculata*		20	1
6	*C. maculata*		12	
7	*C. maculata*		18	
8	*C. maculata*		8	
9	*C. maculata*		13	
10	*C. maculata*		20	
11	*C. maculata*		13	

Bell 2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
12	*C. maculata*		43	
13	*E. moluccana*		18	
			244	

Bell 3				
Tree Number	**Tree Species**	**Fruit/Flowers**	**Width range (cm)**	**Hollows**
1	*C. maculata*		26	
2	*C. maculata*		25	
3	*C. maculata*		12	
4	*E. moluccana*		15	
5	*C. maculata*		11	
6	*C. maculata*		28	
7	*C. maculata*		24	
8	*C. maculata*		11	
9	*C. maculata*		17	
10	*C. maculata*		12	
11	*E. moluccana*		15	
12	*C. maculata*		11	
13	*E. moluccana*		15	
14	*C. maculata*		10	
15	*E. fibrosa*		12	
16	*C. maculata*		8	
17	*C. maculata*		18	
18	*C. maculata*		18	
19	*C. maculata*		12	
20	*C. maculata*		15	
21	*C. maculata*		11	

HVOCAR200901				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		7	
2	*C. maculata*		7	
3	*C. maculata*		7	
4	*C. maculata*		7	
5	*C. maculata*		6	
6	*C. maculata*		12	
7	*E. moluccana*		13	

HVOCAR200901				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
8	*E. moluccana*		10	
9	*C. maculata*		15	
10	*C. maculata*		11	
11	*C. maculata*		15	
12	*C. maculata*		9	
13	*C. maculata*		5	
14	*C. maculata*		7	
15	*A. implexa*		13	
16	*E. moluccana*		11	
17	*C. maculata*		13	
18	*C. maculata*		12	
19	*E. moluccana*		6	
20	*C. maculata*		10	
21	*C. maculata*		5	
22	*E. moluccana*		7	
23	*C. maculata*		8	
24	*C. maculata*		7	
25	*E. moluccana*		12	
26	*C. maculata*		9	
27	*C. maculata*		10	
28	*E. moluccana*		5	

HVOCAR200902				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		6	
2	*C. maculata*		7	
3	*A. implexa*		7	
4	*C. maculata*		6	

HVOWES200801				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		5	
2	*C. maculata*		6	
3	*C. maculata*		5	
4	*C. maculata*		5	
5	*C. maculata*		6	
6	*C. maculata*		6	

HVOWES200801				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
7	*C. maculata*		5	
8	*C. maculata*		6	
9	*C. maculata*		9	
10	*C. maculata*		5	
11	*C. maculata*		5	
12	*E. moluccana*		5	
13	*C. maculata*		5	
14	*C. maculata*		6	
15	*C. maculata*		6	
16	*C. maculata*		5	
17	*C. maculata*		9	
18	*C. maculata*		5	
19	*C. maculata*		6	
20	*C. maculata*		7	
21	*E. moluccana*		7	
22	*C. maculata*		6	
23	*C. maculata*		8	
24	*C. maculata*		11	
25	*C. maculata*		6	
26	*C. maculata*		6	
27	*C. maculata*		6	
28	*C. maculata*		6	
29	*C. maculata*		7	
30	*C. maculata*		10	
31	*C. maculata*		8	
32	*C. maculata*		6	
33	*C. maculata*		6	
34	*C. maculata*		5	
35	*C. maculata*		6	
36	*C. maculata*		7	
37	*C. maculata*		6	

HVOWES201101				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		6	
2	*E. moluccana*		7	
3	*C. maculata*		5	
4	*C. maculata*		5	

HVOWES201101				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
5	*C. maculata*		6	
6	*C. maculata*		7	
7	*C. maculata*		6	
8	*C. maculata*		7	
9	*C. maculata*		8	
10	*C. maculata*		6	
11	*C. maculata*		6	
12	*C. maculata*		7	
13	*E. moluccana*		7	
14	*E. moluccana*		6	
15	*C. maculata*		6	
16	*C. maculata*		6	
17	*E. moluccana*		6	

MTWCDD201101				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		8	
2	*C. maculata*		5	
3	*C. maculata*		4	
4	*C. maculata*		5	
5	*C. maculata*		5	
6	*C. maculata*	flowers	7	
7	*E. moluccana*		6	
8	*E. moluccana*		5	
9	*C. maculata*		5	
10	*C. maculata*		5	
11	*E. moluccana*		4	
12	*C. maculata*		8	
13	*C. maculata*		5	
14	*C. maculata*		7	
15	*C. maculata*		6	
16	*C. maculata*		6	
17	*C. maculata*	heavy flower	9	

MTWMTO200001				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		11	

MTWMTO200001				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
2	*E. moluccana*		10	
3	*E. moluccana*		7	
4	*E. moluccana*		9	
5	*E. moluccana*		6	

MTWNPN200501				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	A. implexa	flowers	15	
2	A. implexa	flowers	15	

MTWNPN200502				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		5	
2	*Unknown*		7	
3	*C. maculata*		10	
4	*C. maculata*		9.5	
5	*C. maculata*		13	
6	*C. maculata*		11	
7	*C. maculata*		9	
8	*C. maculata*		9	
9	*C. maculata*		14	
10	*Unknown*		8.5	
11	*C. maculata*		15	
12	*Unknown*		9.5	
13	*Unknown*		7	
14	*C. maculata*		15	
15	*C. maculata*		8	
16	*Oposite leaves*		5	
17	*C. maculata*		8	
18	*C. maculata*		5.5	
19	*C. maculata*		11.5	
20	*C. maculata*		7.5	
21	*C. maculata*		7.5	
22	*Oposite leaves*		9	
24	*C. maculata*		10	
25	*C. maculata*		11	
26	*C. maculata*		10	

MTWNPN200502				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
27	*C. maculata*		11	
28	*C. maculata*		7	
29	*C. maculata*		9	
30	*E. moluccana*		9.5	

WAMBOGB1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*A. luehmannii*		10	
2	*A. luehmannii*		7	
3	*A. luehmannii*		12	
4	*A. luehmannii*		9	
5	*A. luehmannii*		8	
6	*A. luehmannii*		9	
7	*A. luehmannii*		9	
8	*E. fibrosa*		21	
9	*E. fibrosa*		9	
10	*E. fibrosa*		12	
11	*E. fibrosa*		18	
12	*E. fibrosa*		10	
13	*E. fibrosa*		13	
14	*E. fibrosa*		6	
15	*E. fibrosa*		11	
16	*E. fibrosa*		10	
17	*E. fibrosa*		17	
18	*E. crebra*		18	
19	*E. moluccana*		12	
20	*A. luehmannii*		11	
21	*A. luehmannii*		15	
22	*A. luehmannii*		10	

WAMBOGB2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		13	
2	*E. moluccana*		13	
3	*E. moluccana*		55	
4	*E. moluccana*		7	

WAMBOSPOT1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	E. crebra		17	
2	E. punctata		35	1
3	E. crebra		17	
4	E. crebra		22	
5	E. crebra		21	
6	E. punctata		26	2
7	C. maculata		6	
8	E. punctata		35	2

WAMBOSPOT2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*	fruit	23	
2	*E. moluccana*		16	
3	*C. maculata*	fruit	9	
4	*C. maculata*		10	
5	*C. maculata*		12	
6	*C. maculata*		9, 7.5	
7	*E. moluccana*		23	
8	*E. moluccana*		14	
9	*C. maculata*		11	
10	*C. maculata*		9	
11	*E. moluccana*		11	
12	*E. moluccana*		20	
13	*E. moluccana*		8	
14	*E. moluccana*		7.5	
15	*E. moluccana*		7	
16	*E. moluccana*		9	
17	*C. maculata*		48	
18	*E. moluccana*		13	
19	*E. moluccana*		13	
20	*E. moluccana*		15	
21	*E. moluccana*		14	
22	*E. moluccana*		9	
23	*E. moluccana*		13	
24	*E. moluccana*		8	
25	*E. moluccana*		18	
26	*E. moluccana*		12	
27	*C. maculata*		8	

WAMBOSPOT2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
28	*C. maculata*		9	
29	*E. moluccana*		13	

WAMBOSPOT3				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. crebra*		24	
2	*E. crebra*		17	
3	*E. punctata*		28	
4	*E. crebra*		16	
5	*C. maculata*		24	
6	*C. maculata*		17	
7	*C. maculata*		32	
8	*E. crebra*		22	
9	*E. crebra*		18	

WARKGB1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. crebra*		29	
2	*E. crebra*		16.5	
3	*E. crebra*		15	
4	*E. crebra*		21	
5	*E. crebra*		17	
6	*E. crebra*		9	
7	*E. crebra*		14	
8	*E. crebra*		16	
9	*A. leuhmannii*		10	
10	*E. crebra*		8	
11	*E. crebra*		16	
12	*E. crebra*		11.5	
13	*E. crebra*		14	
14	*E. crebra*		20	
15	*E. crebra*		12	
16	*E. crebra*		10	
17	*E. crebra*		9	
18	*E. crebra*		17	
19	*E. crebra*		12	
20	*E. crebra*		12	
21	*E. crebra*		14	

WARKGB1				
22	*E. crebra*		13	
23	*E. crebra*		23	
24	*A. leuhmannii*		18	
25	*E. crebra*		13	

WARKGB2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*A. leuhmannii*		8	
2	*E. crebra*		26	
3	*A. leuhmannii*		7	
4	*A. leuhmannii*		7	
5	*E. crebra*		14	
6	*E. crebra*		22	
7	*E. crebra*		16	
8	*A. leuhmannii*		8	
9	*A. leuhmannii*		11	
10	*A. leuhmannii*		11	
11	*E. crebra*		14	
12	*A. leuhmannii*		11	
13	*E. crebra*		8	
14	*E. crebra*		9	
15	*E. crebra*		9	
16	*E. crebra*		35	
17	*E. crebra*		18	
18	*E. crebra*		21	
19	*A. leuhmannii*		8	
20	*E. crebra*		18	
21	*E. crebra*		8	
22	*E. crebra*		13	
23	*A. leuhmannii*		8	
24	*E. crebra*		26	

WARKGB3				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*A. leuhmannii*		9	
2	*A. leuhmannii*		11	
3	*E. crebra*		28	
4	*E. amplifolia*		9.5	
5	*E. amplifolia*		9	

WARKGB3				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
6	*A. leuhmannii*		11	
7	*A. leuhmannii*		11	
8	*E. amplifolia*		18	
9	*A. leuhmannii*		18	
10	*E. amplifolia*		26	
11	*A. leuhmannii*		11	
12	*1B*		17	
13	*A. leuhmannii*		14	
14	*E. amplifolia*		19	
15	*E. amplifolia*		7	
16	*E. amplifolia*		17	
17	*E. crebra*		25	
18	*A. leuhmannii*		14	
19	*E. amplifolia*		19	
20	*E. amplifolia*		15	
21	*E. amplifolia*		9.5	
22	*A. leuhmannii*		12	
23	*A. leuhmannii*		13	
24	*E. crebra*		15	
25	*E. amplifolia*		21	
26	*E. amplifolia*		13	
27	*E. amplifolia*		6	
28	*A. leuhmannii*		8	

WARKGB4				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. crebra*		110	3
2	*E. crebra*		20	

BELL1						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	2	*E. moluccana*	1			
				3	2	0.03

BELL2						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	3	*C. maculata*	8			
E. moluccana	4	*E. moluccana*	2			
				17	4	0.085
BELL3						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	3	*C. maculata*	7			
E. moluccana	1	*E. moluccana*	4			
E. crebra	4	*E. crebra*				
A. leuhmannii	1			20	4	0.1
HVOCAR200901						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. moluccana	1	*E. moluccana*	2			
C. maculata	17	*C. maculata*	12			
A. implexa	4	*A. implexa*	2			
				38	4	0.19
HVOCAR200902						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	19	*C. maculata*	24			
E. moluccana	2	*E. moluccana*	1			
Unknown	2					
				48	4	0.24
HVORIV201401						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. moluccana	1	*E. moluccana*	3			
		Unknown	2			
		E. crebra	1	7	4	0.035
HVORIV201402						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. crebra	1					
				1	4	0.005

HVOWES200801						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
C. maculata	20	*C. maculata*	43			
E. moluccana	4	*E. moluccana*	4			
Eucalypt sp.	4	*Eucalypt sp.*	8			
		A. implexa	2	85	4	0.425
HVOWES201101						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
C. maculata	21	*C. maculata*	30			
E. moluccana	10	*E. moluccana*	11			
E. fibrosa	1	*E. fibrosa*				
E. crebra	2	*E. crebra*	4			
A. implexa	6	*A. implexa*	4			
Eucalypt sp.	2	*Eucalypt sp.*	2	93	4	0.465
HVOWES201301						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	3	*E. crebra*	2			
A. implexa	2	*A. implexa*				
Eucalypt sp.	1	*C. maculata*	2			
		E. moluccana	2	12	4	0.06
MTWCDD201101						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
Eucalypt sp. 1	4	*Eucalypt sp. 1*	3			
Eucalypt sp. 2	2	*Eucalypt sp. 2*				
C. maculata	5	*C. maculata*	16			
A. implexa	3	*A. implexa*	2	35	4	0.175
MTWCDD2015						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. fibrosa	1	*E. fibrosa*	1			
C. maculata	33	*C. maculata*	37			
E. moluccana	11	*E. moluccana*	14			
				97	4	0.485
MTWMTO200001						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. cladocalyx	10	*E. cladocalyx*	4	17	4	0.085

E. moluccana	1	*E. moluccana*	2			
MTWMTO200503						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. cladocalyx	14	*E. cladocalyx*	8			
E. moluccana	1					
				23	4	0.115
MTWNPN200501						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
A. implexa	2					
				2	4	0.01
MTWNPN200502						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
C. maculata	13	*C. maculata*	12			
A. mearnsii	3	*A. mearnsii*	2			
				30	4	0.15
MTWNPN200901						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
		C. maculata	43			
		E. crebra	12			
		E. moluccana	14			
		A. implexa	1	70	4	0.35
MTWNPN201101						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
Eucalypt sp. 1	6	*Eucalypt sp. 1*	1			
		Eucalypt sp. 2	5			
				12	4	0.06
MTWNPN201403						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2

		Eucalypt sp. 1	2			
				2	4	0.01
MTWTDI201501						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
Eucalypt sp. 1	1					
				1	4	0.005
MTWWDL201401						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	3	*C. maculata*	5			
A. implexa	1	*A. implexa*	5			
E. moluccana	1	*E. moluccana*				
				15	4	0.075
WAMBOGB1						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
A. leuhmannii	8	*A. leuhmannii*	7			
E. crebra		*E. crebra*	4			
				19	4	0.095
WAMBOGB2						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. moluccana	3	*E. moluccana*	2			
				5	4	0.025
WAMBOSPOT1						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. punctata	1	*E. punctata*				
E. crebra	3	*E. crebra*				
C. maculata	2	*C. maculata*	3			
A. bulgaensis	13	*A. bulgaensis*	11	33	4	0.165
WAMBOSPOT2						
LHS		RHS		Total trees	Width	Trees per m2

Genus	Number	Genus	Number			
E. moluccana	7	*E. moluccana*	5			
C. maculata	3	*C. maculata*	2			
		E. crebra	1			
		A. leuhmannii	1	19	4	0.095
WAMBOSPOT3						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	3	*E. crebra*	3			
C. maculata	2	*C. maculata*	3			
A. implexa	4	*A. implexa*	1			
				16	4	0.08
WARKGB01						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
A. leuhmannii	23	*A. leuhmannii*	26			
E. crebra	4	*E. crebra*	10			
				63	4	0.315
WARKGB02						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	14	*A. leuhmannii*	2			
		E. crebra	5			
				21	4	0.105
WARKGB03						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
A. leuhmannii	27	*A. leuhmannii*	16			
E. crebra	1	*E. crebra*	1			
E. amplifolia	5	*E. amplifolia*	5			
				55	4	0.275
WARKGB04						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	3	*E. crebra*	5			
		A. leuhmannii	2			
				10	4	0.05
HVOLEM2015						

LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	1					
				1	2	0.01
HVORIV201501						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
		E. fibrosa	1			
				1	4	0.005
HVORIV201503						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
C. maculata	1					
				1	4	0.005
HVOWES201602						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. moluccana	2	*E. moluccana*	2			
C. maculata	9	*C. maculata*	5			
				20	4	0.1
HVOWES201603						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
		E. fibrosa	1			
				1	4	0.005

Appendix 7 – Agricultural soil analysis results

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 1	Sample 2	Sample 3	Sample 4
	Sample ID:			HVOCHE201501	HVORIV201601	MTWSPN201501	HVOWES201601
	Crop:			N/G	N/G	N/G	N/G
	Client:			RTCA	RTCA	RTCA	RTCA
				F9706/1	F9706/2	F9706/3	F9706/4
Morgan 1	Calcium	Ca	mg/kg	1749	1280	2555	2212
	Magnesium	Mg		684	699	364	354
	Potassium	K		169	251	270	183
	Phosphorus	P		14	17	20	10
Bray1	Phosphorus	P	mg/kg	30	27	73	28
Colwell				131	80	186	118
Bray2				238	141	397	177
KCl	Nitrate Nitrogen	N	mg/kg	23	8.5	48	4.1
	Ammonium Nitrogen			5.0	3.5	2.7	2.9
	Sulfur	S		23	370	110	605
1:5 Water	pH		units	8.15	7.75	8.07	7.58
	Conductivity		dS/m	0.164	0.551	0.318	0.755
Calculation	Estimated Organic Matter		% OM	4.3	7.3	7.3	6.9
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	16.84	9.81	14.70	14.42
			kg/ha	7558	4402	6598	6473
			mg/kg	3374	1965	2946	2890
	Magnesium	Mg	$cmol^+/Kg$	9.63	8.46	3.46	3.54
			kg/ha	2621	2302	943	964
			mg/kg	1170	1028	421	430
	Potassium	K	$cmol^+/Kg$	1.15	1.19	1.20	0.87
			kg/ha	1010	1038	1055	765
			mg/kg	451	463	471	341
	Sodium	Na	$cmol^+/Kg$	0.88	0.76	0.34	0.64
			kg/ha	452	391	174	327
			mg/kg	202	175	78	146
KCl	Aluminium	Al	$cmol^+/Kg$	0.01	0.01	0.02	0.02
			kg/ha	3	2	3	3
			mg/kg	1	1	1	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	28.51	20.22	19.72	19.48
Base Saturation Calculations	Calcium	Ca	%	59.1	48.5	74.5	74.0
	Magnesium	Mg		33.8	41.8	17.6	18.2
	Potassium	K		4.0	5.9	6.1	4.5
	Sodium - ESP	Na		3.1	3.8	1.7	3.3
	Aluminium	Al		0.0	0.1	0.1	0.1
	Hydrogen	H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio		ratio	1.7	1.2	4.2	4.1
DTPA	Zinc	Zn	mg/kg	12	13	33	20
	Manganese	Mn		6.6	5.2	5.3	9.0
	Iron	Fe		32	32	40	71
	Copper	Cu		3.2	2.0	4.2	2.9
$CaCl_2$	Boron	B	mg/kg	0.74	0.74	0.95	0.94
	Silicon	Si		33	27	25	24
LECO IR Analyser	Total Carbon	C	%	2.46	4.17	4.15	3.93
	Total Nitrogen	N	%	0.19	0.26	0.29	0.29
Calculation	Carbon/ Nitrogen Ratio		ratio	13.3	15.8	14.2	13.7
	Basic Texture			Loam	Loam	Loam	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	105	353	203	483

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 1	Sample 2	Sample 3	Sample 4
			Sample ID:	HVOCHE201501	HVORIV201601	MTWSPN201501	HVOWES201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/1*	*F9706/2*	*F9706/3*	*F9706/4*
Total Acid Extractable	Calcium	Ca	mg/kg	7,508	5,464	10,000	6,464
	Magnesium	Mg		5,993	3,106	1,938	1,309
	Potassium	K		2,087	1,645	1,550	1,405
	Sodium	Na		555	561	238	323
	Sulfur	S		242	633	506	914
Total Acid Extractable	Phosphorus	P	mg/kg	985	434	938	587
Total Acid Extractable	Zinc	Zn	mg/kg	98	80	152	96
	Manganese	Mn		830	257	222	308
	Iron	Fe		40,739	23,036	20,660	25,849
	Copper	Cu		40	23	49	28
	Boron	B		2.6	<2	2.1	<2
	Silicon	Si		1,161	1,804	1,785	2,015
	Aluminium	Al		18,952	7,206	5,720	6,805
Total Acid Extractable	Molybdenum	Mo	mg/kg	0.7	0.9	1.0	0.9
	Cobalt	Co		22	9.3	6.3	8.8
	Selenium	Se		0.6	0.7	0.6	0.7
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	0.8	<0.5
	Lead	Pb		19	17	39	24
	Arsenic	As		5.5	6.7	7.7	8.2
	Chromium	Cr		40	12	9.4	11
	Nickel	Ni		46	14	12	10
	Mercury	Hg		<0.1	<0.1	0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg Calcium
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 5	Sample 6	Sample 7	Sample 8
			Sample ID:	HVOCHE201602	HVORIV201503	HVOLEM201601	MTWMTO20150 1
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/5*	*F9706/6*	*F9706/7*	*F9706/8*
Morgan 1	Calcium	Ca	mg/kg	1824	3829	249	1129
	Magnesium	Mg		613	474	109	392
	Potassium	K		209	236	60	111
	Phosphorus	P		7.3	16	1.4	1.2
Bray1	Phosphorus	P	mg/kg	20	52	4.8	2.8
Colwell				71	213	11	10
Bray2				136	325	12	8
KCl	Nitrate Nitrogen	N	mg/kg	69	7.5	0.8	3.0
	Ammonium Nitrogen			2.8	2.6	1.3	0.9
	Sulfur	S		412	1585	80	98
1:5 Water	pH		units	7.77	7.54	6.16	9.07
	Conductivity		dS/m	0.728	1.685	0.066	0.233
Calculation	Estimated Organic Matter		% OM	5.6	7.7	1.1	3.8
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	15.51	21.41	1.95	6.77
			kg/ha	6961	9610	875	3040
			mg/kg	3107	4290	391	1357
	Magnesium	Mg	$cmol^+/Kg$	7.21	3.94	1.18	4.17
			kg/ha	1962	1072	322	1136
			mg/kg	876	479	144	507
	Potassium	K	$cmol^+/Kg$	1.22	1.08	0.24	0.50
			kg/ha	1071	944	208	434
			mg/kg	478	421	93	194
	Sodium	Na	$cmol^+/Kg$	1.05	1.08	0.15	1.23
			kg/ha	543	558	77	635
			mg/kg	242	249	34	283
KCl	Aluminium	Al	$cmol^+/Kg$	0.02	0.02	0.02	0.02
			kg/ha	3	3	4	3
			mg/kg	1	1	2	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.01	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	25.00	27.52	3.55	12.69
Base Saturation Calculations	Calcium	Ca	%	62.0	77.8	55.0	53.4
	Magnesium	Mg		28.8	14.3	33.4	32.9
	Potassium	K		4.9	3.9	6.7	3.9
	Sodium - ESP	Na		4.2	3.9	4.2	9.7
	Aluminium	Al		0.1	0.1	0.6	0.1
	Hydrogen	H^+		0.0	0.0	0.2	0.0
Calculation	Calcium / Magnesium Ratio		ratio	2.2	5.4	1.6	1.6
DTPA	Zinc	Zn	mg/kg	11	27	1.0	2.3
	Manganese	Mn		8.2	9.2	2.4	0.9
	Iron	Fe		38	48	221	14
	Copper	Cu		1.5	3.5	0.2	1.0
$CaCl_2$	Boron	B	mg/kg	0.79	1.21	0.37	0.19
	Silicon	Si		24	22	30	3
LECO IR Analyser	Total Carbon	C	%	3.19	4.40	0.62	2.15
	Total Nitrogen	N	%	0.25	0.32	0.05	0.09
Calculation	Carbon/ Nitrogen Ratio		ratio	12.6	13.7	12.1	23.4
	Basic Texture			Loam	Loam	Sandy Soil	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	466	1079	42	149

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

					Sample 5	Sample 6	Sample 7	Sample 8
				Sample ID:	HVOCHE201602	HVORIV201503	HVOLEM201601	MTWMTO201501
				Crop:	N/G	N/G	N/G	N/G
				Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*			*Units*	*F9706/5*	*F9706/6*	*F9706/7*	*F9706/8*
Total Acid Extractable	Calcium	Ca		mg/kg	5,195	9,557	432	4,600
	Magnesium	Mg			2,125	1,710	253	3,079
	Potassium	K			1,804	1,460	274	1,241
	Sodium	Na			435	565	81	1,481
	Sulfur	S			615	1,926	82	224
Total Acid Extractable	Phosphorus	P		mg/kg	424	903	72	88
Total Acid Extractable	Zinc	Zn		mg/kg	74	133	5.5	60
	Manganese	Mn			476	351	38	244
	Iron	Fe			39,870	27,802	10,758	17,315
	Copper	Cu			21	44	1.7	12
	Boron	B			<2	3.5	<2	<2
	Silicon	Si			2,072	1,977	1,992	1,654
	Aluminium	Al			10,814	9,637	2,980	4,657
Total Acid Extractable	Molybdenum	Mo		mg/kg	0.9	0.9	0.3	0.6
	Cobalt	Co			11	9.3	3.0	7.1
	Selenium	Se			0.7	0.9	<0.5	<0.5
Total Acid Extractable	Cadmium	Cd		mg/kg	<0.5	0.6	<0.5	<0.5
	Lead	Pb			20	36	5.1	13
	Arsenic	As			6.7	6.0	2.6	5.8
	Chromium	Cr			20	31	5.2	4.8
	Nickel	Ni			18	16	2.1	9.4
	Mercury	Hg			<0.1	<0.1	<0.1	<0.1
	Silver	Ag			<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 cmol$^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations cmol$^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable cmol$^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 9	Sample 10	Sample 11	Sample 12
			Sample ID:	HVOWES201602	MTWSPN201601	MTWSPN201602	MTWMTO201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/9*	*F9706/10*	*F9706/11*	*F9706/12*
Morgan 1	Calcium	Ca	mg/kg	1435	1595	906	1441
	Magnesium	Mg		323	400	335	434
	Potassium	K		161	327	210	186
	Phosphorus	P		4.8	15	12	6.5
Bray1	Phosphorus	P	mg/kg	13	40	41	25
Colwell				58	113	94	54
Bray2				88	196	149	104
KCl	Nitrate Nitrogen	N	mg/kg	1.5	123	14	45
	Ammonium Nitrogen			2.6	12	2.3	2.0
	Sulfur	S		262	250	189	329
1:5 Water	pH		units	7.48	7.04	7.06	8.49
	Conductivity		dS/m	0.403	0.683	0.391	0.626
Calculation	Estimated Organic Matter		% OM	7.2	8.1	5.2	5.2
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	12.32	13.50	7.65	8.98
			kg/ha	5532	6061	3432	4030
			mg/kg	2470	2706	1532	1799
	Magnesium	Mg	$cmol^+/Kg$	3.73	4.74	3.97	4.46
			kg/ha	1017	1291	1082	1213
			mg/kg	454	576	483	542
	Potassium	K	$cmol^+/Kg$	0.88	1.69	0.95	0.80
			kg/ha	771	1480	833	703
			mg/kg	344	661	372	314
	Sodium	Na	$cmol^+/Kg$	0.58	0.90	1.01	1.74
			kg/ha	297	463	518	897
			mg/kg	133	207	231	401
KCl	Aluminium	Al	$cmol^+/Kg$	0.01	0.01	0.02	0.01
			kg/ha	3	2	4	3
			mg/kg	1	1	2	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	17.53	20.84	13.59	15.99
Base Saturation Calculations	Calcium	Ca	%	70.3	64.8	56.2	56.1
	Magnesium	Mg		21.3	22.8	29.2	27.9
	Potassium	K		5.0	8.1	7.0	5.0
	Sodium - ESP	Na		3.3	4.3	7.4	10.9
	Aluminium	Al		0.1	0.1	0.1	0.1
	Hydrogen	H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio		ratio	3.3	2.8	1.9	2.0
DTPA	Zinc	Zn	mg/kg	18	16	12	7.3
	Manganese	Mn		10	23	13	4.6
	Iron	Fe		36	55	97	27
	Copper	Cu		3.2	1.7	1.2	1.1
$CaCl_2$	Boron	B	mg/kg	0.52	0.74	0.83	0.33
	Silicon	Si		23	43	39	12
LECO IR Analyser	Total Carbon	C	%	4.10	4.62	2.95	2.98
	Total Nitrogen	N	%	0.25	0.35	0.20	0.15
Calculation	Carbon/ Nitrogen Ratio		ratio	16.5	13.1	15.1	19.5
	Basic Texture			Loam	Loam	Loam	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	258	437	250	401

Southern Cross University | Environmental Analysis Laboratory | ASPAC

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

	Sample 9	**Sample 10**	**Sample 11**	**Sample 12**
Sample ID:	HVOWES201602	MTWSPN201601	MTWSPN201602	MTWMTO201601
Crop:	N/G	N/G	N/G	N/G
Client:	RTCA	RTCA	RTCA	RTCA

Method	*Nutrient*		*Units*	*F9706/9*	*F9706/10*	*F9706/11*	*F9706/12*
Total Acid Extractable	Calcium	Ca	mg/kg	4,194	5,144	2,809	4,234
	Magnesium	Mg		1,411	1,806	1,160	1,773
	Potassium	K		1,538	2,261	1,229	1,278
	Sodium	Na		260	431	489	1,069
	Sulfur	S		490	529	375	408
Total Acid Extractable	Phosphorus	P	mg/kg	373	624	356	237
Total Acid Extractable	Zinc	Zn	mg/kg	130	94	50	55
	Manganese	Mn		625	380	142	203
	Iron	Fe		62,088	21,776	15,024	25,814
	Copper	Cu		48	25	13	13
	Boron	B		<2	2.1	<2	<2
	Silicon	Si		2,877	2,063	1,866	1,597
	Aluminium	Al		8,204	9,895	6,625	5,124
Total Acid Extractable	Molybdenum	Mo	mg/kg	4.5	0.9	0.8	0.9
	Cobalt	Co		10	8.4	3.9	5.1
	Selenium	Se		0.7	0.9	<0.5	<0.5
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5
	Lead	Pb		30	23	16	16
	Arsenic	As		13	5.8	4.8	7.2
	Chromium	Cr		13	11	6.5	6.1
	Nickel	Ni		12	12	5.4	6.7
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 13	Sample 14	Sample 15	Sample 16
			Sample ID:	MTWNOO201501	HVORIV201501	HVOWES201603	HVOCHE201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
				F9706/13	F9706/14	F9706/15	F9706/16
Morgan 1	Calcium	Ca	mg/kg	1074	1242	872	1580
	Magnesium	Mg		457	430	492	585
	Potassium	K		192	154	173	186
	Phosphorus	P		6.7	4.5	5.5	5.0
Bray1	Phosphorus	P	mg/kg	13	13	15	14
Colwell				48	55	59	43
Bray2				65	70	58	51
KCl	Nitrate Nitrogen	N	mg/kg	1.3	3.9	0.9	11
	Ammonium Nitrogen			2.1	1.8	1.5	1.5
	Sulfur	S		33	27	293	381
1:5 Water	pH		units	7.62	8.36	7.24	8.07
	Conductivity		dS/m	0.134	0.154	0.440	0.523
Calculation	Estimated Organic Matter		% OM	5.0	3.8	5.8	6.7
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	9.65	9.84	7.81	10.28
			kg/ha	4332	4416	3507	4615
			mg/kg	1934	1972	1566	2060
	Magnesium	Mg	$cmol^+/Kg$	5.75	4.97	5.85	5.92
			kg/ha	1565	1353	1593	1611
			mg/kg	699	604	711	719
	Potassium	K	$cmol^+/Kg$	1.04	0.87	0.86	0.79
			kg/ha	910	766	755	692
			mg/kg	406	342	337	309
	Sodium	Na	$cmol^+/Kg$	0.51	0.90	0.96	0.75
			kg/ha	264	462	494	384
			mg/kg	118	206	220	171
KCl	Aluminium	Al	$cmol^+/Kg$	0.01	0.01	0.01	0.01
			kg/ha	3	2	2	2
			mg/kg	1	1	1	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	16.96	16.59	15.50	17.75
Base Saturation Calculations	Calcium	Ca	%	56.9	59.3	50.4	57.9
	Magnesium	Mg		33.9	30.0	37.8	33.3
	Potassium	K		6.1	5.3	5.6	4.5
	Sodium - ESP	Na		3.0	5.4	6.2	4.2
	Aluminium	Al		0.1	0.1	0.1	0.1
	Hydrogen	H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio		ratio	1.7	2.0	1.3	1.7
DTPA	Zinc	Zn	mg/kg	9.2	14	9.0	6.9
	Manganese	Mn		6.4	7.5	6.0	4.9
	Iron	Fe		62	32	62	18
	Copper	Cu		1.1	2.6	1.4	1.8
$CaCl_2$	Boron	B	mg/kg	0.58	0.49	0.89	0.45
	Silicon	Si		32	25	35	19
LECO IR Analyser	Total Carbon	C	%	2.84	2.16	3.31	3.82
	Total Nitrogen	N	%	0.18	0.15	0.18	0.17
Calculation	Carbon/ Nitrogen Ratio		ratio	15.6	14.6	18.6	22.5
	Basic Texture			Loam	Loam	Loam	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	86	98	282	335

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 13	Sample 14	Sample 15	Sample 16
			Sample ID:	MTWNOO201501	HVORIV201501	HVOWES201603	HVOCHE201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
				F9706/13	F9706/14	F9706/15	F9706/16
Total Acid Extractable	Calcium	Ca	mg/kg	4,273	5,515	3,637	6,742
	Magnesium	Mg		2,009	2,546	1,924	3,382
	Potassium	K		1,609	1,577	1,532	1,471
	Sodium	Na		287	422	439	541
	Sulfur	S		266	201	494	584
Total Acid Extractable	Phosphorus	P	mg/kg	350	331	324	360
Total Acid Extractable	Zinc	Zn	mg/kg	59	80	70	67
	Manganese	Mn		259	632	398	520
	Iron	Fe		31,403	35,570	54,331	26,314
	Copper	Cu		13	23	16	22
	Boron	B		<2	<2	2.3	<2
	Silicon	Si		2,059	1,882	2,960	2,166
	Aluminium	Al		9,212	9,874	7,417	5,769
Total Acid Extractable	Molybdenum	Mo	mg/kg	1.0	1.1	1.2	0.7
	Cobalt	Co		6.9	11	8.0	12
	Selenium	Se		0.8	0.8	1.1	<0.5
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5
	Lead	Pb		17	21	17	15
	Arsenic	As		7.4	6.0	12	5.7
	Chromium	Cr		9.0	21	10	16
	Nickel	Ni		8.5	16	11	18
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Southern Cross University | Environmental Analysis Laboratory | ASPAC

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

			Sample 17	Sample 18	Sample 19	Sample 20
Sample ID:			HVOWES201604	MTWSPS201602	HVORIV201502	MTWSPS201601
Crop:			N/G	N/G	N/G	N/G
Client:			RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*	*Units*	*F9706/17*	*F9706/18*	*F9706/19*	*F9706/20*
Morgan 1	Calcium Ca	mg/kg	1542	1519	1225	1984
	Magnesium Mg		414	487	629	514
	Potassium K		139	178	203	207
	Phosphorus P		3.5	3.9	4.0	6.1
Bray1	Phosphorus P	mg/kg	6.1	15	10	26
Colwell			33	81	50	104
Bray2			25	76	69	149
KCl	Nitrate Nitrogen N	mg/kg	5.0	19	13	16
	Ammonium Nitrogen		1.7	1.8	1.9	2.6
	Sulfur S		398	457	20	320
1:5 Water	pH	units	7.76	7.89	8.21	8.23
	Conductivity	dS/m	0.443	0.666	0.141	0.532
Calculation	Estimated Organic Matter	% OM	3.6	5.0	5.0	7.7
Ammonium Acetate + Calculations	Calcium Ca	$cmol^+/Kg$	12.05	12.61	9.82	13.45
		kg/ha	5408	5659	4407	6035
		mg/kg	2414	2526	1968	2694
	Magnesium Mg	$cmol^+/Kg$	4.51	5.63	7.14	5.07
		kg/ha	1228	1532	1944	1381
		mg/kg	548	684	868	617
	Potassium K	$cmol^+/Kg$	0.79	0.88	1.14	0.88
		kg/ha	691	771	998	774
		mg/kg	308	344	446	346
	Sodium Na	$cmol^+/Kg$	0.33	0.94	0.74	1.00
		kg/ha	169	484	382	513
		mg/kg	75	216	171	229
KCl	Aluminium Al	$cmol^+/Kg$	0.01	0.02	0.01	0.02
		kg/ha	2	3	2	3
		mg/kg	1	1	1	1
Acidity Titration	Hydrogen H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
		kg/ha	0	0	0	0
		mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)	$cmol^+/Kg$	17.68	20.07	18.85	20.42
Base Saturation Calculations	Calcium Ca	%	68.1	62.8	52.1	65.9
	Magnesium Mg		25.5	28.0	37.9	24.9
	Potassium K		4.5	4.4	6.0	4.3
	Sodium - ESP Na		1.9	4.7	3.9	4.9
	Aluminium Al		0.0	0.1	0.1	0.1
	Hydrogen H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio	ratio	2.7	2.2	1.4	2.6
DTPA	Zinc Zn	mg/kg	4.7	13	8.9	23
	Manganese Mn		7.4	4.6	5.0	4.2
	Iron Fe		38	46	25	39
	Copper Cu		1.3	2.1	1.6	3.9
$CaCl_2$	Boron B	mg/kg	0.64	0.56	0.41	0.67
	Silicon Si		27	18	8	12
LECO IR Analyser	Total Carbon C	%	2.08	2.83	2.84	4.39
	Total Nitrogen N	%	0.15	0.17	0.18	0.24
Calculation	Carbon/ Nitrogen Ratio	ratio	14.3	16.6	15.4	18.4
	Basic Texture		Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate	equiv. ppm	284	426	90	340

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 17	Sample 18	Sample 19	Sample 20
			Sample ID:	HVOWES201604	MTWSPS201602	HVORIV201502	MTWSPS201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/17*	*F9706/18*	*F9706/19*	*F9706/20*
Total Acid Extractable	Calcium	Ca	mg/kg	4,212	4,410	5,773	7,892
	Magnesium	Mg		1,594	1,808	3,256	3,088
	Potassium	K		1,478	1,370	1,790	1,611
	Sodium	Na		193	458	1,665	557
	Sulfur	S		494	594	210	684
Total Acid Extractable	Phosphorus	P	mg/kg	247	291	380	492
Total Acid Extractable	Zinc	Zn	mg/kg	56	75	79	131
	Manganese	Mn		474	188	567	262
	Iron	Fe		31,840	22,614	40,004	19,427
	Copper	Cu		15	22	22	42
	Boron	B		3.2	2.2	2.5	3.0
	Silicon	Si		1,962	2,025	1,822	1,558
	Aluminium	Al		8,002	7,590	11,780	6,710
Total Acid Extractable	Molybdenum	Mo	mg/kg	0.7	0.9	0.9	0.8
	Cobalt	Co		10	6.3	16	8.4
	Selenium	Se		<0.5	<0.5	<0.5	<0.5
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5
	Lead	Pb		14	23	18	32
	Arsenic	As		8.1	4.8	8.0	5.1
	Chromium	Cr		8.6	8.0	20	9.3
	Nickel	Ni		9.0	8.7	23	13
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 21	**Sample 22**	***Heavy Soil***	***Medium Soil***	***Light Soil***	***Sandy Soil***
			Sample ID:	HVOLEM201501	MTWNPN20140 2				
			Crop:	N/G	N/G				
			Client:	RTCA	RTCA	*e.g Clay*	*e.g Clay Loam*	*e.g Loam*	*e.g Loamy Sand*
Method	*Nutrient*		*Units*	*F9706/21*	*F9706/22*	***Indicative guidelines only- refer Note 6***			
Morgan 1	Calcium	Ca	mg/kg	602	449	*1150*	*750*	*375*	*175*
	Magnesium	Mg		143	57	*160*	*105*	*60*	*25*
	Potassium	K		137	49	*113*	*75*	*60*	*50*
	Phosphorus	P		6.1	5.1	*15*	*12*	*10*	*5.0*
Bray1	Phosphorus	P	mg/kg	24	19	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
Colwell				51	31	*80*	*50*	*45*	*35*
Bray2				41	41	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
KCl	Nitrate Nitrogen	N	mg/kg	2.4	1.0	*15*	*13*	*10*	*10*
	Ammonium Nitrogen			1.8	2.0	*20*	*18*	*15*	*12*
	Sulfur	S		17	3.7	*10.0*	*8.0*	*8.0*	*7.0*
1:5 Water	pH		units	6.98	6.32	*6.5*	*6.5*	*6.3*	*6.3*
	Conductivity		dS/m	0.059	0.032	*0.200*	*0.150*	*0.120*	*0.100*
Calculation	Estimated Organic Matter		% OM	3.6	4.5	*>5.5*	*>4.5*	*>3.5*	*>2.5*
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	5.00	3.92	*15.6*	*10.8*	*5.0*	*1.9*
			kg/ha	2247	1758	*6250*	*4300*	*2000*	*750*
			mg/kg	1003	785	*3125*	*2150*	*1000*	*375*
	Magnesium	Mg	$cmol^+/Kg$	1.47	0.58	*2.4*	*1.7*	*1.2*	*0.60*
			kg/ha	400	157	*580*	*400*	*290*	*150*
			mg/kg	179	70	*290*	*200*	*145*	*75*
	Potassium	K	$cmol^+/Kg$	0.57	0.16	*0.60*	*0.50*	*0.40*	*0.30*
			kg/ha	500	143	*470*	*380*	*300*	*200*
			mg/kg	223	64	*235*	*190*	*150*	*100*
	Sodium	Na	$cmol^+/Kg$	0.12	0.04	*0.3*	*0.26*	*0.22*	*0.11*
			kg/ha	63	21	*138*	*120*	*101*	*51*
			mg/kg	28	9	*69*	*60*	*51*	*25*
KCl	Aluminium	Al	$cmol^+/Kg$	0.02	0.04	*0.6*	*0.5*	*0.4*	*0.2*
			kg/ha	3	8	*108*	*90*	*64.8*	*27*
			mg/kg	2	4	*54*	*45*	*32*	*14*
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.02	*0.6*	*0.5*	*0.4*	*0.2*
			kg/ha	0	0	*12*	*10*	*22.5*	*3*
			mg/kg	0	0	*6*	*5*	*4*	*2*
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	7.19	4.76	*20.1*	*14.3*	*7.8*	*3.3*
Base Saturation Calculations	Calcium	Ca	%	69.7	82.3	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium	Mg		20.5	12.1	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium	K		8.0	3.4	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP	Na		1.7	0.9	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium	Al		0.2	0.9	*6.0*	*7.0*	*10.4*	*12*
	Hydrogen	H^+		0.0	0.4				
Calculation	Calcium / Magnesium Ratio		ratio	3.4	6.8	*6.5*	*6.4*	*4.2*	*3.2*
DTPA	Zinc	Zn	mg/kg	5.3	6.2	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese	Mn		26	7.1	*25*	*22*	*18*	*15*
	Iron	Fe		423	91	*25*	*22*	*18*	*15*
	Copper	Cu		0.4	0.7	*2.4*	*2.0*	*1.6*	*1.2*
$CaCl_2$	Boron	B	mg/kg	0.55	0.31	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon	Si		29	24	*50*	*45*	*40*	*35*
LECO IR Analyser	Total Carbon	C	%	2.07	2.55	*>3.1*	*>2.6*	*>2.0*	*>1.4*
	Total Nitrogen	N	%	0.11	0.11	*>0.30*	*>0.25*	*>0.20*	*>0.15*
Calculation	Carbon/ Nitrogen Ratio		ratio	18.3	23.8	*10-12*	*10-12*	*10-12*	*10-12*
	Basic Texture			Sandy Soil	Sandy Soil	..	..	..	..
	Basic Colour			Brownish	Brownish	..	..	..	..
Calculation	Chloride Estimate		equiv. ppm	38	21	..	..	..	..

Southern Cross University | Environmental Analysis Laboratory | ASPAC

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 21	**Sample 22**	***Heavy Soil***	***Medium Soil***	***Light Soil***	***Sandy Soil***
			Sample ID:	HVOLEM201501	MTWNPN201402				
			Crop:	N/G	N/G				
			Client:	RTCA	RTCA	*e.g Clay*	*e.g Clay Loam*	*e.g Loam*	*e.g Loamy*

Method	*Nutrient*		*Units*	*F9706/21*	*F9706/22*	***Indicative guidelines only- refer Note 6***
Total Acid Extractable	Calcium	Ca	mg/kg	1,622	1,232	*1,000 - 10,000 Ca*
	Magnesium	Mg		329	193	*500 - 5,000 Mg*
	Potassium	K		417	297	*200 - 2,000 K*
	Sodium	Na		63	<50	*100 - 500 Na*
	Sulfur	S		121	91	*100 - 1,000 S*
Total Acid Extractable	Phosphorus	P	mg/kg	163	128	*400 - 1,500 P*
Total Acid Extractable	Zinc	Zn	mg/kg	17	19	*20 - 50 Zn*
	Manganese	Mn		108	63	*200 - 2,000 Mn*
	Iron	Fe		5,762	2,238	*1,000 - 50,000 Fe*
	Copper	Cu		3.6	5.4	*20 - 50 Cu*
	Boron	B		2.3	<2	*2 - 50 B*
	Silicon	Si		1,976	1,346	*1,000 - 3,000 Si*
	Aluminium	Al		2,869	1,440	*2,000 - 50,000 Al*
Total Acid Extractable	Molybdenum	Mo	mg/kg	0.3	<0.2	*0.5 - 3 Mo*
	Cobalt	Co		2	2.2	*5 - 50 Co*
	Selenium	Se		<0.5	<0.5	*0.1 - 2.0 Se*
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	*< 5 Cd*
	Lead	Pb		6.5	5.5	*< 75 Pb*
	Arsenic	As		<2	<2	*< 25 As*
	Chromium	Cr		5.7	2.6	*<25 Cr*
	Nickel	Ni		2.1	2.2	*<150 Ni*
	Mercury	Hg		<0.1	<0.1	*< 3.75 Hg*
	Silver	Ag		<1	<1	*.. Ag*

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Appendix 8 – Microbial soil analysis results

niche
Environment and Heritage

Niche Environment and Heritage

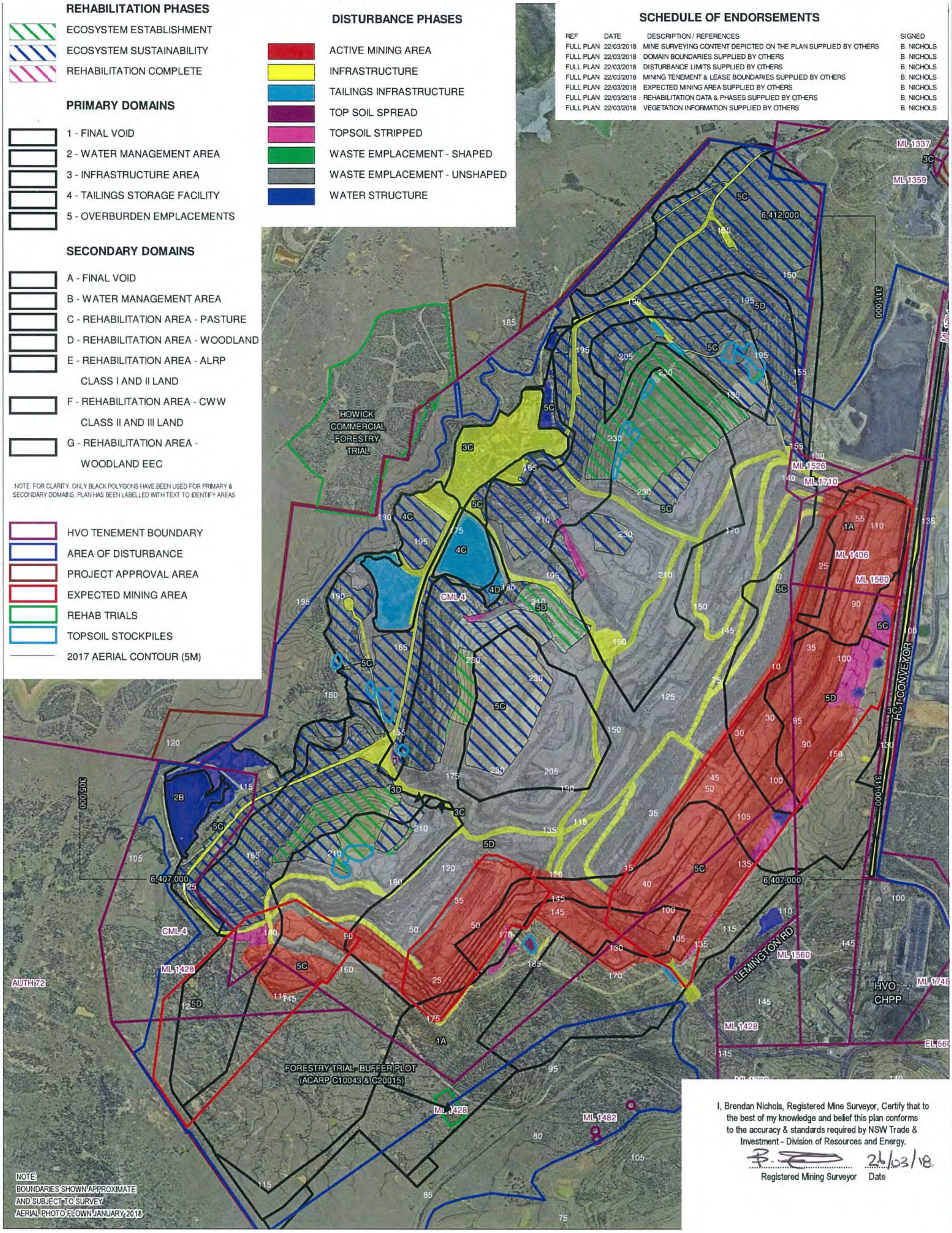
A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box W36 Parramatta NSW 2150
Email: info@niche-eh.com

All mail correspondence should be through our Head Office

Appendix 3: Rehabilitation and Disturbance Summary and Maps



SCHEDULE OF ENDORSEMENTS

REF	DATE	DESCRIPTION / REFERENCES	SIGNED
FULL PLAN	22/03/2018	MINE SURVEYING CONTENT DEPICTED ON THE PLAN SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DOMAIN BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DISTURBANCE LIMITS SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	MINING TENEMENT & LEASE BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	EXPECTED MINING AREA SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	REHABILITATION DATA & PHASES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	VEGETATION INFORMATION SUPPLIED BY OTHERS	B. NICHOLS

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

26/03/18

Registered Mining Surveyor Date

YANCOAL
兖煤澳大利亚有限公司

Hunter Valley Operations

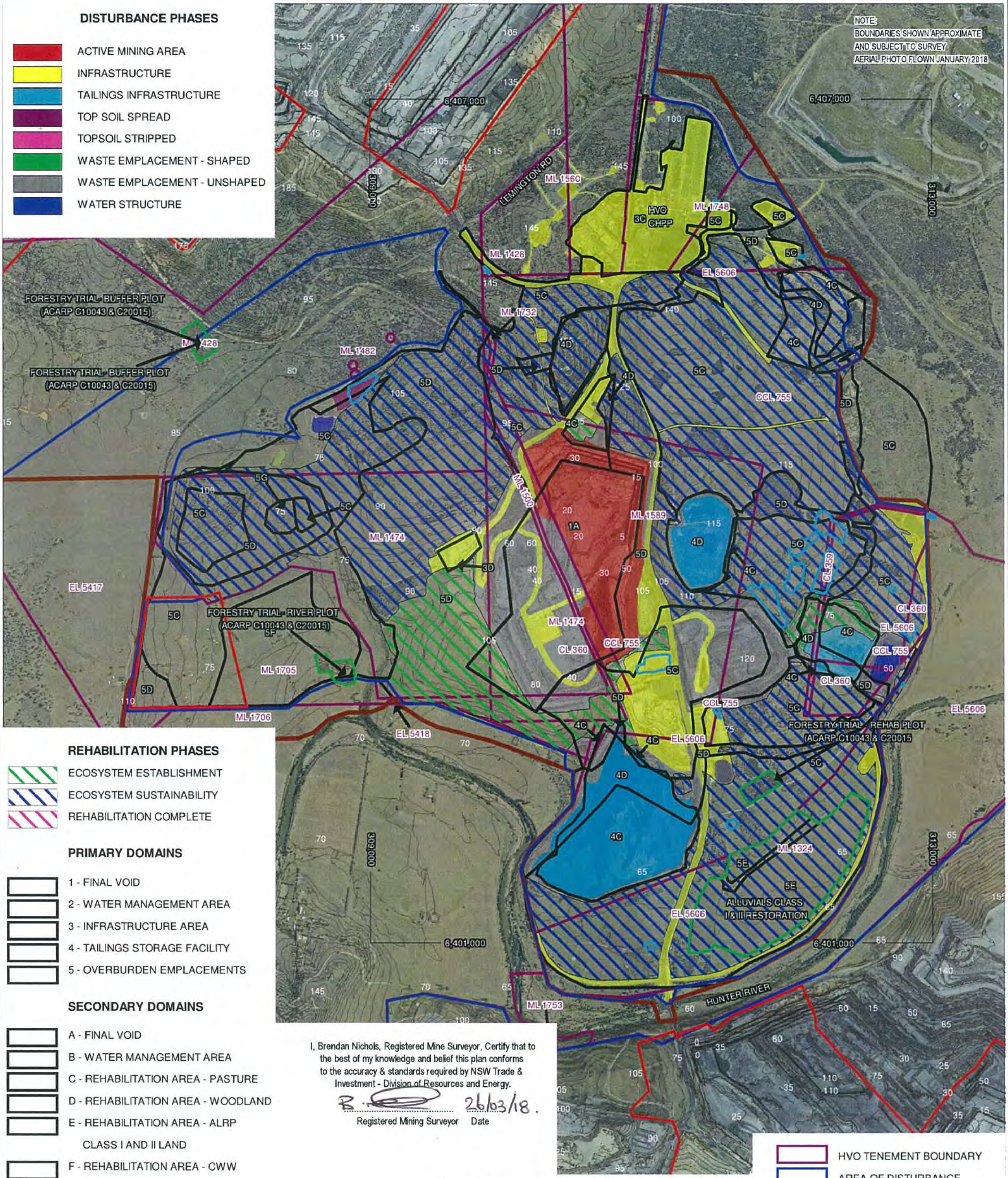
AEMR - West Pit - 2017

0 0.5 1
KILOMETRES

File: HVO AEMR 180313.WOR
HVO West Pit AEMR 180322.PDF

Date: 22/03/18
Produced By: SC
Map Size: A4 Portrait
Coordinate System: MGA94 Zone 56
Revision 01
Data Source Various
Scale 1:35,000 (A4)

DISCLAIMER



DISTURBANCE PHASES

- ACTIVE MINING AREA
- INFRASTRUCTURE
- TAILINGS INFRASTRUCTURE
- TOP SOIL SPREAD
- TOPSOIL STRIPPED
- WASTE EMPLACEMENT - SHAPED
- WASTE EMPLACEMENT - UNSHAPED
- WATER STRUCTURE

REHABILITATION PHASES

- ECOSYSTEM ESTABLISHMENT
- ECOSYSTEM SUSTAINABILITY
- REHABILITATION COMPLETE

PRIMARY DOMAINS

- 1 - FINAL VOID
- 2 - WATER MANAGEMENT AREA
- 3 - INFRASTRUCTURE AREA
- 4 - TAILINGS STORAGE FACILITY
- 5 - OVERBURDEN EMPLACEMENTS

SECONDARY DOMAINS

- A - FINAL VOID
- B - WATER MANAGEMENT AREA
- C - REHABILITATION AREA - PASTURE
- D - REHABILITATION AREA - WOODLAND
- E - REHABILITATION AREA - ALRP CLASS I AND II LAND
- F - REHABILITATION AREA - CWW CLASS II AND III LAND
- G - REHABILITATION AREA - WOODLAND EEC

NOTE: FOR CLARITY, ONLY BLACK POLYGONS HAVE BEEN USED FOR PRIMARY & SECONDARY DOMAINS. PLAN HAS BEEN LABELLED WITH TEXT TO IDENTIFY AREAS

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

B. [signature] 26/03/18.
Registered Mining Surveyor Date

- HVO TENEMENT BOUNDARY
- AREA OF DISTURBANCE
- PROJECT APPROVAL AREA
- EXPECTED MINING AREA
- REHAB TRIALS
- TOPSOIL STOCKPILES
- 2017 AERIAL CONTOUR (5M)

SCHEDULE OF ENDORSEMENTS

REF	DATE	DESCRIPTION / REFERENCES	SIGNED
FULL PLAN	22/03/2018	MINE SURVEYING CONTENT DEPICTED ON THE PLAN SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DOMAIN BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DISTURBANCE LIMITS SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	MINING TENEMENT & LEASE BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	EXPECTED MINING AREA SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	REHABILITATION DATA & PHASES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	VEGETATION INFORMATION SUPPLIED BY OTHERS	B. NICHOLS

YANCOAL
兖煤澳大利亚有限公司

Hunter Valley Operations

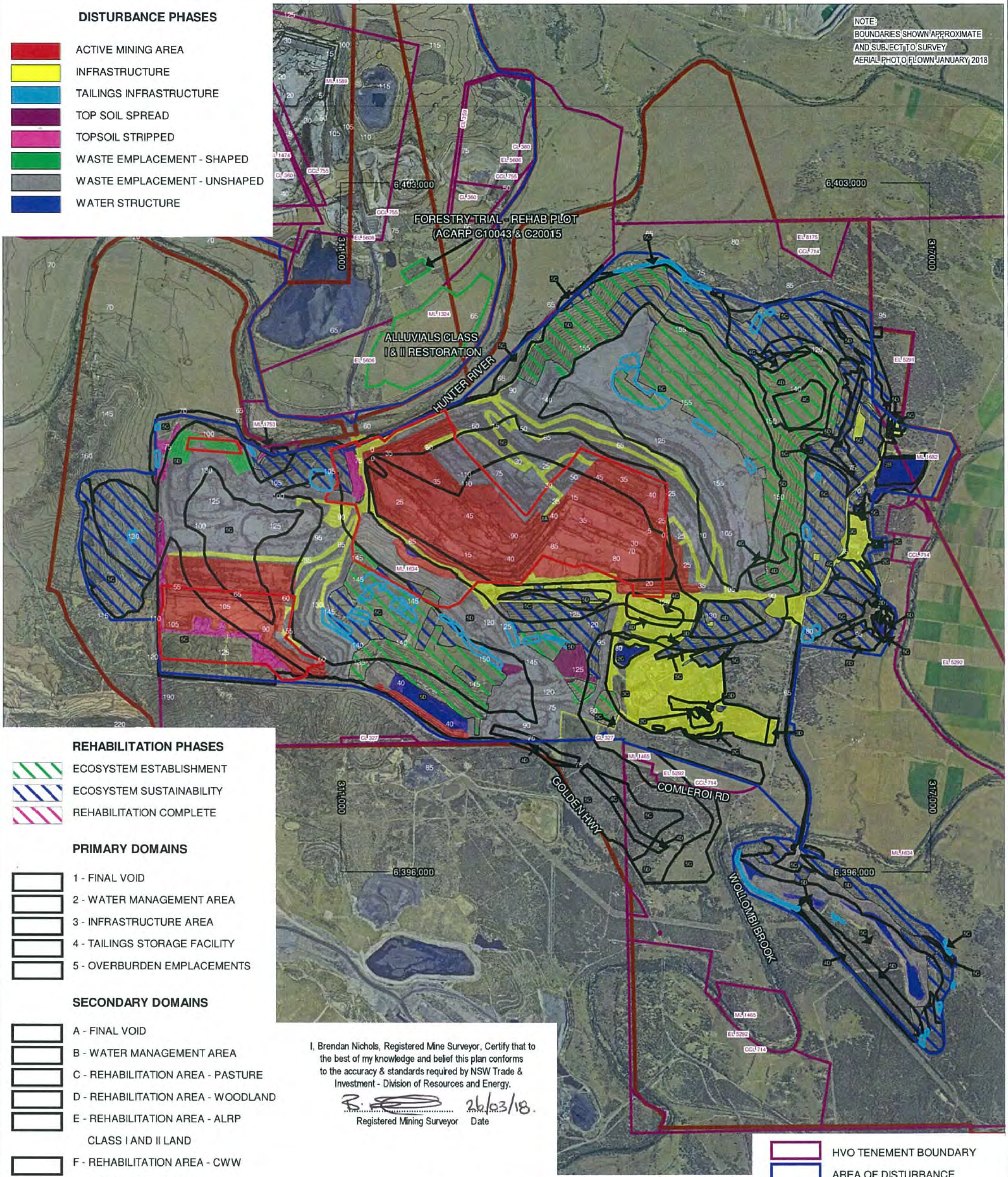
AEMR - Carrington Pit - 2017

N

0 0.5 1
KILOMETRES

File: HVO AEMR 180313.WOR
HVO Carrington Pit AEMR 180322.PDF

Date:	22/03/18
Produced By:	SC
Map Size:	A4 Portrait
Coordinate System:	MGA94 Zone 56
Revision	01
Data Source	Various
Scale	1:35,000 (A4)



DISTURBANCE PHASES

- ACTIVE MINING AREA
- INFRASTRUCTURE
- TAILINGS INFRASTRUCTURE
- TOP SOIL SPREAD
- TOPSOIL STRIPPED
- WASTE EMPLACEMENT - SHAPED
- WASTE EMPLACEMENT - UNSHAPED
- WATER STRUCTURE

REHABILITATION PHASES

- ECOSYSTEM ESTABLISHMENT
- ECOSYSTEM SUSTAINABILITY
- REHABILITATION COMPLETE

PRIMARY DOMAINS

- 1 - FINAL VOID
- 2 - WATER MANAGEMENT AREA
- 3 - INFRASTRUCTURE AREA
- 4 - TAILINGS STORAGE FACILITY
- 5 - OVERBURDEN EMPLACEMENTS

SECONDARY DOMAINS

- A - FINAL VOID
- B - WATER MANAGEMENT AREA
- C - REHABILITATION AREA - PASTURE
- D - REHABILITATION AREA - WOODLAND
- E - REHABILITATION AREA - ALRP CLASS I AND II LAND
- F - REHABILITATION AREA - CWW CLASS II AND III LAND
- G - REHABILITATION AREA - WOODLAND EEC

NOTE: FOR CLARITY, ONLY BLACK POLYGONS HAVE BEEN USED FOR PRIMARY & SECONDARY DOMAINS. PLAN HAS BEEN LABELLED WITH TEXT TO IDENTIFY AREAS

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

B. [signature] 26/03/18.

Registered Mining Surveyor Date

- HVO TENEMENT BOUNDARY
- AREA OF DISTURBANCE
- PROJECT APPROVAL AREA
- EXPECTED MINING AREA
- REHAB TRIALS
- TOPSOIL STOCKPILES
- 2017 AERIAL CONTOUR (5M)

SCHEDULE OF ENDORSEMENTS

REF	DATE	DESCRIPTION / REFERENCES	SIGNED
FULL PLAN	22/03/2018	MINE SURVEYING CONTENT DEPICTED ON THE PLAN SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DOMAIN BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DISTURBANCE LIMITS SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	MINING TENEMENT & LEASE BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	EXPECTED MINING AREA SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	REHABILITATION DATA & PHASES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	VEGETATION INFORMATION SUPPLIED BY OTHERS	B. NICHOLS

YANCOAL
兖煤澳大利亚有限公司

Hunter Valley Operations

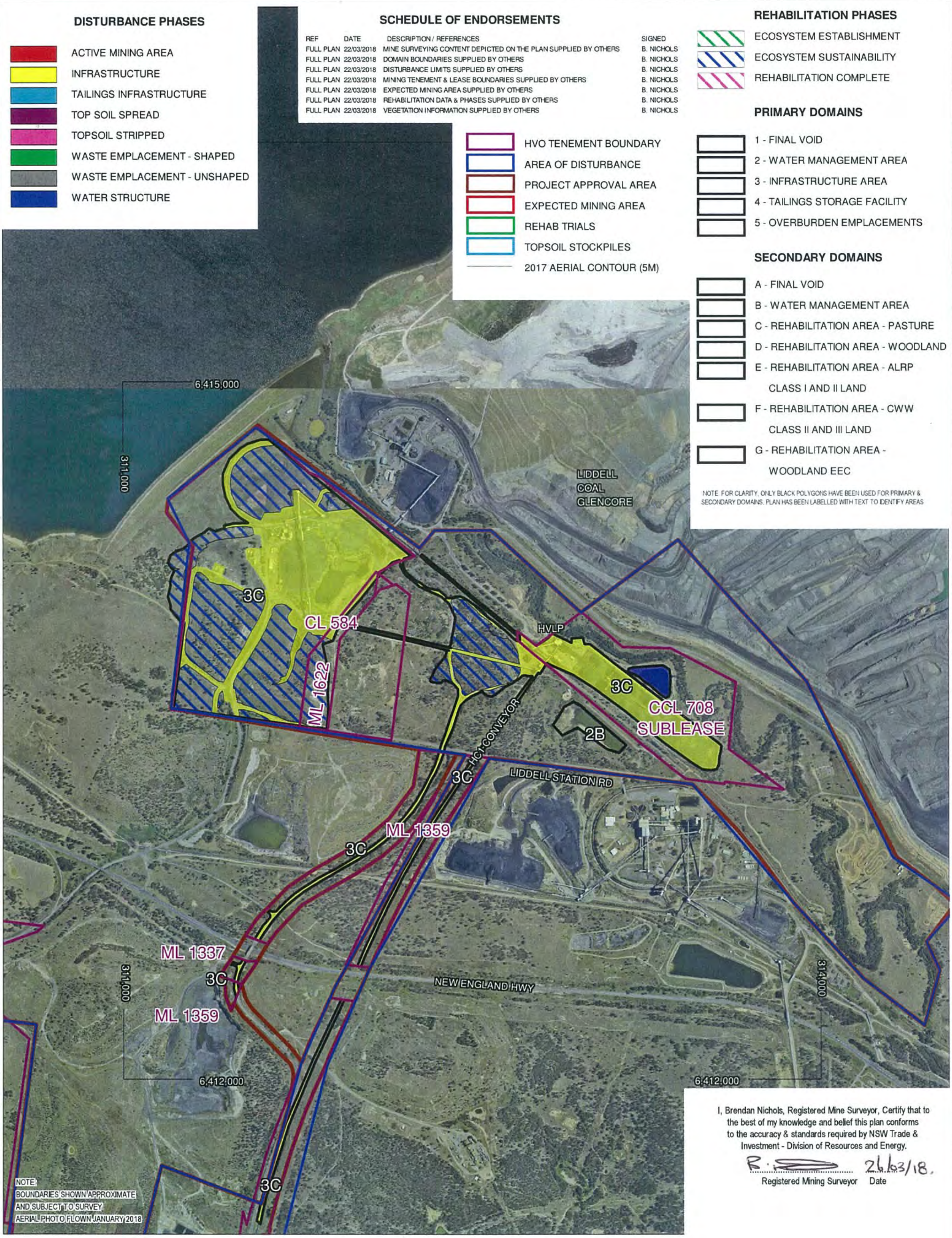
N

AEMR - HVO South - 2017

0 0.8 1.6
KILOMETRES

File: HVO AEMR 180313.WOR
HVO South AEMR 180322.PDF

Date:	22/03/18
Produced By:	SC
Map Size:	A4 Portrait
Coordinate System:	MGA94 Zone 56
Revision	01
Data Source	Various
Scale	1:50,000 (A4)



SCHEDULE OF ENDORSEMENTS

REF	DATE	DESCRIPTION / REFERENCES	SIGNED
FULL PLAN	22/03/2018	MINE SURVEYING CONTENT DEPICTED ON THE PLAN SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DOMAIN BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	DISTURBANCE LIMITS SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	MINING TENEMENT & LEASE BOUNDARIES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	EXPECTED MINING AREA SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	REHABILITATION DATA & PHASES SUPPLIED BY OTHERS	B. NICHOLS
FULL PLAN	22/03/2018	VEGETATION INFORMATION SUPPLIED BY OTHERS	B. NICHOLS

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

26/03/18.

Registered Mining Surveyor Date

YANCOAL
兖煤澳大利亚有限公司
Hunter Valley Operations

N

AEMR - HVLP NLP - 2017

0 400 800
METRES

File: HVO AEMR 180313.WOR
HVO HVLP NLP AEMR 180322.PDF

Date:	22/03/18
Produced By:	SC
Map Size:	A4 Portrait
Coordinate System:	MGA94 Zone 56
Revision	01
Data Source	Various
Scale	1:20,000 (A4)

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
Cheshunt Barry's (dam & surrounds)	Native Woodland	313,405.7 E 6,401,815.0 N	2.7	▪ The area is located immediately upstream of the engineered Cheshunt Levee embankment. The landform was constructed from historically disturbed surface materials, relict natural topography, and the emplacement of mine waste. ▪ Typical slope of the landform is flat with gentle undulations (0-4 degrees) with a primarily north easterly aspect. Areas immediately adjacent the dam impoundment progressively grade more steeply to the inner embankments of the impoundment. Areas adjacent the rehabilitation slope grade to 10 degrees. ▪ Drainage is via overland flow to the dam impoundment. ▪ Dam construction involved enlargement of the existing drainage sump by excavation of natural and mine spoil to achieve the design capacity and construction of an engineered spillway. The outer elements of the landform adjacent the dam were bulk shaped and shallow ripped while the inner elements along the waste emplacement toe were bulk shaped, deep ripped and oversize rock material removed. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100 mm. ▪ Recycled gypsum soil ameliorant was applied at 10 t/ha and the area was mulched with recycled hemp fibre. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required. ▪ Native Woodland Mix was broadcast at 17 kg/ha to an aerated pattern.
Cheshunt Barry's (RL95-125 slope)	Exotic Pasture Cover Crop	312,930.7 E 6,401,146.8 N	5.4	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily north eastern aspect. ▪ Drainage is via northerly draining contours reporting to an engineered rock-lined chute which drains to a basal dam (described above). ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required, and the area was sprayed with herbicide prior to sowing. ▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 25 kg/ha.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
Cheshunt Barry's (RL140-155 slope)	Exotic Pasture Cover Crop	313,483.8 E 6,401,344.5 N	14.1	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily north eastern aspect. ▪ Drainage is via northerly draining contours reporting to an engineered rock-lined chute which drains to a basal dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles, ahead of mine stripping, and rehabilitation disturbance was spread at a nominal thickness of 100mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required, and the area was sprayed with herbicide prior to sowing ▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 25 kg/ha.
Riverview Glider (RL80)	Exotic Pasture Cover Crop	313,677.0 E 6,397,657.2 N	7.6	▪ The landform was constructed from a waste emplacement. ▪ The landform is flat to gently sloping (0-4 degrees) with a primarily easterly aspect. ▪ Drainage is via overland flow to widely spaced drainage channels/contours which converge above a basal dam. Rip-rap armouring was placed along sections of the drains and the basal reach and dam inlet. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required. ▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 25 kg/ha.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
Riverview Glider (RL110 slope)	Exotic Pasture Cover Crop	313,444.8 E 6,397,850.2 N	4.0	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily south-easterly aspect. ▪ Drainage is via north draining contours reporting to an engineered rock-lined chute. With wider area completion waters from the chute will report to the RL80 Dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles, ahead of mine stripping, and rehabilitation disturbance was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required. ▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 25 kg/ha.
Riverview Glider (RL125 flat)	Exotic Pasture Cover Crop	313,086.6 E 6,398,252.3 N	4.8	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief undulations (0-2 degrees) and with primarily northern and eastern aspect. ▪ Drainage is via overland flow to adjacent northern and eastern rehabilitation areas. South draining contours on the eastern rehab slope (rehab in process) report to an engineered rock-lined chute and then to the RL80 Dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles and ahead of mine stripping was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required. ▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 25 kg/ha.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
Riverview Void (slope)	Exotic Pasture Cover Crop	312,165.1 E 6,397,853.9 N	6.0	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 12-14 degrees with a primarily south easterly aspect. ▪ Drainage is via west draining contours reporting to an engineered rock-lined chute. Chute drainage subsequently reports to the Riverview Void located to the south of the void slope. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles and ahead of mine stripping was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock and debris removal, and aerating as required. ▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 25 kg/ha.
South Facilities (former Lemington Pad)	Native Pasture Light Woodland	316,254.2 E 6,399,697.8 N	2.2	▪ The landform was in-situ from relict natural topography and historically disturbed surface materials. ▪ Typical slope of the landform is flat and gently undulating (0-4 degrees) with a primarily northern aspect. ▪ Drainage is primarily via overland flow with north flowing drainage channels located central and to the near east of the area. Drainage reports to a dam located to the near north. ▪ Landform surface preparation comprised area clean-up, hardstand recovery, minor shaping, drainage establishment/re-establishment, and shallow ripping. Existing mature vegetation was retained in-situ. ▪ Where relict topsoil was absent or required augmentation, clay loam topsoil from existing stockpiles was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and hemp fibre were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation and aerating as required. ▪ Native Pasture Light Woodland Mix was broadcast at 19.25 kg/ha to an aerated pattern.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
South East Tailing Storage Facility	Pasture	312,115.4 E 6,403,231.2 N	15.6	▪ The landform was constructed from a decommissioned tailings storage facility and surrounding waste emplacement. Material placed to the TSF surface was size selected and emplaced in accordance with the engineering design. ▪ The former TSF surface area is gently sloping (1-2 degrees) with fall to a southerly drainage sump within the uncapped area of the TSF. Northern and eastern areas are sloping batters (10-14 degrees). ▪ Drainage from batters is via south flowing contours which report to an adjacent water storage void. Drainage from the TSF surface is via overland flow to a managed drainage sump which dewaters to the adjacent void. ▪ Landform surface preparation comprised bulk shaping, shallow or deep ripping depending upon location, rock raking, and removal of oversize rock material. ▪ Substrate material comprised weathered mine spoil. ▪ Recycled gypsum soil ameliorant was applied at 10 t/ha, the area mulched with recycled hemp fibre, and ameliorants lightly incorporated to the substrate. ▪ CNA Custom Pasture Mix was broadcast sown at 50 kg/ha.
West Pit North Dump (N2 RL190)	Native Pasture Light Woodland	310,064.6 E 6,410,627.7 N	6.6	▪ The landform was constructed from a waste emplacement. ▪ The area is flat (0-2 degrees) and without dominant aspect in the western portion, transitioning to an easterly facing slope (6-10 degrees) in the eastern area. ▪ Drainage in the western area is via overland flow to a local habitat dam while central and eastern sections drain to the slope and associated south draining contours. Contours currently report to the adjacent active mine area with future integration to formal drainage to occur in association with rehab progression. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles and ahead of mine stripping was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required. ▪ Native Pasture Light Woodland Mix was drilled at 19.25 kg/ha to an aerated pattern.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
West Pit North Dump (N2 RL230 historic completion)	Native Pasture Light Woodland	309,231.3 E 6,409,901.2 N	1.7	▪ This area of rehabilitation edge was completed during 2015 and 2016 however had not previously been reported. ▪ The area is flat with localised micro-relief undulations (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow to localised drainage depressions and habitat ponds, and to a shallow west flowing drainage channel which currently reports to the southern edge of the western rehab slope. The slope footprint to which the drain currently reports is identified for a future rock-lined drainage chute. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles (2015) and mine advance stripping (2016) was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100t/ha respectively during each annual program. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required. ▪ The eastern portion of the area was drilled to Native Pasture Light Woodland Mix at 12.7 kg/ha in July 2016. The western portion of the area was initially sown to millet at 30 kg/ha in late 2015 and has subsequently been managed fallow with sowing to final native pasture light woodland planned during 2018.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
West Pit South Dump (RL230 flat)	Native Pasture Light Woodland	308,496.0 E 6,408,478.9 N	13.0	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief undulations (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow to localised drainage depressions, to adjacent rehabilitation to the north and west, and to active mine areas to the east. Drainage depressions and flows from the northern areas and slope crest drain to contours and then to an engineered rock-lined chute which reports to wider area rehab drainage at base of slope. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing stockpiles and ahead of mining stripping was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock removal, and aerating as required. ▪ Native Pasture Light Woodland Mix was drilled at 14.0 kg/ha to an aerated pattern.
West Pit South Dump (RL230 slope)	Native Woodland	308,062.2 E 6,408,846.5 N	11.1	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily northerly aspect. ▪ Drainage is via westerly draining contours reporting to an engineered rock-lined chute and then to the wider-area drainage network. Flat areas at the top of slope drain to the slope crest and to the upper contour or to adjacent mine areas. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from ahead of mine stripping was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock and debris removal, and aerating as required. ▪ Native Woodland Mix was drilled at 14.7 kg/ha to an aerated pattern.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
West Pit Wilton (slope)	Native Grass Cover Crop	307,451.2 E 6,407,501.8 N	3.6	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily northerly aspect. A small portion of the area at the top of slope is flat and without dominant aspect. ▪ Drainage is via westerly draining contours reporting to existing west draining contours along the northern rehab slope. Flat top of slope areas drain to the slope crest and the upper contour or to adjacent mine areas. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from ahead of mine stripping was spread at a nominal thickness of 100 mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock and debris removal, and aerating as required. ▪ Native Woodland Mix was drilled at 14.7 kg/ha to an aerated pattern.
West Pit Wilton (topsoil stockpiles)	Native Grass Cover Crop	307,438.9 E 6,407,311.1 N 306,977.1 E 6,407,142.6 N	0.6 2.3	▪ Topsoil stockpiles overlie the landform surface. The underlying landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief undulations (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow to adjacent flat and gently undulating rehabilitation areas, and to the active mine. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. Placed topsoils were shaped to a flat mound with gently sloping sides. ▪ The stockpiles are comprised of clay loam topsoil from ahead of mine pre-stripping. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10 t/ha and 100 t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation and debris removal. Stockpile surfaces were sprayed with herbicide prior to sowing. ▪ Native Grass Seed Mix was spread to the disturbed surface 22 kg/ha.

Appendix 4: Rehabilitation Tables

Annual Rehabilitation Report Form, Rehabilitation Maps and Rehabilitation Summary

Annual Rehabilitation Report Form – Mines
Year Ending: 2017
Mine: Hunter Valley Operations
Company: Rio Tinto Coal Australia – Coal and Allied
Plans Attached:
Hunter Valley Operations – AEMR 2017
Approved Mining Operations Plan:
HVO South MOP Amendment B (2015 – 2018) – Approval Date 8/12/2017
HVO North MOP Amendment B (2015 – 2018) – Approval Date 8/12/2017
Total Area Covered by Mining Operations Plan:
HVO North MOP – 5,434ha
HVO South MOP – 5,221ha
Total Area Covered by Mining Lease for This Mine: 10,655ha

HVO North includes Newdell

HVO North

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	1A	Final Void	Final Void	211.4	213.3
	2B	Water Management Areas	Water Management Areas	16.3	16.3
	3C	Infrastructure Area	Rehabilitation Area - Pasture	169.1	167.6
	3D	Infrastructure Area	Rehabilitation Area - Woodland	0.9	4.5
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	117.7	115.7
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	63.0	56.2
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	737.9	705.3
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	619.8	637.2
	5E	Overburden Emplacement Area	Rehabilitation Area - Class 2 and 3 Land	0	0
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	22.6	26.2
	Total Active			**1958.7**	**1942.2**
1.2 Decommissioning	**Total - Decommissioning**			**0.0**	**0**
1.3 Landform Establishment	**Total - Landform Establishment**			**4.3 (Included in 1.1)**	**1.1 (Included in 1.1)**
1.4 Growth Medium Development	**Total - Growth Medium Development**			**5.1 (Included in 1.1)**	**5.4 (Included in 1.1)**
1.5 Ecosystem and Land Use Establishment	1A	Final Void	Final Void	7.9	7.9
	3D	Infrastructure Area	Rehabilitation Area - Woodland	0.1	0.1
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	2.9	8.5
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	0.3	4.6
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	105.0	82.4
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	138.0	139.4

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
	Total - Ecosystem and Land Use Establishment			**254.2**	**242.8**
1.6 Ecosystem and Land Use Development	3C	Infrastructure Area	Rehabilitation Area - Pasture	0.0	47.5
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	36.6	36.1
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	28.2	28.0
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	940.0	901.4
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	414.4	504.4
	5E	Overburden Emplacement Area	Rehabilitation Area - Class 1 and 2 Land	72.3	72.3
	5G	Overburden Emplacement Area	Rehabilitation Area – Woodland EEC	0.0	4.3
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	52.3	3.8
	Total - Ecosystem and Land Use Development			**1543.8**	**1597.8**
1.7 Rehabilitation Complete	**Total - Rehabilitation Complete**			**0**	**0**
1.8 Total Area Disturbed (items 1.1 to 1.7)	1A	Final Void	Final Void	219.3	221.2
	2B	Water Management Areas	Water Management Areas	16.3	16.3
	3C	Infrastructure Area	Rehabilitation Area - Pasture	169.1	215.1
	3D	Infrastructure Area	Rehabilitation Area - Woodland	1.0	4.6
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	157.2	160.2
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	91.5	88.8
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	1782.9	1689.1
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	1172.2	1281.0
	5E	Overburden Emplacement Area	Rehabilitation Area - Class 1 and 2 Land	72.3	72.3
	5G	Overburden Emplacement Area	Rehabilitation Area – Woodland EEC	0.0	4.3
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	74.9	30.0
	Total Footprint			**3756.7**	**3782.9**

HVO South

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	1A	Final Void	Final Void	274.5	274.9
	2B	Water Management Areas	Water Management Areas	11.8	11.8
	2C	Water Management Areas	Rehabilitation Area - Pasture	6.7	8.3
	2D	Water Management Areas	Rehabilitation Area - Woodland	1.8	1.8
	3C	Infrastructure Area	Rehabilitation Area - Pasture	100.6	100.9
	3D	Infrastructure Area	Rehabilitation Area - Woodland	8.5	8.5
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	4.5	9.5
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	9.8	10.9
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	681.1	655.3
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	544.0	542.8
	Total Active			**1643.3**	**1624.7**
1.2 Decommissioning	**Total - Decommissioning**			**0.0**	**0**
1.3 Landform Establishment	**Total - Landform Establishment**			**14.2 (Included in 1.1)**	**19.3 (Included in 1.1)**
1.4 Growth Medium Development	**Total - Growth Medium Development**			**14.5 (Included in 1.1)**	**13.7 (Included in 1.1)**
1.5 Ecosystem and Land Use Establishment	3C	Infrastructure Area	Rehabilitation Area - Pasture	0.0	1.1
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	18.25	18.2
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	40.7	40.7
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	195.8	210.1

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	154.1	168.2
	Total - Ecosystem and Land Use Establishment			408.8	438.3
1.6 Ecosystem and Land Use Development	3C	Infrastructure Area	Rehabilitation Area - Pasture	0.7	1.2
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	10.7	10.7
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	19.9	19.4
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	304.9	306.0
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	254.0	260.0
	Total - Ecosystem and Land Use Development			**590.2**	**597.4**
1.7 Rehabilitation Complete	Total - Rehabilitation Complete			0	0
1.8 Total Area Disturbed (items 1.1 to 1.7)	1A	Final Void	Final Void	274.5	274.9
	2B	Water Management Areas	Water Management Areas	11.8	11.8
	2C	Water Management Areas	Rehabilitation Area - Pasture	6.7	8.3
	2D	Water Management Areas	Rehabilitation Area - Woodland	1.8	1.8
	3C	Infrastructure Area	Rehabilitation Area - Pasture	101.3	103.2
	3D	Infrastructure Area	Rehabilitation Area - Woodland	8.5	8.5
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	33.4	38.3
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	70.4	71.1
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	1181.8	1171.5
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	952.1	971.1
	Total Footprint			**2642.3**	**2660.4**

Table 2: Soil Management and Erosion, 2017

Soil Stockpiling/ Use	Soil Used This Period (m3)	Soil Pre-stripped This Period (m3)	Stockpile Inventory to Date (m3)	Soil Stockpiled Last Report (m3)
	100,400	88,300	863,113	875,213
2.2 Erosion Treatment	Total Area to Date (ha)	Total Area Last Report (ha)	Total Area This Report (ha)	Area Retreated This Period (ha)
	Not Available	5.0	58.4	0
Approx. area of sheet or gully erosion requiring reshaping topdressing and/or resowing	Not Available			

Table 3: Weed Control

	Area (ha)
3.1 Approx. area adversely affected by weeds as of the date of this report	Not Available
3.2 Area treated for weed control during the period covered by the report	370.5ha
3.3 Give summary of control strategies used and verification by approval agency(s)	
Species targeted in rehabilitation areas during 2017 included: galenia, Rhodes grass, green panic, couch grass, *Acacia saligna*, mustard weed (Brassica), farmers friend (*Bidens pilosa*) and paddys lucerne (*Sida rhombifolia*).	

Table 4: Management of Rehabilitation Areas

4.1 Area treated with maintenance fertiliser	0ha
4.2 Area treated by rotational grazing, cropping or slashing	1,210ha
Give Summary	820ha HVO rehabilitation area licence agreement in place for grazing. Temporary grazing licences aimed at reducing fuel loads are in place for a further 390ha of rehabilitated land across HVO.

Table: 5 Variations to Rehabilitation Program

Has rehabilitation work proceeded generally in accordance with the conditions of an accepted Mining Operations Plan.	HVO North - Yes HVO South – Substantially
If not please cite any approval granted for variations, or briefly describe the seasonal conditions or other reasons for any changes and the nature of any changes which have been made.	
HVO North net rehabilitation (net rehabilitation = rehabilitation – rehabilitation disturbance) completed during period 2015 to 2017: Actual = +41.9ha vs MOP target = -96.1ha. HVO North net rehabilitation progress 138ha ahead of MOP target for period 2015 to 2017. HVO South net rehabilitation completed during period 2015 to 2017: Actual = +90.3ha vs MOP target = +128.5ha. HVO South net rehabilitation progress 38ha behind MOP target for period 2015 to 2017. HVO South rehabilitation progress delayed due to HVO seeking approval for Cheshunt dumps to be raised to higher level.	

Table 6: Planned Operations During the Next Report Period

6.1 Area estimated to be disturbed	226.2ha
6.2 Area estimated to be rehabilitated	100ha