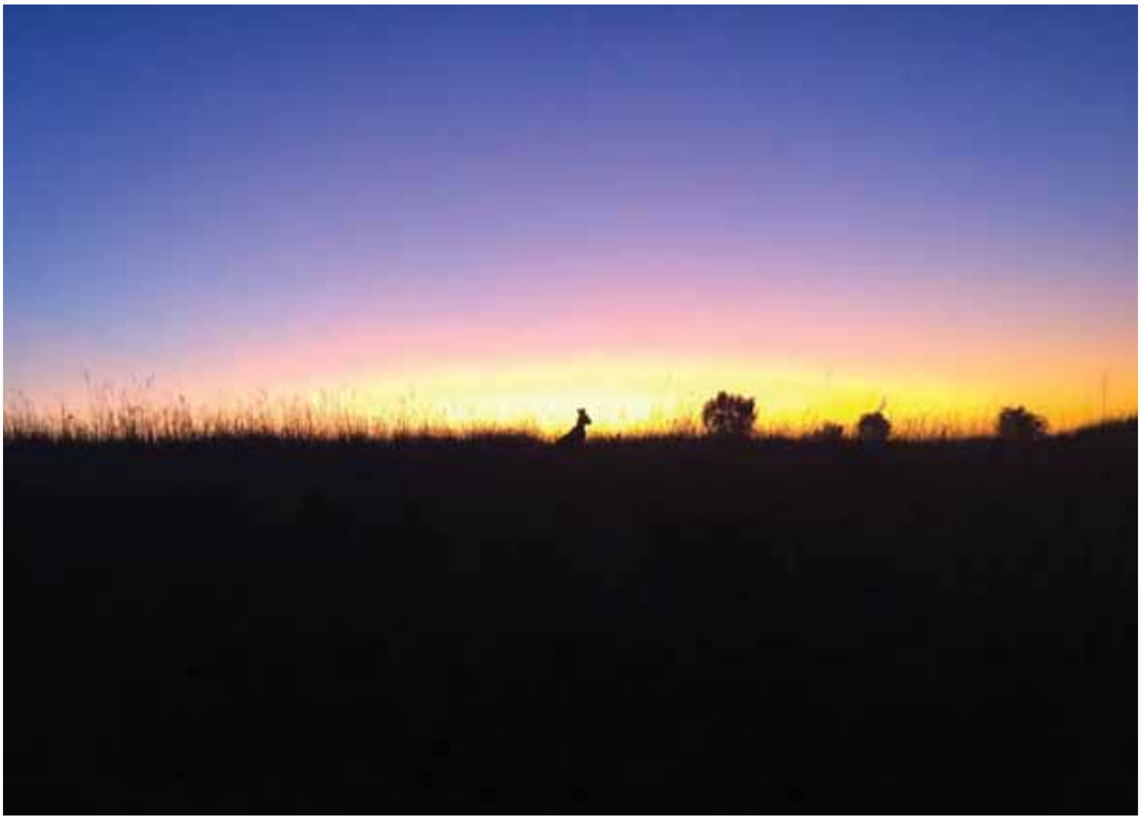
# Mount Thorley Warkworth

# 2015 Annual Environmental Review

March 2016



*Eastern Grey Kangaroo on rehabilitated land at Warkworth Mine*

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| | |
|---|---|
| Name of Operations | Mount Thorley Warkworth |
| Name of Operator | Coal & Allied Operations Pty Limited |
| Development consent /project approval | |
| Name of holder of development consent/project approval | Coal & Allied Operations Pty Limited |
| Mining Lease Number | Contained within Section 1.3 of this report |
| Name of Mining Lease Holder | Mount Thorley Operations Pty Ltd<br>Warkworth Mining Limited |
| Water Licence Number | Contained within Section 1.4 of this report |
| Name of Water Licence Holder | Contained within Section 1.4 of this report |
| MOP/RMP Start Date | 4/11/2014 |
| MOP/RMP End Date | 30/11/2016 |
| Annual Review Start Date | 01/01/2015 |
| Annual Review End Date | 31/12/2015 |

**I, Mark Rodgers, certify that this audit report is a true and accurate record of the compliance status of Mt Thorley Warkworth for the period 1 January 2015 to 31 December 2015 and that I am authorised to make this statement on behalf of Rio Tinto Coal Australia.**

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 | Mr Mark Rodgers |
| Title of Authorised Reporting Officer | General Manager Operations |
| Signature of Authorised Reporting Officer | |
| Date | 30/3/16 |

# Executive Summary

Mount Thorley Warkworth (MTW) is an integrated operation of two open cut coal mines, Warkworth Mining Limited (WML) and Mount Thorley Operations (MTO). This Annual Review reports on the environmental performance of Mount Thorley Warkworth (MTW) for the period 1 January 2015 to 31 December 2015.

This report has been prepared in accordance with conditions of the development consents and Mining Leases (ML) held by MTW which require a report of the operation's environmental performance to be provided on an annual basis. The structure of the 2015 Annual Review intends to align with the NSW Government *Post-approval requirements for State significant mining developments – Annual Review Guideline (October 2015).* MTW produced 17.1 million tonnes of run-of-mine (ROM) coal during 2015, and 11.9 million tonnes of saleable coal, against an approved ROM coal production rate of 28 million tonnes per annum (mtpa).

### Noise

MTW's noise performance improved significantly in 2015. A reduction of approximately 60% was recorded in attended noise measurements which exceed the trigger for action compared to 2014.

Work continued during 2015 to reduce the noise from MTW's Heavy Mobile Equipment (HME) fleet. As at February 2016, 73% of Haul Trucks, 67% of Dozers, 75% of Drills and 38% of Excavators are operating as sound suppressed units, attenuated to the "Stage Two" target of 115dB(A). There were zero non-compliances recorded against MTW's consented noise limits. A total of 7,647 hours of mine stoppage were recorded due to proactive and reactive measures to minimise noise.

### Blasting

During the reporting period 466 blast events were initiated at MTW. There were zero non-compliances against the airblast overpressure or ground vibration conditions listed in MTWs Environment Protection Licences or Planning Approvals. MTW employs a blast fume management protocol to mitigate generation of post blast fume emissions. Two category 3 blast fumes were notified to DP&E in accordance with their notification requirements. Both fume events dissipated at height over mine owned land. Zero category 4 or 5 events were recorded.

### Air Quality

During 2015, MTW complied with all short term and annual average air quality criteria. A total of 5,809 hours of mine stoppage was recorded following implementation of proactive and reactive measures to minimise dust. A total of 138 ha of land were aerially seeded during autumn to minimise wind eroded dust from overburden areas not yet available for rehabilitation.

### Heritage

During the reporting period there were 66 GDPs assessed for cultural heritage management considerations with regard to mining development disturbance activities at MTW. In all cases the ground disturbance works were conducted on Aboriginal cultural heritage sites avoidance basis so that no extant sites were impacted by these activities. There were no incidents nor any unauthorised disturbance caused to Aboriginal cultural or historic heritage sites at MTW during 2015. Condition

inspections were conducted at the Springwood Homestead and Mt Thorley Brick Farmhouse and maintenance and stabilisation works programs have been developed for these properties.

### Surface Water

Surface water monitoring activities continued in 2015 in accordance with the MTW Water Management Plan. Improvements to water management in 2015 have continued to focus on future water supply security, seeking to reduce reliance on abstraction from the Hunter River by sourcing water from neighbouring mines during peak demand periods. Works included the construction of a water transfer pipeline, linking MTW to the HVO Riverview Void, to permit transfer of excess water from MTW and recovery of water where required. Two incidents involving water required notification to government agencies. No material environmental harm resulted from these incidents. Each incident was investigated with corrective and preventative actions implemented.

### Groundwater

Groundwater monitoring activities were undertaken in 2015 in accordance with the MTW 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.

Groundwater monitoring data is reviewed on a quarterly basis. There were zero non-compliances related to groundwater in 2015.

### Visual amenity

Work continued on dumping, shaping and final rehabilitation of the South Pit North area during 2015. The mine received 44 lighting complaints from 11 households, with 29 complaints from a single household. Lighting complaints are investigated and light emissions from the mine are routinely checked at night by the Community Response Officers.

### Rehabilitation and Land Management

A total of 75.7 ha rehabilitation was undertaken during 2015 against a MOP target of 73.8 ha. Total disturbance undertaken was 32.9 ha, 49.1ha lower than the MOP projection of 82ha. Capping and rehabilitation of Tailings Dam 1 was completed during 2015. An annual site weed survey was undertaken during November 2015 and will form the basis of ongoing weed management works during 2016.

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# 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: Reference Table**

| Were all conditions of the relevant approval(s) complied with? | |
|---|---|
| DA 34/95 (MTO) | No |
| DA 300-9-2002-i (WML) | No |

**Table 2: Non-compliances**

| Relevant approval | Condition number | Condition description (summary) | Compliance status | Where addressed in Annual Review |
|---|---|---|---|---|
| DA34/95 (MTO) DA 300-9-2002-i (WML) | Schedule 3 Condition 32 | Water Discharges / Pollution of Waters | Non-Compliant (Medium) | 11.1 |
| DA34/95 (MTO) | Schedule 3 Condition 32 | Water Discharges | Non-Compliant (Medium) | 11.1 |

**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 :<br>• Potential for serious environmental consequences, but is unlikely to occur; or<br>• Potential for moderate environmental consequences, but is unlikely to occur |
| Low | Non-compliant | Non-compliance with :<br>• Potential for moderate environmental consequences, but is unlikely to occur; or<br>• 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) |

Source: NSW Government *Post-approval requirements for State significant mining developments – Annual Review Guideline (October 2015).*

# 2. INTRODUCTION

Mount Thorley Warkworth Coal Mine (MTW) is an integrated operation consisting of Warkworth Mining Limited (WML) and Mount Thorley Operations (MTO), situated 14 km southwest of Singleton, in the Upper Hunter Valley region of NSW.

MTW is managed and operated by Coal & Allied, a Rio Tinto Group Company, on behalf of the joint venture partners:

- Mount Thorley: Coal & Allied Industries Limited (80%) and POSCO Australia Pty Ltd (20%)
- Warkworth: Coal & Allied Warkworth Australasia Pty Ltd (26.82%), Coal & Allied Resources Limited (28.75%), Mitsubishi Development Pty Ltd (28.9%), Nippon Steel Australia Pty Ltd (9.53%), Mitsubishi Materials [Australia] Pty Limited (6%)

MTW is located in an area adjacent to other coal mines (Figure 1). Other industry in the locality includes: the Mount Thorley Industrial Estate; the Dyno Nobel Facility; Steggles Quarantine Facility; and the Redbank Power Station (currently not in operation). Other surrounding land uses predominantly consist of a military base and agriculture. The villages of Bulga and Warkworth are located to the southwest and northwest of MTW operations respectively.

## 2.1 Document purpose

This report summarises the environmental performance of MTW in accordance with conditions of the development consents and Mining Leases (ML) held by site. The structure of the 2015 Annual Review intends to align with the NSW Government *Post-approval requirements for State significant mining developments – Annual Review Guideline (October 2015).*


**Figure 1: MTW Site Layout and Locality Plan**

## 2.2 Mine Contacts


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# 3. APPROVALS

## 3.1 Approvals, leases and licenses

### 3.1.1 Current Approvals

The status of MTO and WML development consents, licenses and relevant approvals at 31st December 2015 are summarised in Table 3 to Table 9.

**Table 3: Operations Approvals- Warkworth**

| Approval Number | Description | Authority | Dates |
|---|---|---|---|
| DA 300-9-2002-i | Extension of Warkworth Coal Mine – Extend Mining to Wallaby Scrub Road | DP&E | 20/5/2003 |
| DA 300-9-2002-i Mod 1 | Modification of DA 300-9-2002-i – Rejects and ROM Bins Modifications | DP&E | 19/10/2004 |
| DA 300-9-2002-i Mod 2 | S96(1) modification of the original Lot and DP schedule in DA 300-9-2002-i | DP&E | 2/2/2007 |
| DA 300-9-2002-i Mod 3 | S96(2) modification of DA 300-9-2002-i for upgrades to the MTW electrical switchyard | DP&E | 31/10/2007 |
| DA 300-9-2002-i Mod 4 | S75W modification of DA 300-9-2002-i for the coal bed methane pilot programme | DP&E | 15/9/2008 |
| DA 300-9-2002-i Mod 5 | S96 (1A) modification of DA 300-9-2002-i for the relocation of the Reload Facility and Light Vehicle Wash Bay | DP&E | 28/10/2009 |
| DA 300-9-2002-I Mod 6 | S75W modification of DA 300-9-2002-i for a 350m extension of mining activities | DP&E | 29/01/2014 |
| DA 292/2009 | Demolition of buildings at 573 Wallaby Scrub Road, WARKWORTH (Lot 16 DP 755267) in Rural 1(a) | DP&E | 8/10/2009 – 8/10/2014 |
| EPBC 2009/5081 | Approval under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) to extend the existing Warkworth Coal Mine over an additional 705 hectares of land at Warkworth NSW including associated modifications to existing mine infrastructure | DSEWPaC | 9/8/2012 – 31/3/2033 |
| EPBC 2002/629 | Approval under the EPBC Act to construct and operate an open cut coal mine extension at the Warkworth Coal Mine | DSEWPaC | 18/2/2004 (varied on 6/4/2004, 24/5/2004, 19/11/2004 and 13/7/2012) – 25/2/2039 |
| SSD-6464 | Warkworth Continuation Project | DP&E | 26/11/2015 |

**Table 4: Operations Approvals - Mount Thorley**

| Approval Number | Description | Authority | Dates |
|---|---|---|---|
| DA 34/95 | Development Consent Conditions - Construction and Operation of Surface Coal Mine Extensions. | DP&E | 22/6/1996 |
| DA 34/95 Mod 3 | Modification of DA 34/95 – Rejects and ROM Bins Modifications | DP&E | 19/10/2004 |
| DA 34/95 Mod 4 | Section 96 (1A) Modification of DA 34/95 – Extension to Mine Water Dam 9S | DP&E | 7/5/2009 |
| DA 34/95 Mod 5 | Section 96 (1A) Modification of DA 34/95 – Extension of the existing Abbey Green North Pit | DP&E | 2/5/2012 – 2/5/2033 |
| SSD-6465 | Mount Thorley Continuation Project | DP&E | 26/11/2015 |

**Table 5: Licences and Permits**

| Licence Number | Description | Authority | Expiry Date |
|---|---|---|---|
| **Warkworth** | | | |
| EPL1376 | Environment Protection Licence | EPA | N/A |
| NDG018727* | Dangerous Goods Licence | WorkCover | N/A |
| 50661122 | Radiation Licence | EPA | 02 May 2016 |
| XSTR100160 | Licence to Store – Explosives Act | WorkCover NSW | 13 November 2018 |
| **Mount Thorley** | | | |
| EPL24 | Environment Protection Licence | EPA | N/A |
| EPL1976 | Environment Protection Licence | EPA | N/A |
| NDG018727* | Dangerous Goods Licence | WorkCover | N/A |
| 5061110 | Radiation Licence | EPA | 31 July 2016 |

* Mount Thorley and Warkworth are now operating under the same Dangerous Goods License

Note: Environment Protection Licences remain in force until the licence is surrendered by the licence holder or until it is suspended or revoked by the EPA or the Minister. A licence may only be surrendered with the written approval of the EPA.

**Table 6: Mining Tenements**

| Mining Tenement | Type | Purpose | Status | Dates |
|---|---|---|---|---|
| **Warkworth** | | | | |
| CCL 753 | Consolidated Coal Lease | Prospecting and Mining Coal | Granted | 23/05/1990 - 17/02/2023 |
| ML 1412 | Mining Lease | Prospecting and Mining Coal | Granted | 11/01/1997 - 10/01/2018 |
| ML 1590 | Mining Lease | Prospecting and Mining Coal | Granted | 27/02/2007 - 26/02/2028 |
| MLA 352 | Mining Lease Application | Prospecting, Mining Coal and Purposes | Application Pending | Mining Lease Application Lodged 2nd June 2010 |
| **Mount Thorley** | | | | |
| CL 219 | Coal Lease | Prospecting and Mining Coal | Granted | 23/09/1981 - 22/09/2023 |
| (Part) ML 1547 | Sub-Lease | Mining Purposes | Registered | The part sublease area known as the "Bulga Mining Sublease" expired on 30th June 2015. An application to relinquish this sublease was made on 14th December 2015. |
| EL 7712 | Exploration Licence | Prospecting Coal | Granted | 23/2/2011 - 22/02/2016 |
| MLA 353 | Mining Lease Application | Prospecting, Mining Coal and Purposes | Application Pending | Mining Lease Application Lodged 2nd June 2010 |

Note: The authority for all mining tenements is Department of Industry, Skills and Regional Development (Resources & Energy Division).

**Table 7: Other Approvals**

| Approval | Authority | Dates |
|---|---|---|
| **Emplacement Areas** | | |
| **Warkworth** | | |
| Swan Lake Void | DPI | 21/10/2002 |
| Tailings Dam 2 | DPI | 22/10/2002 |
| Tailings Dam 2 –130RL | DPI | 9/12/2003 |
| **Mount Thorley** | | |
| Section 126 Variation to Reject Emplacement Area | DPI | 20/3/2001 |
| Section 126 Construction of Reject Emplacement Area Centre Ramp Tailings Dam | DPI | 9/4/2001 |
| Mini Strip 24 Tailings Storage Facility | DPI | 8/9/2004 |
| Dam Safety Committee Centre Ramp Tailings Storage Facility Stage 2 | DPI | 12/2/2004 |
| Section 126 Centre Ramp Tailings Dam – Raising height of embankment | DPI | 10/5/2006 |
| Section 126 Abbey Green South Tailings Dam | DPI | 10/5/2006 |
| **Other Approvals** | | |
| Installation of a single 500mm water pipeline under Putty Road | RMS | 31/10/2007 |
| Installation of two 600mm tailings pipelines under Putty Road | RMS | 1/2/2007 |
| Resource Recovery Exemption for coal washery rejects at Mount Thorley Warkworth | DECC | 1/2/2010 |

**Table 8: Water Licences**

| Licence Number | Type | Purpose | Legislation | Description | Renewal Date |
|---|---|---|---|---|---|
| 20BL168821 | Bore | Monitoring Bore | Part 5 Water Act 1912 | Bores: MTAGP1, MTAGP2, ABGOH07, ABGOH43, ABGOH44, ABGOH45 | Perpetuity |
| 20BL170011 | Bore | Excavation - Mining | Part 5 Water Act 1912 | Mount Thorley Excavation | 26 November 2016 |
| 20BL170012 | Bore | Excavation - Mining | Part 5 Water Act 1912 | Warkworth Pit Excavation | 26 November 2016 |
| 20BL171729 | Bore | Monitoring Bore | Part 5 Water Act 1912 | G3 | Perpetuity |

| Licence Number | Type | Purpose | Legislation | Description | Renewal Date |
|---|---|---|---|---|---|
| 20BL171841 | Bore | Monitoring Bore | Part 5 Water Act 1912 | OH1126 | Perpetuity |
| 20BL171842 | Bore | Monitoring Bore | Part 5 Water Act 1912 | OH944 | Perpetuity |
| 20BL171843 | Bore | Monitoring Bore | Part 5 Water Act 1912 | OH1137 | Perpetuity |
| 20BL171844 | Bore | Monitoring Bore | Part 5 Water Act 1912 | Bores: OH1123 (E), OH1123 (W) | Perpetuity |
| 20BL171845 | Bore | Monitoring Bore | Part 5 Water Act 1912 | OH1124 | Perpetuity |
| 20BL171847 | Bore | Monitoring Bore | Part 5 Water Act 1912 | Bores: OH1127, OH787 | Perpetuity |
| 20BL171848 | Bore | Monitoring Bore | Part 5 Water Act 1912 | OH1125 | Perpetuity |
| 20BL171849 | Bore | Monitoring Bore | Part 5 Water Act 1912 | OH1122 | Perpetuity |
| 20BL171850 | Bore | Monitoring Bore | Part 5 Water Act 1912 | OH1138 | Perpetuity |
| 20BL171864 | Bore | Monitoring Bore | Part 5 Water Act 1912 | Bores: OH786, OH942 | Perpetuity |
| 20BL171891 | Bore | Monitoring Bore | Part 5 Water Act 1912 | Bores: OH1121, OH788, OH943 | Perpetuity |
| 20BL171892 | Bore | Monitoring Bore | Part 5 Water Act 1914 | Bores: WOH2153 (PZ2), WOH2154 (PZ1), WOH2155 (PZ4), WOH2156 (PZ3) | Perpetuity |
| 20BL171893 | Bore | Monitoring Bore | Part 5 Water Act 1918 | Bores: WOH2141 (PZ6), Ground Water Alluvial Modelling | Perpetuity |
| 20BL171894 | Bore | Monitoring Bore | Part 5 Water Act 1913 | WOH2139 (PZ5) | Perpetuity |
| 20BL172272 | Bore | Monitoring Bore | Part 5 Water Act 1912 | PZ9S, PZ9D | Perpetuity |
| 20BL172273 | Bore | Monitoring Bore | Part 5 Water Act 1912 | PZ8S, PZ8D | Perpetuity |
| 20BL173062 | Bore | Monitoring Bore | Part 5 Water Act 1912 | SR011 | Perpetuity |
| 20BL173063 | Bore | Monitoring Bore | Part 5 Water Act 1912 | SR008, SR009 | Perpetuity |
| 20BL173064 | Bore | Monitoring Bore | Part 5 Water Act 1912 | SR010 | Perpetuity |

| Licence Number | Type | Purpose | Legislation | Description | Renewal Date |
|---|---|---|---|---|---|
| 20BL173065 | Bore | Monitoring Bore | Part 5 Water Act 1912 | SR012 | Perpetuity |
| 20FW213276 (formerly 20CW802601) | Flood Work Approval | Block Dam | Water Management Act 2000 | Charlton Rd Levee | 23 August 2020 |
| 20WA209905 WAL - TBA (Formerly 20SL051292) | Stream Diversion | Bywash Dams | Water Management Act 2000 | Doctors Creek Bywash | 31 July 2022 |
| 20CA209904 WAL - 19022 | Stream Diversion | Bywash Dams | Water Management Act 2000 | Sandy Hollow Creek | 25 February 2023 |

**Table 9: Surface Water Extraction Licenses**

| Licence Number | Type | Purpose | Description | Renewal Date | Approved Extraction (ML)* | Actual Extraction 2015 (ML) |
|---|---|---|---|---|---|---|
| 20AL201242 (see WAL963) | Water Access Licence | Water Access Licence | Warkworth Mining Limited Hunter River Pump (General Security) | Perpetuity | 243 | 0 |
| 20AL209903 (Formerly - 20SL050187) (see WAL19022) | Diversion Works | Irrigation | Sandy Hollow Creek (Unregulated River – Singleton Water Source) | 25 February 2023 | 60 | 0 |
| 20AL201254 (see WAL969) | Water Access Licence | Water Access Licence | Glennies Creek Pump (General Security) | Perpetuity | 39 | 0 |
| WAL10543 | Water Access Licence | Certificate of Title | Refer 20AL201239 and 20WA201241 | Perpetuity | 1,012 | 171 |
| WAL10544 | Water Access Licence | Certificate of Title | Refer 20AL201240 and 20WA201241 (Hunter Regulated River – Domestic | Perpetuity | 5 | 0 |

| Licence Number | Type | Purpose | Description | Renewal Date | Approved Extraction (ML)* | Actual Extraction 2015 (ML) |
|---|---|---|---|---|---|---|
| | | | and Stock) | | | |
| WAL963 | Water Access Licence | Certificate of Title | Refer 20AL201242 and 20AL201242 | Perpetuity | 243 | 0 |
| WAL19022 | Water Access Licence | Certificate of Title | Refer 20AL209903 and 20CA209904 | 25 February 2023 | 60 | 0 |
| WAL969 | Water Access Licence | Certificate of Title | Refer 20AL201254 and 20CA201255 | Perpetuity | 39 | 0 |

* Approved extraction limits are for a financial year.

### 3.1.2 Management Plans, Programmes and Strategies

Table 10 details the Management Plans and strategies which were in place during the reporting period, required under the modified Mount Thorley (DA 34/95) and Warkworth (DA-300-9-2202-i) approvals.

Table 11 details the Management Plans and strategies which are required under the Warkworth (SSD-6464) and Mount Thorley (SSD-6465) Development Consent instruments issued in November 2015.

A Mining Operations Plan (MOP) was developed to replace the previous MOP and cover the existing MTW operations, as well as the approved operations outlined in the Environmental Impact Statements for the Warkworth Continuation 2014 and Mt Thorley Operations 2014. The MOP outlines the proposed operational and environmental management activities planned for MTW. Details regarding the submissions and approval dates for the current MOP are shown in Table 12.

**Table 10: Status of Management Plans required under Warkworth (DA 300-2002-i) and Mount Thorley (DA 34/95) Approvals**

| Management Plan | Status (most recent approval) |
|---|---|
| Noise Management Plan | 29/01/2015 |
| Blast Management Plan | 10/09/2014 |
| Air Quality and Greenhouse Gas Management Plan | 06/08/2014 |
| Water Management Plan | 26/06/2015 |
| Heritage Management Plan | 13/08/2014 |
| WML Archaeology and Cultural Heritage Management Plan | 01/09/2003 |
| Rehabilitation Management Plan | 2/11/2014 |
| Environmental Management Strategy | 31/1/2013 |
| Flora and Fauna Management Plan | 01/03/2013 |
| Bushfire Management Plan | 27/05/2003 |

**Table 11: Status of Management Plans Required under Warkworth Continuation (SSD-6464) and Mount Thorley Operations (SSD-6465) Project Approvals**

| Plan / Program / Strategy | Status (approval date) |
|---|---|
| Air Quality Management Plan | 03/02/2016 |
| Noise Management Plan | 03/02/2016 |
| Blast Management Plan | 28/01/2016 |
| Water Management Plan | 29/01/2016 |
| Aboriginal Heritage Management Plan | 28/01/2016 |

| Plan / Program / Strategy | Status (approval date) |
|---|---|
| Rehabilitation Management Plan (addressed in MOP) | 05/02/2016 |
| Environmental Management Strategy | 03/02/2016 |

**Table 12: MOP Approval status for Mount Thorley Warkworth**

| Mining Operations Plan | Date Submitted | Date Approved |
|---|---|---|
| Mount Thorley Warkworth MOP 2012 to 2016 | June 2012 | Nov 2012 |
| Mount Thorley Warkworth MOP 2014 to 2016 | 24/09/2014 | 30/09/2014 |
| Mount Thorley Warkworth MOP 2014 to 2016 Amendment A (change to final landform) | 4/11/2014 | 24/11/2014 |
| Mount Thorley Warkworth MOP 2016 | 30/11/2015 | 05/02/2016 |

# 4. OPERATIONS SUMMARY

## 4.1 Summary of Mining Activities

Areas to be mined are geologically modelled, a mine plan is formed and the relevant mining locations are surveyed prior to mining. Figure 2 illustrates the mining process. MTW have no active underground workings.

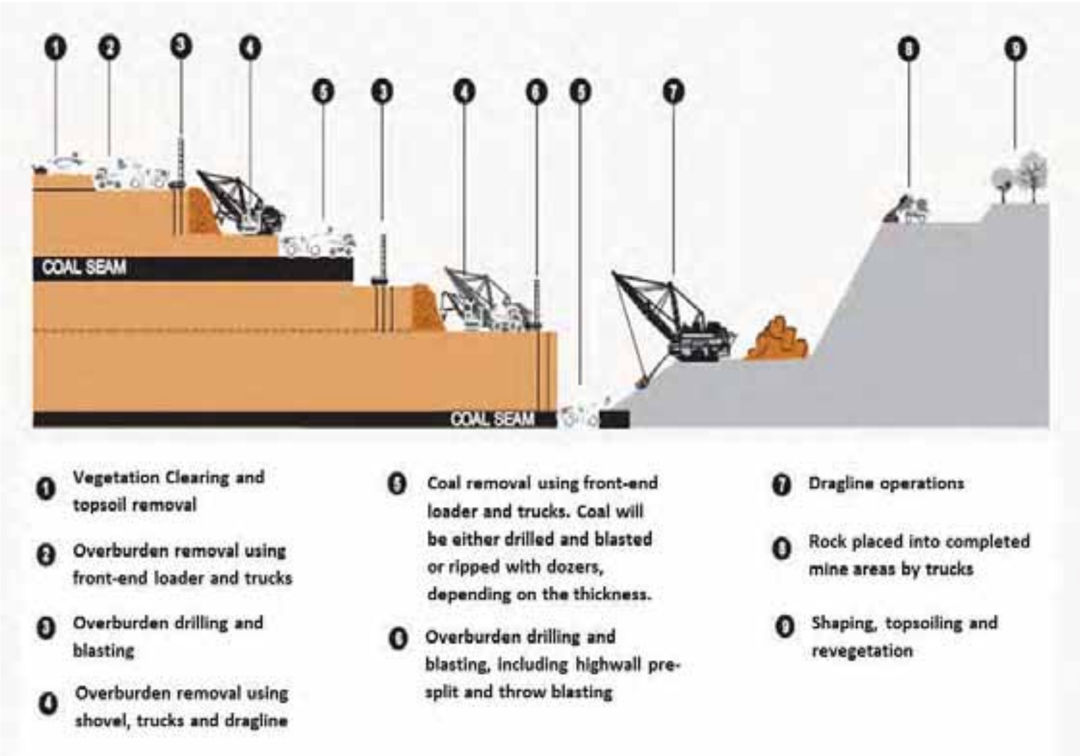


**Figure 2: Mining Process**

Within the Warkworth lease, mining activities will continue to advance in a westerly direction in both North and West Pits. South Pit has reached its final western limit with the final strip to be completed to depth in 2016. Within the Mount Thorley lease, mining has reached the western limit with remaining reserves to be mined to depth over the coming two years. All mining related activity is in line with the current MOP. No additional or replacement heavy equipment is planned for purchase in 2016. Sound attenuation of the existing truck fleet will continue in 2016.

The planned 2016 production and waste schedule for MTW is summarised below:

- 17.3 Mt ROM coal;
- 11.8 Mt Product coal;
- 133 Mbcm overburden (including rehandle); and
- 5.4 Mt Tailings and reject

The Planned ROM coal production represents approximately 60% of the approved maximum ROM coal production for MTW.

Coal will continue to be transported via conveyer to the Mount Thorley Coal Loader and railed to the port.

## 4.2 Mineral Processing

All processing and rejects/tailings disposal activities undertaken in 2015 were consistent with the approved MOP and no changes were made to the processing and rejects/tailings disposal methods.

The currently active tailing emplacements are the Centre Ramp Tailings Storage Facility and Abbey Green South Tailings Storage Facility. Tailings Dam 2 was previously used to receive ash from Redbank Power Station. Ash emplacement to Tailings Dam 2 ceased in July 2014 following the cessation of operations at Redbank Power Station. The contract to receive ash from Redbank has been finalised and no more ash will be received. During 2015, capping works upon Tailings Dam 1 were completed, with preparatory capping works on Tailings Dam 2 to commence in 2016.

## 4.3 Production Statistics

Under the Project approvals in place during the reporting period, extraction of up to 28 million tonnes of ROM coal from MTW is permitted in a calendar year, comprising up to 18 million tonnes from ROM coal from the Warkworth Mine and 10 million tonnes from the Mount Thorley Mine. MTW Production Statistics for the previous, current and future reporting period are summarised in Table 13.

**Table 13: Summary of Production at MTW in 2015**

| Material | Approved Limits | Reporting Period 2014 | Reporting Period 2015 | Forecast for 2016 |
|---|---|---|---|---|
| **Prime Waste (kbcm)** | N/A | 98,019 | 103,156 | 133,000 |
| **MTO ROM Coal (Mtpa)** | 10 (DA 34/95) | 5.62 | 3.32 | 4.30 |
| **WML ROM Coal (Mtpa)** | 18 (DA-300-9-2002-i) | 12.07 | 13.74 | 13.00 |
| **ROM Coal (Mtpa)** | 28 (Combined) | 17.69 | 17.06 | 17.30 |
| **Coarse Reject (kt)** | N/A | 3,715 | 3, 583 | 3,633 |
| **Fine Reject – Tailings (kt)** | N/A | 1,681 | 1,403 | 1,767 |
| **Product (kt)** | N/A | 12,076 | 11,864 | 11,800 |

## 4.4 Summary of Changes (developments and equipment upgrades)

- Mining activity during the reporting period with regard to volumes, location and equipment was consistent with 2014
- South Pit accelerated rehabilitation plan has progressed in line with the consent condition

- Tailings Dam 1 capping and rehabilitation at Warkworth was completed during 2015.

# 5. ACTIONS REQUIRED FROM PREVIOUS ANNUAL REVIEW

An annual environmental inspection was undertaken by officers of DRE on 19th June 2015. DP&E met with MTW on 26th May 2015 to clarify points raised in the 2014 Annual Environmental Review. Both departments were generally satisfied with the contents of the report; however a number of actions were identified as part of the inspection and review of the document. The actions and responses are shown in Table 14 and Table 15.

**Table 14: Response to Actions arising from DRE review of 2014 AR**

| Issue | Recommended Action | Annual Review section |
|---|---|---|
| Performance Criteria: Native Vegetation | Develop a monitoring program for native vegetation communities including analogue and rehabilitated mine site locations. | Monitoring program for native vegetation rehabilitation commenced in 2015. Permanent monitoring transects established for 12 reference sites and 17 MTW rehabilitation sites. Monitoring report (prepared by Niche Environment and Heritage) included in Appendix 4. |
| Ecosystem and Landuse Establishment – Species Specific Habitat | DRE encourages the development and implementation of a Habitat Augmentation Plan with performance criteria for nesting structures and woody debris/rock piles. | Performance criteria included in MTW MOP for habitat augmentation in rehabilitation areas. Guidelines for habitat augmentation in rehabilitation areas will be developed during 2016. |
| Appendix 6 – Rehabilitation and Disturbance Summary Maps | DRE encourages MTW to incorporate additional information regarding landform establishment (slope, drainage, substrate, material characterisation, morphology and aspect) | Additional information included in Appendix 3 |
| Hydrocarbon Management | Review the Hydrocarbon Management Plan against the Bioremediation Management guideline to be issued by the Department Planning & Environment | The MTW Hydrocarbon Management Plan was last revised on the 30/04/2015. DP&E is yet to release its guideline. |

**Table 15: Response to Actions arising from DP&E review of 2014 AR**

| Issue | Recommended Action | Annual Review section |
|---|---|---|
| AR Report: Community Complaints | The report indicated a rise in community complaints for noise in the 2014 year. It rose from 631 in 2013 to 809 in 2014, bringing it back to levels similar to 2012. This is the highest number of noise complaints for any mine in the Hunter area. Whilst a number of well planned activities have been implemented to address community concern, all methods available need to be considered to reduce this indicator of concern for noise. It was pleasing to see that dust complaints had dropped for the same period. | Refer to section 9.1 |
| AR Report: Water Management | Water input into the Warkworth mine remains high. Use of Hunter River water has dropped due to the increased use of water from the Wambo mine. This is a good initiative. Should Warkworth gain an extended approval to justify the expense, improvements to the Warkworth water management system will be needed to reduce the need to import water and reduce the risk of needing to discharge water from the site in wet periods. | Refer to section 7.1 |

# 6. ENVIRONMENTAL PERFORMANCE

## 6.1 Meteorological Data

Meteorological data is collected to assist in day to day operational decisions, planning, and environmental management and to meet Project Approval requirements. MTW operates a real time meteorological (weather) station which is located on Charlton Ridge. The meteorological station measures wind speed, wind direction, temperature, humidity, solar radiation, rainfall, and sigma theta. The meteorological station instruments are installed, calibrated, and maintained according to the relevant Australian Standard AS 3580.14 (2011). Meteorological data is available to employees and contractors via the Coal & Allied intranet. This service provides the mining operations with the trend assessment details required for informed operational decisions aimed at minimising impacts from the operation. Daily Meteorological data summaries are presented in the Monthly Environmental Monitoring reports, available via the Rio Tinto website (www.riotinto.com).

## 6.2 Noise

### 6.2.1 Management

MTW manages noise to ensure compliance with permissible noise limits at nearby private residences. A combination of both proactive and reactive control mechanisms are employed on a continuous basis to ensure effective management of noise emissions is maintained. Noise management strategies and processes employed at MTW are detailed in the MTW Noise Management Plan (available for viewing via the Rio Tinto website www.riotinto.com).

MTW's noise performance improved significantly in 2015, demonstrated across a number of key metrics:

- Community complaints received – reduced by 40% from 2014;
- Number of CRO noise measurements which exceed the trigger for action – reduced by 60% from 2014; and
- Number of equipment downtime hours logged in response to noise management triggers – reduced by 60% from 2014.

A range of projects and processes were introduced and undertaken during 2015 to deliver this improved performance. These are described herein.

### 6.2.2 Sound Attenuation Program

Extensive work was undertaken during 2015 to sound attenuate MTW's Heavy Mobile Equipment (HME) fleet. A total of 46 Haul Trucks (approximately 50% of the truck fleet) received mitigation treatment during 2015. Overall progress toward 100% fleet attenuation is provided in Table 16.

**Table 16: Sound Attenuation Summary**

| Fleet Type | Sound attenuation progress (Feb 2015) | Sound attenuation progress (Feb 2016) |
|---|---|---|
| Haul Trucks | 28% | 73% |
| Dozers | 63% | 67% |
| Drills | 38% | 75% |
| Excavators | 38% | 38% |

Highlights and milestones achieved during 2015 include:

**Caterpillar 795F**

Phase 4 upgrade completed on 12 Trucks, building on existing sound attenuation packages:

- Body panels were redesigned for reliability; and
- Engine Bay edge sealing

Phase 4 upgrades, whilst not relied upon for delivery to specification, greatly improved reliability and maintainability of the attenuation components.

Figure 3 shows the body panels fitted to a tray of a Caterpillar 795F truck.

**Figure 3: 795 body panel retention fitted to Truck 437.**

## Komatsu 830E (AC)

Upgrade of kit on nine (9) 400 Series Trucks, and ten (10) 700 Series Trucks achieved sound power reductions from 118dB(A) to 115dB(A). At a cost of approximately $4.5M, these upgrades included:

- Full refurbishment of sound media;
    - Engine enclosures
    - Louvres etc
- New exhaust system; and
- Axel box blower hose attenuation

Figure 4 shows a new exhaust silencer which dampens noise associated with the engine exhaust system.

**Figure 4: New exhaust silencer which was fitted to Truck 407.**

## Caterpillar 789C

Following works completed in 2014, the remaining ten (10) trucks in the 789C fleet were attenuated to Stage Two. These units previously did not have any sound attenuation equipment installed. Fitment of Stage Two attenuation components has achieved a nominal reduction of 5dB(A) per truck on these units. Attenuation comprises:

- Radiator Fan Splitter;
- Body Panels; and
- Dual Skin Exhaust

Of note, sound power level testing undertaken on a number of trucks in the 789C fleet achieved the “Stage 3” sound attenuation target (113dB(A), 121dB(L)) – a significant achievement.

## Caterpillar 785C

Attenuation package was installed on five (5) trucks during 2015, similar to the stage two components of the 789c attenuation package, including;

- Radiator Fan Splitter;
- Body Panels; and
- Dual Skin Exhaust

Table 17 below summarises the performance of the sound attenuation program on the different truck fleet types attenuated during 2015.

**Table 17: Sound attenuation program effectiveness 2015**

| Fleet Type | Test Scenario | Pre Attenuation (dB(A)) | Post Attenuation (dB(A)) | Difference (dB(A)) |
|---|---|---|---|---|
| **Caterpillar 795** | Static | 120 | 113 | 7 |
| | Uphill Loaded | 125 | 116 | 9 |
| | Downhill Unloaded | 121 | 114 | 7 |
| **Komatsu 830E AC** | Static | 118 | 110 | 8 |
| | Uphill Loaded | 123 | 112 | 11 |
| | Downhill Unloaded | 121 | 113 | 8 |
| **Caterpillar 789C** | Static | 115 | 110 | 5 |
| | Uphill Loaded | 118 | 113 | 5 |
| | Downhill Unloaded | 117 | 109 | 8 |
| **Caterpillar 785C** | Static | 119 | 111 | 8 |
| | Uphill Loaded | 122 | 114 | 8 |
| | Downhill Loaded | 117 | 113 | 4 |

### 6.2.3 Sound Power Control

In addition to visual inspections, MTW implements a Sound Power Level (SWL) screening program to assess the sound power outputs of individual pieces of equipment (Figure 5). Following completion of the sound attenuation program (scheduled to be completed at the end of 2016); sound power level testing will be undertaken on 33% of the attenuated haul fleet each year.

Forty-Four sound power level assessments were undertaken, across a total of 33 pieces of attenuated equipment in 2015.


**Figure 5 - Sound Power Screening being performed on Truck 762 following installation of sound attenuation components**

### 6.2.4 Real Time Noise Management

MTW's Real-Time noise management framework provides an effective tool for managing instances of elevated noise, ensuring compliance is maintained, and responding to community concerns.

Acting as a conduit between the monitoring system, the mine Shift Co-ordinator, and members of the local community, the Community Response Officer Role is pivotal in the effective implementation of the management framework, validating real-time alerts through supplementary handheld noise measurements and audible observations, driving operational change as required, and responding to community complaints. A summary of supplementary handheld noise measurements conducted by the Community Response Officers in 2015 is presented in Table 18.

**Table 18: Summary of hand held noise monitoring conducted by Community Response Officer 2015**

| Monitoring Location | Number of Assessments | Number of measurements >WML trigger^ | Number of measurements > MTO trigger^ | Average WML noise level ($L_{Aeq\ 5min}$ dB(A))* | Average MTO noise level ($L_{Aeq\ 5min}$ dB(A))* |
|---|---|---|---|---|---|
| Wollemi Peak Road (Bulga RFS) | 3006 | 87 | 104 | 33.8 | 35.1 |
| Bulga Village | 1082 | 5 | 2 | 33.7 | 33.3 |
| Inlet Road West | 1250 | 12 | 10 | 30.8 | 30.2 |
| Long Point | 1292 | - | - | 32.9 | 30.6 |
| Other | 20 | - | - | - | - |
| South Bulga | 72 | - | | - | |
| Wambo Road | 1424 | 6 | - | 33.6 | 31.9 |
| Total | 8146 | 110 | 116 | - | - |

^Triggers are internally set thresholds for operational response and are specified in the MTW Noise Management Plan. The number of measurements greater than the trigger cannot be used an assessment or interpretation of compliance. Compliance assessment is provided in 6.2.3 and 6.2.4.

*Average noise levels do not take account of measurements taken where the noise source of interest was recorded as inaudible.

In response to the events listed in Table 18 which exceeded the trigger, 7,647 hours of equipment downtime were recorded to manage noise during 2015. This is a significant decrease (approximately 60%) in the number of downtime hours recorded in 2015 (20,470),

and mirrors the reduction in number of supplementary noise measurements completed which exceed the trigger for management action.

### 6.2.5 Performance

A total of 95 compliance measurements were completed in accordance with the MTW Noise Monitoring Programme during the reporting period. Each measurement involves an assessment of mine noise against the various $L_{Aeq}$ and $L_{A1,\ 1min}$ noise criteria in place under the Warkworth and Mount Thorley Approvals (a total of 665 assessments). Noise monitoring results are presented in the monthly Environmental Monitoring Reports, available via the Rio Tinto website (www.riotinto.com).

In accordance with Section 4 of the NSW Industrial Noise Policy, MTW has assessed measured noise levels collected during the attended compliance programme for low frequency content, and applied the modifying factor adjustment where applicable. The application of the modifying factor results in six exceedances of the WML $L_{Aeq}$ Impact Assessment Criteria and four exceedances of the MTO $L_{Aeq}$ Impact Assessment Criteria (refer to Table 19). The Department of Planning and Environment was notified in writing of each measurement.

MTW reports these measurements so as to ensure full disclosure, however it remains MTW's position that the prescribed methodology is unsuitable when applied to receptors at large distances from mine noise sources due to the nature of noise attenuation. Excess attenuation of noise with distance is greater for high frequency noise than it is for low frequency noise. At significant distance from a noise source (such as private residences from the MTW complex) this often results in large differentials between $L_{Aeq}$ and $L_{Ceq}$. The NSW Industrial Noise Policy requires the penalty to be applied in these instances, irrespective of actual low frequency affectation. As such, MTW does not consider these instances to constitute non-compliance with the conditions of approval.

During 2015, NSW EPA released the Draft NSW Industrial Noise Guideline for industry and public comment. The Draft guideline sets out a proposed change to the framework for the assessment of low frequency noise emissions from industrial premises. Coal & Allied looks forward to the finalisation of the guideline, and the introduction of a more appropriate methodology for assessing low frequency affectation for open cut mines in the Hunter Valley in the future.

**Table 19: Attended noise measurements exceeding consent conditions following application of INP low frequency penalty**

| Location | Date/Time | Relevant Criteria | Criterion (dB)* | $L_{Aeq}$(dB) | Revised $L_{Aeq}$ (dB) | Exceeds by (dB) |
|---|---|---|---|---|---|---|
| Inlet Road West | 25/05/2015 00:22 | WML $L_{Aeq}$ impact assessment criteria | 35 | 32 | 37 | 2 |
| Wambo Road | 24/05/2015 23:52 | WML $L_{Aeq}$ impact assessment criteria | 38 | 36 | 41 | 3 |

| Location | Date/Time | Relevant Criteria | Criterion (dB)* | $L_{Aeq}$(dB) | Revised $L_{Aeq}$ (dB) | Exceeds by (dB) |
|---|---|---|---|---|---|---|
| Inlet Road West | 12/06/2015 00:42 | WML $L_{Aeq}$ impact assessment criteria | 35 | 32 | 37 | 2 |
| Wambo Road | 12/06/2015 00:10 | WML $L_{Aeq}$ impact assessment criteria | 38 | 35 | 40 | 2 |
| Wambo Road | 24/07/2015 00:08 | WML $L_{Aeq}$ impact assessment criteria | 38 | 34 | 39 | 1 |
| Wollemi Peak Road | 12/08/2015 01:09 | WML $L_{Aeq}$ impact assessment criteria | 35 | 33 | 38 | 3 |
| South Bulga | 12/06/2015 01:42 | MTO $L_{Aeq}$ impact assessment criteria | 37 | 35 | 40 | 3 |
| Wollemi Peak Road | 12/06/2015 01:20 | MTO $L_{Aeq}$ impact assessment criteria | 38 | 37 | 42 | 4 |
| Wollemi Peak Road | 24/07/2015 01:37 | MTO $L_{Aeq}$ impact assessment criteria | 38 | 34 | 39 | 1 |
| Inlet Road West | 9/11/2015 01:05 | MTO $L_{Aeq}$ impact assessment criteria | 35 | 33 | 38 | 3 |

### 6.2.6 Comparison against Last Years' Results

Changes in mine operations and variations in meteorological conditions from year to year makes it difficult to directly compare noise results from one year to another to assess the effectiveness of the noise management system. A comparison of non-compliances and exceedances between years is used as a measure of the effectiveness of noise management measures employed on site, and the level to which risks are being adequately addressed. Non-compliance is determined with reference to the applicable conditions of consent and the *NSW Industrial Noise Policy*.

Details of this comparison are provided in Table 20, which demonstrates a continuation of the effective management delivered in 2014.

**Table 20: Comparison of 2014 noise monitoring results against previous years'**

| Year | Number of assessments | Number of measurements greater than allowable noise limits (under applicable met conditions) | Number of non-compliances |
|---|---|---|---|
| **2015** | 665 | 0 | 0 |
| **2014** | 700 | 0 | 0 |
| **2013** | 456 | 11 | 7 |
| **2012** | 562 | 13 | 3 |
| **2011** | 572 | 11 | 4 |

| | | | |
|---|---|---|---|
| **2010** | 561 | 3 | 3 |
| **2009** | 569 | 10 | 4 |

Given the large dataset available, a comparison between the results collected through the supplementary noise monitoring regime from year to year is also considered valuable. Improved noise performance is demonstrated through this data, with reductions in the number of measurements which exceed the noise management trigger at all monitoring locations. Further, reductions in the average noise levels measured across the reporting period are evident at the majority of monitoring locations with the exception of the Wambo Road and South Bulga monitoring locations, which recorded marginally higher average noise levels in 2015. It should be noted however that MTO noise levels at these two locations remained below the noise management trigger for all measurements collected during 2015.

**Table 21: Comparison of CRO noise measurement performance**

| Monitoring Location | Number of Assessments | | Number of measurements >WML trigger^ | | Number of measurements > MTO trigger^ | | Average WML noise level ($L_{Aeq\ 5min}$ dB(A))* | | Average MTO noise level ($L_{Aeq\ 5min}$ dB(A))* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| **Wollemi Peak Road (Bulga RFS)** | 2,330 | 3,006 | 124 | 87 | 135 | 104 | 33.5 | 33.8 | 35.4 | 35.1 |
| **Bulga Village** | 1,073 | 1,082 | 22 | 5 | 1 | 2 | 33.9 | 33.7 | 33.9 | 33.3 |
| **Inlet Road West** | 545 | 1,250 | 21 | 12 | 21 | 10 | 31.7 | 30.8 | 31.7 | 30.2 |
| **Long Point** | 1,232 | 1,292 | 8 | 0 | 0 | 0 | 33.1 | 32.9 | 33.1 | 30.6 |
| **South Bulga** | 196 | 72 | 2 | 0 | 5 | 0 | 33.1 | 31.5 | 32.3 | 32.9 |
| **Wambo Road** | 2,568 | 1,424 | 194 | 6 | 0 | 0 | 35.6 | 33.6 | 31.4 | 31.9 |
| **Total** | 7,944 | 8,126 | 392 | 110 | 162 | 116 | NA | NA | NA | NA |

^Triggers are internally set thresholds for operational response and are specified in the MTW Noise Management Plan. The number of measurements greater than the trigger cannot be used an assessment or interpretation of compliance. Compliance assessment is provided in 6.2.3 and 6.2.4.

*Average noise levels do not take account of measurements taken where the noise source of interest was recorded as inaudible.

### 6.2.7 Comparison against EA Predictions

Table 22 provides a comparison of 2015 attended monitoring data and the predicted noise levels modelled in the 2002 Warkworth EIS. Comparison has been made against the modelled worst case noise levels for Year 10 and Year 15 of the development (nominally 2013 and 2018). The comparison data has been sourced from the modelled noise levels at the nearest residential receivers to the current monitoring locations. Reported 2015 data is the calculated quarterly average of WML contribution to measured $L_{Aeq\ (15\ minute)}$ results obtained through compliance assessment (irrespective of applicability of noise criteria due to meteorological conditions).

Where a monitoring event has been assessed as being “inaudible” or “not measurable”, a conservative value of 25dB has been used to calculate the $L_{Aeq}$ average for the quarter.

**Table 22: Predicted Night Time WML (EIS 2002) $L_{Aeq\ (15\ minute)}$ noise levels and averaged 2014 monitoring results**

| Monitoring Location | Year 10 Modelled Noise $L_{Aeq\ (15\ minute)}$ (dB) | Year 15 Modelled Noise $L_{Aeq\ (15\ minute)}$ (dB) | Quarter 1 2015 average $L_{Aeq\ (15\ minute)}$ (dB) | Quarter 2 2015 average $L_{Aeq\ (15\ minute)}$ (dB) | Quarter 3 2015 average $L_{Aeq\ (15\ minute)}$ (dB) | Quarter 4 2015 average $L_{Aeq\ (15\ minute)}$ (dB) |
|---|---|---|---|---|---|---|
| Mount Thorley Industrial Estate | 44.5 | 43.6 | 28.3 | 36.0 | 39.3 | 29.3 |
| Bulga Village | 27.9 | 27.8 | 25.7 | 28.3 | 25.0 | 28.3 |
| Gouldsville Road | 36.6 | 35.5 | 25.0 | 31.0 | 31.7 | 27.7 |
| Inlet Road West* | <35 | <35 | 29.7 | 32.0 | 23.3 | 25.0 |
| Long Point* | 35-40 | 35-40 | 25.0 | 25.0 | 29.3 | 25.0 |
| Wollemi Peak Road* | <35 | <35 | 27.0 | 27.0 | 29.3 | 25.0 |
| South Bulga | 24.5 | 23.8 | 27.0 | 26.7 | 26.7 | 25.0 |
| Wambo Road | 29.7 | 30.1 | 26.0 | 34.7 | 28.0 | 26.3 |

*Denotes – No nearby receiver location modelled

### 6.2.8 Compliance Audits

No audits were undertaken in 2015. An Independent Environmental Audit was undertaken during January 2016. The audit report will be published on the Rio Tinto website when finalised. A summary of findings will be presented in the 2016 Annual Review.

## 6.3 Blasting

### 6.3.1 Blasting Management

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

During the reporting period, Coal and Allied overhauled the blast monitoring network and commenced operation of a new network of "Kaboom" monitors, designed, serviced and maintained by a local supplier. The change reinforces MTW's commitment to utilise suppliers from the local area wherever possible. The new system operates in accordance with AS2187.2-2006 to measure ground vibration and airblast overpressure of each event at a high sampling frequency. Monitors function as regulatory compliance monitors in accordance with the MTW Blast Monitoring Programme (appended to Blast Management Plan) and are located on (or in locations representative of) privately owned land. During 2015 monitors were situated at the following locations (Figure 6):

- Abbey Green (Abbey Green Station, Putty Road, Glenridding);
- Bulga Village (Wambo Road, Bulga);
- Mount Thorley Industrial Estate (known as MTIE - Putty Road, Mount Thorley)
- Wambo Road (Wambo Road, Bulga);
- Warkworth Village (former Warkworth Public School, Warkworth); and
- Wollemi Peak Road (intersection of Putty & Wollemi Peak Roads, Bulga).

The South Bulga monitoring location (Putty Road, Bulga) was decommissioned in April 2015 in consultation with the DP&E Singleton compliance office and local residents.


**Figure 6: Blast Monitoring Locations**

### 6.3.2 Performance

During the reporting period MTW detonated 466 discrete blasts in 390 blast events. Results of ground vibration and airblast overpressure recorded during 2015 are presented in Figure 7 to Figure 13. Results from the South Bulga monitoring location (Figure 13) are presented for the period 1st January 2015 – 31st March 2015. The monitor was decommissioned after this date.

All blasts returned results below the relevant airblast overpressure / ground vibration criteria for all monitoring locations.

Road closures occurred for all blasts within 500 metres of a public road. Public roads were also closed on occasions to mitigate potential impact upon road users from dust or when blast fume management zones encompassed public roads.

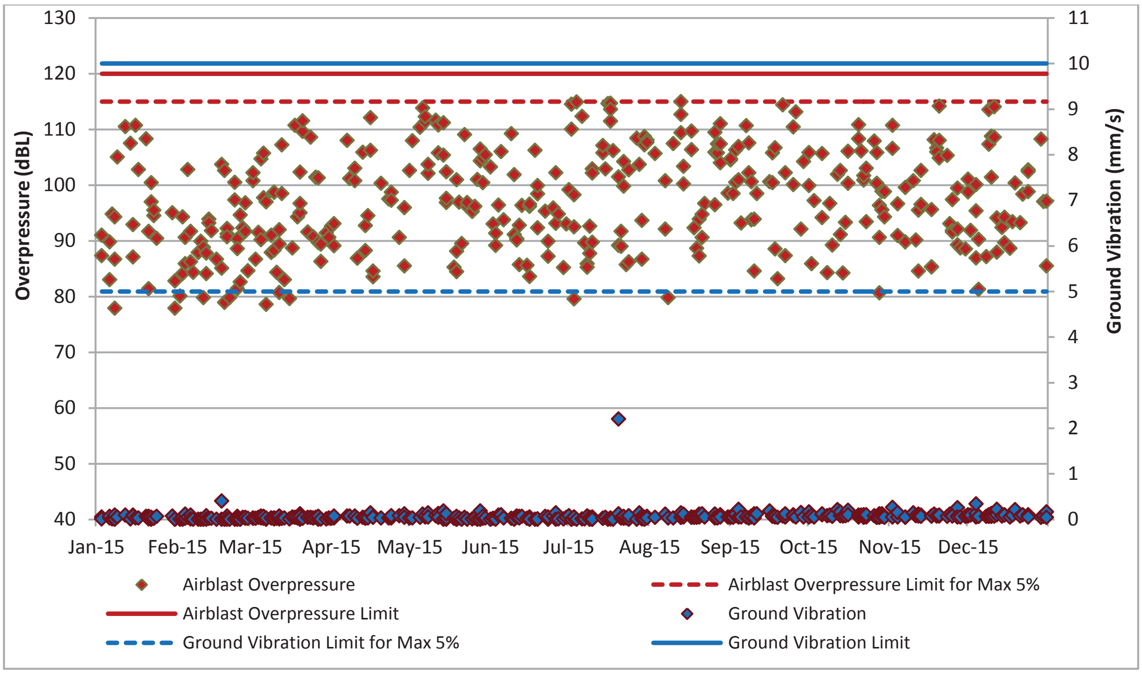


**Figure 7: Abbey Green blasting results**

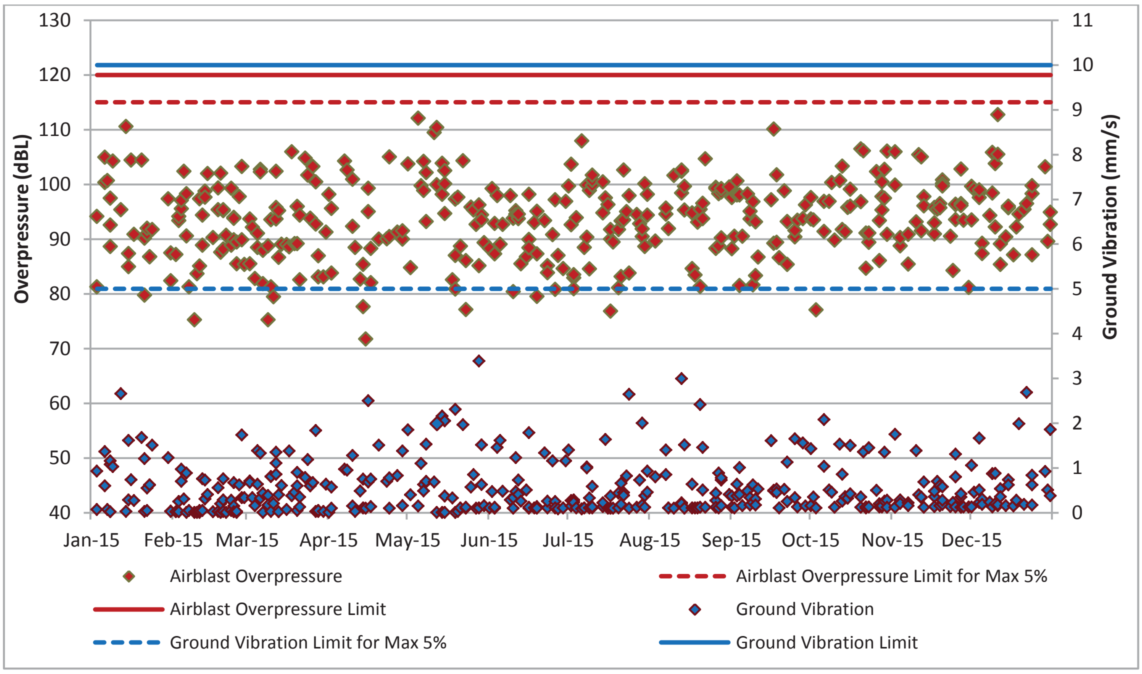


**Figure 8: Bulga Village blast results**

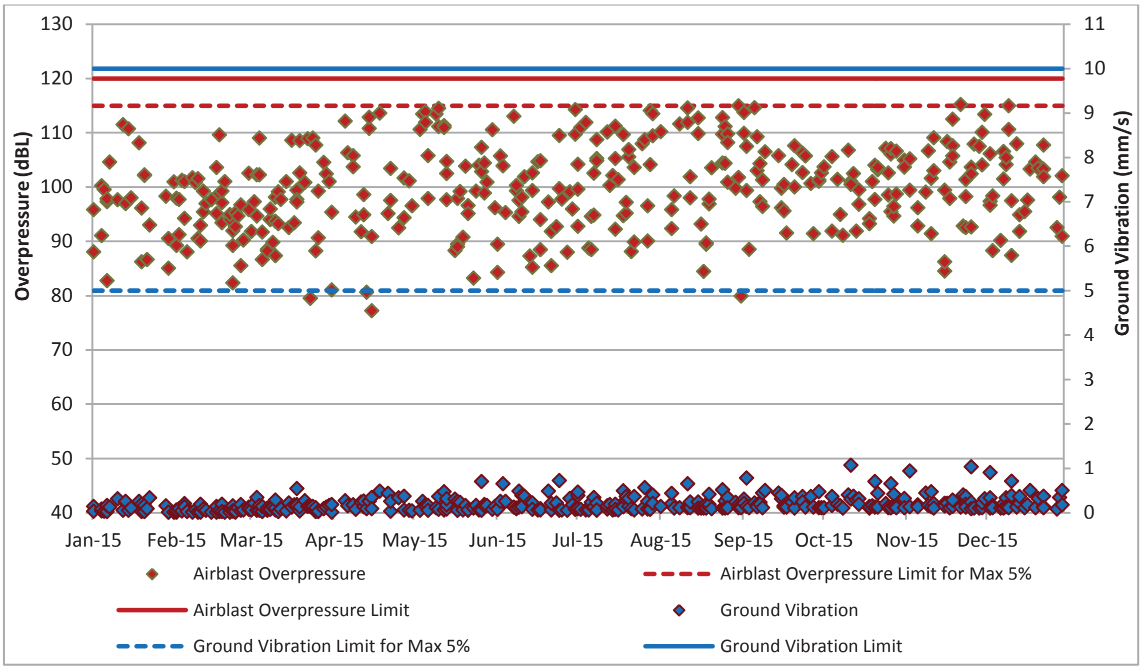


**Figure 9: MTIE blast results**

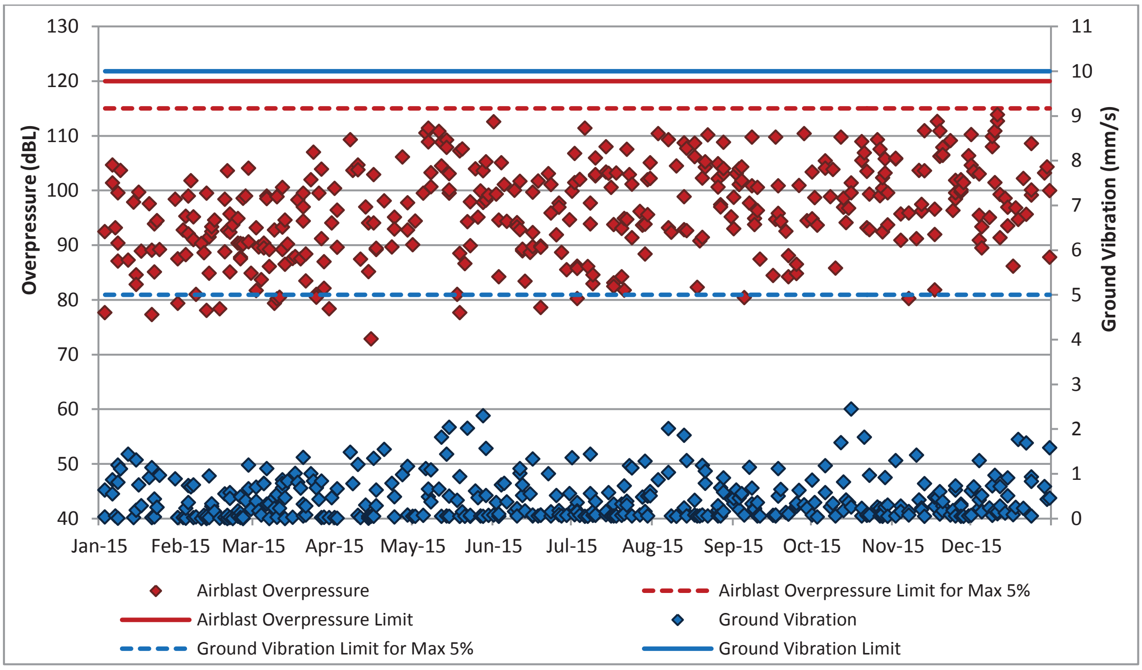


**Figure 10: Wollemi Peak Road Bulga blast results**

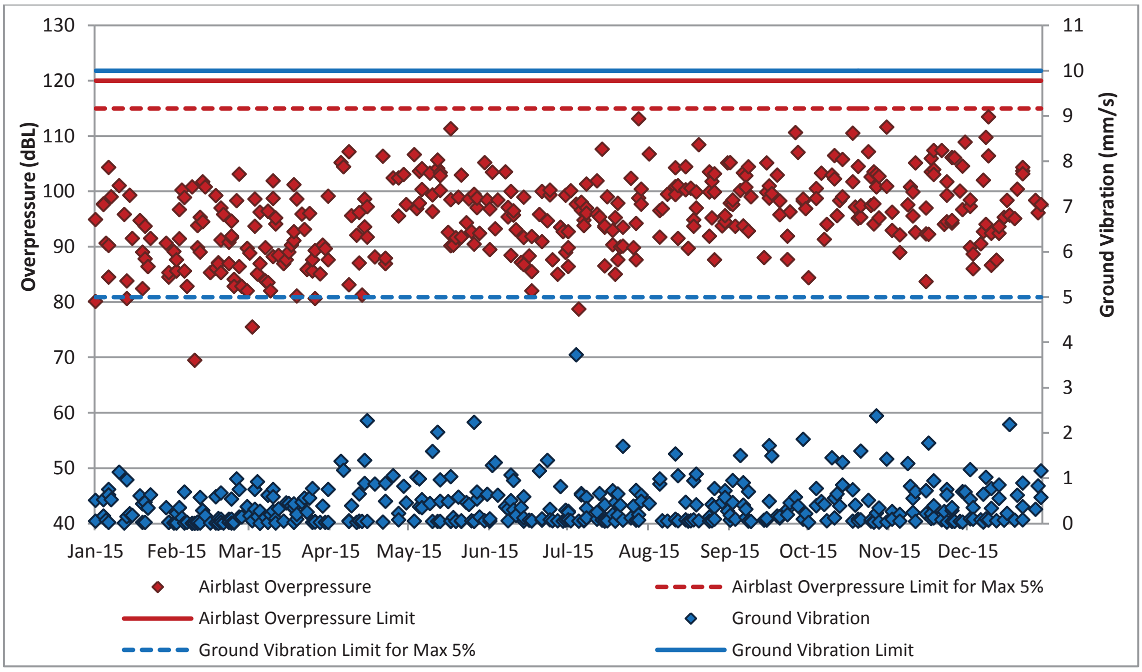


**Figure 11: Wambo Road blast results**

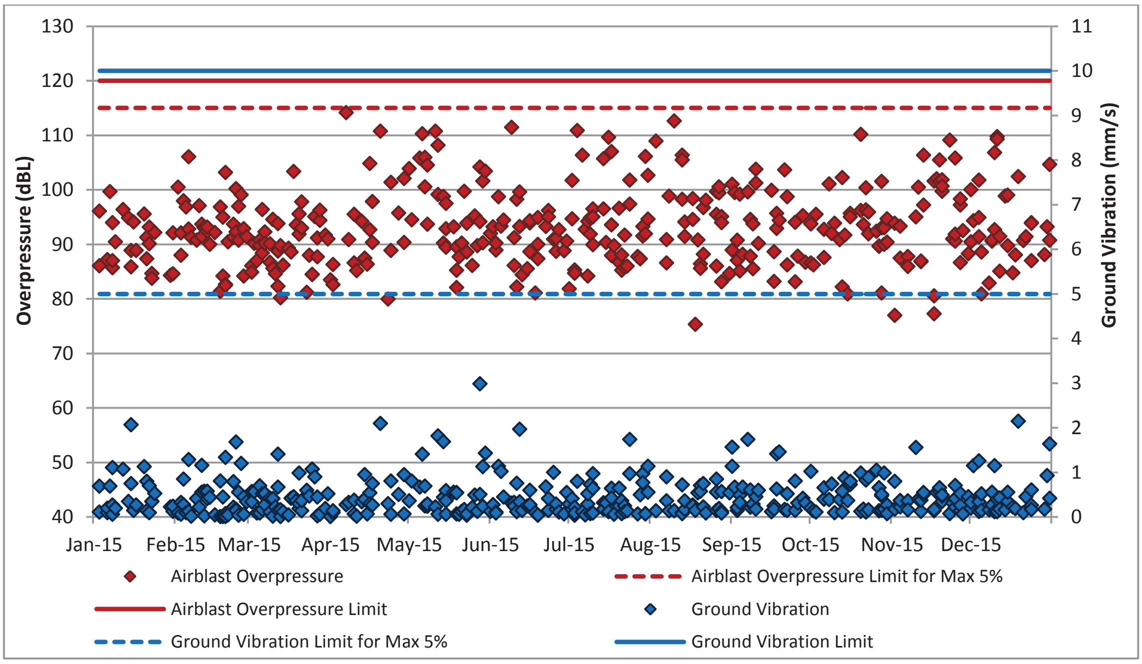


**Figure 12: Warkworth blast results**

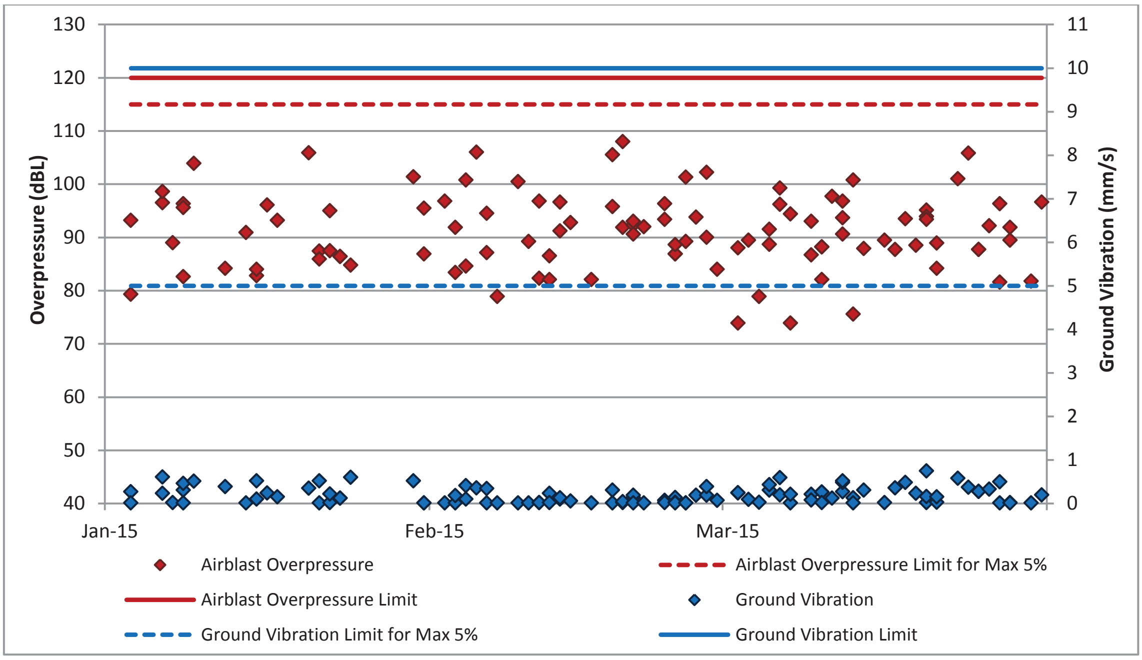


**Figure 13: South Bulga blast results**

### 6.3.3 Blast fume management

MTW operates a Post Blast Fume Generation Mitigation and Management Plan. This document outlines the practices to be utilised to reduce generation of post blast fume, and reduce potential offsite impact from any fume which may be produced. This includes risk assessment of the likelihood of fume production, 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.

During 2015, no category four or five fume events were recorded. Two category three blast fume events were recorded on 12 January and 4 November 2015; the DP&E were notified in accordance with the MTW Blast Management Plan. At DP&E's request, an incident report was subsequently provided for the event on 4 November 2015. The blast fume originated from a blast fired in South Pit of the Warkworth Mine. The fume cloud migrated to the North–North-East, passing through the Putty Road at or about the location of the road closure point, and dissipated over lands owned by Warkworth Mining Limited to the east of WML.

No further information has been requested from the Department in relation to this event.

Rankings for visible blast fume according to the AEISG scale for shots fired during 2015 and comparison to rankings distribution during previous years is provided in Table 23.

**Table 23: Visible blast fume rankings according to the AEISG colour scale**

| AEISG Ranking | 2015 | 2014 | 2013 |
|---|---|---|---|
| **0** | 374 | 355 | 398 |
| **1** | 56 | 61 | 56 |
| **2** | 27 | 18 | 15 |
| **3** | 9 | 8 | 5 |
| **4** | 0 | 0 | 0 |
| **5** | 0 | 0 | 0 |
| **Total*** | 466 | 442 | 474 |

* 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 Comparison of Monitoring Results Against Previous Years' Performance and EA Predictions

Blasting results recorded in 2015 are similar to results recorded in previous years and are consistent with EA predictions.

#### 6.3.5 Audits and Reviews

There were no audits or reviews undertaken during 2015. An Independent Environmental Audit was undertaken during January 2016. The audit report will be published on the Rio Tinto website when finalised. A summary of findings will be presented in the 2016 Annual Review.

## 6.4 Air Quality

### 6.4.1 Management

Air quality management at MTW is prescribed by the Air Quality Management Plan (available on the Rio Tinto Website), the management plan;

- Describes procedures required to ensure compliance with the Approval conditions relating to air quality including the measures that Coal & Allied will use to manage air quality.
- Details the management framework and mitigation actions to be taken while operating
- Provides a mechanism for assessing air quality monitoring results against the relevant impact assessment criteria.

### 6.4.2 Air Quality Performance

#### 6.4.2.1 Real-Time Air Quality Management

MTW'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.

434 real-time alarms for air quality and wind conditions were received and acknowledged during 2015. In response 5,809 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) is presented in Figure 14.

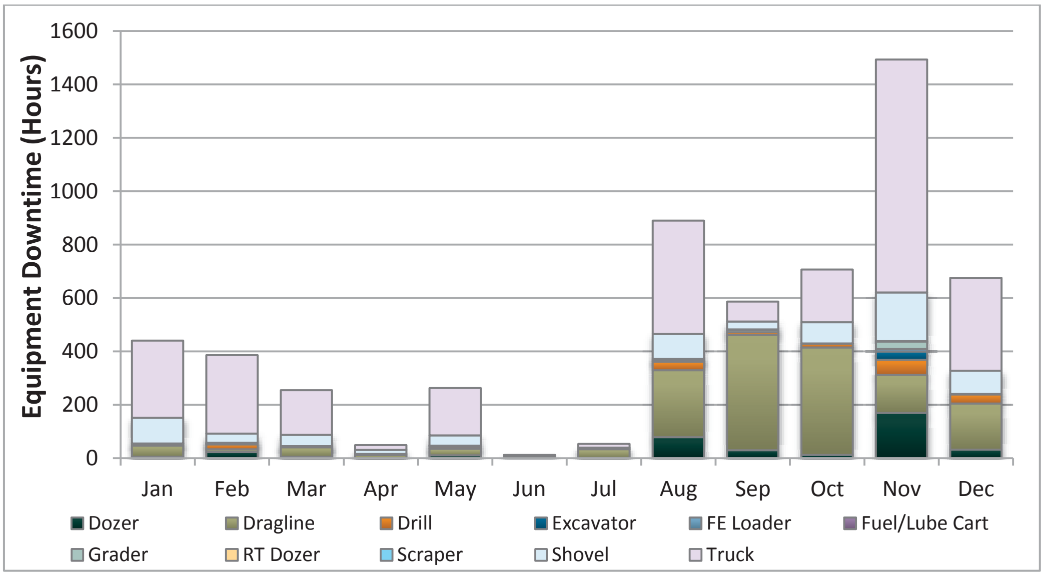

**Figure 14: Equipment downtime for dust management by month**

#### 6.4.2.2 Temporary Stabilisation

Aerial Seeding was undertaken in early May 2015 by a fixed wing aircraft to provide temporary cover to areas exposed to wind generated dust and erosion at MTW. Waste dumps and exposed areas were selected for seeding if they were not planned to be disturbed within six months. The 138 hectares of area seeded included waste dumps and ahead of mining disturbance (see Figure 15). All areas were seeded using an exotic pasture grass and legume mix suitable for autumn sowing. The seed mix was revised slightly from previous years to reduce the number of species to those which were most successful from previous years. A starter fertiliser was mixed with the seed prior to loading to provide sufficient nutrients for plant growth.


**Figure 15: 2015 Aerial Seeding Areas**

### 6.4.3 Air Quality Monitoring

Air quality monitoring at MTW is undertaken in accordance with the MTW Air Quality Monitoring Programme and protocol for evaluating non-compliances (http://www.riotinto.com/documents/MTW_Air_Quality_and_Greenhouse_Gas_Management_Plan.pdf). The monitoring network comprises an extensive array of monitoring equipment which is utilised to assess performance against the relevant conditions of MTW's approvals. Air quality monitoring locations are shown in Figure 16. During 2015, MTW complied with all short term and annual average air quality criteria.

Air quality compliance criteria are shown in Table 24 and Table 25, along with a summary of MTW's performance against the criteria. Whilst MTW operates under two separate Planning Approvals the following compliance assessment has been undertaken on a 'whole of MTW 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 MTW Monthly Environmental Monitoring Report, which can be viewed on the Rio Tinto website.


**Figure 16: Air and Meteorological Monitoring Locations MTW 2015**

**Table 24: Air quality impact assessment criteria and 2015 compliance assessment (WML DA 300_9_2002_i and MTO DA 34/95)**

| 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 $\mu g/m^3$ | Long Term (Annual) | 100% |
| Particulate matter <10µm ($PM_{10}$) | 30 $\mu g/m^3$ | Long Term (Annual) | 100% |
| | 50 $\mu g/m^3$ | Short Term (24 hour) | 100% |

**Table 25: Air quality land acquisition criteria and 2015 compliance assessment (WML DA 300_9_2002_i and MTO DA 34/95)**

| 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 $\mu g/m^3$ | Long Term (Annual) | 100% |
| Particulate matter <10µm ($PM_{10}$) | 30 $\mu g/m^3$ | Long Term (Annual) | 100% |
| | [a]150 $\mu g/m^3$ | Short Term (24 hour) | 100% |
| | [b]50 $\mu g/m^3$ | Short Term (24 hour) | 100% |

[a] – Background $PM_{10}$ concentrations due to all other sources plus the incremental increase in $PM_{10}$ concentrations due to the mine alone
[b] – Incremental increase in $PM_{10}$ concentrations due to the mine alone

#### 6.4.3.1 Deposited Dust

Deposited dust is monitored at nine locations situated on, or representative of privately-owned land, in accordance with AS3580.10.1 (2003). The 2015 annual average insoluble matter deposition rates compared with the depositional dust impact assessment criterion and previous years' data, shown in Figure 17. During 2015, all annual average insoluble matter deposition rates recorded on privately owned land 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 2g/m²/month (Figure 18).

During 2015, monthly dust deposition rates equal to or greater than the long term impact assessment criteria of 4g/m²/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 MTW's level of contribution to any elevated result. Details of excluded results are presented in the relevant MTW Monthly Environmental Monitoring Report.

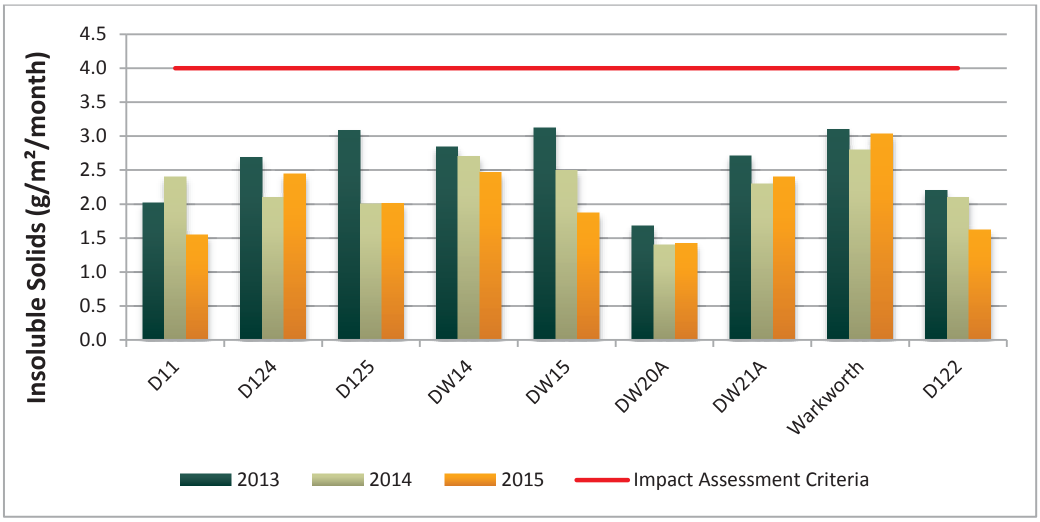


**Figure 17: 2015 Depositional Dust results compared against the impact assessment criteria and previous years' results**

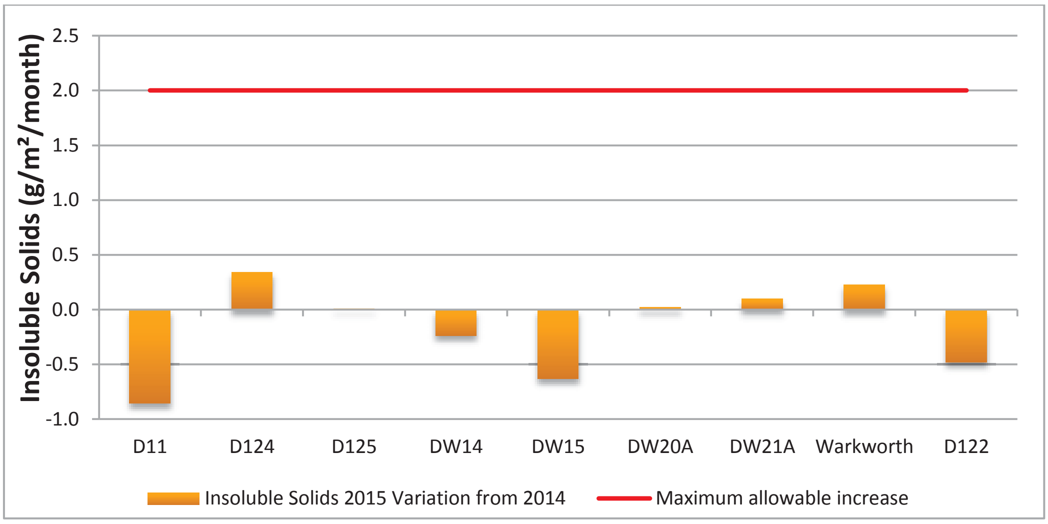


**Figure 18: Variation in insoluble solids deposition rate from 2014 to 2015 compared against the impact assessment criteria**

#### 6.4.3.2 Total Suspended Particulates (TSP)

Total Suspended Particulates (TSP) are measured at five locations situated on or representative of privately owned land in accordance with AS3580.9.3(2003). Annual average TSP concentrations recorded in 2015 compared with the long term impact assessment criterion and previous years' data, are shown Figure 19. During 2015 all annual average results were compliant with the impact assessment and land acquisition criteria.

During the reporting period, 3 out of 305 TSP measurements were not able to be collected on the scheduled sampling date (based on a sampling frequency of every six days).

The annual average TSP concentrations recorded in 2015 are generally consistent with those recorded during previous years (Figure 19), with the exception of the MTO-TSP1 monitoring location which recorded an annual average of 48.4µg/m³ (a reduction of approximately 21 µg/m³ on 2014 results). The 2015 result is consistent with the long range average of 48.5 µg/m³ (2001-2015).

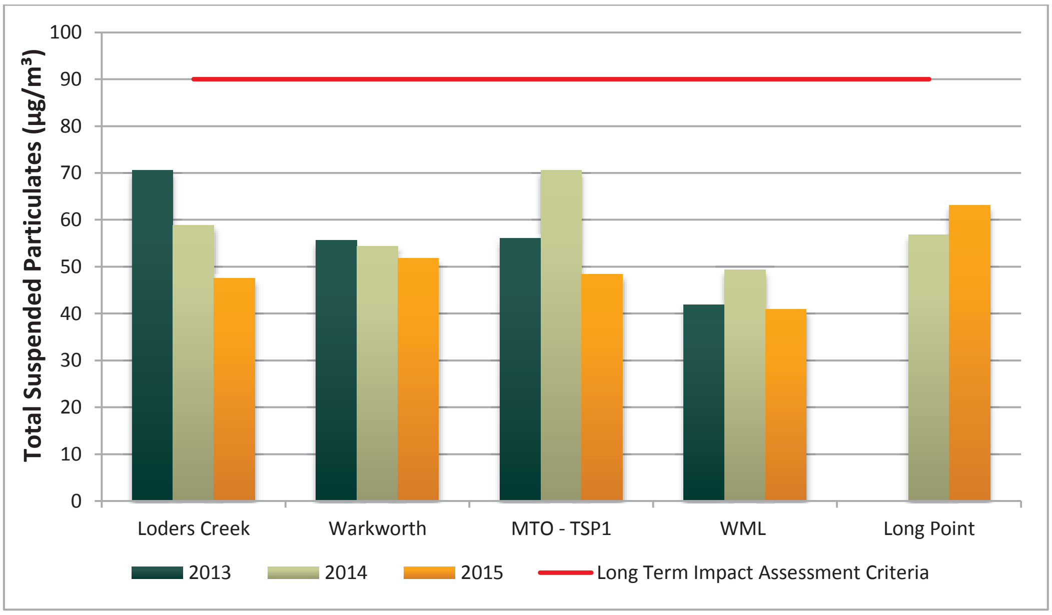


**Figure 19: 2015 TSP Annual Average compared against the impact assessment criteria and previous years' results**

#### 6.4.3.3 Particulate Matter <10µm ($PM_{10}$)

Compliance assessment for Particulate Matter <10µm ($PM_{10}$) is measured at five locations on privately owned land in accordance with AS3580.9.6 (2003). During 2015, all short term and annual average results were compliant with the impact assessment and land acquisition criteria.

#### 6.4.3.4 Short term $PM_{10}$ impact assessment criteria

2015 monitoring results for $PM_{10}$ (24 hour) collected through the High Volume Air Sampler monitoring regime compared against the short term impact assessment criteria is shown in Figure 20. All 24hr average results recorded by MTW's surrounding network of TEOM monitors are presented on a quarterly basis in Figure 20 to Figure 24.

During Quarter 2 the Bulga TEOM experienced a complex hardware and communications fault which took an extended period of time to diagnose and rectify. The monitor was returned to service following installation of replacement parts during July. During the period of monitor outage, MTW augmented its real-time monitoring network with data from the OEH operated (UHAQMN) "Bulga" monitor.

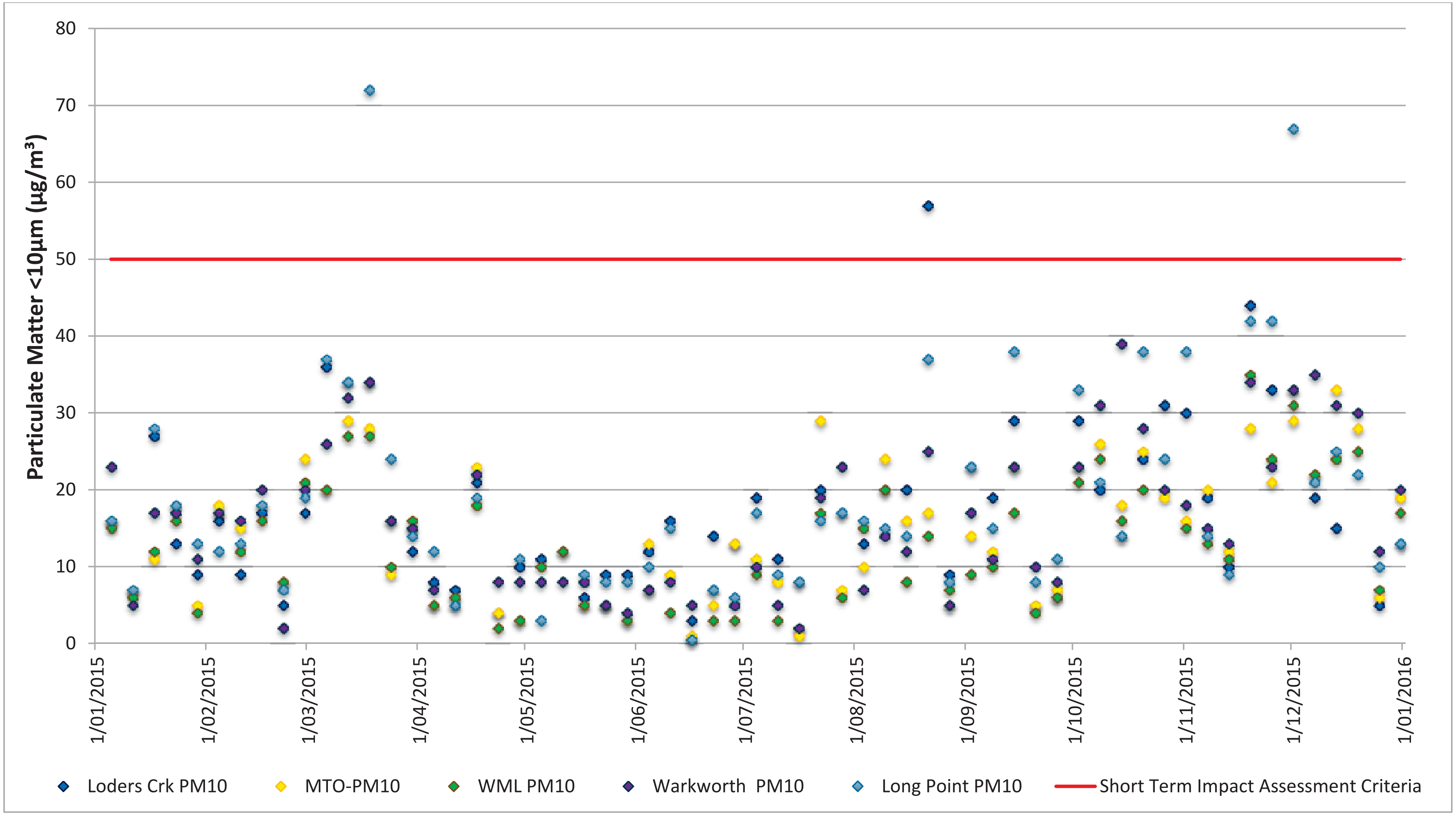


**Figure 20: $PM_{10}$ 24hr monitoring results (measured by MTW $PM_{10}$ HVAS network)**

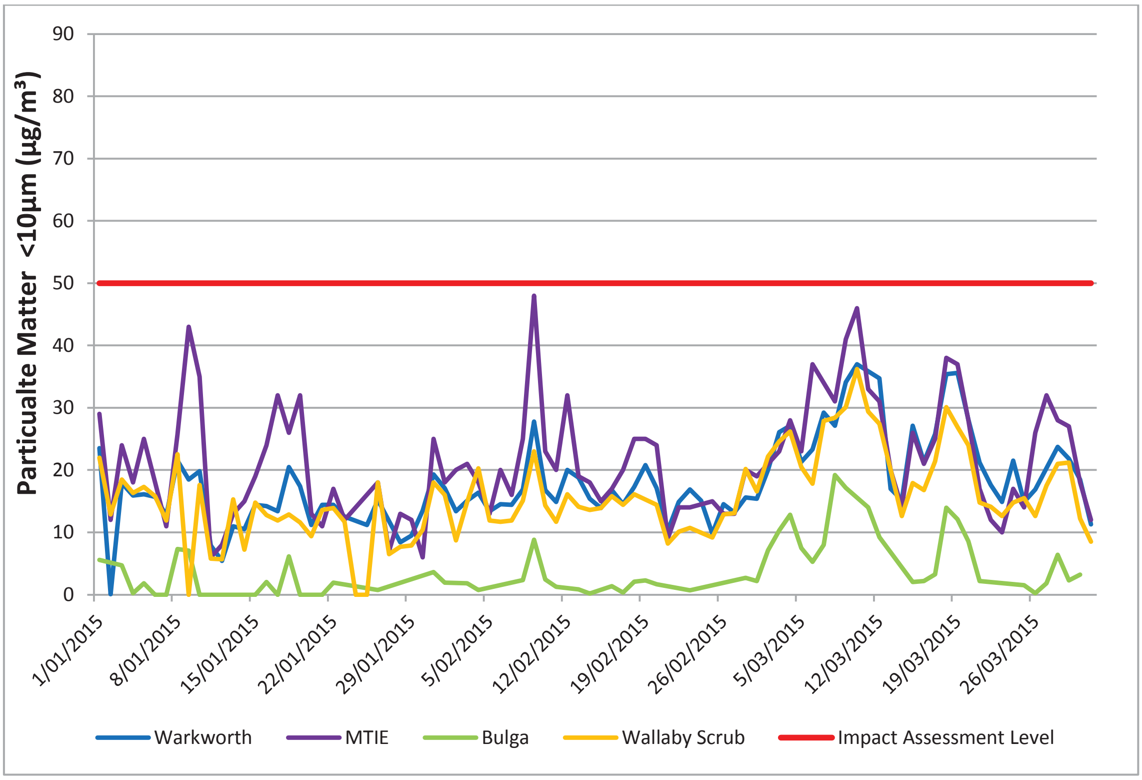


**Figure 21: 24hr average $PM_{10}$ measured at TEOM monitors surrounding MTW - Quarter One 2015**

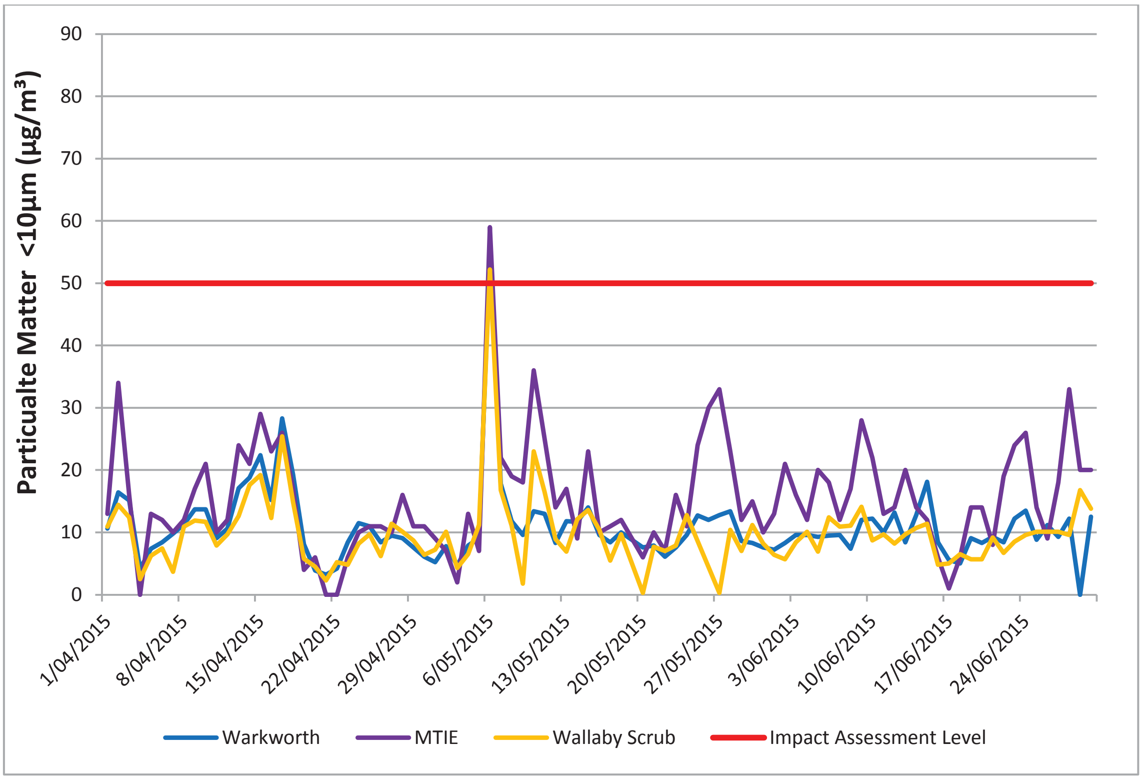


**Figure 22: 24hr average $PM_{10}$ measured at TEOM monitors surrounding MTW - Quarter Two 2015**

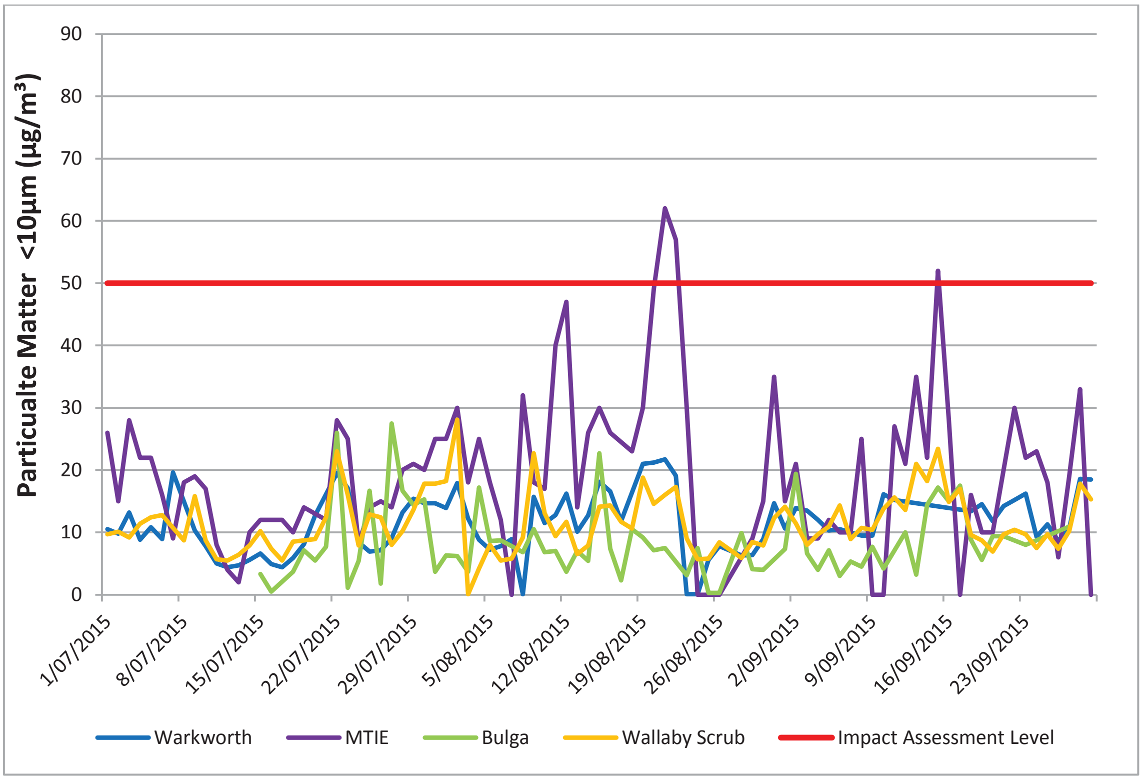


**Figure 23: 24hr average $PM_{10}$ measured at TEOM monitors surrounding MTW - Quarter Three 2015**

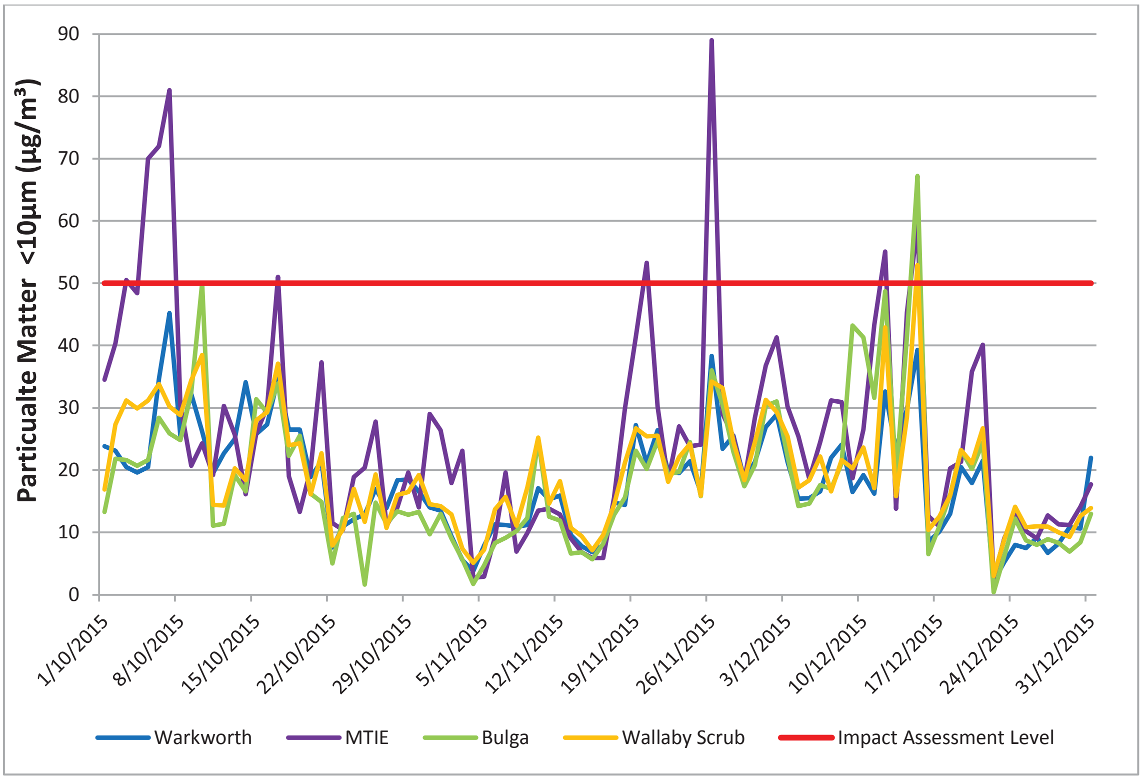


**Figure 24: 24hr average $PM_{10}$ measured at TEOM monitors surrounding MTW - Quarter Four 2015**

Three high volume air samples and 16 TEOM $PM_{10}$ measurements exceeded the 24 hour short term impact assessment criteria during the reporting period. Each was investigated to determine the level of contribution from MTW activities to the elevated result, and compared against the compliance protocol outlined in the MTW Air Quality and Greenhouse Gas Management Plan. The DP&E were notified at the time of each exceedance, with follow-up notifications to confirm the outcome of the investigation undertaken. All recorded exceedances were determined to be compliant with the relevant criterion.

A summary of the investigations undertaken for each short term $PM_{10}$ exceedance are provided in Table 26.

**Table 26 : 24 hour $PM_{10}$ investigations - 2015**

| Date | Site | 24hr $PM_{10}$ result ($\mu g/m^3$) | Estimated contribution from MTW ($\mu g/m^3$) | Discussion |
|---|---|---|---|---|
| 18/03/2015 | Long Point $PM_{10}$ (HVAS) | 72 | - | Based on meteorological conditions on the day (predominantly Northerly and Nor-Westerly winds), the result could not be attributable to MTW. A maximum potential contribution to this result was not able to be determined in this instance. |
| 06/05/2015 | Wallaby Scrub Road $PM_{10}$ (TEOM) | 52.2 | - | Elevated results are a consequence of a large dust storm which originated from the Victorian Mallee and South-West NSW, resulting in exceedances being recorded at 38 of 43 EPA $PM_{10}$ monitoring locations across NSW. |
| 06/05/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 59.0 | 6.8 | |
| 06/05/2015 | Warkworth $PM_{10}$ (TEOM) | 54.8 | - | |
| 21/08/2015 | Loders Creek $PM_{10}$ (HVAS) | 57.0 | 32.0 | An internal investigation determined that the maximum potential contribution to be less than the measured result. As the calculated contribution was less than 50µg/m³ or less than 75% of the measured result MTW operations are not considered to be a significant contributor to the results described in the MTW Air Quality and Greenhouse Gas Management Plan. |
| 22/08/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 55.2 | 36.5 | |
| 15/09/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 52.5 | 26.3 | |
| 30/09/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 53.7 | 24.4 | |
| 05/10/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 70.0 | 43.2 | |
| 06/10/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 72.0 | 33.8 | |
| 07/10/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 81.0 | 38.8 | |
| 17/10/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 51.0 | 17.1 | |
| 20/11/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 53.3 | 29.0 | |
| 26/11/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 88.1 | - | Extreme weather day with high winds and elevated $PM_{10}$ recorded across the Upper Hunter. MTW Operations ceased between 7:00am to 3:00pm. NSW Department of Planning and Environment were notified of measured results and actions taken on the day to manage air quality, and did not request any further investigation be undertaken. |
| 01/12/2015 | Long Point $PM_{10}$ (HVAS) | 67 | 36 | An internal investigation determined that the maximum potential contribution to be less than the measured result. As the calculated contribution was less than 50µg/m³ or less than 75% of the measured result MTW operations are not considered to be a significant contributor to the results described in the MTW Air Quality and Greenhouse Gas Management Plan. |
| 12/12/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 55.7 | 6.4 | |
| 15/12/2015 | Mount Thorley Industrial Estate $PM_{10}$ (TEOM) | 59.5 | - | This day was highly affected by smoke haze which blanketed the valley airshed, |

| | | | | |
|---|---|---|---|---|
| 15/12/2015 | Wallaby Scrub Road $PM_{10}$ (TEOM) | 67.2 | - | from fires burning on the day of the measurement, and the previous day. NSW Department of Planning and Environment were notified of measured results and actions taken on the day to manage air quality, and did not request any further investigation be undertaken. |
| 15/12/2015 | Bulga $PM_{10}$ (TEOM) | 53.0 | - | |

#### 6.4.3.5 Long term $PM_{10}$ impact assessment criteria

Annual average $PM_{10}$ concentrations recorded at the five monitoring locations in 2015, compared with the long term $PM_{10}$ impact assessment criterion and previous years' data, are shown in Figure 25. During 2015, all annual average $PM_{10}$ concentrations recorded on privately owned land were compliant with the assessment criterion. Compared to 2014, all monitoring locations recorded lower results, likely attributable to increased rainfall recorded in 2015.

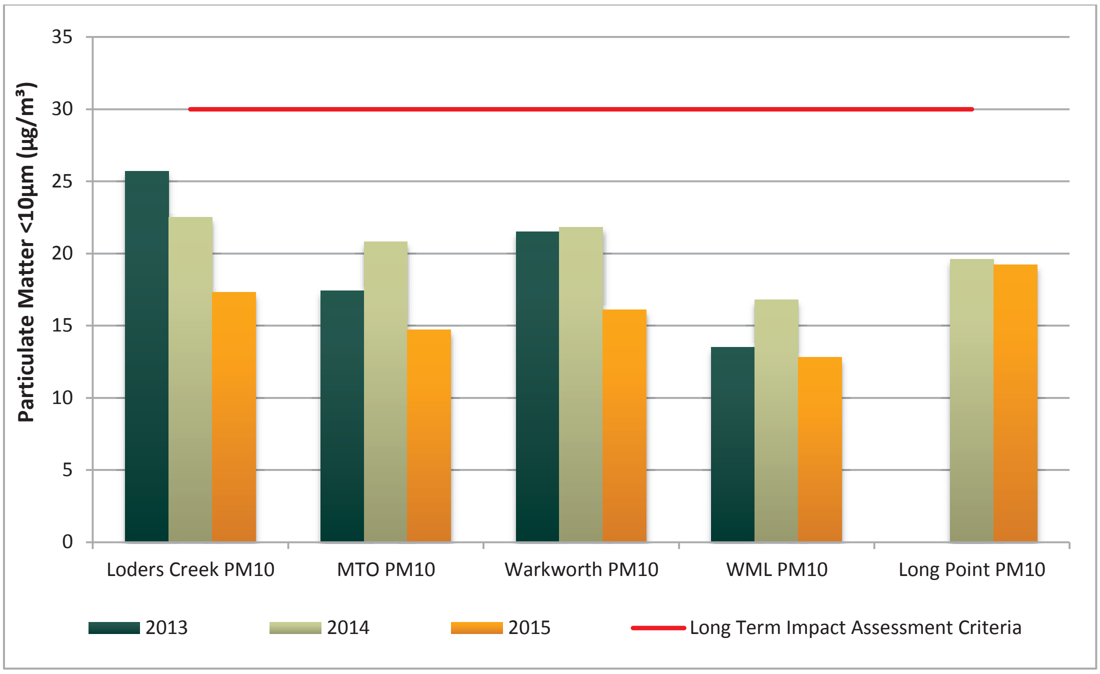


**Figure 25: Annual average HVAS $PM_{10}$ results 2013 to 2015**

#### 6.4.3.6 Comparison of 2015 Air Quality data against EA predictions

Table 27 and Table 28 show a comparison between 2015 air quality data and the predictions made in the 2002 Warkworth Environmental Impact Statement (EIS). Comparisons have been made against the predictions listed in the EIS for the Year 10 (2013) and Year 15 (2018) for the nearest private residence to each monitoring location.

Annual average $PM_{10}$ measurements at all locations in 2015 were consistent with the modelled range for Year 10 of the development (nominally 2013). Long Point $PM_{10}$ recorded an annual average result of 19.2µg/m$^3$, exceeding the predicted annual average (<15µg/m$^3$). Given prevailing winds in the Hunter Valley and the location of the monitor relative to MTW operations it is unlikely that the measured increases are a direct result of MTW activity.

**Table 27: 2014 $PM_{10}$ Annual Average results compared against cumulative predictions for Years 10 and 15 - Warkworth EIS (2002).**

| Monitoring Location | Long Term (annual average) $PM_{10}$ criteria | | |
|---|---|---|---|
| | Year 10 (µg/m$^3$) | Year 15 (µg/m$^3$) | 2015 Annual Average (µg/m$^3$) |
| MTO $PM_{10}$ | 20-30 | 20-30 | 14.7 |
| Loders Creek $PM_{10}$ | 20-30 | 15-20 | 17.3 |
| WML $PM_{10}$ | 10-20 | 15-20 | 12.8 |
| Warkworth $PM_{10}$ | 10-20 | 15-20 | 16.1 |
| Long Point $PM_{10}$ | 10-20 | <15 | 19.2 |

TSP annual averages at all monitoring locations except MTO TSP1 were higher than modelled predictions for both Year 10 and Year 15 scenarios, but generally consistent with years' previous. The difference between modelled predictions and the measured result can be explained as a function of model inputs which do not account for TSP contribution from regional particulate events such as bushfires, stock movement, dust from local roads and driveways and agricultural activity.

**Table 28: 2014 TSP Annual Average results compared against Cumulative Predictions for 2013 and 2018 Warkworth EIS (2002).**

| Monitoring Location | Long Term (annual average) TSP criteria | | |
|---|---|---|---|
| | Year 10 (µg/m$^3$) | Year 15 (µg/m$^3$) | 2014 Annual Average (µg/m$^3$) |
| MTO TSP1 | 30-50 | 30-50 | 48.4 |
| Loders Creek TSP | 20-30 | 20-30 | 47.6 |
| WML- HV2a | 20-30 | 20-30 | 40.9 |
| Warkworth | 20-30 | 20-30 | 51.8 |
| Long Point | 20-30 | 20-30 | 63.1 |

## 6.5 Heritage Summary

### 6.5.1 Aboriginal Heritage

#### 6.5.1.1 Aboriginal Archaeological and Cultural Heritage Investigations

No cultural heritage mitigation programs were required at MTW during 2015 as operations have been confined within development areas where AHIP salvage activities have been completed.

ACHMP compliance inspections were conducted during early December 2015 for areas where proposed groundwater monitoring bores are to be drilled and constructed. The inspections found that all the proposed drill locations did not impact on nearby Aboriginal cultural heritage sites and that the sites have been managed in conformance with the

ACHMP requirements. Condition monitoring of those cultural heritage sites peripheral to authorised development disturbance areas were conducted at regular intervals to ensure operational compliance with the ACHMPs.

#### 6.5.1.2 Audits and Incidents

During the reporting period there were 66 GDPs assessed for cultural heritage management considerations with regard to mining development disturbance activities at MTW. In all cases the ground disturbance works were conducted on an Aboriginal cultural heritage sites avoidance basis so that no extant sites were impacted by these activities. There were no incidents nor any unauthorised disturbance caused to Aboriginal cultural heritage sites at MTW during 2015.

### 6.5.2 Historic Heritage

#### 6.5.2.1 Historic Heritage Activities

Conservation Management Plans (CMPs) have been prepared for all the key historic features located within the MTW leases including RAAF Base Bulga, Great North Road, Springwood Homestead and Mt Thorley Brick Farmhouse. During 2015 condition inspections were conducted at the Springwood Homestead and Mt Thorley Brick Farmhouse and maintenance and stabilisation works programs have been developed for these properties. There were no incidents nor any unauthorised disturbance caused to historic heritage sites at MTW during 2015.

## 6.6. Visual Amenity and Lighting

### 6.6.1. Management

Coal & Allied aims to provide sufficient lighting for work to be undertaken safely, whilst minimising disturbance to neighbouring residents and public roads, particularly nearby residents in Bulga Village, Warkworth Village, Long Point, Gouldsville, Scott's Flats, and Milbrodale; and vehicular traffic on the Putty Road and Golden Highway. MTW has developed and implemented and work instruction which describes management of lighting to minimise light spillage and glow during both mining operations and periods of construction at MTW.

Actions undertaken in 2015 to manage visual amenity and lighting impacts include:

- Regular inspections conducted by Community Response Officers to observe operating practices and to ensure lights are not shining towards or affecting public roads. Lights are checked each shift when operating near roads and, if they are believed to adversely impact public roads methods of control are identified and implemented.
- Yellow and white lights are distributed based on risk and external exposure
- Alternate sheltered dumps are operated or work areas are shut down if lighting or visual amenity issues arise and cannot be sufficiently managed.

Work continued on dumping, shaping and final rehabilitation of the South Pit North area during 2015. This area of the operation is highly visible to our neighbours to the east of MTW. This work will assist in managing noise and dust from mining operations as well as improve the visual aesthetics of the site.

## 6.7. Waste

### 6.7.1. Management

The management of waste generated on the site is undertaken in accordance with Coal & Allied's Total Waste Management System which is designed to track and record all wastes leaving the site to meet regulatory requirements.

Non-hazardous waste not suitable for recycling is removed by a licensed contractor and disposed of at the Singleton Council Landfill, or other appropriate licensed facilities. Co-mingled recyclable non-hazardous wastes are removed by a licensed contractor to a materials recycling facility at Thornton where wastes are sorted for further recycling.

Hydrocarbon wastes are managed and recycled in accordance with Coal & Allied's environmental work instruction for non-mineral waste management. Hydrocarbon waste is recycled via a licensed waste hydrocarbon disposal company.

The sewage treatment and disposal facilities at MTW consist of packaged sewage treatment plants which treat, disinfect and dispose, or re-use the treated effluent on site. The remaining effluent from some septic systems that cannot be treated on site is removed via licensed contractor to approved facilities for disposal.

All waste management contractors working at MTW are licensed by the EPA.

### 6.7.2. Performance

During the reporting period MTW continued to undertake regular inspections of areas where wastes are generated and stored, to reinforce the principles of a good waste management including waste segregation and maximising recycling.

In 2015 around 18 per cent of non-mineral waste material generated at MTW was disposed to licensed offsite landfill facilities, with the remaining wastes diverted to recycling or secondary use pathways.

There were no non-compliances or complaints related to waste management in 2015.

# 7. WATER MANAGEMENT

## 7.1. Water Balance

### 7.1.1. Water Management

An adaptive management approach is implemented at MTW to achieve the following objectives for water management:

- Minimise the use of fresh water;
- Impacts on the environment and MTW neighbours are minimised; and
- Interference to mining production is minimal.

This is achieved by:

- 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 water management system; and
- Disposing of water to the environment in accordance with statutory requirements.

Plans showing the layout of all water management structures and key pipelines are shown in Figure 26. The MTW Water Management Plan contains further detail on management practices and is available on the Rio Tinto website.

Improvements to water management in 2015 have continued to focus on future water supply security, seeking to supplement abstraction from the Hunter River by sourcing water from neighbouring mines during peak demand periods. This includes:

- Modelling using the numerical water balance to determine water sharing opportunities between MTW and HVO;
- Construction of a water transfer pipeline, linking MTW to the HVO Riverview Void, to permit transfer of excess water from MTW and recovery of water where required; and
- Progressive implementation of secondary containment and leak detection on water pipelines, commencing with pipelines linking MTW with the South Lemington Void and Lemington Underground (LUG) Bore.

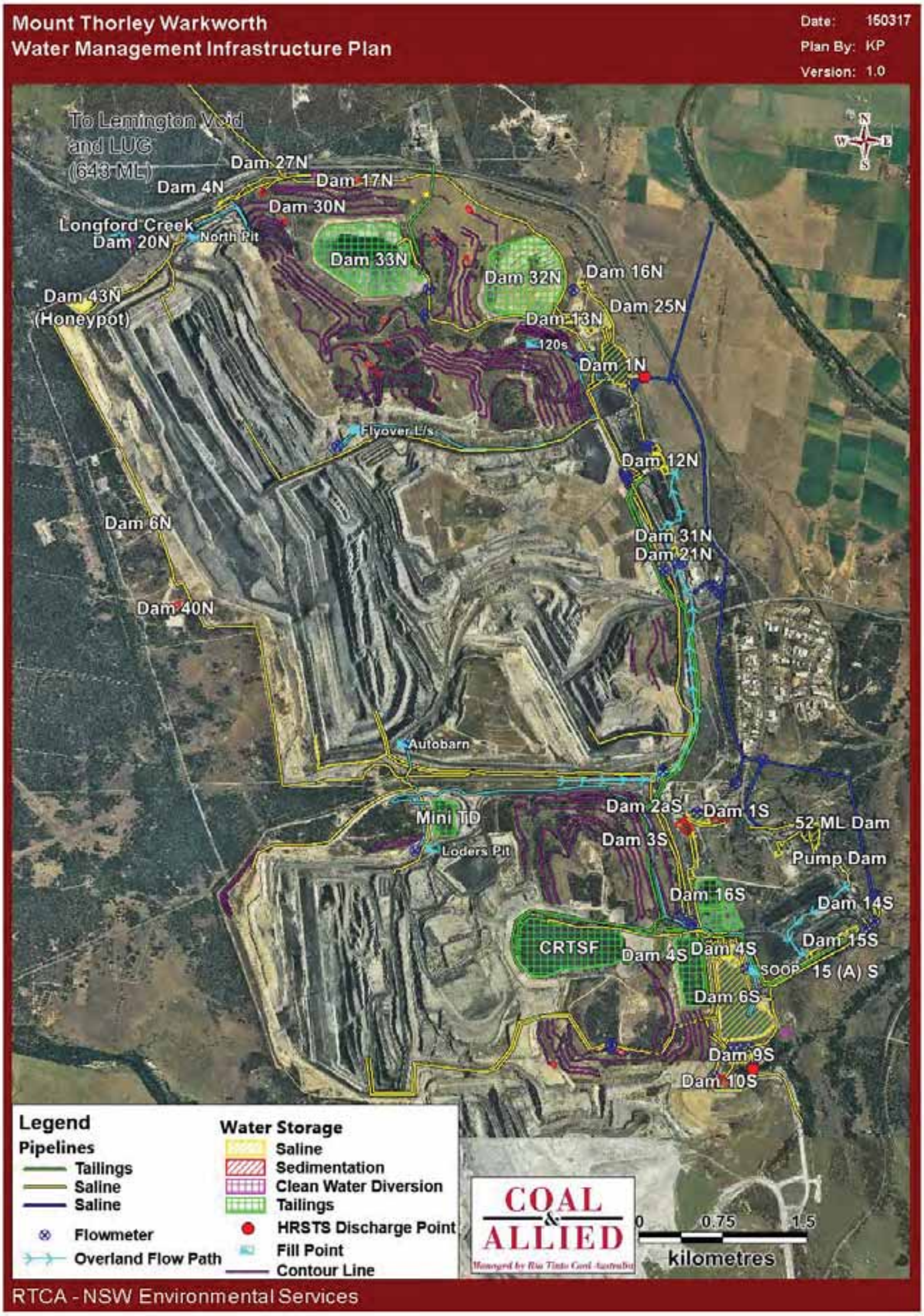


**Figure 26: Water Management Infrastructure Plan**

### 7.1.2. Water Performance

#### 7.1.2.1. Water Balance

MTW uses a water balance to record and assess water flux, but also to forecast and plan water management needs. These annual site water balances are then compared to previous results. A 2015 static water balance for MTW is presented in Table 29 and a simplified schematic of this balance is included as Figure 27. A salt flux schematic is shown in Figure 28.

**Table 29: Static Model Results, annual water balance**

| Water Stream | Volume (ML) (% Total) |
|---|---|
| **Inputs** | |
| Rainfall Runoff | 6,100 (78%) |
| Hunter River (MTJV supply scheme) | 171 (2%) |
| Potable (Singleton Shire Council / trucked) | 33 (<1%) |
| Groundwater | 605 (8%) |
| Recycled to CHPP from tailings (not included in total) | 4,072 |
| Imported (HVO, including LUG bore, Wambo) | 0 (0%) |
| Water from ROM Coal | 958 (12%) |
| **Total Inputs** | **7,867** |
| **Outputs** | |
| Dust Suppression | 2,489 (32%) |
| Evaporation – mine water dams | 1,100 (14%) |
| Entrained in process waste | 1,355 (18%) |
| Discharged (HRSTS) | 812 (11%) |
| Water in coarse reject | 658 (9%) |
| Water in product coal | 1,031 (13%) |
| Miscellaneous use (washdown etc.) | 256 (3%) |
| **Total Outputs** | **7,701** |
| **Change in storage (increased)** | **166** |

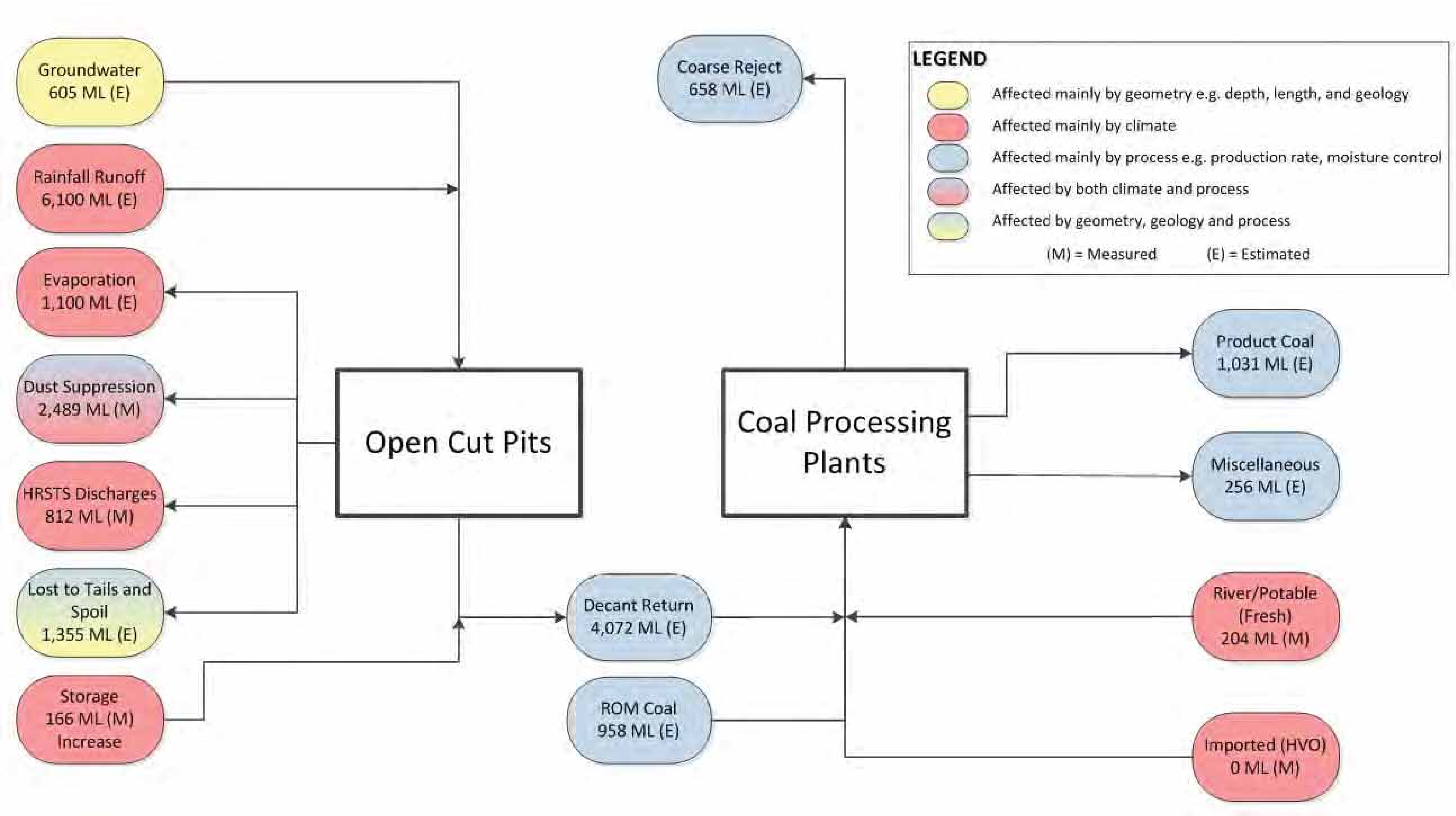


**Figure 27: Schematic Diagram MTW Water Flux**

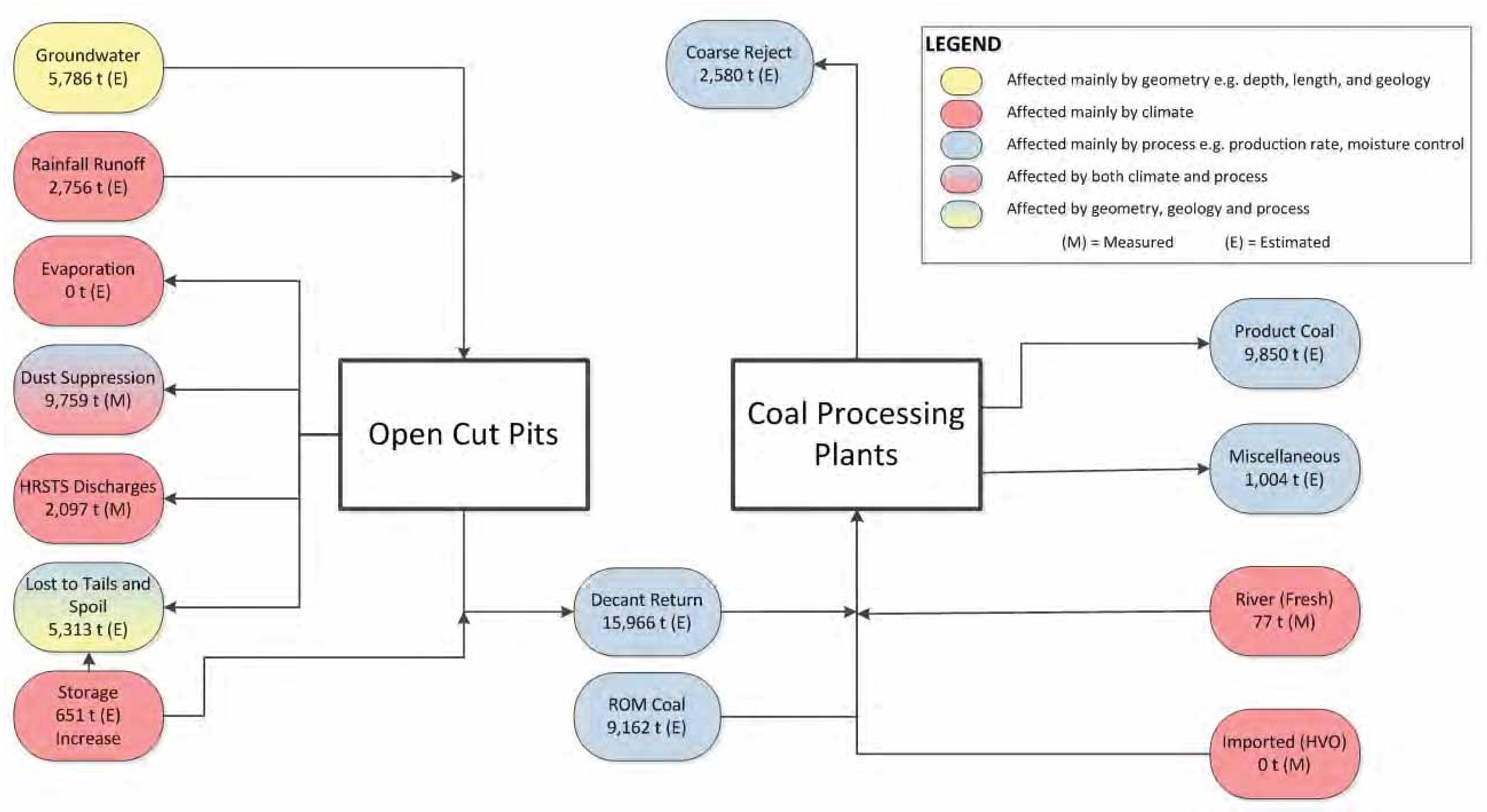


**Figure 28: Schematic Diagram MTW Salt Flux**

#### 7.1.2.2. Water Inputs

A total of 769.2 mm of rainfall was recorded at MTW in 2015 producing an estimated 6,100 ML of runoff from developed, disturbed and mining catchments. Water falling on undisturbed clean water catchments is diverted off site into natural systems where possible. Rainfall runoff was the largest input to the site mine water balance in 2015.

As the site water inventory is drawn down, importation of poor quality water from neighbouring mines occurs to meet site demand. In 2015 however, due to above average rainfall, no imported mine water was required to meet site demands.

For ancillary (non-mining) purposes a small quantity of water (171 ML) was sourced from the Hunter River via the Mount Thorley Joint Venture (MTJV) water supply scheme. Singleton Shire Council holds the high security water licence on behalf of the scheme members. Singleton Shire Council maintains and operates the scheme to supply raw water to MTW, Glencore's Bulga-Beltana complex, and to meet Council's own needs. MTW's share of the scheme allocation is 1,012 ML per financial year.

Abstraction of water from the Hunter River in 2015 reduced by 683 ML compared to 2014. The reduction in demand is due to sufficient water inventory on site as a result of above average rainfall. Water take by source is listed in Table 30.

**Table 30: Water Take for the reporting period**

| Water Licence # | Water Sharing Plan, source and management zone | Entitlement Units (ML/a) | Passive take/inflows (ML/a) | Active pumping (ML/a) | Total (ML/a) |
|---|---|---|---|---|---|
| WAL10543 MTJV Licence | Hunter Regulated River WSP, Hunter Regulated River Water Source, Zone 2B | 1,012 | 0 | 171 | 171 |
| WAL963 Hunter River pump | Hunter Regulated River WSP, Hunter Regulated River Water Source, Zone 2B | 243 | 0 | 0 | 0 |
| WAL969 Glennies Creek pump | Hunter Regulated River WSP, Hunter Regulated River Water Source, Zone 1B | 39 | 0 | 0 | 0 |
| WAL19022 Sandy Hollow Creek | Hunter Unregulated River WSP, Singleton Water Source | 60 | 0 | 0 | 0 |
| 20BL170011 Mount Thorley Pit | Part 5 Water Act 1912 | 180 | N/A | 0 | N/A |
| 20BL170012 Warkworth Pit | Part 5 Water Act 1912 | 750 | N/A | 0 | N/A |

Groundwater Licences under Part 5 of the Water Act 1912 are held for each mining excavation area, to account for passive take via seepage inflows, as detailed in Table 8:

- 20BL170011 Mount Thorley Pit
- 20BL170012 Warkworth Pit

Licence conditions require the volume and quality of water taken by the works to be measured and reported on an annual basis. Groundwater inflows via pit wall seepage is at low rates, with a significant proportion evaporating at the coal face. The remainder reports to the pit floor, where it may accumulate along with direct rainfall, rainfall runoff and leakage from spoils. As a result it is not possible to physically measure the volume of water taken by these groundwater licences, nor the quality of waters extracted via seepage to the pits. In line with the Statement of Commitments listed in the MTW Continuation 2014 EIS, a formal review of depressurisation of coal measures and alluvium will be undertaken annually, commencing with the 2016 reporting period. This review will include a review of take from each water source, including connected alluvium.

#### 7.1.2.3. Water Outputs

Significant water uses at MTW in 2015 were for dust suppression on haul roads, mining areas and coal stockpiles (2,489ML), evaporation from Dams (1,100ML) and water entrained in Process Waste (1,355ML).

MTW 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. HRSTS discharges are undertaken in accordance with HRSTS regulations, EPL 1376 and EPL 1976. MTW maintains two licensed HRSTS discharge monitoring locations:

- Dam 1N, located at WML North, which discharges to Doctor's Creek
- Dam 9S, located at MTO South, which discharges to Loders Creek.

As required by the EPLs, MTO and WML submitted an HRSTS discharge report for the 2014/15 financial year. A total of 812 ML of excess water was discharged off site during 2015 via the Hunter River Salinity Trading Scheme (HRSTS). Non-compliances related to HRSTS discharges are outlined in Chapter 11.

#### 7.1.2.4. Review of Site Water Balance against EA Predictions

The site water balance predicted in the 2010 EA (EMGA Mitchell McLennan, 2010) has been compared to the actual site water balance in 2015. Table 31 provides a summary of comments regarding the comparison. The imported water requirement for 2015 was significantly less than predicted due to higher than average rainfall.

**Table 31: Comparison of 2010 Predicted and 2015 Actual Water Balance**

| Prediction | Review comment |
|---|---|
| "Surface water runoff represents the predominant inflow to the system, accounting for more than 50% of all water inflows". | The rainfall runoff contribution estimated in the water balance indicates that actual was greater than predicted. Surface runoff represented 78% of all water inflows in 2015. |
| "An average imported water requirement of 450ML per year is predicted over the mine life". | The 2015 draw from external supplies was 204 ML. Usage was significantly less than predicted due to rainfall runoff contributing a large proportion of water to meet site needs. |
| "Storage risk profiles for in-pit storage all demonstrate storage levels less than 500ML for more than 95% of the time. All pits are generally maintained in a dewatered state at least 85% of the time". | Minutes from monthly Water Management Meetings indicate in-pit storage levels were less than 500 ML for about 80% of 2015. This is greater than predicted due to higher than average rainfall. |
| "Acceptable management of mine water should be achievable without the need for additional salinity credits under the HRSTS". | MTW traded salinity credits as required to optimise the site water inventory. |

## 7.2. Surface Water

### 7.2.1. Water Management

Surface water monitoring activities continued in 2015 in accordance with the MTW Water Management Plan and MTW Surface Water Monitoring Programme. MTW maintains a network of surface water monitoring sites located at site dams and surrounding natural watercourses, see Figure 29. 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. Primary water storage 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 review involves a comparison of measured pH, EC and 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 MTW Water Management Plan.

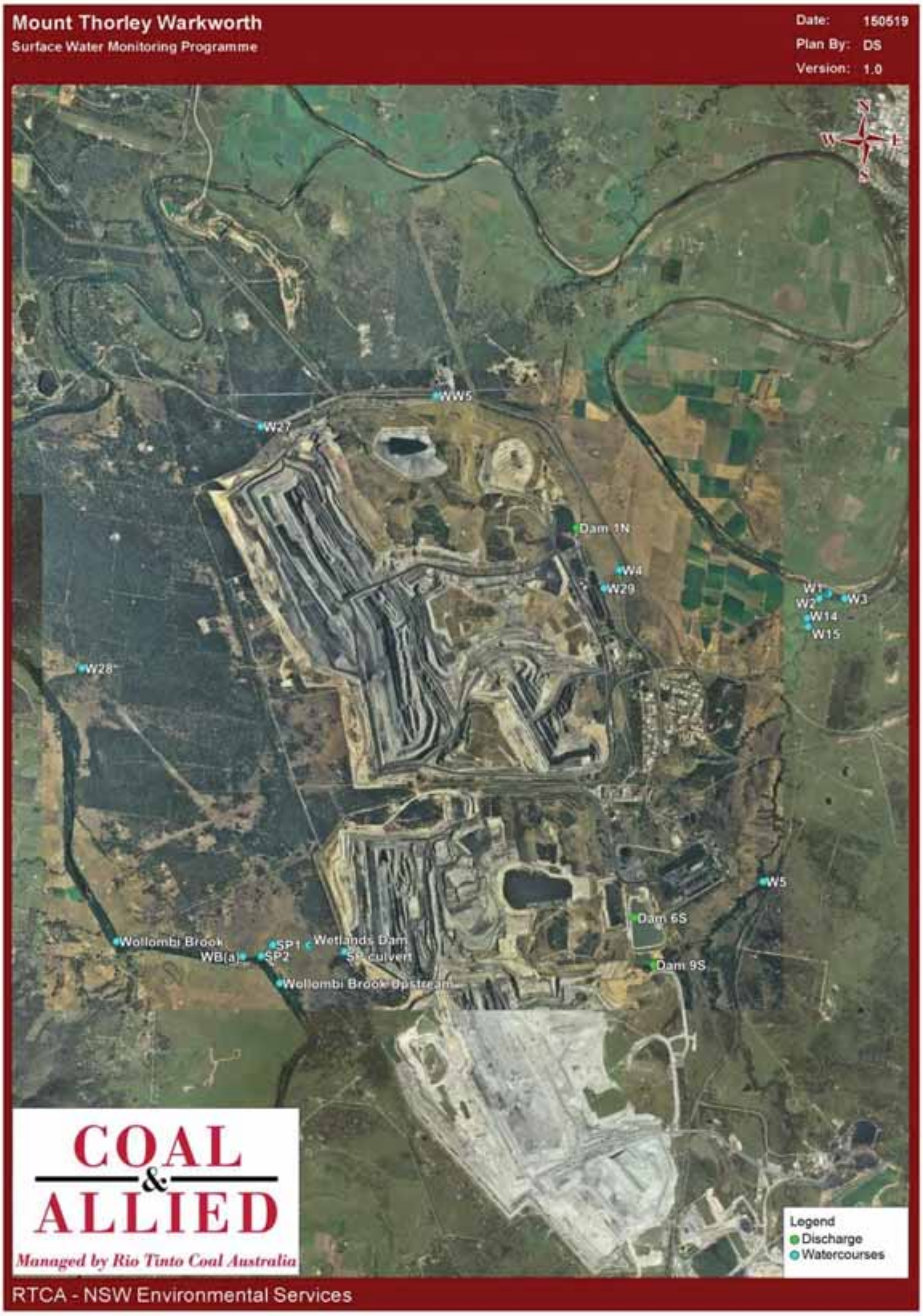


**Figure 29: Surface Water Monitoring Points**

### 7.2.2. Surface Water Monitoring

Routine surface water monitoring was undertaken from 21 sites. Sampling of surface waters was carried out in accordance with AS/NZS 5667.6 (1998). Analysis of surface water was carried out in accordance with approved methods by a NATA accredited laboratory.

Water quality is evaluated through the assessment of pH, Electrical Conductivity (EC) and Total Suspended Solids (TSS). Fourteen surface water sites were also sampled for comprehensive analysis annually. All required sampling and analysis was undertaken, except as detailed in Table 32. Trigger tracking results are described in Table 33.

**Table 32: MTW Water Monitoring Data Recovery for 2015 (by exception)**

| Location | Data Recovery (%) | Comment |
|---|---|---|
| **W4** | 75% | Site recorded as dry during December monitoring event. |
| **W14** | 50% | Site recorded as dry during March and December monitoring events. |
| **W15** | 75% | Site recorded as dry during December monitoring event. |
| **W27** | 75% | Site recorded as dry during December monitoring event. |
| **WW5** | 50% | Site recorded as dry during March and December monitoring events. |
| **SP1** | 92% | Site recorded as dry during December monitoring event. |

A summary of all surface water monitoring results is provided in the MTW Monthly Environmental Monitoring Reports, and can be viewed via the Rio Tinto website.

Figure 30 to Figure 35 show long term water quality trends for the Hunter River, Wollombi Brook, other surrounding tributaries and site dams. Measurements of EC and pH were stable during the reporting period and consistent with historical trends. The ephemeral nature of streamflow in watercourses is the primary reason for considerable variation in field water quality values. Application of a revised TSS trigger commenced in the second half of 2016, from a sampling site-based 95$^{th}$ percentile trigger, to a standard 50 mg/L trigger across all sites. The revised trigger limit has resulted in a significant reduction in the TSS trigger, to allow for sufficient investigation of any potentially deleterious results. These are outlined below in Table 33.

**Table 33: Surface Water Monitoring - Trigger Tracking Results**

| Location | Date | Trigger Limit | Action taken in response |
|---|---|---|---|
| **W5** | 11/08/2015<br>10/09/2015 | **EC - 95$^{th}$ Percentile** | Watching Brief* |

| Location | Date | Trigger Limit | Action taken in response |
|---|---|---|---|
| | 21/10/2015 | | Elevated EC due to low flow conditions associated with limited rainfall runoff. Data consistent with historical trend. No further action required. |
| **W28** | 09/09/2015 | **TSS – 50mg/L (ANZECC criteria)** | Re-assess immediately following next event-based sampling run, and undertake field investigations where repeat exceedance identified. |
| | 08/12/2015 | **TSS – 50mg/L (ANZECC criteria)** | TSS recorded is consistent with historical trend; sample taken from dam, not flowing at time of sampling. No further action required. |
| **W29** | 09/09/2015 | **TSS – 50mg/L (ANZECC criteria)** | Re-assess immediately following next event-based sampling run, and undertake field investigations where repeat exceedance identified. *(Follow up measurement below trigger).* |
| **WW5** | 10/09/2015 | **TSS – 50mg/L (ANZECC criteria)** | Re-assess immediately following next event-based sampling run, and undertake field investigations where repeat exceedance identified. *(Follow up measurement dry).* |

* = 1st / 2nd trigger. No specific action required. Watching brief established, pending outcomes of subsequent monitoring event.

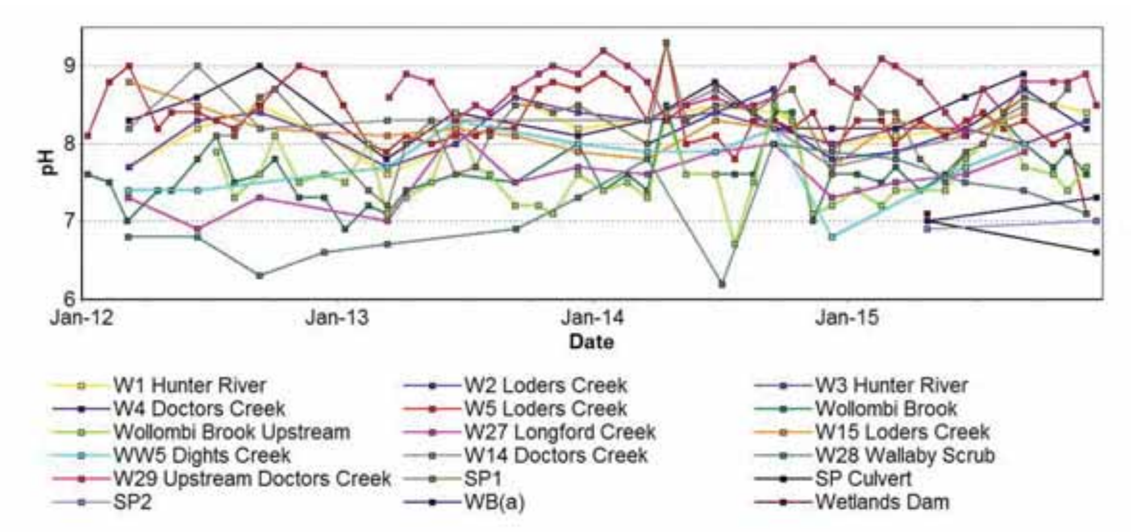


**Figure 30: Watercourse pH Trends 2012 to 2015**

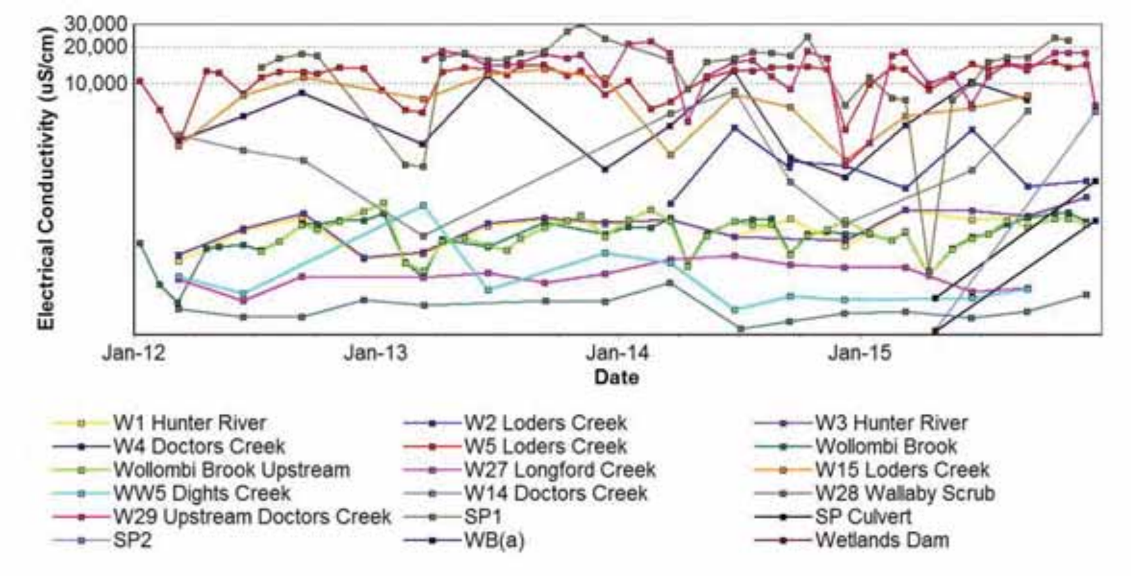


**Figure 31: Watercourse EC Trends 2012 to 2015**

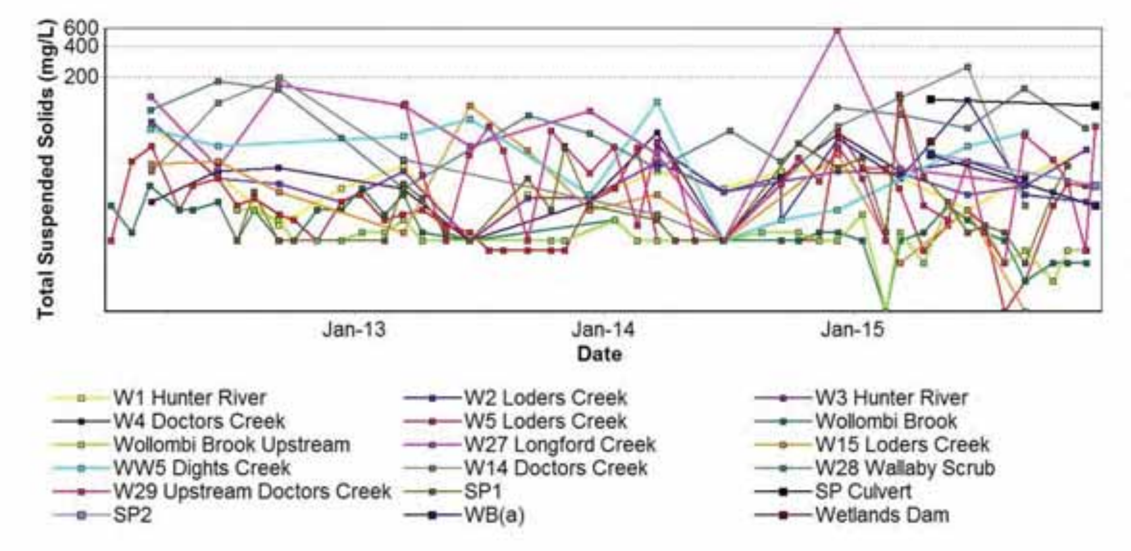


**Figure 32: Watercourse TSS trends 2012 to 2015**

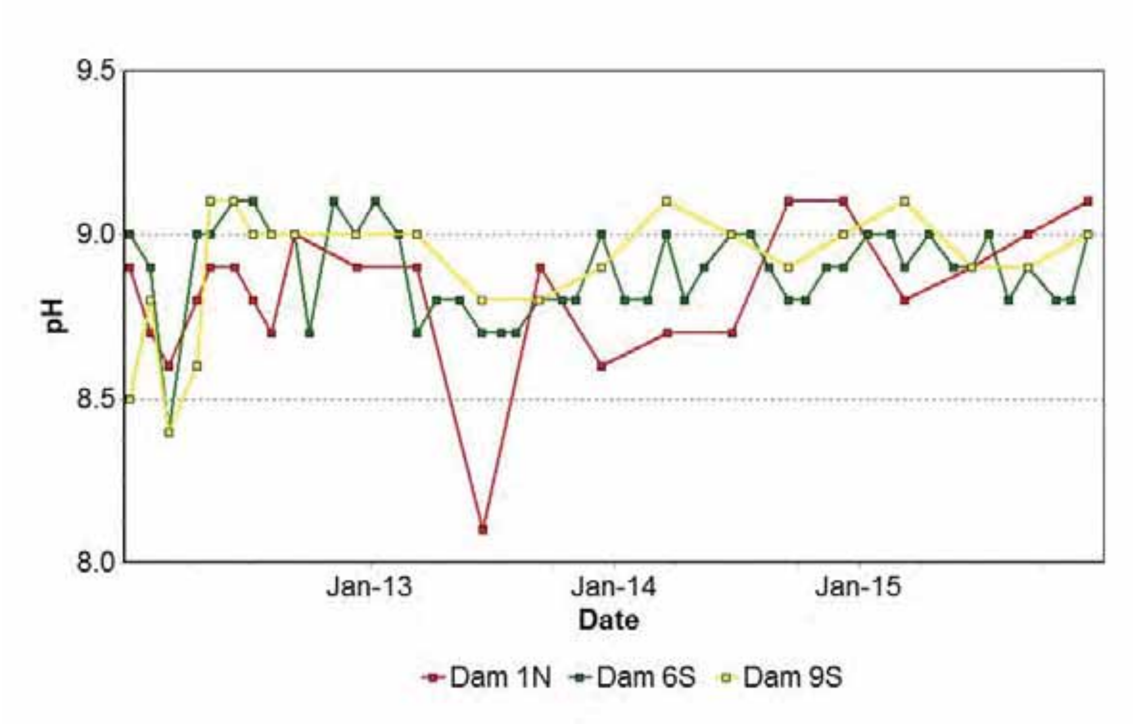


**Figure 33: Site Dams pH trends 2012 to 2015**

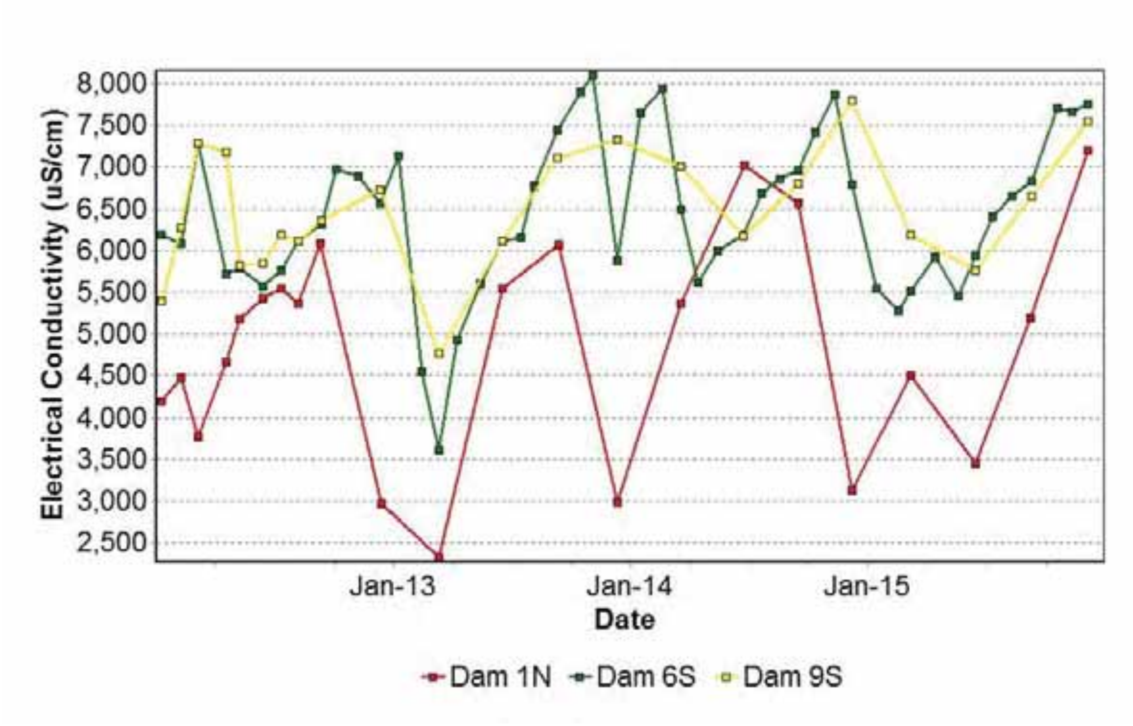


**Figure 34: Site Dams EC trends 2012 to 2015**

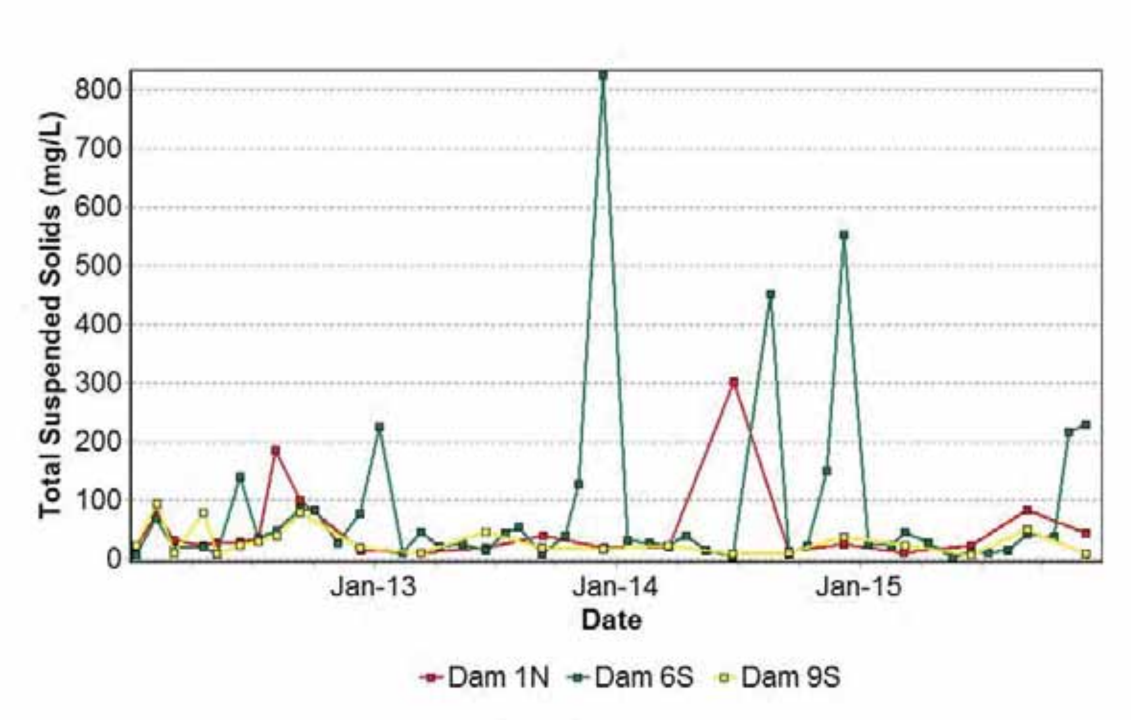


**Figure 35: Site Dams TSS trends 2012 to 2015**

### 7.2.3. Audits and Reviews

No independent audits were undertaken at MTW during 2015. An Independent Environmental Audit was undertaken during January 2016. The audit report will be published on the Rio Tinto website when finalised. A summary of findings will be presented in the 2016 Annual Review.

## 7.3. Groundwater

### 7.3.1. Groundwater Management

Groundwater monitoring activities were undertaken in 2015 in accordance with the MTW 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 MTW 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. 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 (5th and 95th percentile) which have been derived from the historical data set. The response to measured excursions outside the trigger limits is detailed in the MTW Water Management Plan.

The monitoring locations are shown in Figure 36.

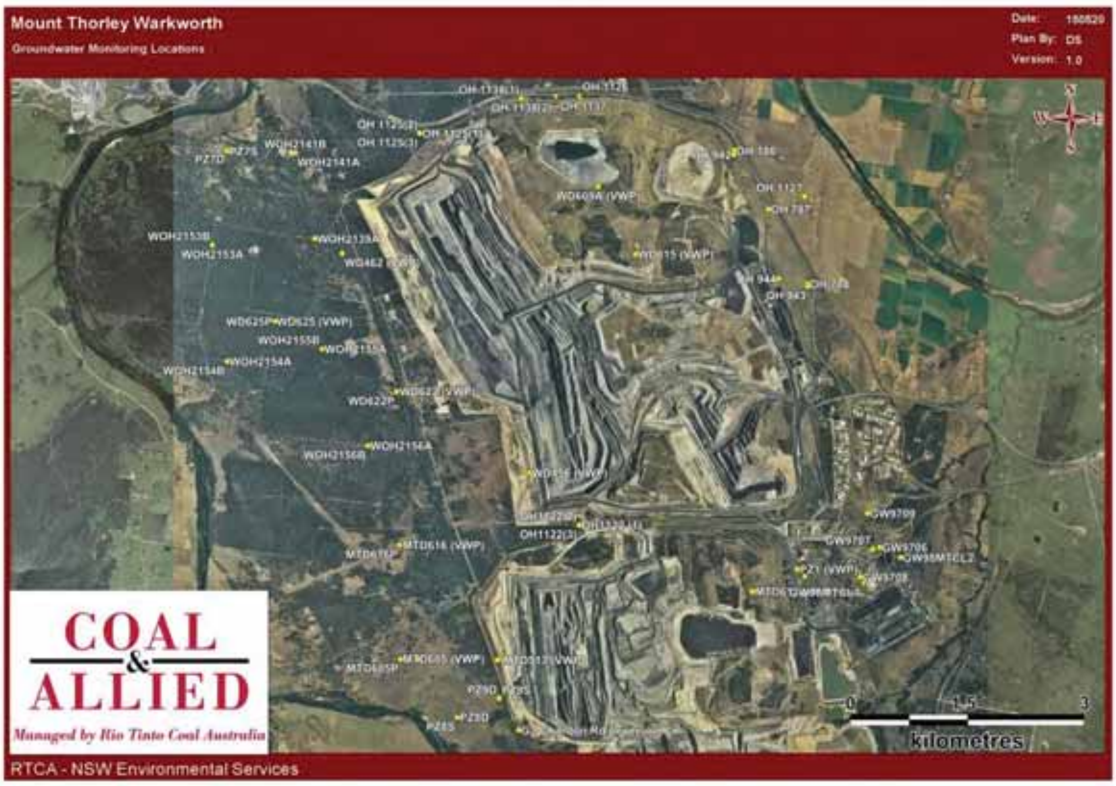


**Figure 36: Groundwater Monitoring Network at MTW in 2015**

### 7.3.2. Groundwater Performance

Sampling of ground waters was carried out on 142 occasions from 39 bores across Mount Thorley Warkworth in accordance with AS/NZS 5667.6 (1998). Where laboratory analysis was undertaken, this was performed by a NATA accredited laboratory. Groundwater sampling and analysis was undertaken as required with the following exceptions detailed in Table 34.

**Table 34: MTW Water Monitoring Data Recovery for 2015 (by exception)**

| Location | Data Recovery (%) | Comment |
|---|---|---|
| **PZ7S** | 75% | No safe access to site during June monitoring event. |
| **PZ7D** | 75% | No safe access to site during June monitoring event. |
| **OH1122(3)** | 0% | Site recorded as dry during 2016 monitoring events. To be removed from monitoring programme. |
| **WOH2139(a)** | 25% | No safe access to site due to track damage during June, September and December monitoring events. |
| **WOH2141B** | 0% | Insufficient water to allow sampling during 2015 monitoring events. |
| **WOH2156B** | 75% | Insufficient water to allow sampling during June monitoring event. |

A summary of the monitoring results for MTW Groundwater Sites is provided in the Monthly Environmental Monitoring Reports, available via the Rio Tinto website (www.riotinto.com).

### 7.3.3. Groundwater Monitoring Summary

The following section presents groundwater monitoring data in relation to the geographic locations and target stratigraphy for groundwater monitoring bores. Each location is discussed below, and a summary of monitoring data presented. Where monitoring results were recorded outside the internal trigger limit, these results are summarised in tables for each location.

#### 7.3.3.1. Bayswater Seam Bores

Groundwater monitoring in the Bayswater area was undertaken from seven sites during 2015. A total of 28 samples were collected during the reporting period. The pH, EC and SWL trends for 2012 to 2015 for Bayswater groundwater bores are shown in Figure 37, Figure 38 and Figure 39 respectively.

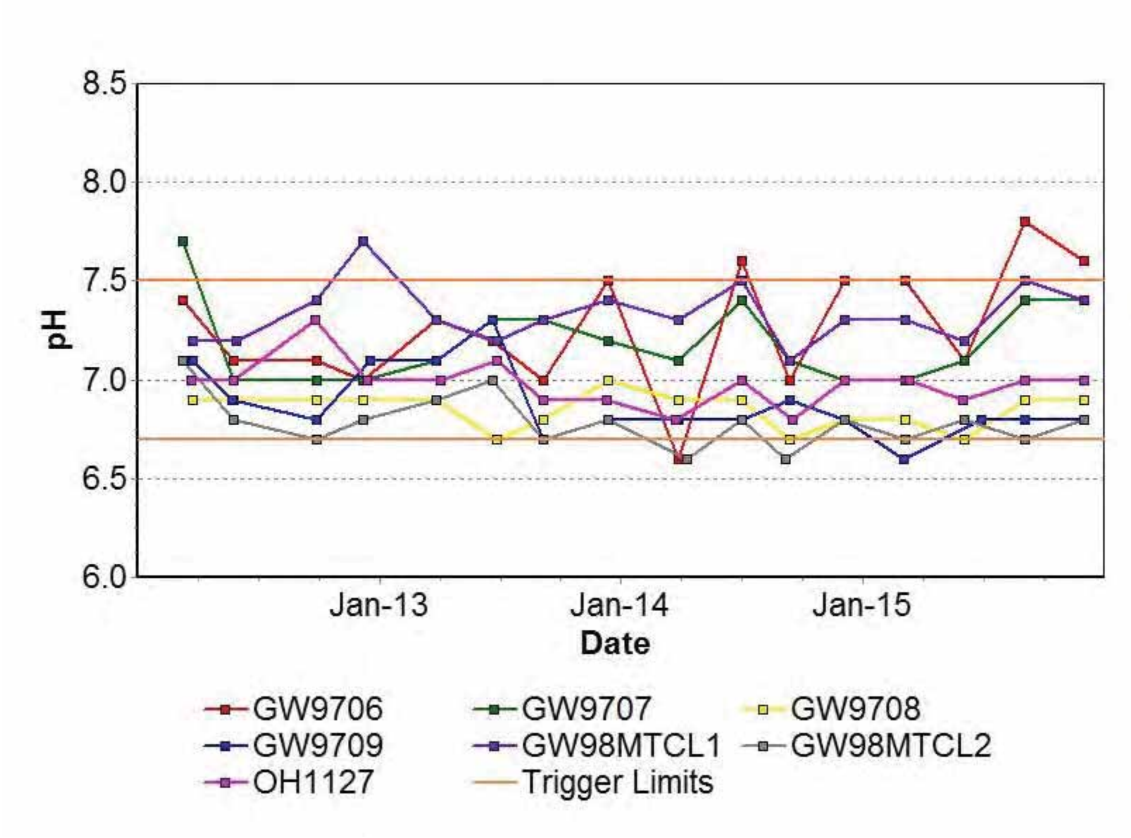


**Figure 37: Bayswater Seam pH trends 2012 to 2015**

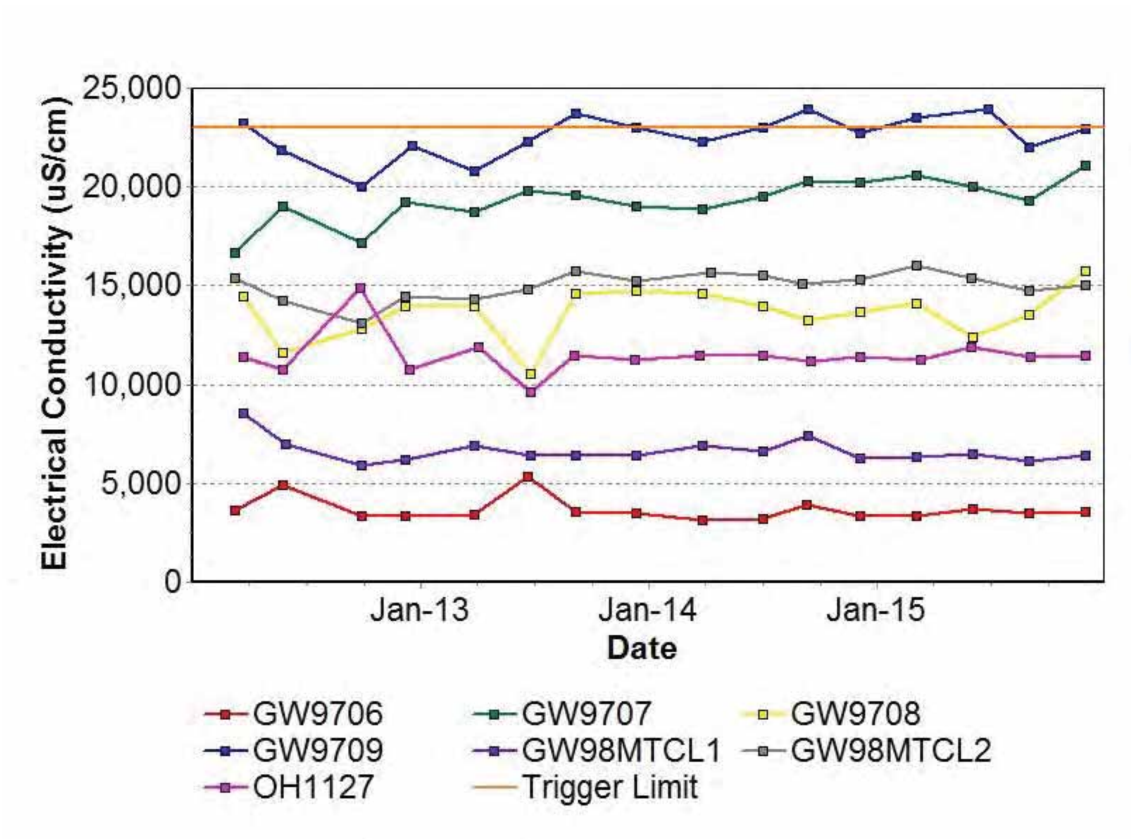


**Figure 38: Bayswater Seam EC trends 2012 to 2015**

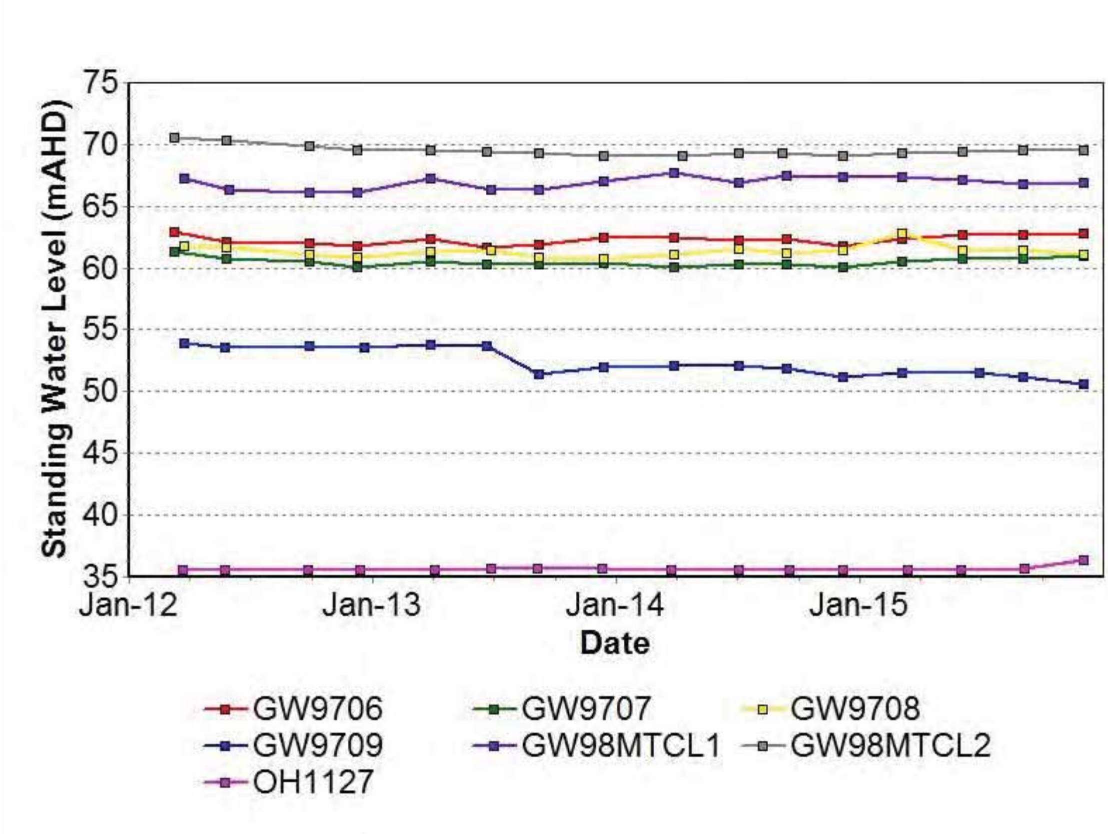


**Figure 39: Bayswater SWL trends 2012 to 2015**

#### 7.3.3.2. Bowfield Seam Bores

Groundwater monitoring in the Bowfield seam area was undertaken from two sites during 2015. A total of 4 samples were collected during the reporting period; OH1122(3) was recorded as dry throughout 2015 as the target coal seam has been locally depressurised. Bore OH1122(3) will be removed from the monitoring programme. The pH, EC and SWL trends for 2012 to 2015 for Bowfield groundwater bores are shown in Figure 40, Figure 41 and Figure 42 respectively.

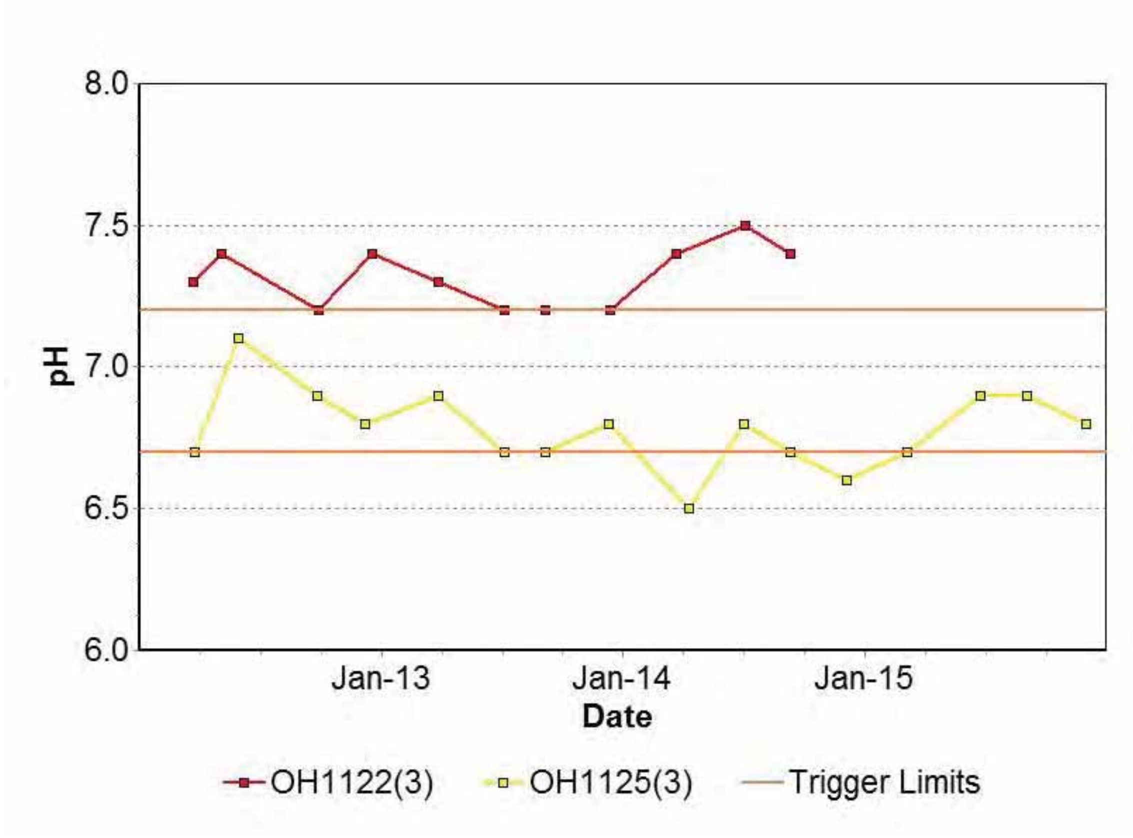


**Figure 40 : Bowfield Seam pH Trends 2012 to 2015**

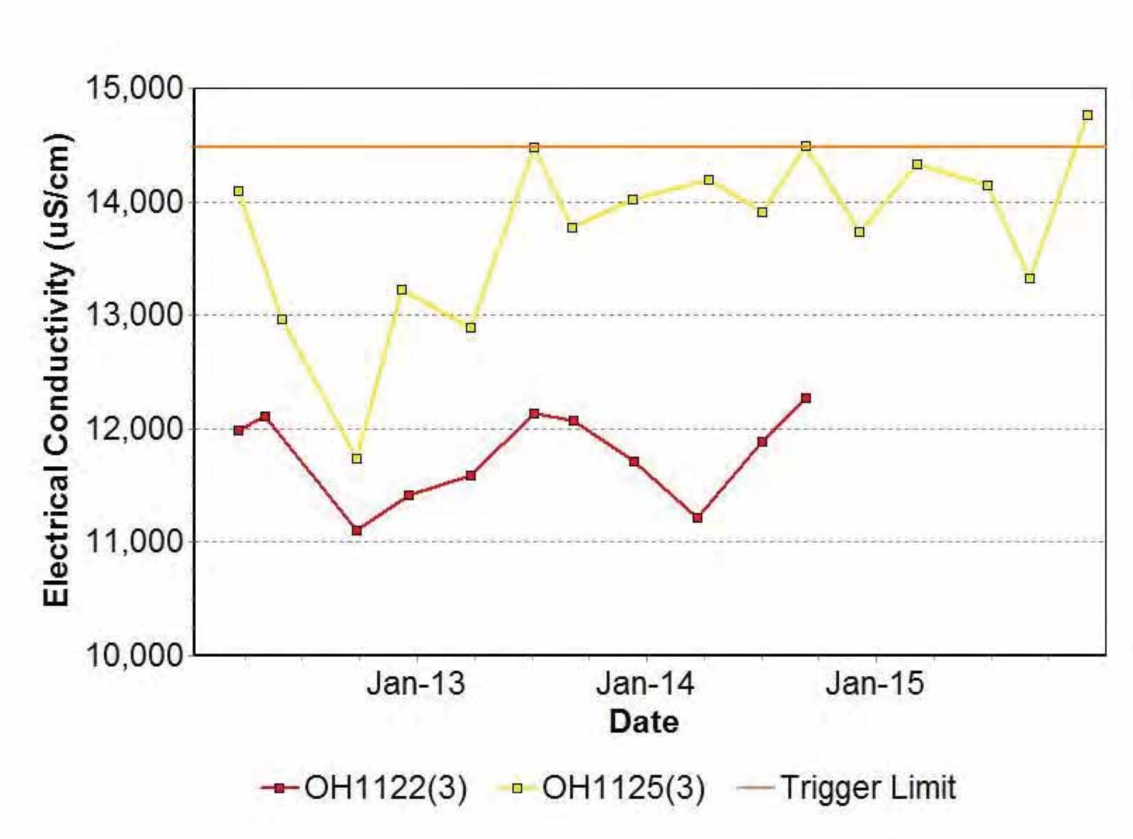


**Figure 41: Bowfield Seam EC Trends 2012 to 2015**

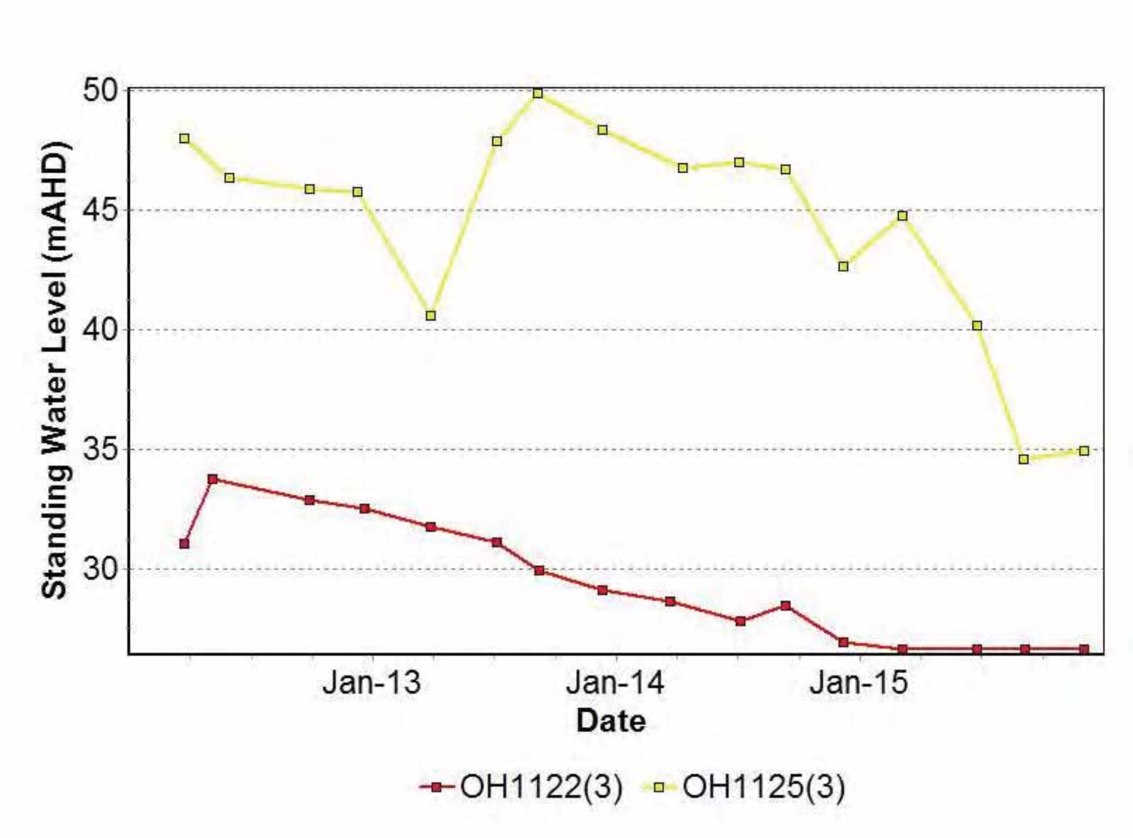


**Figure 42: Bowfield Seam SWL Trends 2012 to 2015**

#### 7.3.3.3. Blakefield Seam Bores

Groundwater monitoring in the Blakefield seam area was undertaken from four sites during 2015. A total of 9 samples were collected during the reporting period. The pH, EC and SWL trends for 2012 to 2015 for Blakefield groundwater bores are shown in

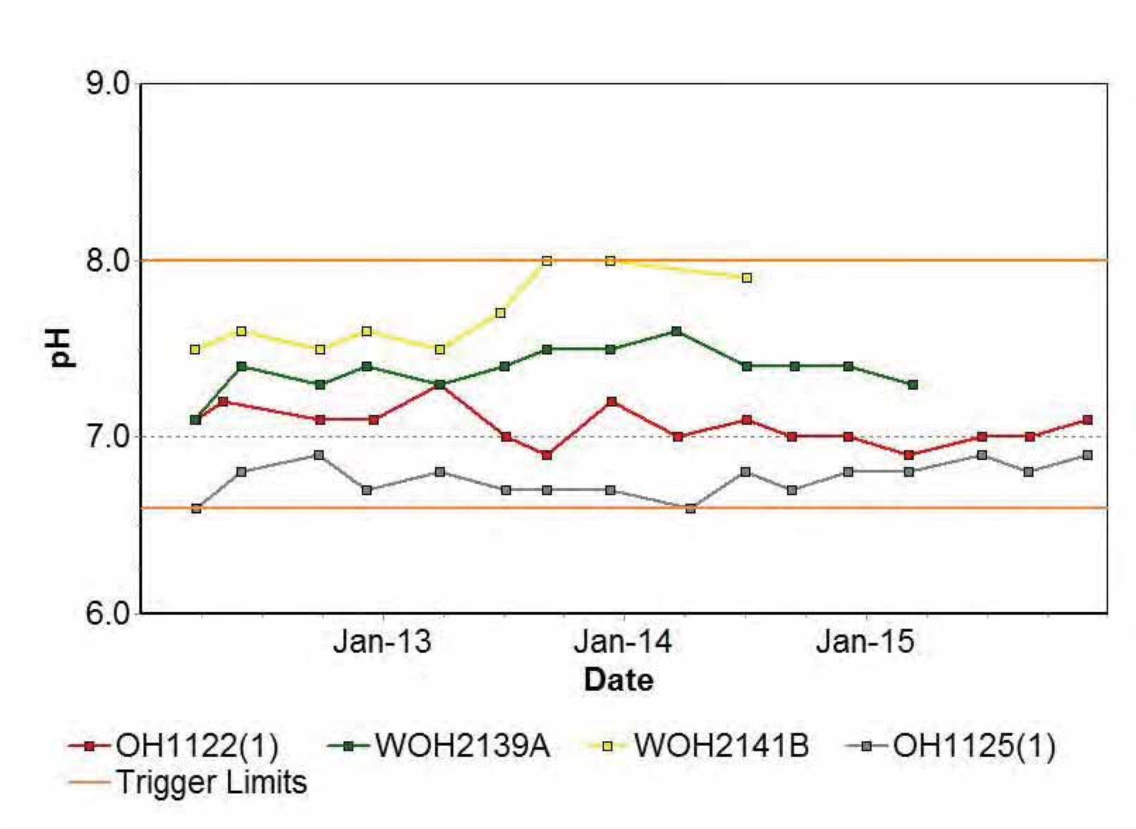


Figure 43, Figure 44 and Figure 45 respectively. WOH2141B was recorded as containing insufficient water to allow sampling during the reporting period. WOH2139A was not sampled in June, September and December as there was no safe access to site. Track repair works are scheduled for completion in early 2016.

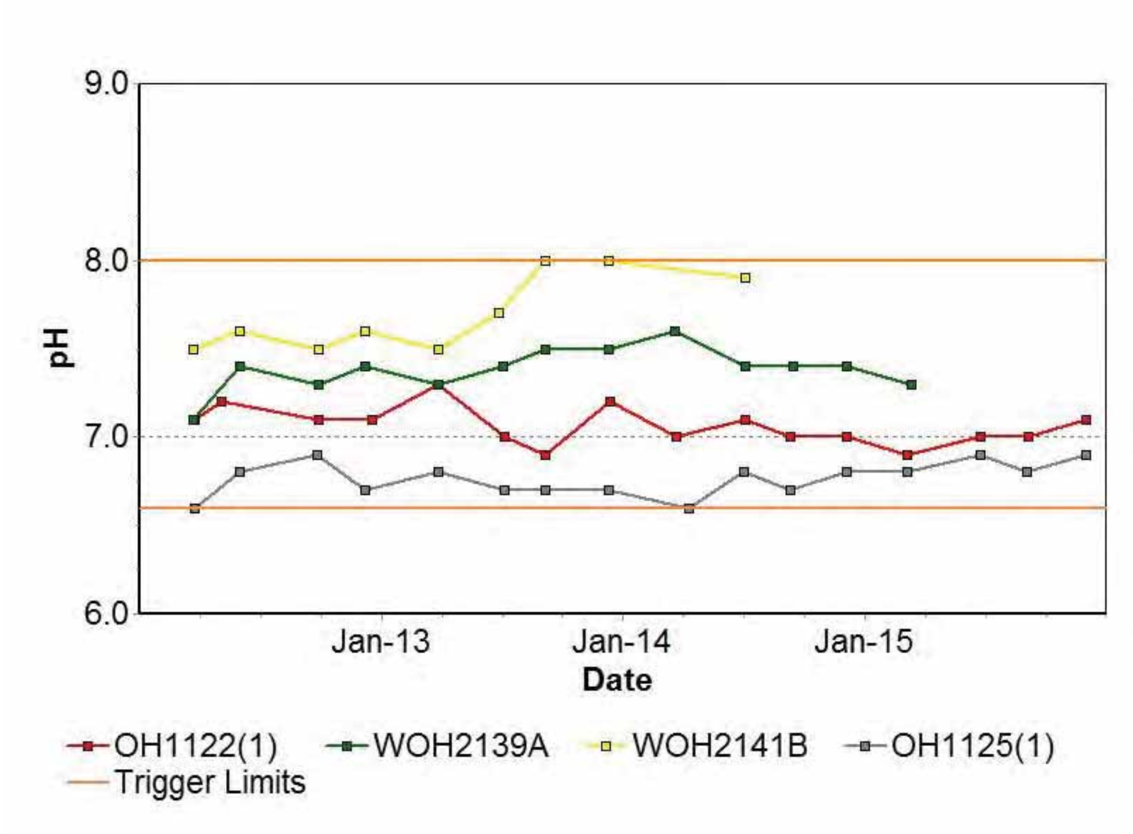


**Figure 43: Blakefield Seam Groundwater pH Trends 2012 to 2015**

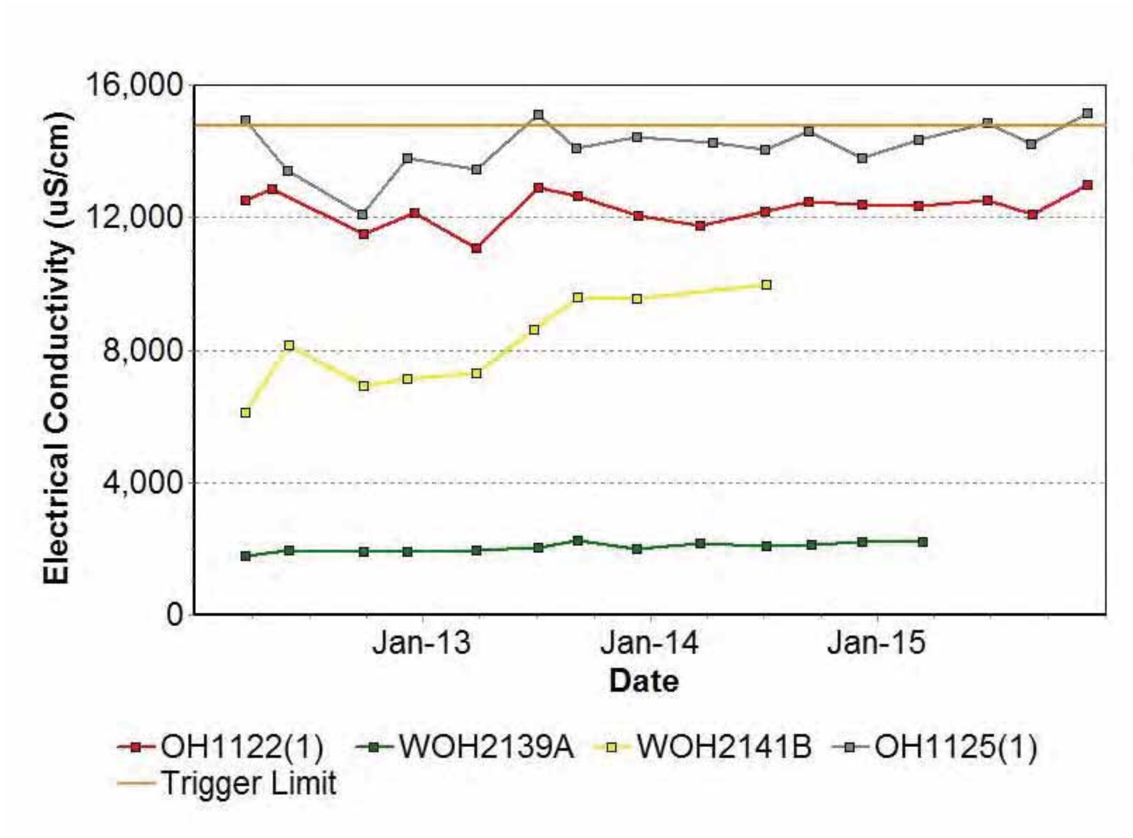


**Figure 44: Blakefield Seam Groundwater EC Trends 2012 to 2015**

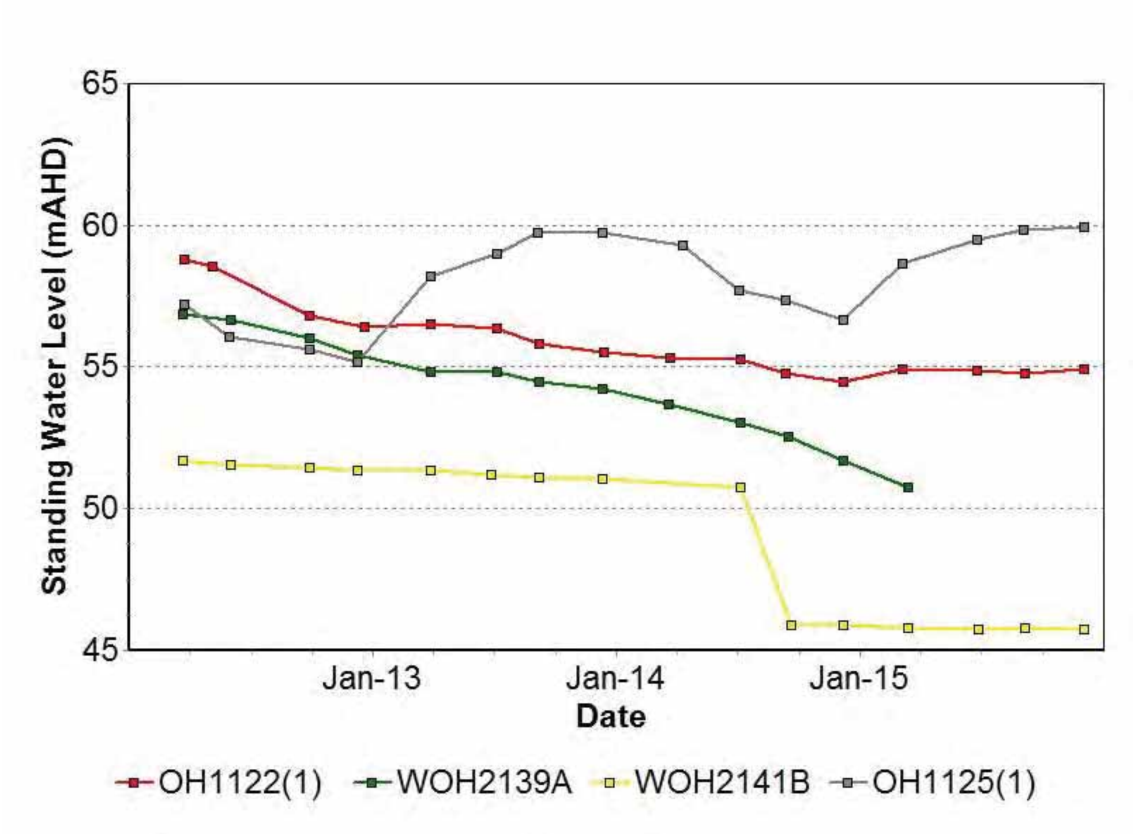


**Figure 45: Blakefield Seam Groundwater SWL Trends 2012 to 2015**

#### 7.3.3.4. Hunter River Alluvium Bores

Groundwater monitoring in the Hunter River Alluvium seam area was undertaken from six sites during 2015. A total of 24 samples were collected during the reporting period. The pH, EC and SWL trends for 2012 to 2015 for Hunter River Alluvium groundwater bores are shown in Figure 46, Figure 47 and Figure 48 respectively.

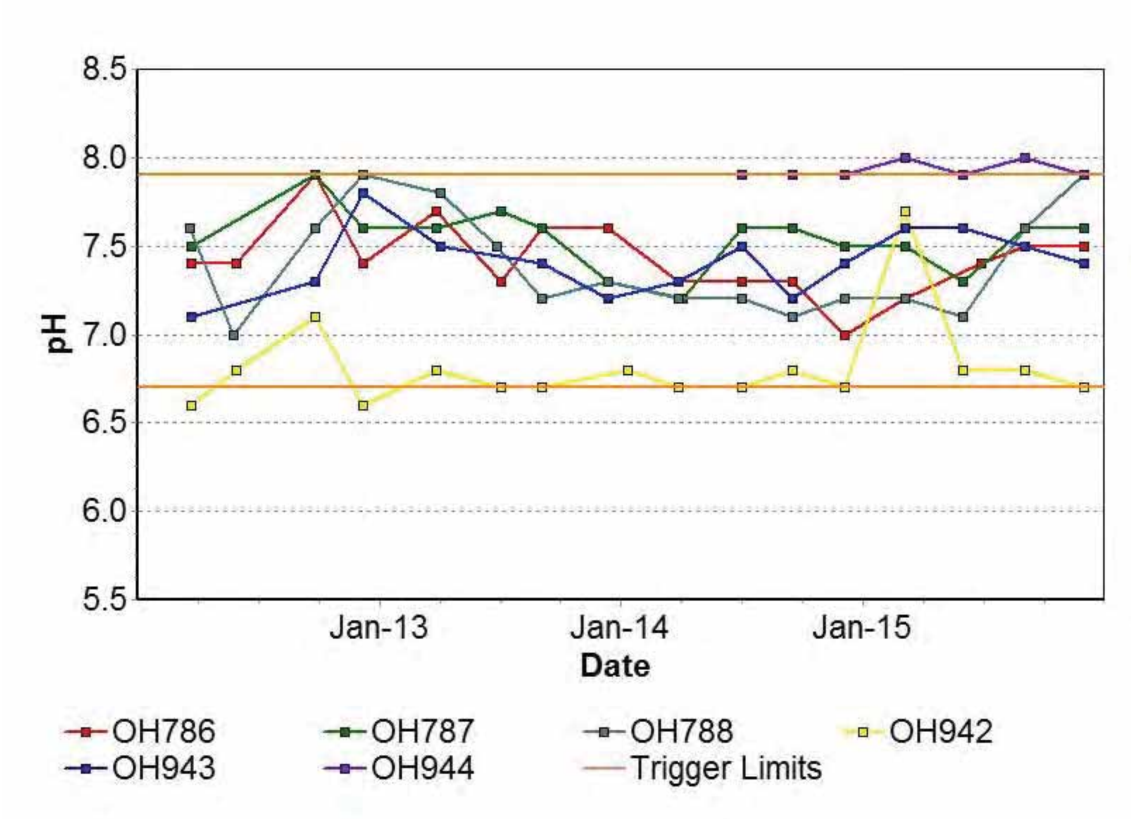


**Figure 46: Hunter River Alluvium Seam Groundwater pH Trends 2012 to 2015**

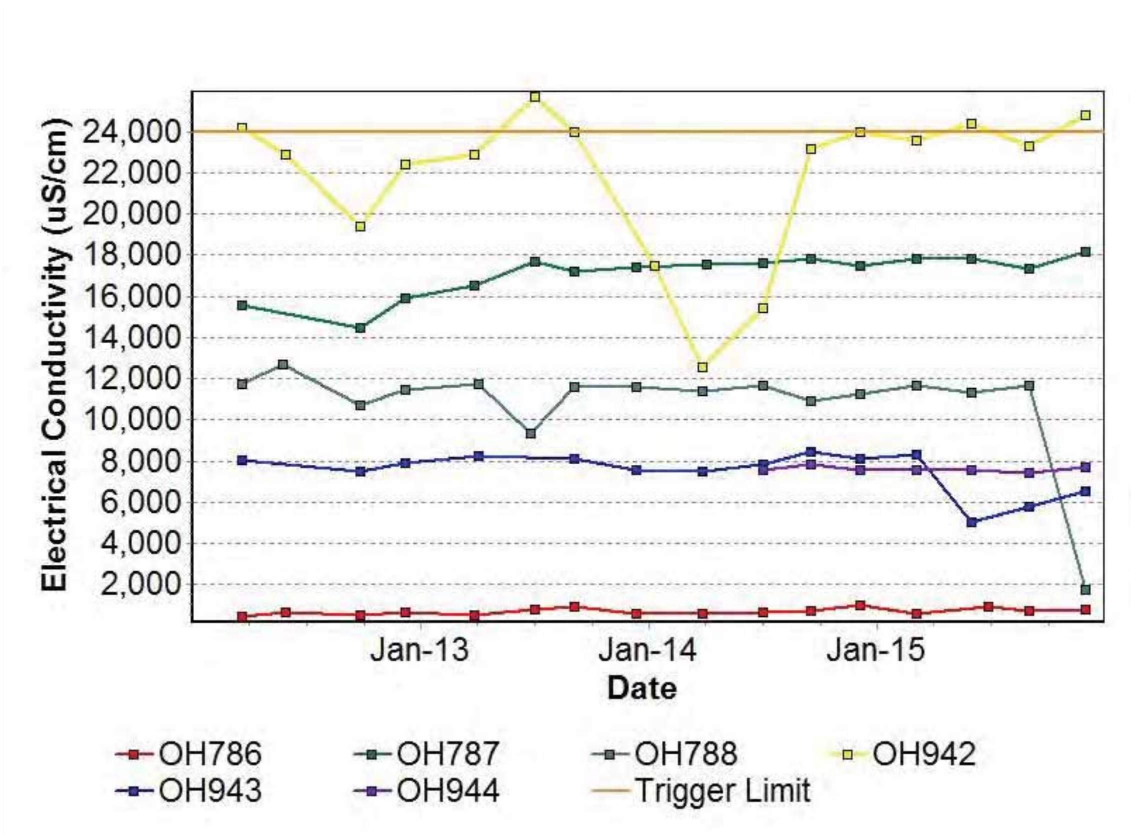


**Figure 47: Hunter River Alluvium Seam Groundwater EC Trends 2012 to 2015**

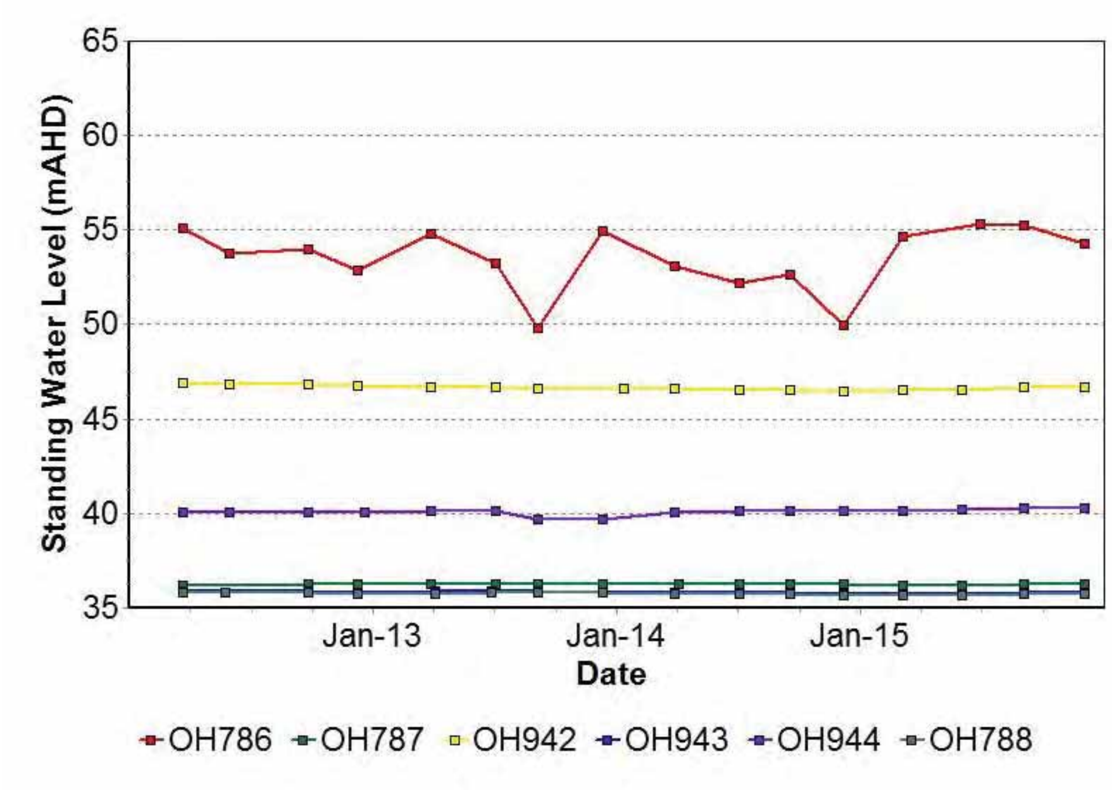


**Figure 48: Hunter River Alluvium Seam Groundwater SWL Trends 2012 to 2015**

#### 7.3.3.5. Redbank Bores

Groundwater monitoring in the Redbank seam area was undertaken from four sites during 2015. A total of 16 samples were collected during the reporting period. The pH, EC and SWL trends for 2012 to 2015 for Redbank groundwater bores are shown in Figure 49, Figure 50 and Figure 51 respectively. Trigger tracking results are detailed in Table 35. A steady declining trend in water levels at all monitoring sites continued during the reporting period, as a result of coal seam depressurisation due to mining.

**Table 35 : MTW Redbank Seam Groundwater 2015 internal trigger tracking**

| Location | Date | Trigger limit | Action taken in response |
|---|---|---|---|
| **WOH2156A** | 16/06/2015 | **pH - 5th percentile** | Watching Brief * |
| **WOH2156A** | 04/09/2015 | | |
| **WOH2156A** | 02/12/2015 | | Low pH is likely the result of coal seam depressurisation, as evidenced by falling water level. This trend is consistent with effects of nearby mining. No further action required. |

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

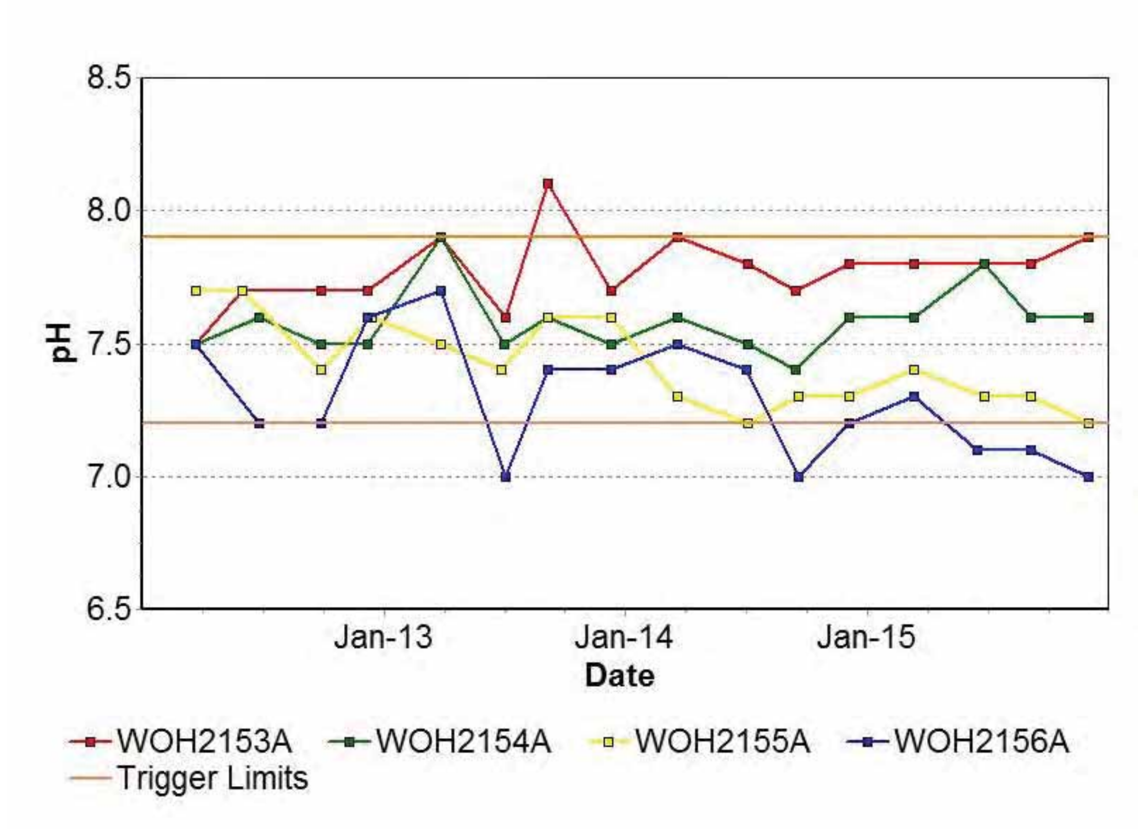


**Figure 49: Redbank Seam Groundwater pH Trends 2012 to 2015**

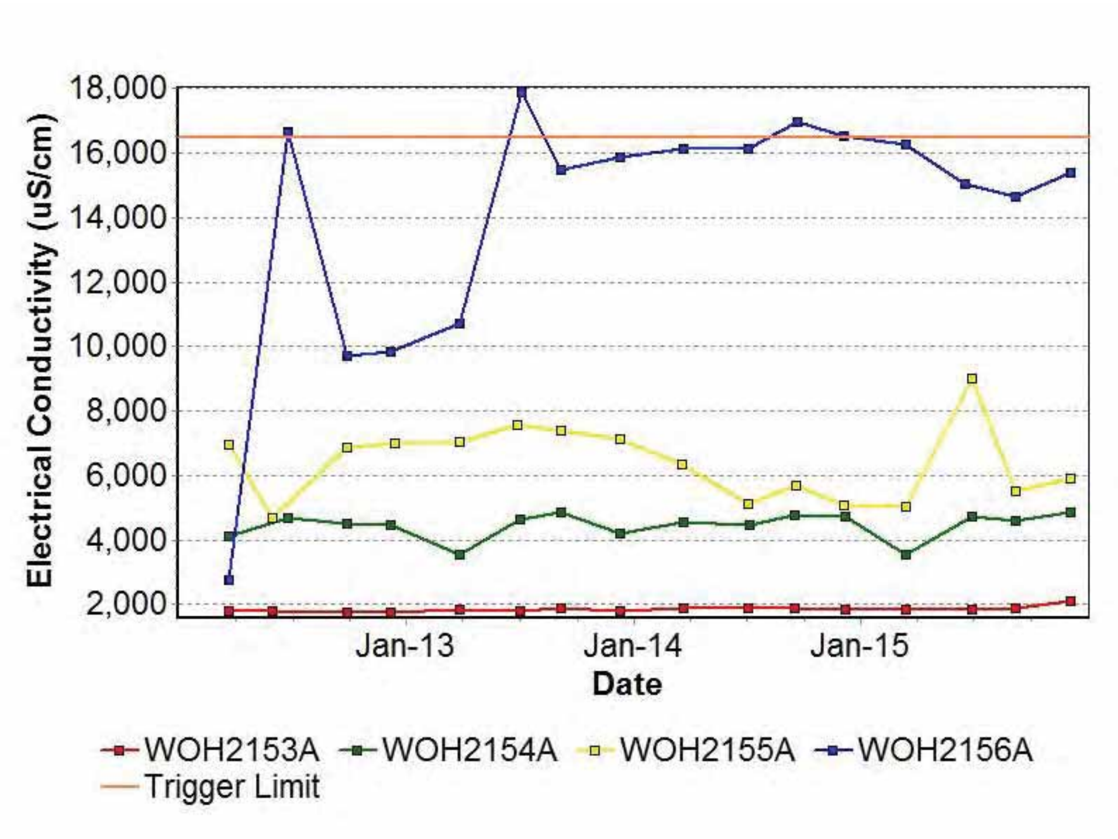


**Figure 50: Redbank Seam Groundwater EC Trends 2012 to 2015**

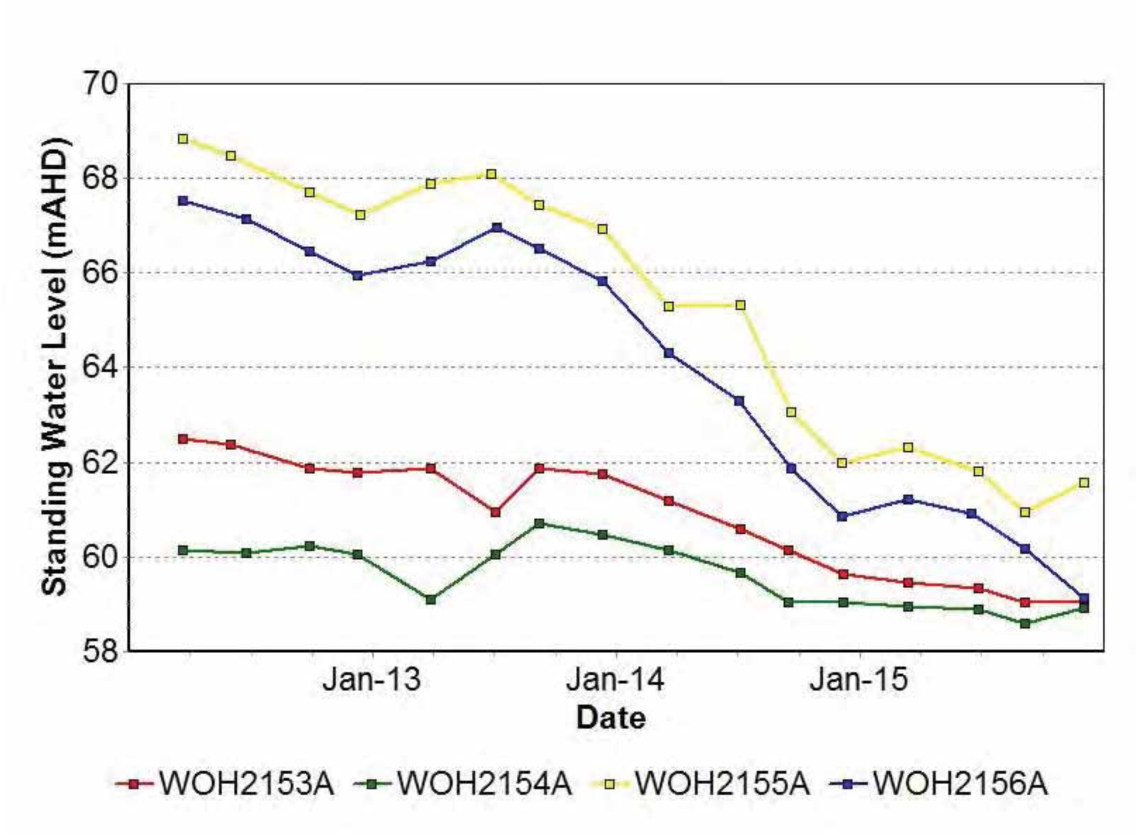


**Figure 51: Redbank Seam Groundwater SWL Trends 2012 to 2015**

#### 7.3.3.6. Shallow Overburden Bores

Groundwater monitoring in the Shallow Overburden seam area was undertaken from three sites during 2015. A total of 11 samples were collected during the reporting period. The pH, EC and SWL trends for 2012 to 2015 for Shallow Overburden groundwater bores are shown Figure 52, Figure 53 and Figure 54 respectively. A steady declining trend in the water level of PZ9D is likely a result of depressurisation due to mining; the bore is immediately adjacent to the Mt Thorley mine.

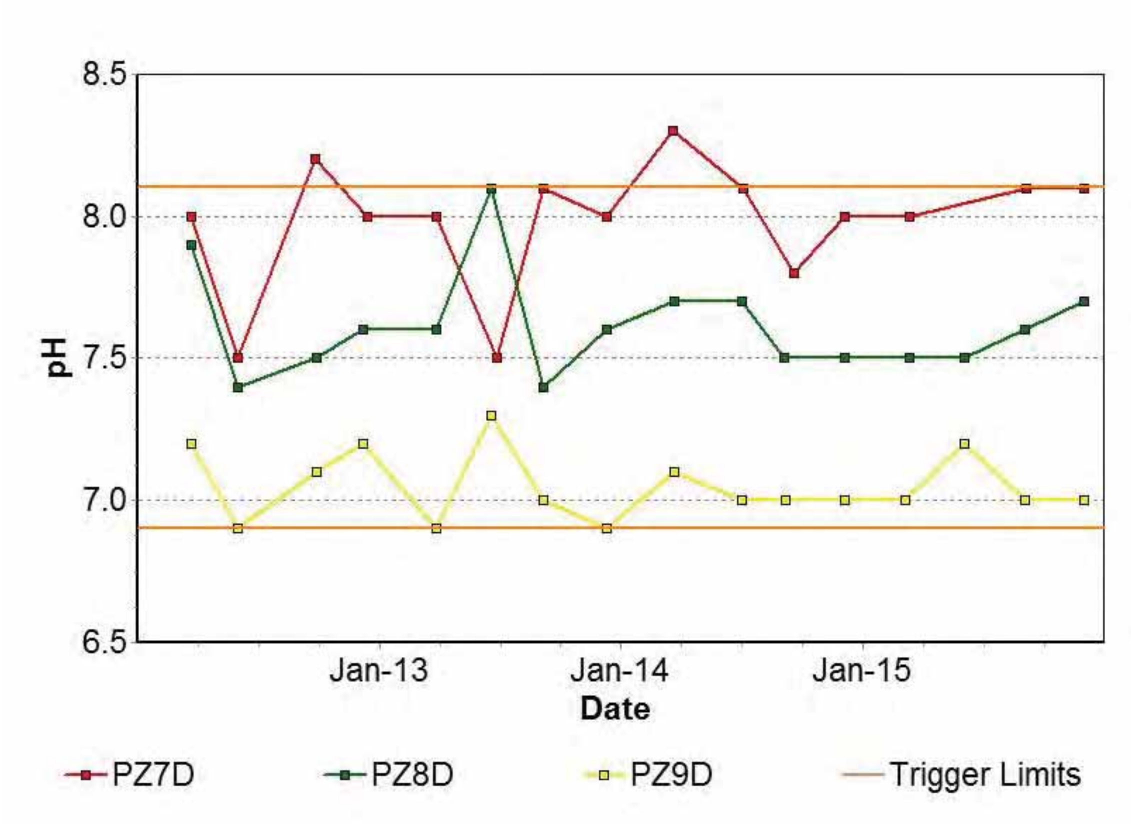


**Figure 52 : Shallow Overburden Seam Groundwater pH Trends 2012 to 2015**

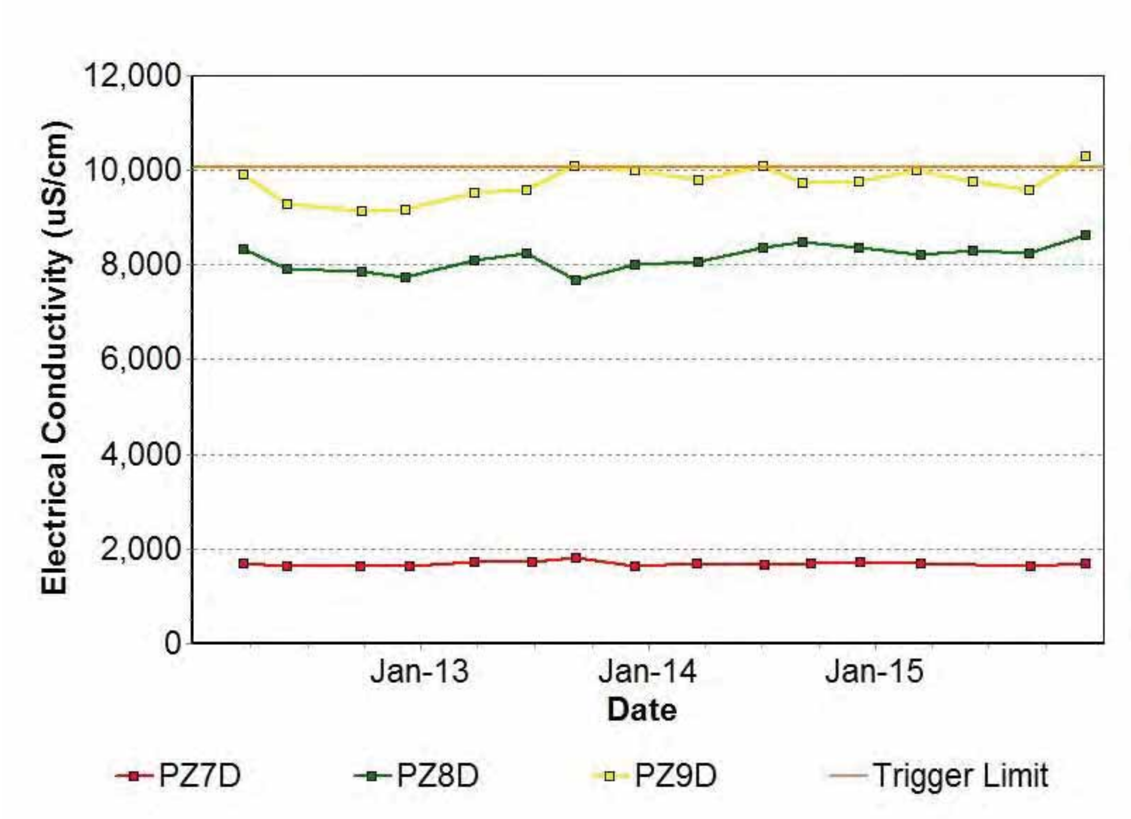


**Figure 53: Shallow Overburden Seam Groundwater EC Trends 2012 to 2015**

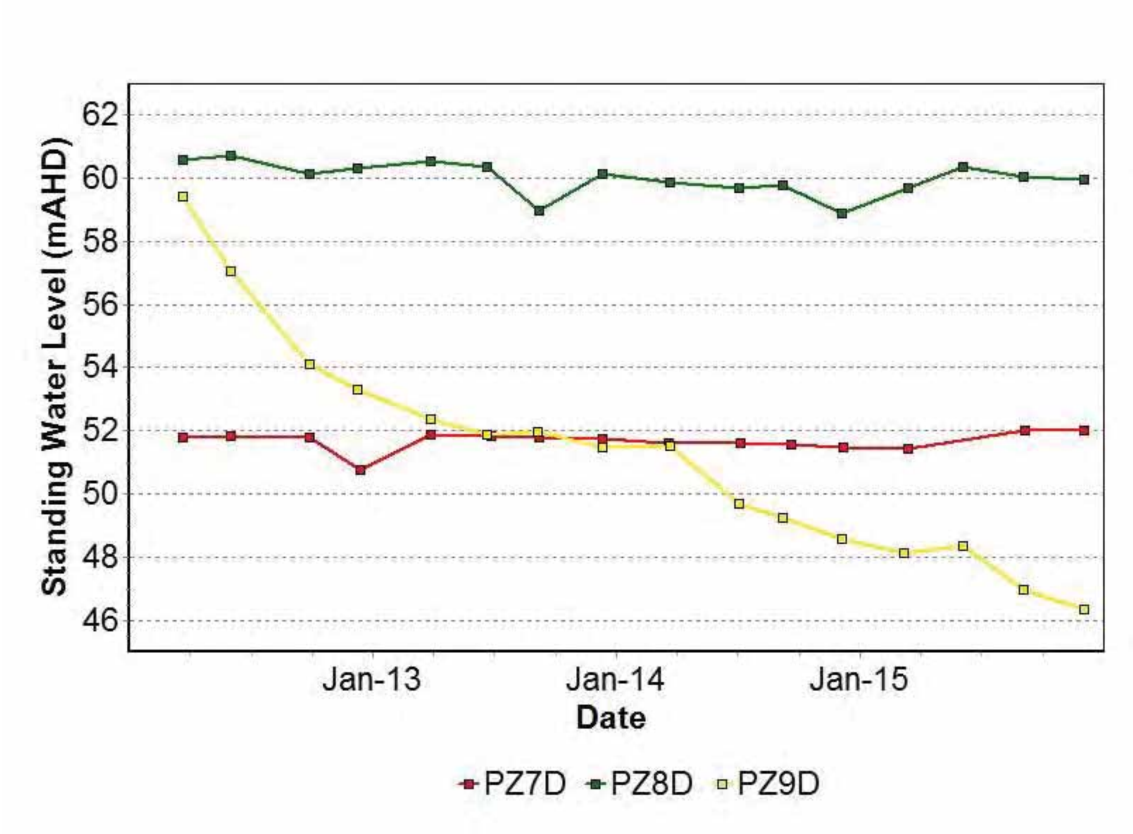


**Figure 54: Shallow Overburden Seam Groundwater SWL Trends 2012 to 2015**

#### 7.3.3.7. Vaux Seam Bores

Groundwater monitoring in the Vaux seam area was undertaken from three sites during 2015; a total of 12 samples were collected. The pH, EC and SWL trends for 2012 to 2015 for Vaux groundwater bores are shown in Figure 55, Figure 56 and Figure 57 respectively; results are consistent with historical trends.

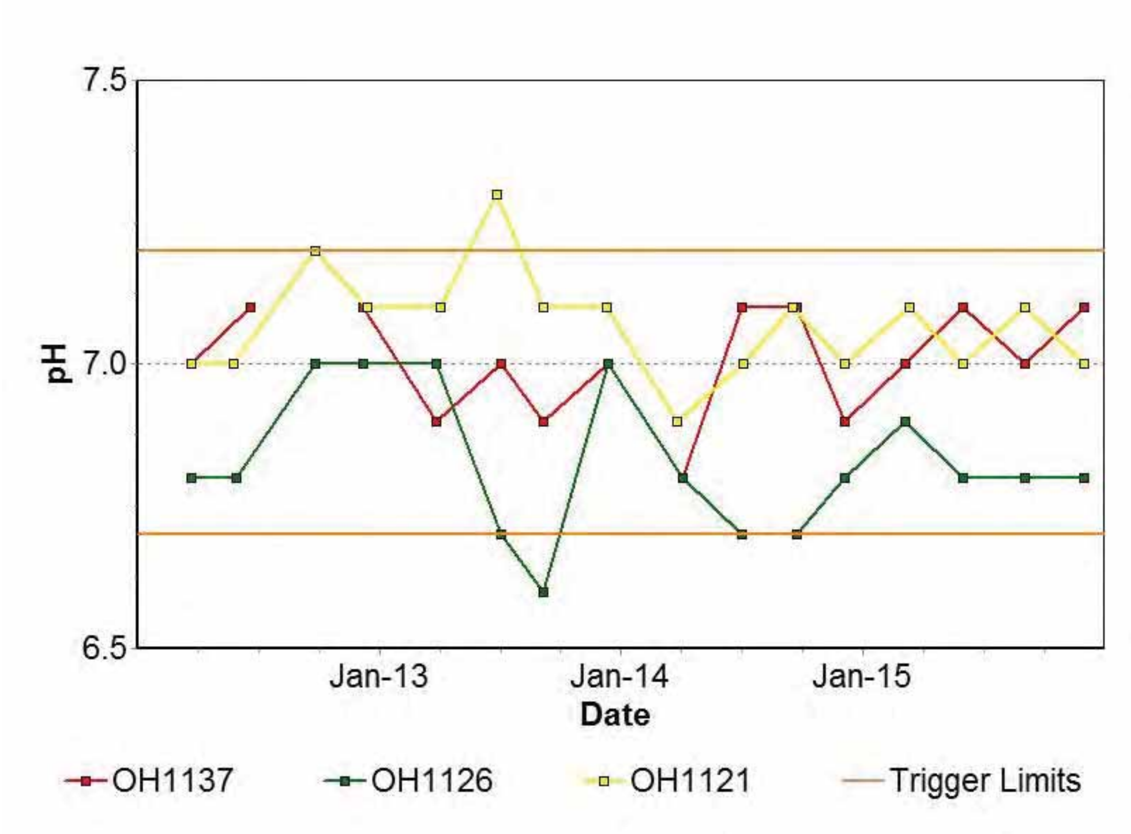


**Figure 55: Vaux Seam Groundwater pH Trends 2012 to 2015**

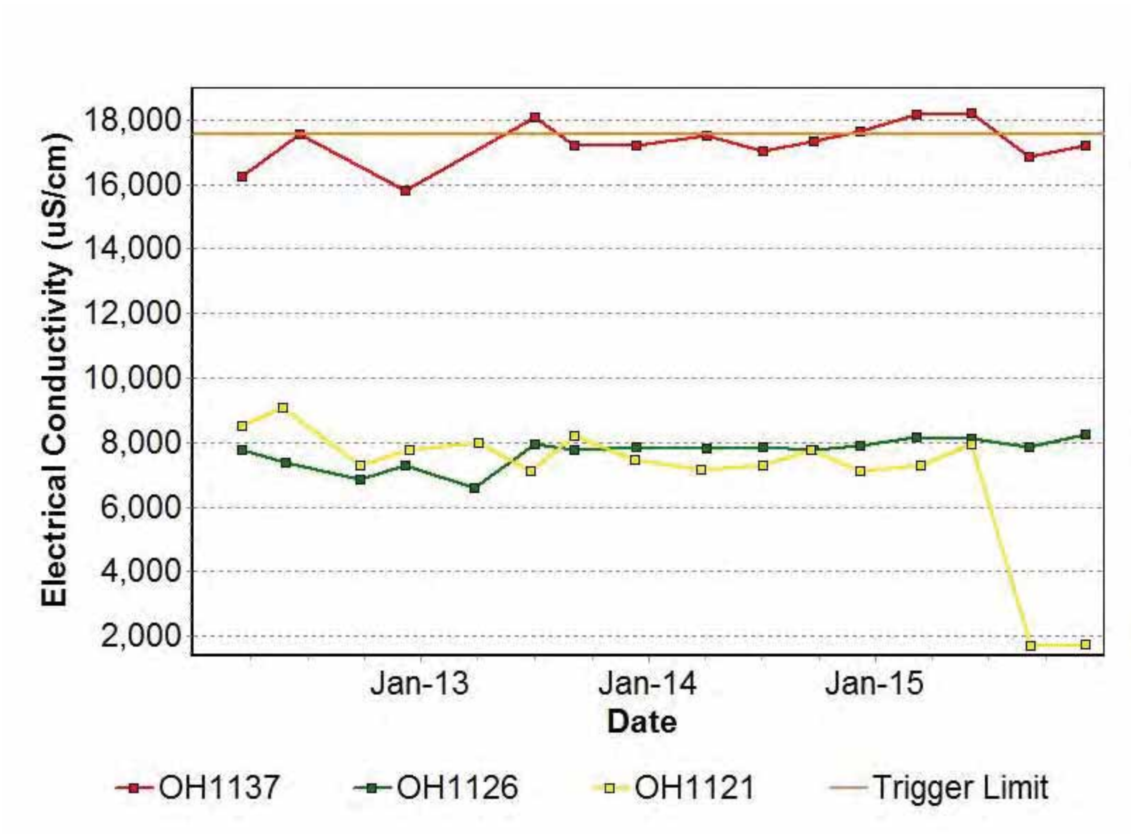


**Figure 56: Vaux Seam Groundwater EC Trends 2012 to 2015**

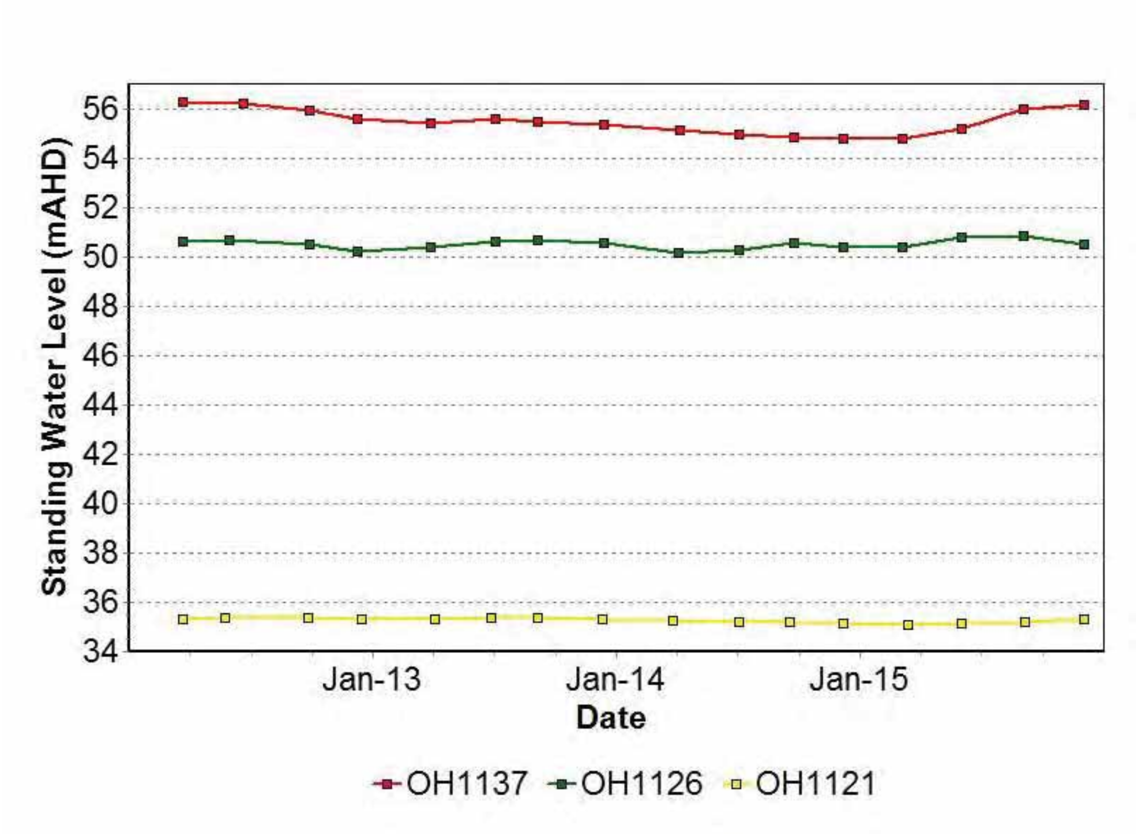


**Figure 57: Vaux Seam Groundwater SWL Trends 2012 to 2015**

### 7.3.3.8. Wambo Seam Bores

Groundwater monitoring in the Wambo seam bores were undertaken from five sites during 2015. A total of 19 samples were collected during the reporting period. The pH, EC and SWL trends for 2012 to 2015 for Wambo groundwater bores are shown in Figure 58, Figure 59 and Figure 60 respectively. Trigger tracking results are detailed in Table 36. WOH2156B had insufficient water to allow sampling during the June monitoring event. Depressurisation of the Wambo seam due to mining activities to the east appears evident in bores G3 and WOH2156B. A significant increase in water level in bore G3 was noted in December; follow-up monitoring will determine actions required.

**Table 36: MTW Wambo Seam Groundwater 2015 internal trigger tracking**

| Location | Date | Trigger limit | Action taken in response |
|---|---|---|---|
| G3 | 05/03/2015 | EC – 95th percentile | Watching Brief * |
| | 04/06/2015 | | |
| | 02/09/2015 | | Elevated EC is likely the result of coal seam depressurisation, as evidenced by falling water level. This trend is consistent with effects of nearby mining. No further action required. |
| | 01/12/2015 | | Elevated EC is the result of coal seam depressurisation due to nearby mining. No further action required. |
| G3 | 05/03/2015 | pH – 95th percentile | Watching Brief * |
| | 04/06/2015 | | |

| | | | |
|---|---|---|---|
| | 02/09/2015 | | Elevated pH is likely the result of coal seam depressurisation, as evidenced by falling water level. This trend is consistent with effects of nearby mining. No further action required. |
| WOH2156B | 12/03/2015 | EC – 95th percentile | Watching Brief * |
| | 04/09/2015 | | |
| | 02/12/2015 | | Elevated EC is likely the result of coal seam depressurisation, as evidenced by falling water level. This trend is consistent with effects of nearby mining. No further action required. |

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

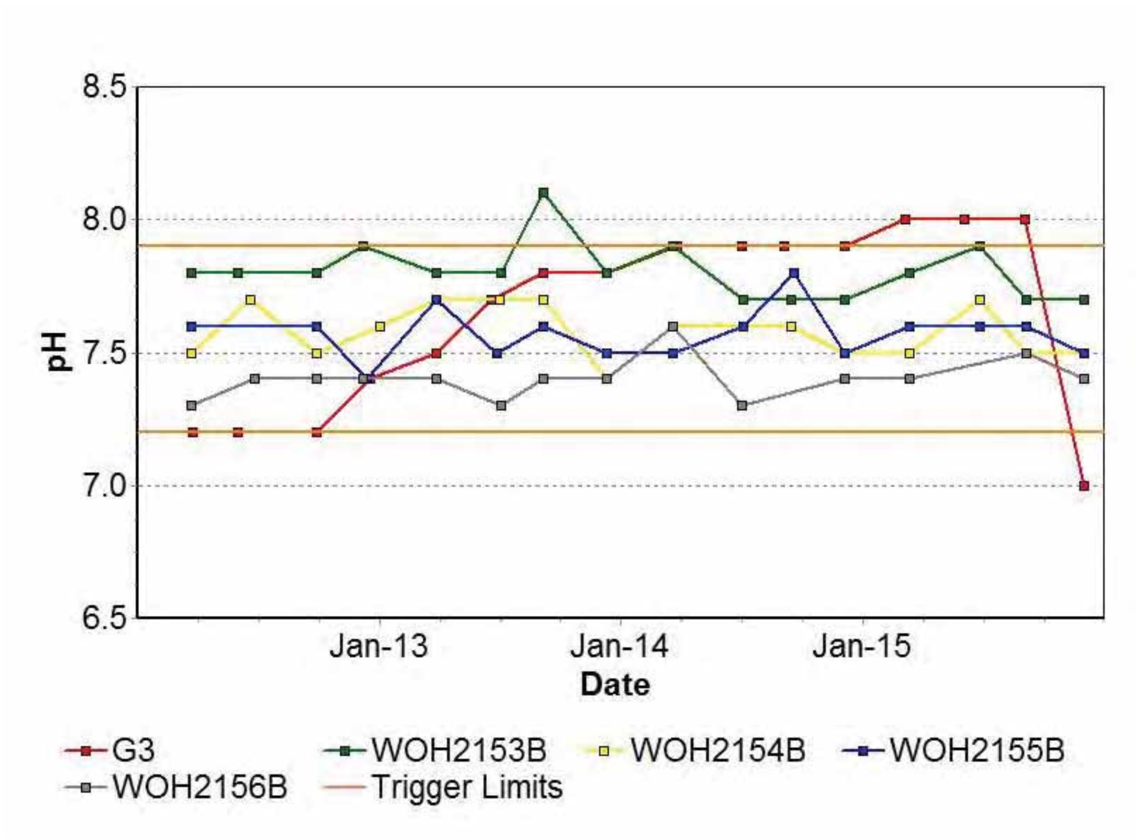


**Figure 58: Wambo Seam Groundwater pH Trends 2012 to 2015**

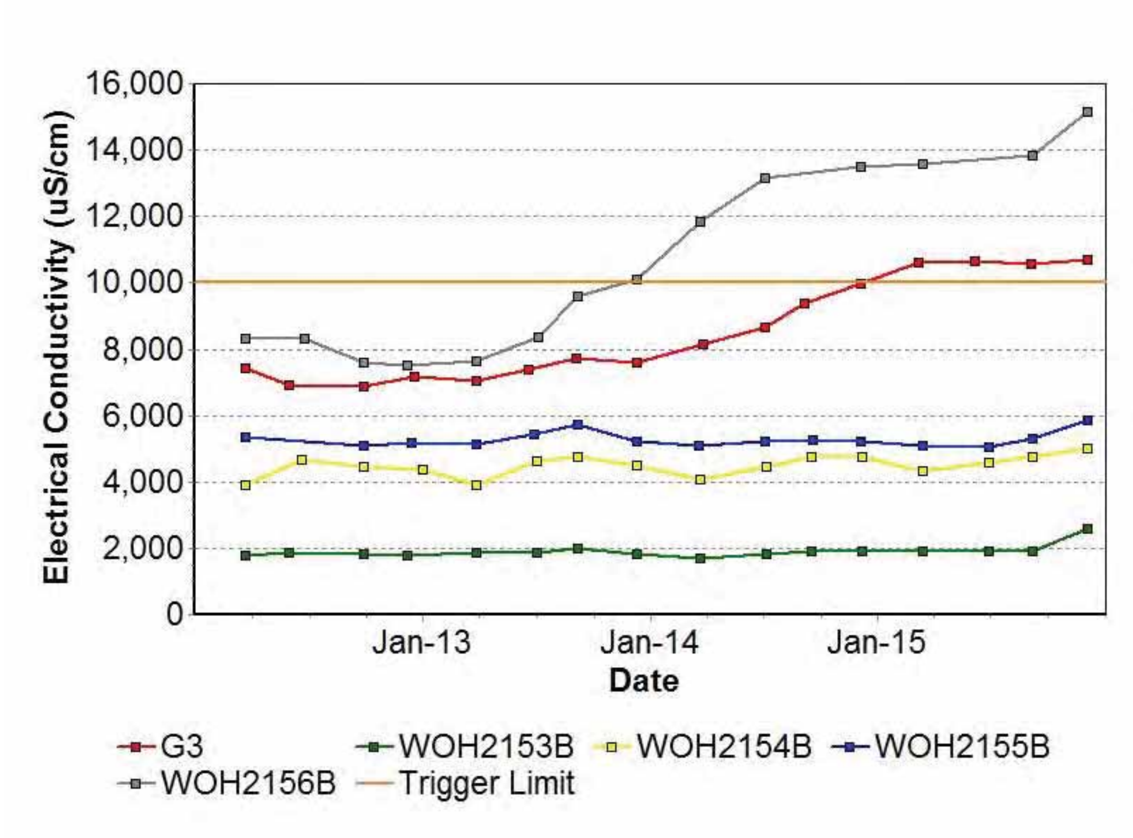


**Figure 59: Wambo Seam Groundwater EC Trends 2012 to 2015**

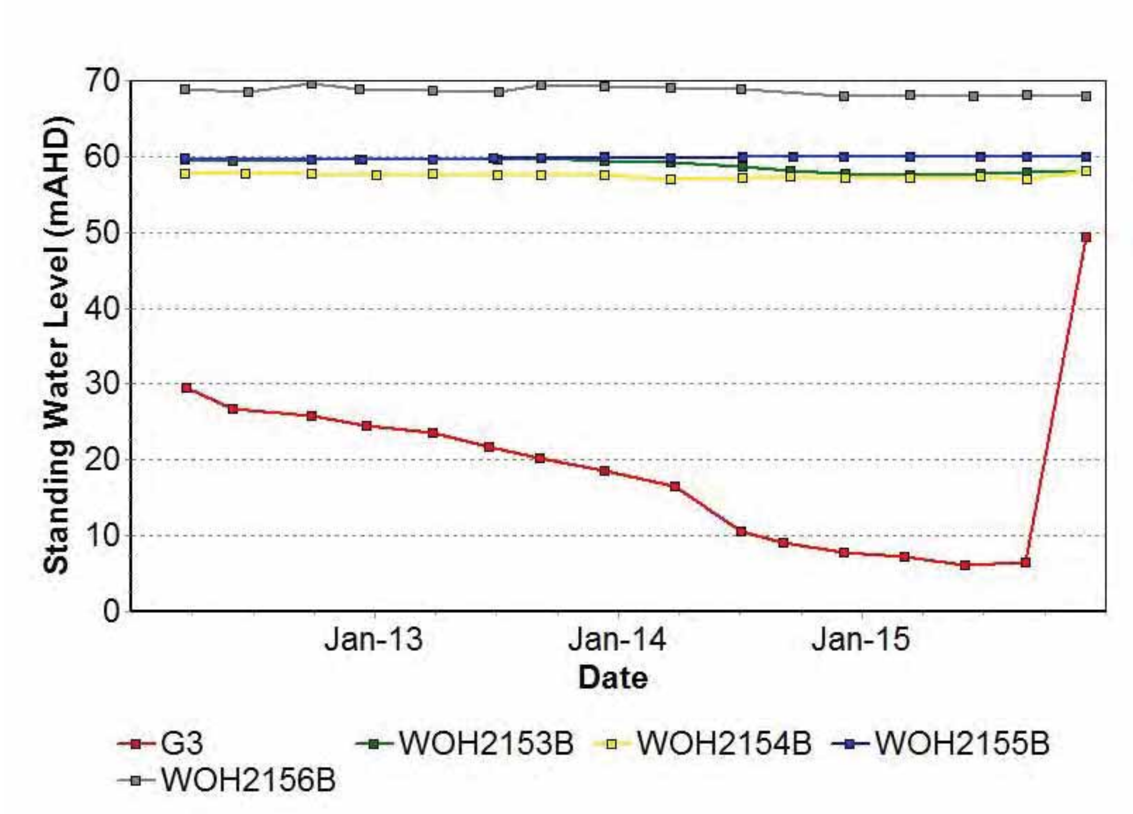


**Figure 60: Wambo Seam Groundwater SWL Trends 2012 to 2015**

#### 7.3.3.9. Warkworth Seam Bores

Groundwater monitoring in the Warkworth seam area was undertaken from two sites during 2015; eight samples were collected. The pH, EC and SWL trends for 2012 to 2015 for Warkworth seam bores are shown in Figure 61, Figure 62 and Figure 63 respectively.

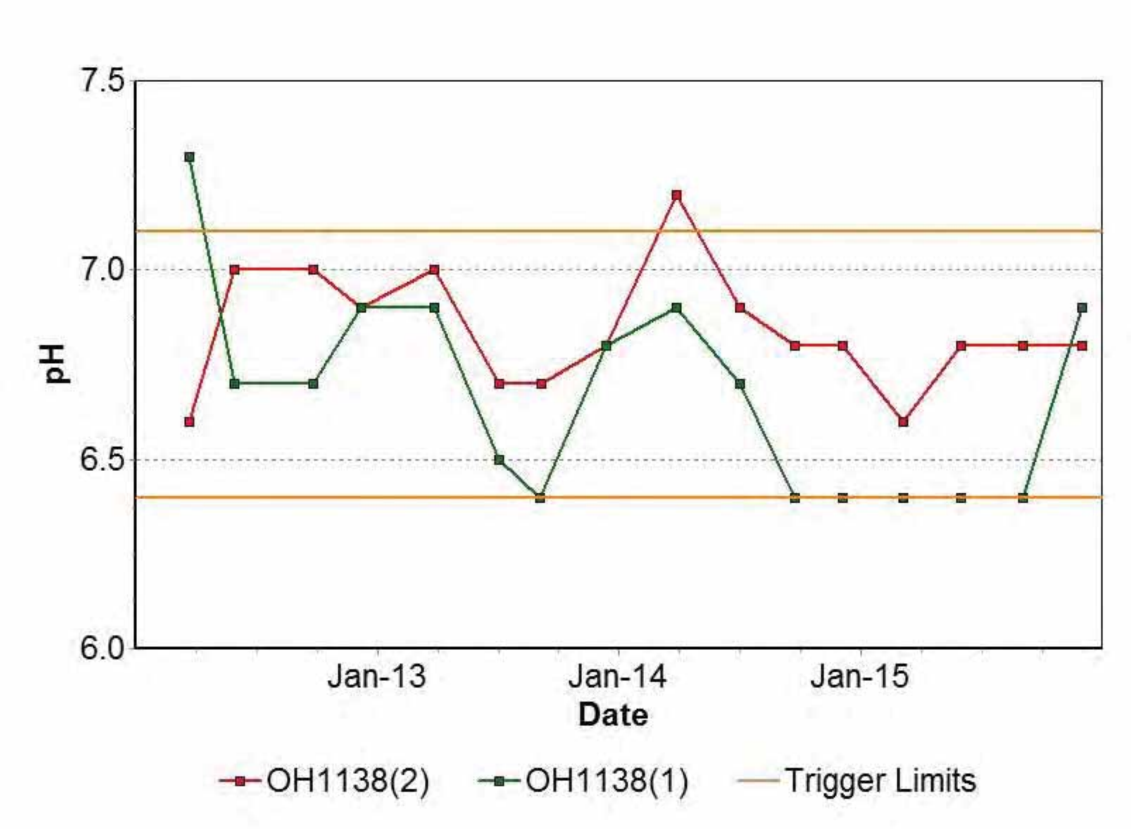


**Figure 61: Warkworth Seam Groundwater pH Trends 2012 to 2015**

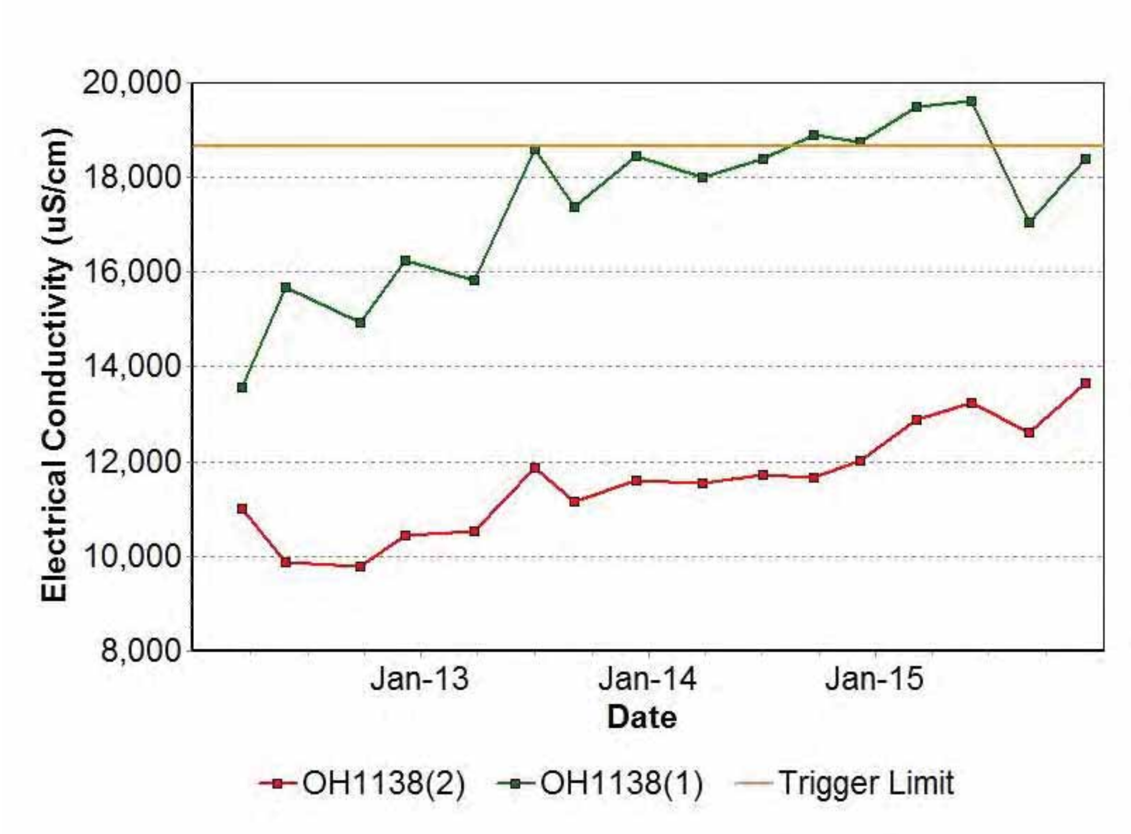


**Figure 62: Warkworth Seam Groundwater EC Trends 2012 to 2015**

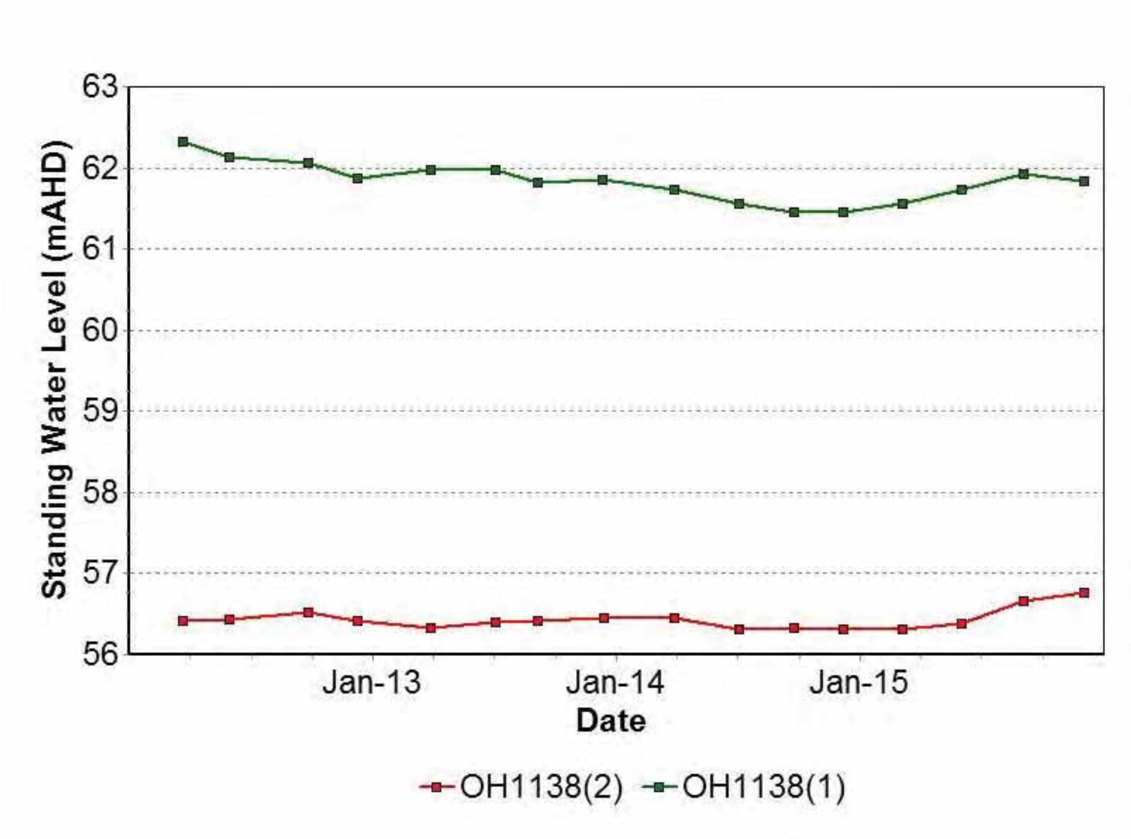


**Figure 63: Warkworth Seam Groundwater SWL Trends 2012 to 2015**

#### 7.3.3.10. Wollombi Brook Alluvium Seam Bores

Groundwater monitoring in the Wollombi Brook Alluvium seam area was undertaken from two sites during 2015; eight samples were collected. The pH, EC and SWL trends for 2012 to 2015 are shown in Figure 64, Figure 65 and Figure 66 respectively. Water levels in the bores show a rising trend following heavy rainfall in April, followed by a recession, however it is noted there was no change in the EC trend during the reporting period.

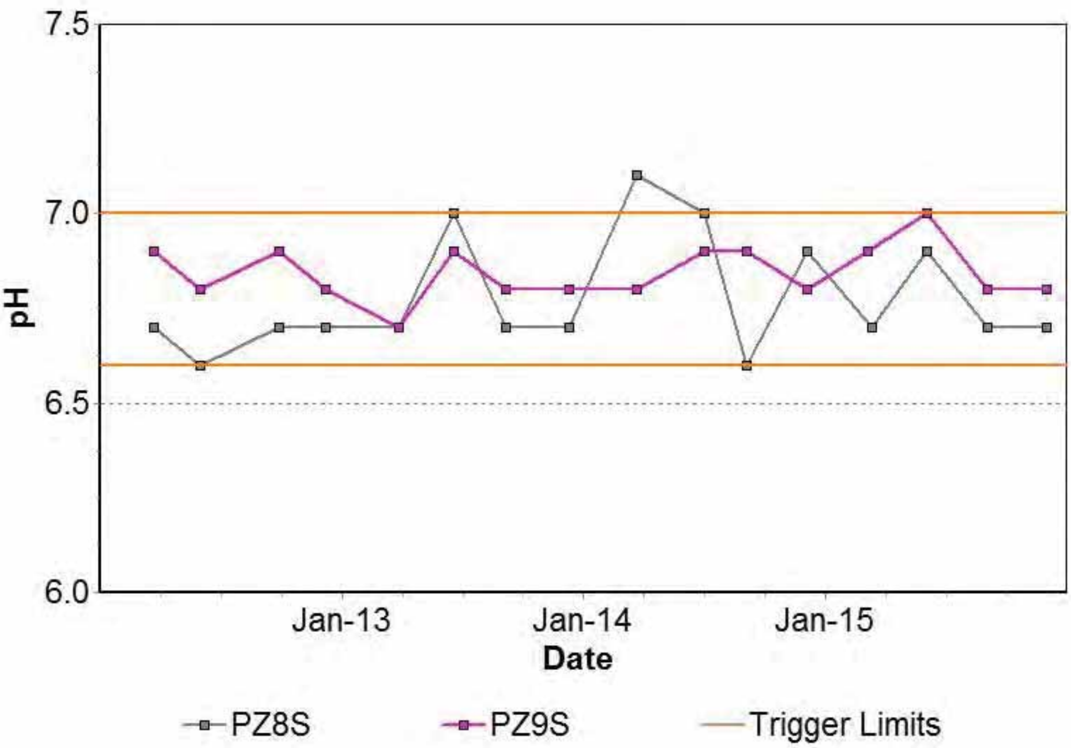


**Figure 64: Wollombi Brook Alluvium Seam Groundwater pH Trends 2012 to 2015**

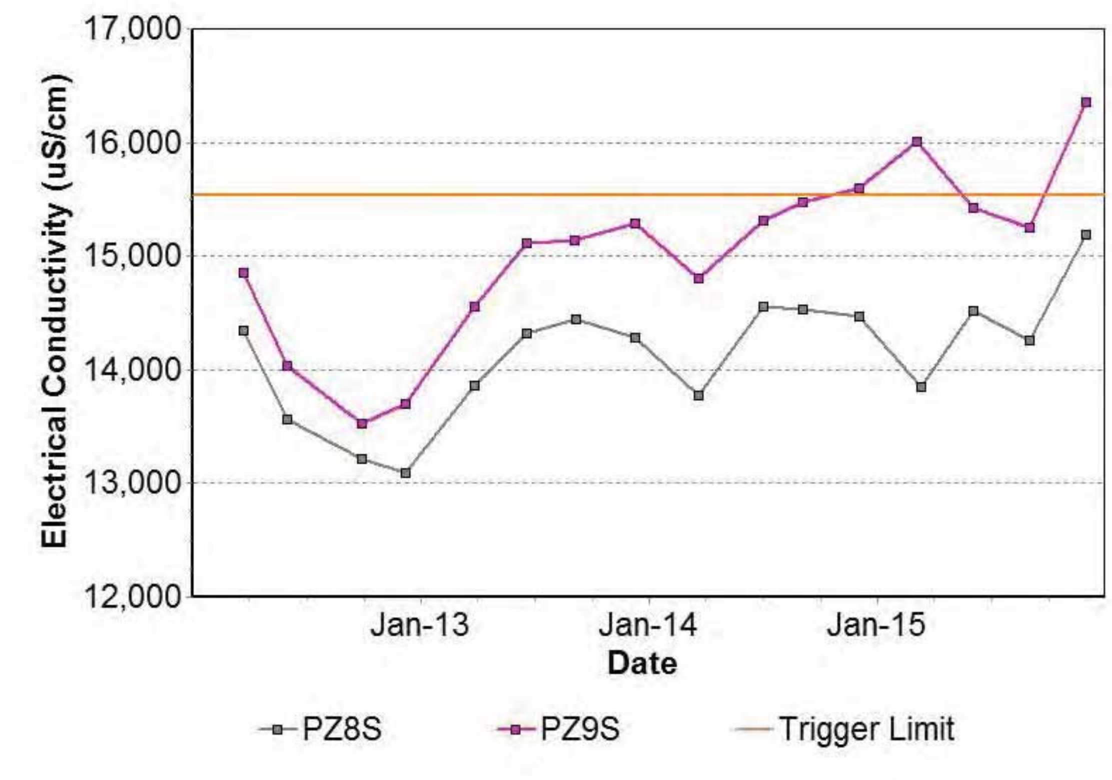


**Figure 65: Wollombi Brook Alluvium Seam Groundwater EC Trends 2012 to 2015**

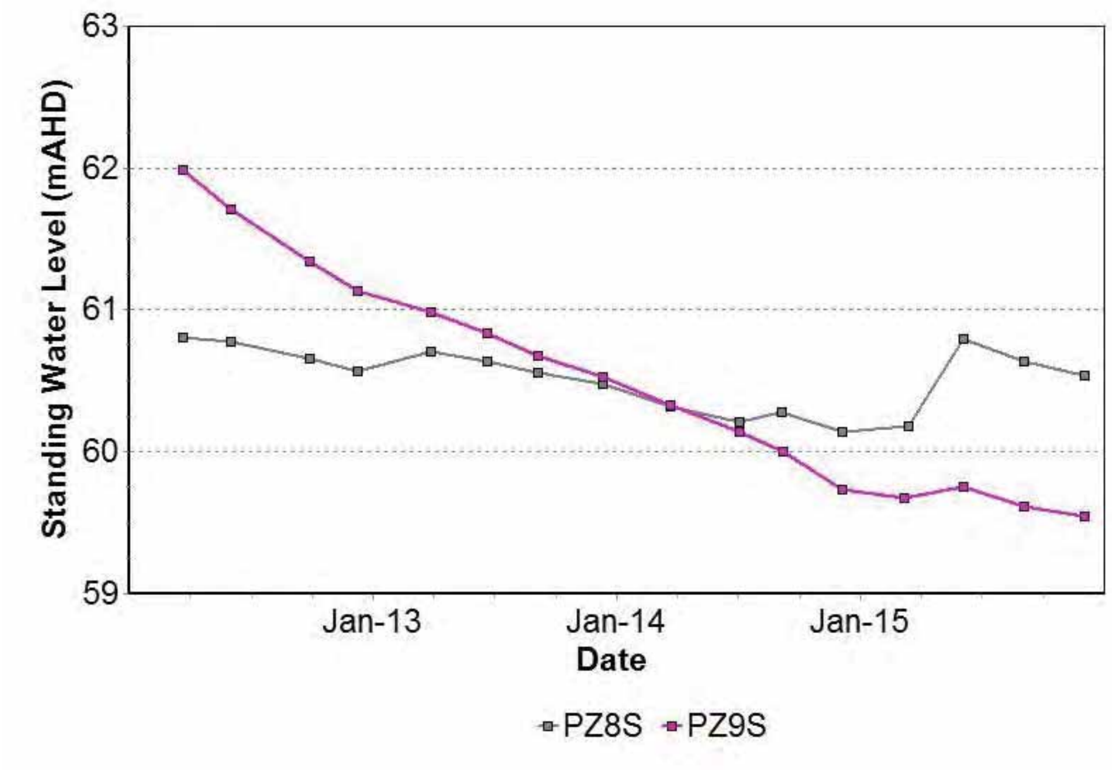


**Figure 66: Wollombi Brook Alluvium Seam Groundwater SWL Trends 2012 to 2015**

#### 7.3.3.11. Aeolian Warkworth Sands

Groundwater monitoring in the Aeolian Warkworth Sands was undertaken from one site during 2015. A total of three samples were collected; sampling was not completed in June as there was no safe access to site. The pH, EC and SWL trends for 2012 to 2015 are shown in Figure 67, Figure 68 and Figure 69 respectively.

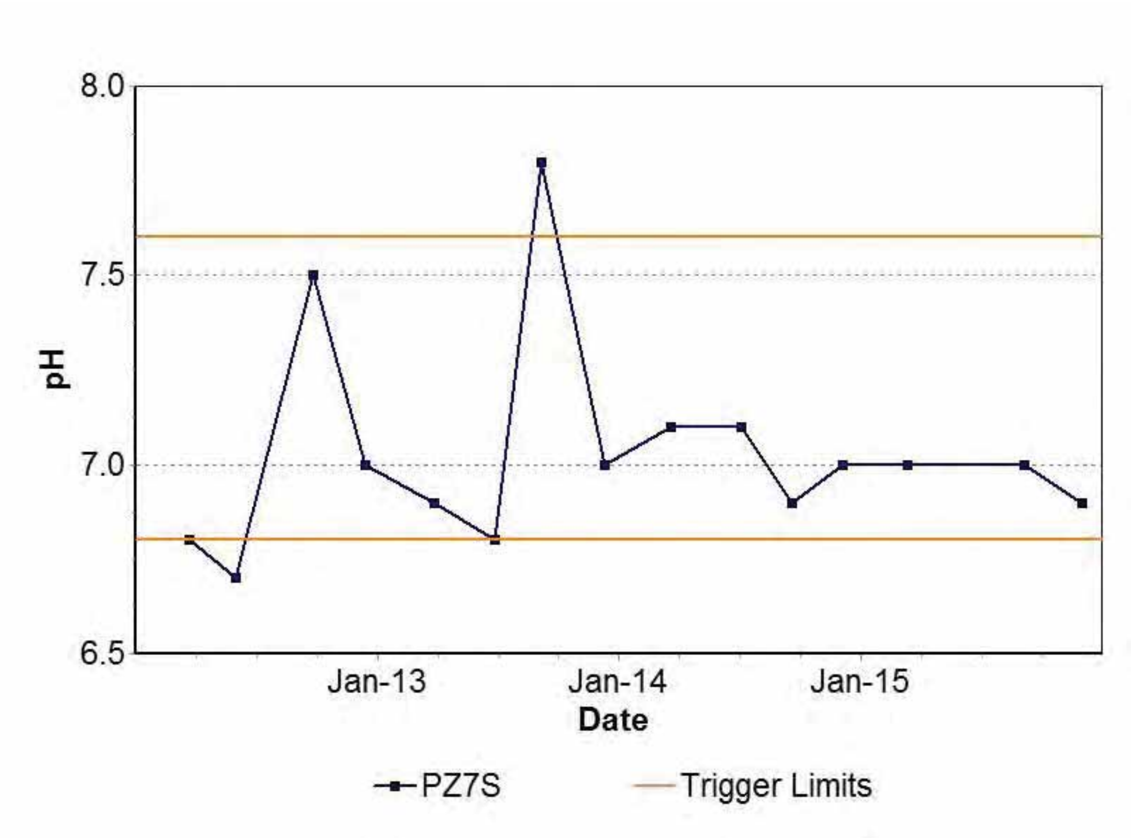


**Figure 67 : Aeolian Warkworth Sands Groundwater pH Trends 2012 to 2015**

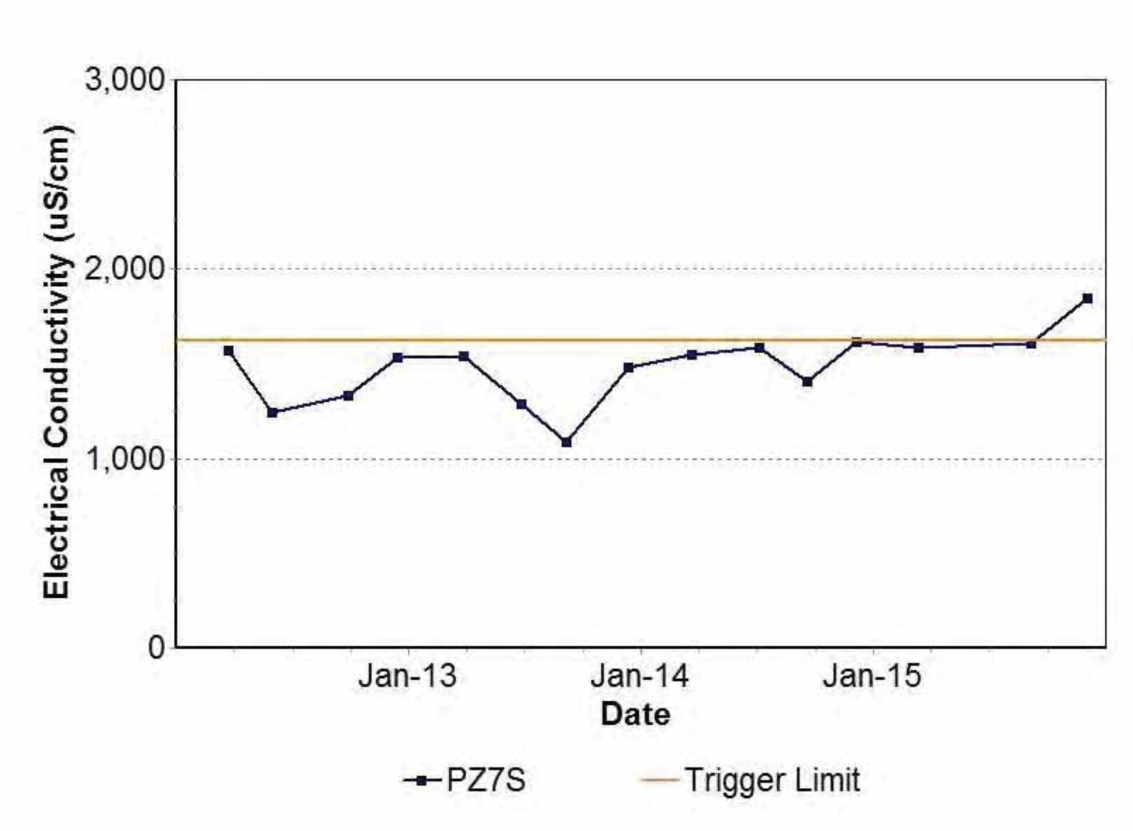


**Figure 68: Aeolian Warkworth Sands Groundwater EC Trends 2012 to 2015**

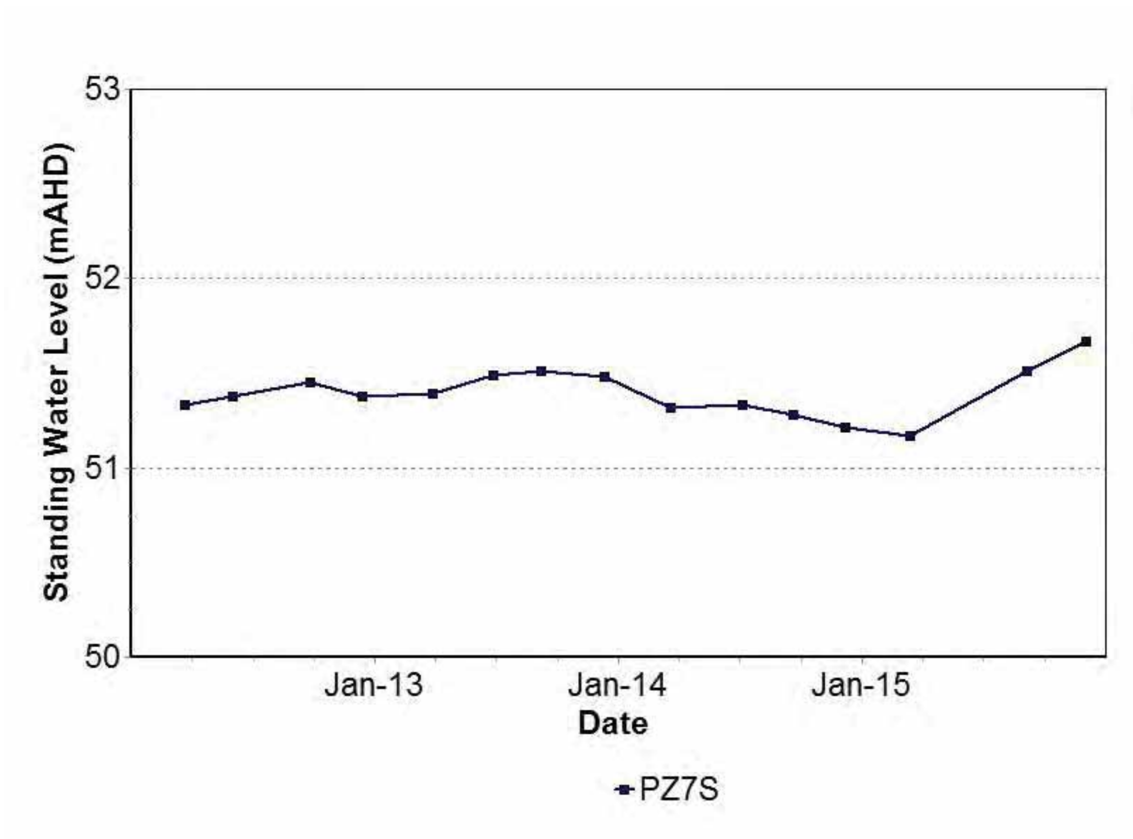


**Figure 69: Aeolian Warkworth Sands Groundwater SWL Trends 2012 to 2015**

### 7.3.4. Comparison of Water Quality Data with EA Predictions

The 2002 Warkworth Coal Mine EIS (ERM, 2002) indicated that the quality of groundwater entering the pits at MTW would continue to reflect an average of water quality for the coal measures spoils and contributions from the surrounding coal measures. An EC for water ranging from 4,000 to 6,500 µS/cm, based on measured data from Dam 1N (as the central repository for mine dewatering), was given. As Dam 1N can receive water abstracted from the Hunter River Dam 9S has been used for analogous comparison. The average EC measured in Dam 9S during the reporting period was 6,535 µS/cm, consistent with the predicted range.

### 7.3.5. Audits and Reviews

No independent audits were undertaken at MTW in 2015. An Independent Environmental Audit was undertaken during January 2016. The audit report will be published on the Rio Tinto website when finalised. A summary of findings will be presented in the 2016 Annual Review.

# 8. REHABILITATION

Rehabilitation progress has been compared to the MOP that was current at the end of the reporting period (MTW MOP 2014-2016 approved 24th November 2014).

## 8.1. Summary of Rehabilitation

A total of 75.7 ha rehabilitation was undertaken during 2015 against a MOP target of 73.8 ha. Total disturbance undertaken during 2015 was 32.9 ha, 49.1ha lower than the MOP projection of 82 ha. The disturbance during 2015 was made up of 30.7 ha of new disturbance and 2.2 ha of disturbance of previously rehabilitated area.

**Table 37: Key Rehabilitation Performance Indicators**

| Mine Area Type | Previous Reporting Period (Actual) Year 2014 (ha) | This Reporting Period (Actual) 2015 (ha) | Next Reporting Period (Forecast) Year 2016 (ha) |
|---|---|---|---|
| A. Total mine footprint[1] | 3,435.4 | 3,500.6 | 3,641.0 |
| B. Total Active Disturbance[2] | 2,512.3 | 2,466.3 | 2,533.0 |
| C. Land being prepared for rehabilitation[3] | 14.1 | 26.7 | 26.4 |
| D. Land under active rehabilitation[4] | 909.0 | 1,007.6 | 1,081.6 |
| E. Completed rehabilitation[5] | 0 | 0 | 0 |

[1] **Total mine footprint** includes all areas within a mining lease that either have at some point in time or continue to pose a rehabilitation liability due to mining and associated activities. As such it is the sum of total active disturbance, decommissioning, landform establishment, growth medium development, ecosystem establishment, ecosystem development and relinquished lands (as defined in DRE MOP/RMP Guidelines). Please note that subsidence remediation areas are excluded.

[2] **Total active disturbance** includes all areas ultimately requiring rehabilitation such as: on-lease exploration areas, stripped areas ahead of mining, infrastructure areas, water management infrastructure, sewage treatment facilities, topsoil 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).

[3] **Land being prepared for rehabilitation** – includes the sum of mine disturbed land that is under the following rehabilitation phases – decommissioning, landform establishment and growth medium development (as defined in DRE MOP/RMP Guidelines).

[4] **Land under active rehabilitation** – includes areas under rehabilitation and being managed to achieve relinquishment – includes the following rehabilitation phases as described in the DRE MOP/RMP Guidelines – “ecosystem and land use sustainability” (revegetation assessed as showing signs of trending towards relinquishment OR infrastructure development).

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

### 8.1.1 Management

Performance criteria for each rehabilitation phase have been detailed in the Mining Operations Plan (MOP) for MTW. 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.

Although the performance criteria have been set, the target levels or values will be based on monitoring results from reference sites and therefore not determined until the end of 2016. After 2016, the results of the rehabilitation monitoring programme will be able to be compared against the target levels to determine if rehabilitation has been successful or if additional intervention is needed.

Monitoring of grazing sites has commenced for both reference sites and rehabilitation sites across HVO and MTW. AECOM prepared a report detailing the monitoring results and this was included in the 2014 Annual Environmental Review. Eight reference sites have been selected across Coal & Allied owned land adjacent to HVO and MTW. These sites were selected to cover the various soil types found in the area and to cover different Land Capability Classes (five sites on Land Capability Class IV to VI; and three sites on Land Capability Class I-III). Monitoring has also been conducted on four sites each at HVO and MTW on rehabilitated land returned to grazing.

The monitoring program for rehabilitated land returned to native vegetation was commenced by ecologists from Niche Environment and Heritage during 2015. A report has been prepared, detailing the results of this monitoring program, and is presented in Appendix 5. Monitoring was conducted across 12 reference sites within the two target vegetation communities Central Hunter Grey Box-Ironbark Woodland EEC, and Ironbark-Spotted Gum-Grey Box Forest EEC. A total of 19 rehabilitation sites were monitored across MTW with sites selected to include rehabilitation of varying ages and different rehabilitation methods.

## 8.2. Decommissioning

Capping and rehabilitation of Tailings Dam 1 was completed during 2015. The drainage lines and batters were spread with topsoil while the remaining surface of the TSF was rehabilitated using a growth medium of selected mine spoil ameliorated with compost and gypsum.

## 8.3 Rehabilitation Performance

Table 38 summarises rehabilitation completed during the reporting period compared with the rehabilitation commitments in the MTW MOP. Table 39 details the disturbance completed in 2015. Appendix 3 provides the Annual Rehabilitation Report Form, including rehabilitation progress for each domain through the rehabilitation phases.

The area of rehabilitation that was sown during the reporting period slightly exceeded the combined MOP target for Mt Thorley and Warkworth.

The 2015 rehabilitation areas for MTW are shown in Appendix 4.

**Table 38: Rehabilitation Completed in 2015**

| MOP | Pit Area | 2015 Rehabilitation (ha) | | Cumulative Rehabilitation During MOP Period* (ha) | |
|---|---|---|---|---|---|
| | | Actual | MOP Commitment | Actual | MOP Commitment |
| MTW | Mt Thorley | 0 | 11.0 | 0 | 11.0 |
| | Warkworth | 75.7 | 62.8 | 179.8 | 164.9 |
| | MTW Total | 75.7 | 73.8 | 179.8 | 175.9 |

Note: Rehabilitation areas relate to areas at or past the phase of Ecosystem and Landuse Establishment.
* MOP Period is 2014 - 2016

**Table 39: Disturbance Completed in 2015**

| MOP | Pit Area | 2015 Disturbance (ha) | | Cumulative Disturbance During MOP Period* (ha) | |
|---|---|---|---|---|---|
| | | Actual | MOP Commitment | Actual | MOP Commitment |
| MTW | Mt Thorley | 0.8 | 17.3 | 34.3 | 104.5 |
| | Warkworth | 32.1 | 64.7 | 121.2 | 136.8 |
| | MTW Total | 32.9 | 82.0 | 155.5 | 241.3 |

* MOP Period is 2014 – 2016

Progressive rehabilitation commitments are outlined in the Warkworth Continuation 2014 and Mt Thorley Operations 2014 Environmental Impact Statements. These documents

modelled a total of 767 ha of rehabilitation would be complete by 2014, and a further 336 ha would be completed in the period 2015 to 2017, making a modelled total at the end of 2017 of 1,103ha. At the end of the reporting period there had been 1,008 hectares of rehabilitation completed across MTW, consistent with the EIS forecasts. A map showing the comparison of areas rehabilitated versus EIS predictions is included in Appendix 5.

The South Pit South Accelerated Rehabilitation Plan was prepared in 2014 to address lagging rehabilitation in the South pit area of Warkworth. The Plan details how rehabilitation in this area will progress between 2014 and 2018. For the period 2014 to 2015 the Plan committed to 78.4 ha of rehabilitation being completed. The actual rehabilitation amounts to 99.7 ha, which is 21.4 ha ahead of the planned progress.

### 8.3.1 Rehabilitation Programme Variations

No variations to the rehabilitation programme occurred during the reporting period.

Management of rehabilitated areas is undertaken when required or when issues are identified through monitoring, auditing or inspections. During 2015, a maintenance fertiliser application was applied to 78 ha of established pasture rehabilitation in North Pit North. A licence agreement is in place for grazing 90 ha of Warkworth North Pit North rehabilitation area.

Repairs to the drop structure in South Pit North rehabilitation were completed in 2015. The upgraded drop structure has performed well in subsequent rainfall events.

During 2015, a tractor-mounted weed wiper was trialled in rehabilitation areas to enable taller growing weeds to be selectively targeted with herbicide. The weed wiper was found to be effective at removing quick-growing exotic grass species (ie Rhodes Grass, Green Panic etc.) from areas that had been sown with native seed mixes.

## 8.4 Topsoil Management

Topsoil is managed according to Coal & Allied Ground Disturbance Permit and land management procedures. Table 40 outlines the topsoil used and stockpiled during 2015. There were 43.8 ha of rehabilitation top soiled during 2015, using stockpiled and pre-stripped soil resources. Note there was a considerable amount of subsoil in stockpiles that was removed from the topsoil stockpile inventory reported in 2014 due to unsuitable properties for use in rehabilitation activities.

**Table 40: Soil Management**

| Soil Used This Period ($m^3$) | Soil Prestripped This Period ($m^3$) | Soil Stockpiled to Date ($m^3$) | Soil Stockpiled Last Report ($m^3$) |
|---|---|---|---|
| 43,800 | 32,880 | 760,061 | 1,174,066 |

## 8.5 Tailings Management

Capping and rehabilitation of Tailings Dam 1 was completed during 2015. Capping work, using breaker rock form the South CHPP, continued on the Interim TSF.

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 41 below outlines the current state of decant water pumping infrastructure across the active and inactive TSF's at MTW.

**Table 41: Tailings Management**

| Facility | Status | Decant System |
|---|---|---|
| Centre Ramp TSF | Active | Decant pumps in place, regular pumping |
| Abbey Green South | Active | Decant pumps installed as required due to infrequent filling regime. |
| TD2 | Inactive | Diesel Pump in place |
| Interim TSF | Inactive | Floating solar pump installed |
| Ministrip TSF | Inactive | Diesel Pump in place, pumping as required |

## 8.6 Weed Control

### 8.6.1 Weed Treatment

The weeds identified at MTW 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 66 days of weed management work was undertaken on site at MTW during 2015, with 148 ha of land treated, including maintenance of access tracks and Environmental Monitoring Points. The weeds targeted during the 2015 weed management program were based on the results of the 2014 weed survey. Figure 70 illustrates the weed treatment areas at MTW. Weed treatment areas are assessed following the completion of periods of work to determine the effectiveness of control works.

The species focussed on during treatment included:

- African Boxthorn *(Lycium ferocissimum)*
- Lantana *(Lantana Camara)*
- Castor Oil Plant *(Ricinus communis)*
- Galenia *(Galenia pubescens)*
- Mother of Millions *(Bryophyllum delagoense)*
- Pampas Grass / African Love Grass *(Grass sp)*
- African Olive *(Olea europea subspecies cuspidae)*

- 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)*

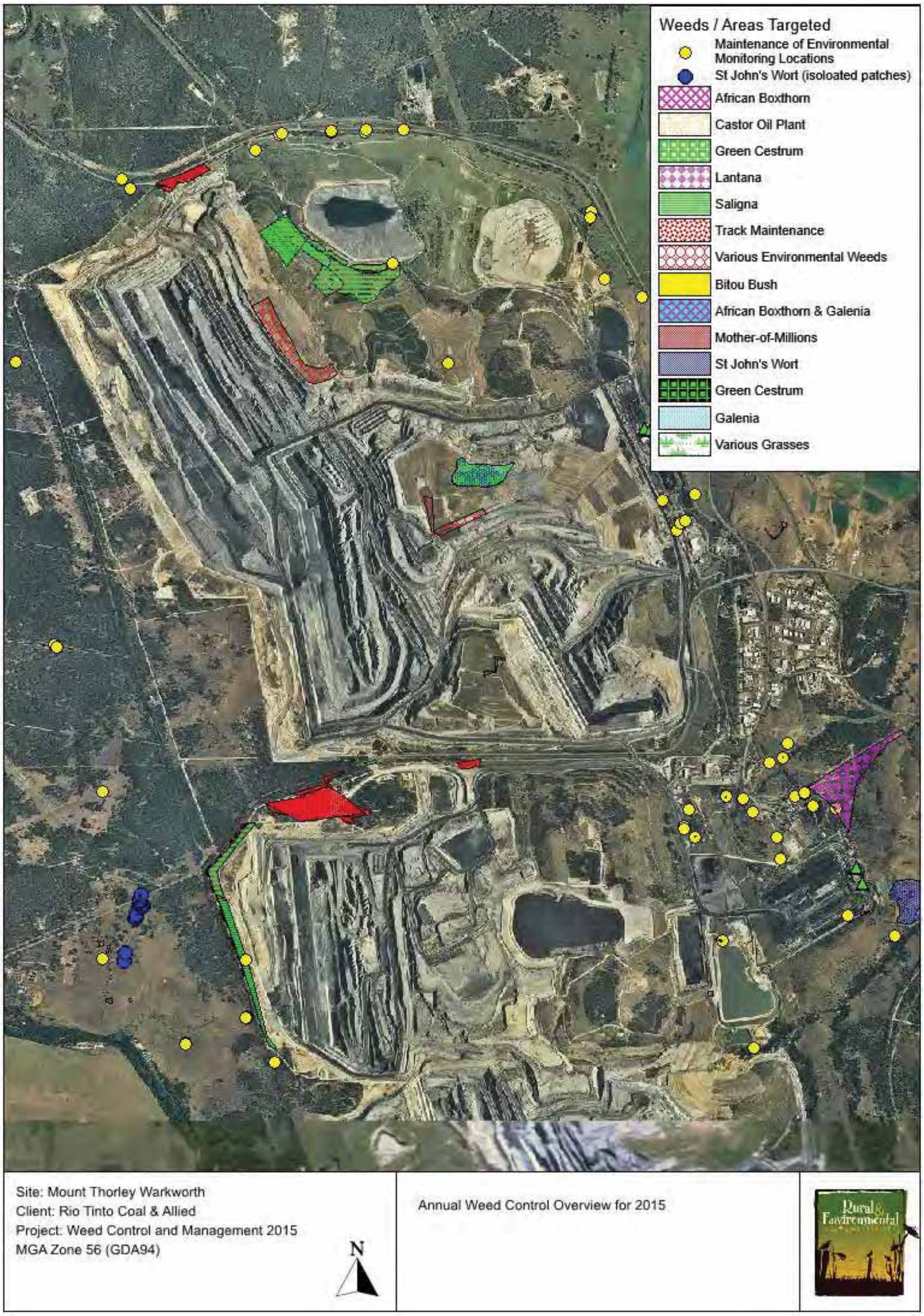


**Figure 70: Annual Weed Control Overview for 2015**

### 8.7.2 Annual Weed Survey

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

An annual site weed survey was undertaken during November 2015. The following summarises the results of the survey:

Six WONS were identified during the survey, they included:

- African Boxthorn (*Lycium ferocissimum)*
- Bitou bush (*Chrysanthemoides monilifera subspecies rotundata)*
- Lantana (*Lantana camara*)
- Pear Species,
    - Creeping Pear (Opuntia humifusa)
    - Prickly Pear Opuntia stricta)
    - Tiger Pear (Optunia aurantiaca)

Two other noxious weeds were identified at MTW during the survey, including:

- Mother of Millions *(Bryophyllum delagonese)*
- St Johns Wort *(Hypericum perforatum)*

Seven environmental weed species were identified at MTW during the survey, they included:

- African Olive *(Olea europea subspecies cuspidae)*
- Castor Oil Plant *(Ricinus communis)*
- Galenia (*Galenia pubescens)*
- Moth Vine (*Araujia sericifera*)
- Various Thistles
    - Scotch Thistle (*Onopordum acanthium),*
    - Saffron Thistle(Carthamus lanatus)
    - Variegated Thistle (Silybum marianum) (to a lesser degree)

Eight weeds that are not officially declared or listed were also recorded at MTW including:

- Aloe Vera (*Aloe vera*)
- Century plant (*Agave americana*)
- Fennel *(Foeniculum vulgare),* sparsely scattered over entire site
- Golden wreath wattle or Saligna (*Acacia saligna)* – sparsely scattered over entire site
- Narrow Leaved cotton bush (*Gomphocarpus fructicosus*)- sparsely scattered over entire site
- Rhodes Grass (*Chloris gayana Kunth)*
- Spiny Rush *(Juncas acutus)*

- Wild Rose (*Rosa species*)

Species identified during the 2015 survey will form the basis of ongoing weed management works during 2016.

## 8.8 Vertebrate Pest Management

As part of MTW's Vertebrate Pest Action Plan a control programme is carried out quarterly and on a seasonal basis. Two 1080 baiting programmes were undertaken by REM during Winter and Spring 2015, to target wild dogs and foxes. Baits were checked weekly over a four week period and replaced each week where taken.

In Winter 44 baits were taken by dogs (and one bait by a fox) across 40 bait sites. In Spring, 77 baits were taken by dogs and six taken by foxes across 60 bait sites.

Additional pest management programmes included:

- Feral cat trapping; three cats were caught and humanely euthanised.
- Feral pig trapping in areas where pigs were evident at MTW and the Warkworth Biodiversity Area during winter. Three traps were set with seven feral pigs trapped and euthanised.

MTW will continue to carry out quarterly vertebrate pest control programmes during 2016 to limit feral pest impacts on landholdings and surrounding neighbours.

Table 42 summarises the results from the programmes carried out at MTW during 2015 with baiting locations and results for the Spring program illustrated in Figure 71.

**Table 42: Vertebrate Pest Control Summary**

| | Total Lethal Baits Laid | Wild Dog Takes | Fox Takes |
|---|---|---|---|
| Winter | **120** | **44** | **1** |
| Spring | **180** | **77** | **6** |
| **Total** | **300** | **121** | **7** |


**Figure 71: Baiting Station Locations and Results at MTW during the Spring 2015 Control Program**

## 8.8 Green Offsets

### 8.8.1 Management

The Warkworth Mine's impacts on biodiversity values are offset through the protection and management of Biodiversity Areas (BAs) which are managed in accordance with the Local, Putty Road, and Regional Offset Management Plans (OMPs).

The OMPs 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 Rio Tinto website.

### 8.8.2 Research

The University of New England (UNE) whom undertook the *Restoration Research for Warkworth Sands Woodlands* project continued to publish the research papers arising from this research in 2015.

### 8.8.3 Green Offsets Management Activities

The OMPs describe the Conservation Management Strategies. The following are the key actions completed throughout 2015 across all the BAs:

- Weed Control: Declared and environment weeds were sprayed by contractors within the Green Offset, Northern and Southern BAs, control targeted significant outbreaks of lantana, mother of millions and prickly pear.
- Vertebrate Pest Management: Contractors completed on ground control (including opportunistic shooting at the Regional BAs) throughout 2015, targeting wild dogs and pigs.
- Strategic Grazing: No strategic grazing was undertaken in the BAs in 2015.
- Revegetation: Re-establishment of Warkworth Sand grassland, including the rehabilitation of a disused sand quarry commenced in 2014. Following survival surveys 3 and 6 months post planting, additional tube stock were planted in the WSW re-establishment areas in spring 2015.
- Seed Collection: Opportunistic seed collection was undertaken by contractors in the Green Offset, Northern and Southern BAs during 2015, focussing on the WSW and Ironbark vegetation community. Tube stock for future plantings is currently being propagated from the seed collected.
- Infrastructure Management and Improvement: A boundary fence and track condition audit was completed within the Green Offset and Southern BAs. A new boundary fence was constructed at the Bowditch BA, and boundary fences on the Goulburn River BA were repaired.

- Fire Management: The Regional Offset Bushfire Management Plan and the Warkworth Mine Bushfire Management Plan were reviewed.

### 8.8.4 Audits and Reviews

An independent audit of the EPBC 2002/629 Annual Report as required by Condition 3 of EPBC 2002/629 was undertaken by SMEC. The audit consisted of a review of documents supporting the EPBC approval and the implementation of these documents along with a site inspection of the regional offsets – Goulburn River Biodiversity Area and Bowditch Biodiversity Area. The audit found that Rio Tinto was compliant with all conditions of the EPBC Approval, and recommended minor updates to the Regional OMP.

# 9. COMMUNITY

## 9.1. Complaints

A total of 655 complaints were recorded during the reporting period; a breakdown of complaints is shown in Table 43. In summary:

- 32% reduction in complaints received during 2015;
- 40% reduction in noise complaints is attributed to installation of sound attenuation to an additional 40 trucks (section 3.2 Operational Noise); and
- A notable increase in lighting complaints from 2014. Analysis of received lighting complaints identifies 65% of the lighting complaints in 2015 attributed to a single residence (zero complaints had been received in 2014 from this residence).
- Complaints relating to blasts during 2015 were steady compared to the previous reporting period.
- There were zero complaints relating to water during the reporting period.

During 2015 MTW received 492 noise complaints compared to 809 in 2014 (a reduction of approximately 40%). The majority of complaints came from residents in the Bulga community. It is noted that the level of complaints received from Bulga residents remains high (despite improvements in noise management and a demonstrated high level of compliance in this area), confirming that noise remains a key area of concern with near neighbours.

During 2015 MTW received 62 dust complaints, compared to 27 in 2014, an increase of approximately 130% on 2014 level, but consistent with the number of complaints received in 2013 (48 complaints received).

**Table 43: Summary of Complaints by type for 2013 to 2015**

| Complaint type | 2015 | 2014 | 2013 |
|---|---|---|---|
| Noise | 492 | 809 | 633 |
| Blasting | 54 | 52 | 38 |
| Dust | 62 | 27 | 48 |
| Lighting | 44 | 15 | 20 |
| Water | 0 | 0 | 0 |
| Other | 3 | 8 | 2 |
| **Total** | **655** | **911** | **741** |

*A full summary of complaints recorded in 2015 is presented in Appendix 1*

### 9.1.1. Community Response Officers

Since 2012 three community response officers have been working with the mining team at MTW to provide community members with a more direct line of communication to the mine, particularly during the night. In addition to providing a timely response to community concerns during non-work hours their role includes on and off site inspections, capturing and communicating operational changes in response to alarms, weather conditions and community feedback and calls to MTW's Community Complaints Hotline. They also suggest continuous improvement ideas to further improve environmental performance.

## 9.2. Review of Community Engagement

### 9.2.1. Communication

Coal & Allied has previously distributed a Hunter Valley Community Newsletter, containing regular updates about MTW and its community activities, to businesses and residences in the Singleton and Muswellbrook Local Government Areas (LGAs). In 2015, an autumn edition of the newsletter was issued, before Coal & Allied transitioned to full-page newspaper advertorials.

Newspaper advertorials were published in The Singleton Argus, Muswellbrook Chronicle and The Scone Advocate in the months of June and November. The three publications have a combined readership of approximately 16,000 people. Coal & Allied intends to continue placing these full-page advertorials as yet another way to communicate about its operations.

Quarterly letters are sent to MTW's near neighbours to provide an overview of mining operations and other relevant activities, as well as inform residents about how impacts are being managed. In addition, Coal & Allied issues correspondence to specific near neighbours who may be affected by certain changes. In 2015, this included communication relating to the Planning Assessment Commission approvals process, as well as information regarding Zone of Acquisition (ZoA) and Zone of Mitigation (ZoM) conditions following the approval of MTW's expansion application.

During July, a Coal & Allied information stall was held at the Gowrie Street Mall shopping complex at Singleton, in a bid to gather support for the MTW continuation project. Residents were provided information about the approval process, with community members asked to offer their support by completing a submission on the 'Voice of Mining' website.

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

- Engagement and consultation with near neighbours to provide project updates at key project milestones and activities, and in response to concerns/queries raised by individual near neighbours
- Local Council briefings
- School engagement- working with teachers and students to assist and enhance learning outcomes and build relationships
- Participation in the Upper Hunter Mining Dialogue – a programme co-ordinated by the NSW Minerals Council to engage the community across the Hunter Valley

- Hosting the Singleton Professions Forum – a career expo-style event aimed at supporting career options and diversity within the Singleton area
- Capacity building: building the capacity of local Aboriginal businesses and community organisations to bid for and win small to medium contracts in the mining industry. This involved Procurement and Projects team site visits, and support for the development of teaming agreements with mainstream contractors.

#### 9.2.2. Community Consultation Committee

The MTW CCC met on a quarterly basis to discuss our operations. The Committee is comprised of Coal & Allied representatives, community members and other key external stakeholders, including Council. The MTW CCC minutes are available on the Rio Tinto website. The community is invited to visit the website to learn more about the MTW CCC, as well as other Coal & Allied operations and projects.

### 9.3. Community Development

In 2015, Coal & Allied 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)
- Coal & Allied Aboriginal Community Development Fund (ACDF)
- Mount Thorley Warkworth Site Donations Committee
- Community partnerships

#### 9.3.1. Community Development Funding Programs

In 2015, the ACDF and CDF programmes contributed more than $900,000 to support capacity building and contribute to the long-term sustainability of surrounding communities. For more information about Coal & Allied community funding programmes visit http://www.riotinto.com/energy/community-funds-10413.aspx.

**Community Development Fund (CDF)**

This year marked 17 years of operation of the CDF, which has invested $14.5 million to support more than 120 community projects across the areas of health, education, environment and economic development in the Hunter Valley since its inception in 1999.

In 2015, the CDF invested more than $900,000 in 10 new programmes aimed at delivering long-term benefits for communities in the CDF catchment, which included the Singleton, Muswellbrook, and Upper Hunter LGAs. A further $1.5 million is available for allocation in 2016-2017.

**Table 44: Coal & Allied Community Development Fund projects approved in 2015**

| Programme | Partner |
|---|---|
| Enterprise Facilitation | Sirolli Institute |
| Supporting Children's Developing Social Competence | Early Links Inclusion Support Service |
| Science and Engineering Challenge, and SMART Program (2015 - 2017) | University of Newcastle |
| Upper Hunter Education Fund Scholarships (2015 - 2017) | Upper Hunter Education Fund |
| Upper Hunter Beef Bonanza | Upper Hunter Beef Bonanza |
| Singleton High School Agricultural Course | Singleton High School |
| University of Newcastle Scholarships | University of Newcastle |
| Singleton Community College Strategic Plan | Singleton Community College |
| HSC Study Camps | Upper Hunter Education Fund |
| Ready 4 School Program | Jerrys Plains Public School |

**Table 45: Active Coal & Allied Community Development Fund programmes running throughout 2015**

| Programme | Partner |
|---|---|
| Upper Hunter Shire Council Community Engagement | Upper Hunter Shire Council |
| Building Skills and Leadership Capacity in Rural NSW | Royal Agricultural Society (NSW)Foundation |
| Hunter Youth Leadership Program | The Australian Outward Bound Development Fund |
| People in Your Neighbourhood- Sustainability Street | Muswellbrook Shire Council |
| Tocal Schools Steer Challenge | Department of Primary Industries Tocal College |
| Local SME Supply Chain Participant project | HunterNet |
| Scholarship Program | University of Newcastle |
| Economic Development and Funding Coordinator | Singleton Council |
| Business Development Officer | Singleton Business Chamber |
| Singleton Place Making (ends in July 2015) | Singleton Council |
| Science and Engineering Challenge and SMART Program | University of Newcastle |

| | |
|---|---|
| Enterprise Facilitation | Sirolli Institute |
| Upper Hunter Beef Bonanza | UHBB |
| Supporting Children's Developing Social Competence | Early Links |
| Upper Hunter Education Fund Scholarships | UHEF |

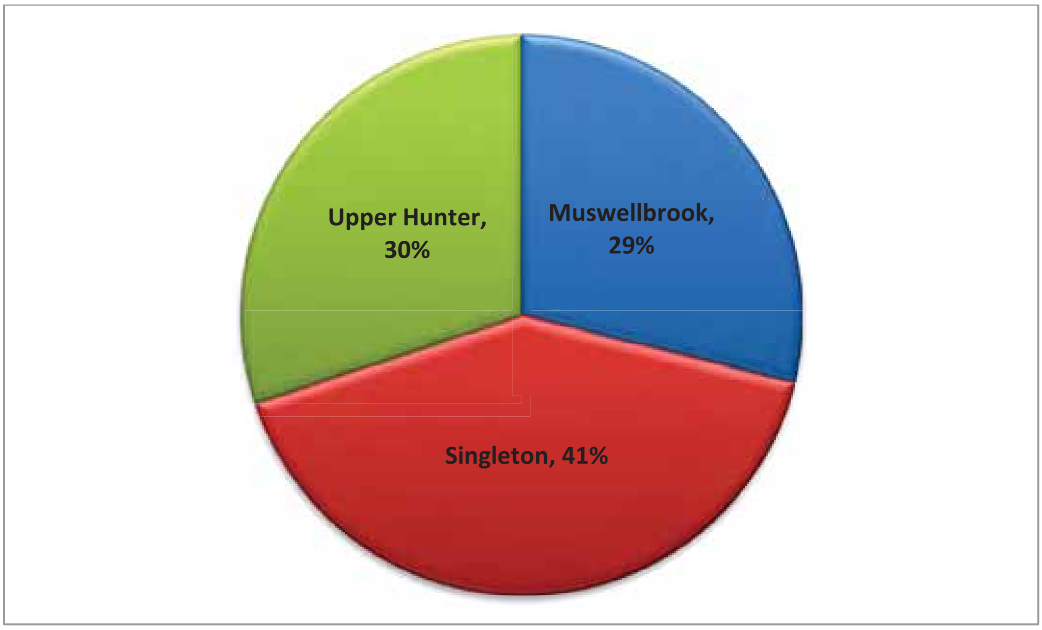


**Figure 72: Distribution of Community Development Fund by LGA 2015**

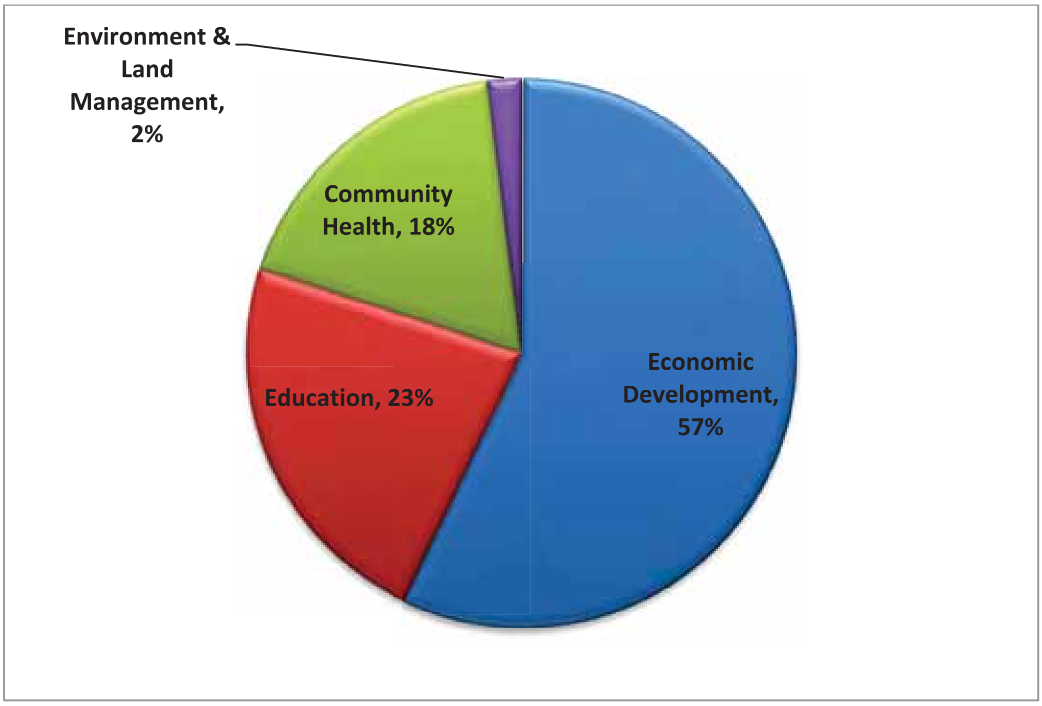


**Figure 73: Distribution of Community Development Fund by category 2015**

## Aboriginal Community Development Fund (ACDF)

In 2015, the ACDF invested almost $480,000 through 22 partnerships in education, community and business development and culture. This represented approximately 90% of available funds. These partnerships demonstrated strong potential to deliver meaningful benefit and/or long-term sustainable outcomes for Aboriginal communities in the Singleton, Muswellbrook and Upper Hunter Local Government Areas (LGA).

All flagship partnerships were aligned to ACDF strategic investment priorities, whilst smaller projects reflected a broad range of community needs and interests within established ACDF funding categories.

A longstanding and highly valued partnership is the Singleton Schools Dance Program. Through this program, Singleton High School and two town and rural primary schools employ a dance teacher each fortnight to educate and engage Aboriginal students in their culture. The participating schools have established dance groups which perform at school assemblies for NAIDOC and Reconciliation Week. A larger, inter-school dance group come together to perform at significant community events.

Now in its 6th year, the program has made a significant contribution to a visible and positive presence for Aboriginal peoples and culture within the schools and through the community performances, helped to build awareness and understanding between the school community, local Aboriginal and wider communities.

The ACDF is accessible to any Aboriginal person residing in, or who is from, the Upper Hunter Valley, or organisation undertaking a project to benefit specific Aboriginal target groups or wider Aboriginal communities in the Upper Hunter Valley.

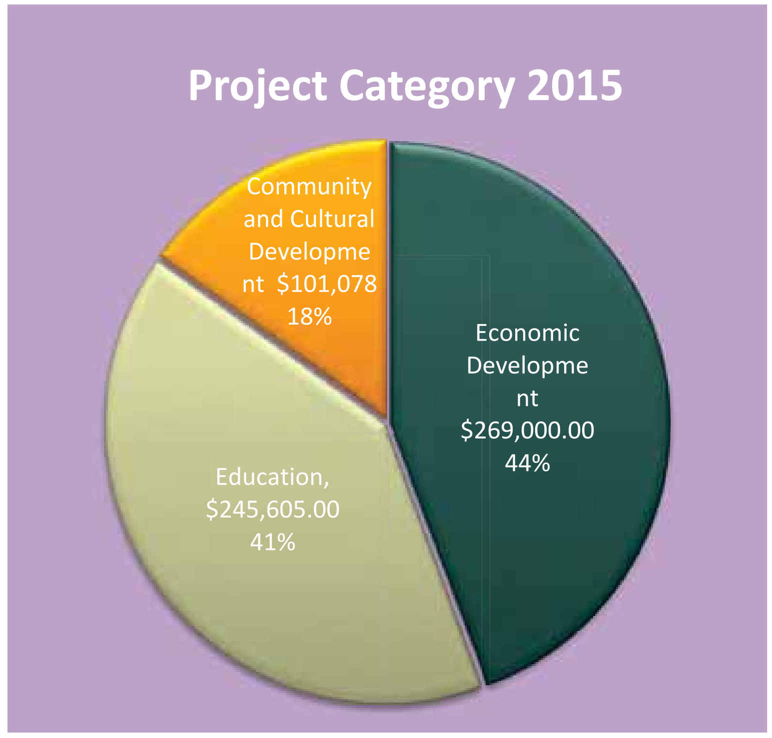


**Figure 74: Distribution of Aboriginal Community Development Fund by Category**

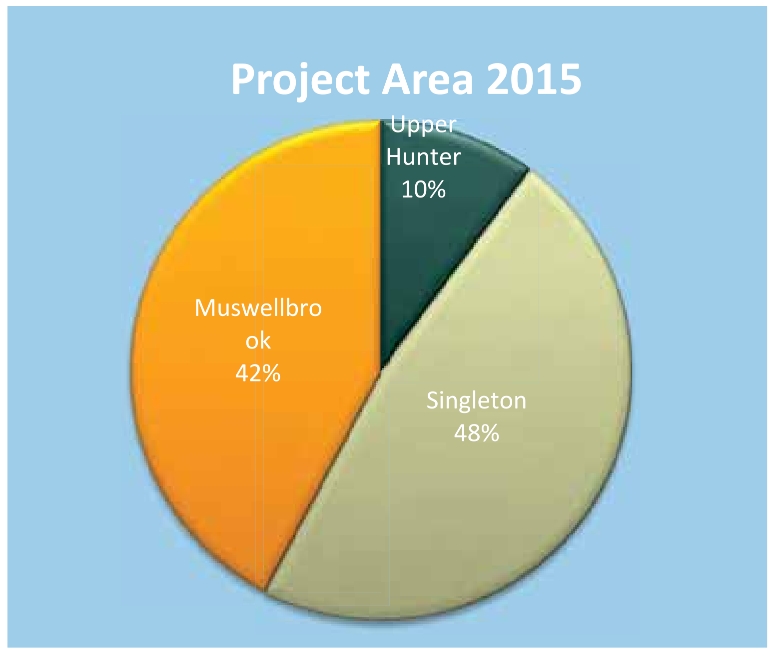


**Figure 75: Distribution of Aboriginal Community Development Fund by LGA**

**Table 46: Coal & Allied Aboriginal Community Development Fund projects approved in 2015**

| Programme | Partner |
|---|---|
| Max Potential | Future Achievement Australia Foundation |
| Microenterprise Development in the Upper Hunter (Renewed) | Many Rivers Microfinance |
| Wonnarua Mining Rehabilitation Operations | Wonnarua Mining Rehab Pty Ltd (Wonnarua Nation Aboriginal Corp) |
| Study Assistance | Fiona Murray |
| The Australian Outward Bound Scholarships | Australian Outward Bound |
| Ka Wul - New Definition (Renewed) | Singleton High School |
| Singleton Art Prize | Rotary Club of Singleton on Hunter Inc. |
| Aboriginal Business Development and Employment Forum | NSW Indigenous Chamber of Commerce |
| Partnerships for Success (Renewed) | Polly Farmer Foundation |
| Administration Traineeship | Wanaruah Local Aboriginal Land Council |
| Muswellbrook Youth Workshop | Bangarra Dance Theatre |
| NAIDOC Celebrations | St James Primary School |
| Les Elvin Funeral Expenses | NSW Indigenous Chamber of Commerce |

**Table 47: Active Coal & Allied Aboriginal Community Development Fund projects approved in prior funding cycles**

| Programme | Partner |
|---|---|
| Strategic planning and operational support | Wonnarua Nation Aboriginal Corp |
| Ka-wul New Beginnings | Singleton High School |
| NAIDOC Week | Singleton Schools Management Group |
| YINPI - Post School Pathways Program | Singleton High School |
| Warrae Wanni School Readiness (renewed 2014-2015) | Muswellbrook South School |
| Kawul - New Directions | Singleton High School |
| Parents and Learning (PAL) | Napranum Pre-School |
| Dookal Group Pty Ltd | Ungooroo Aboriginal Corporation |
| NAIDOC week activities | Wanaruah Local Aboriginal Land Council |

| | |
|---|---|
| Singleton Schools Aboriginal Dance Group (renewed) | Broke Public School |
| The Gundi Programme | St Heliers Correctional Centre |
| Industry scholarships | University of Newcastle |
| Wupa@Wanaruah Art and Cultural Event | Ungooroo Aboriginal Corporation |

### 9.3.2. Site Donations

Coal & Allied considers applications for local donations and sponsorships that have a clear community benefit. In 2015, MTW provided almost $100,000 to 43 local projects and initiatives, including:

- Singleton Art Prize
- WildLife Aid
- Singleton Show
- Singleton Beef and Land Management Prime Stock Competition
- Singleton Bulls Junior Rugby Club
- Singleton Council Mayoral Scholarships
- Cancer Council NSW Relay for Life
- Darlington Rural Fire Brigade
- Westpac Rescue Helicopter Service Mining Rugby League Knockout Competition
- Branxton Greta Community Business Chamber Umbrella Festival
- Australian Families of the Military Research and Support Foundation (AFOM) – Invisible Wounds Community Workshop (mental health)

### 9.3.3. Community Partnerships

Coal & Allied has retained an active partnership programme in 2015 with key organisations that provide a service valued by the community and have an approach to their business that is aligned with Coal & Allied principles. Partners include:

- Hunter Valley Research Foundation
- Westpac Rescue Helicopter Service
- Olympic Park Muswellbrook

# 10. INDEPENDENT AUDIT

No Independent Environmental Audits were undertaken during the reporting period. An Independent Environmental Audit was undertaken during January 2016. The audit report will be published on the Rio Tinto website when finalised. A summary of findings will be presented in the 2016 Annual Review.

# 11. INCIDENTS AND NON-COMPLIANCES

## 11.1 Water

### 21 April 2015

A rain event of approximately 135 mm was received on site over a three day period, from Monday 20th to Wednesday 22nd April 2015. The rain was associated with a significant regional event as a result of an east coast low, which persisted over the Lower Hunter during this period.

Discharges occurred from the following dams as a result of the storm event:

- Mine water Dam 1N commenced overflow via the spillway at approximately 3pm on 21st April 2015. Discharge of water via the licenced HRSTS discharge point commenced at 4:06pm (outside of the discharge block, due to commence at 8pm), in an effort to control the discharge of water via the spillway. Based on the water level in the dam, overflow via the spillway ceased at approximately 6:30am on 22nd April 2015. Licenced discharge of water via the HRSTS discharge point continued until 4:37pm on 26th April 2015.
- Mine water Dam 21N commenced overflow via the spillway into Doctors Creek diversion channel between 10:30am and 12:30pm on 21st April 2015. Dam 21N receives runoff from the Warkworth workshop, administration areas and truck wash. Overflow ceased at approximately 1am on 22nd April 2015, following sustained abstraction of water back into the mine water management system.
- The CC5 sump commenced overflow into Doctors Creek diversion channel between 10:30am and 12:30pm on 21st April 2015. Overflow ceased at approximately 9am on 22nd April 2015, following sustained abstraction of water back into the mine water management system.
- Sediment Dam 15N commenced overflow into the Doctors Creek catchment between 10:30am and 1:30pm on 21st April 2015. Dam 15N receives runoff water from the capped TD1 tailings dam and North pit rehabilitation, via adjacent Sediment Dams 13N and 14N. Overflow ceased between 7am and 9:30am on 22nd April 2015, following abstraction of water to Dam 1N.
- Sediment Dam 3S commenced overflow into the Powerline dam (clean water dam) and in turn to a tributary of Loders Creek between 10:30am and 1:30pm on 21st April 2015. Dam 3S receives runoff water from adjacent rehabilitated areas and localised haul road runoff. Overflow ceased at approximately 8:30am on 23rd April 2015, following abstraction of water back into the mine water management system.
- The Bin 2 basin commenced overflow into a tributary of Loders Creek at approximately 10:30am on 21st April 2015. The Bin 2 basin receives stormwater runoff from the coal loader area. Overflow ceased prior to 9:30am on 22nd April 2015.

Any water that overtopped from the dams above was caused by the rainfall runoff volume exceeding the design criteria for the dam. At Dam 1N it was determined that the catchment area was greater than the design catchment area for the maximum operating level. A specialist water management consultant was engaged to undertake a catchment review and

provide recommendations to mitigate the risk of reoccurrence. Work is underway to address the recommendations of the report.

Both the Department of Planning & Environment and the Environment Protection Authority were notified of the event on 27 April 2015, with a follow up incident report prepared and sent to DP&E on 13 May 2015.

### 26 August 2015

During HRSTS discharge event for Block 2015-238(1) daily sampling from Dam 9S (EPL Discharge Point 4) recorded a Total Suspended Sediment concentration above the limit defined in EPL 1976.

Particulars of the incident are as follows:

- Pre-discharge sampling was undertaken on 25/8 in anticipation of potential for a discharge block being released. The results showed TSS within licence limits.
- Discharge commenced at 17:40 on 25/8, for discharge Block 2015-238(1).
- Sampling was undertaken at 17:45 on 25/8 following commencement of discharge. The results showed TSS within licence limits.
- Sampling was undertaken at 07:45 on 26/8. Physical observations of water quality at the time of sampling did not give cause for concern.
- Lab results for the sample taken at 07:45 were received via email at 12:44; results showed TSS above licence limits. Following confirmation of the exceedance the discharge was stopped at 13:08.
- Follow-up sampling was undertaken at 15:10 on 26/8; the results (received via email at 18:58) were consistent with the earlier measurement.
- Sampling was undertaken in Loders Creek downstream of the discharge point and at the Hunter River upstream and downstream of the confluence with Loders Creek. The results indicate no adverse impact downstream of the discharge point.
- There is no evidence of any environmental harm given the quality of water in Loders Creek and the Hunter River.

Both the Department of Planning & Environment and the Environment Protection Authority were notified of the event on 27 August 2015, with a follow up incident report prepared and sent to EPA on 2 September 2015. The EPA issued a formal warning on 26 October 2015, in relation to the water quality exceedance (Condition L2.4 of EPL1976).

# 12. ACTIVITIES TO BE COMPLETED IN THE NEXT REPORTING PERIOD

## 12.1 Noise

Significant sound attenuation works are planned in the 2016 rebuild schedule. MTW is committed to achieving 100% attenuation across the Truck, Dozer, Drill and Excavator fleets by the end of 2016. To achieve this outcome, the following works are planned:

- Haul Trucks
  - 11x Komatsu 830E-DC Trucks will receive mitigation treatment via installation of a newly designed attenuation package (designed to achieve 115dB(A));
  - 12x Komatsu 830E-AC Trucks (completion of works described above) – scheduled for completion by March 2016.
- Excavators
  - 2x EX3500-5 Excavators will receive attenuation components including sound attenuated engine exhaust and Fan speed controller;
- Drills
  - 4x Production Drills will receive attenuation components including exhaust systems, louvres and custom engine panelling;
- Dozers
  - 9x Dozers – Sound attenuation components (designed by the equipment manufacturer) will be fitted. The standard package includes engine panelling, sound suppressed idlers and sprockets.

## 12.2 Blasting

A review of the MTW Blast Management Plan and Blasting Permissions pages will be completed during 2016. No further improvements works are planned at this time.

## 12.3 Air Quality

During 2015, MTW commenced discussions with NSW EPA and Department of Planning & Environment to propose and assess changes to MTW's real-time air quality monitoring network, in line with the EPA's Air Quality Monitoring Optimisation Project. At the time of preparation of this report, MTW is assessing a number of locations for monitor relocation / establishment. It is anticipated that two or more monitor relocations will occur during 2016, in consultation with the regulatory agencies, and the CCC.

## 12.4 Public Reporting – InSite

To increase transparency with interested members of the community, MTW launched "InSite" in early 2016, a public website which will display up to date information on air quality and noise management. The website will be updated each weekday, displaying noise measurements taken by the MTW Community Response Officers, results of real-time air quality monitoring as details of any complaints received and changes made to the operation for noise / air quality management. The website can be viewed at http://insite.riotinto.com/.

## 12.5 Noise and Air Quality Management – Public Information Session

In approving the Warkworth Continuation (SSD-6464) and Mount Thorley Operations (SSD-6465) projects in November 2015, the Planning Assessment Commission noted that "noise and air quality are long-standing issues between the Warkworth Mine and the Bulga community." In order to improve understanding of the systems and processes in place at MTW to manage noise and air quality, the PAC has recommended MTW undertake additional consultation with near neighbours to explain the operation and outcomes of the noise and air quality management systems in place. The PAC notes "there are additional requirements in the management plans to include provisions for keeping the local community informed about the operations of the noise and air quality management systems and monitoring programs. This would include regular briefings and a public information session within six months of the granting of any development consent."

MTW will undertake these additional consultation measures as proposed, though a public information session, to be completed before 26th May 2016.

## 12.6 Cultural Heritage

### Aboriginal Cultural Heritage

Ongoing Aboriginal archaeological and cultural heritage management activities will occur in 2016 at MTW in accordance with the ACHMP and the recently approved Warkworth Extension Stage 1 HMP, to inform ongoing land management and development planning. An MTW complex-wide AHMP will be developed during 2016 in accordance with the conditions of the Warkworth & Mount Thorley Project Approvals. Condition monitoring of those sites peripheral to authorised disturbance areas will be conducted at regular intervals to ensure operational compliance with the ACHMPs. The AHIMS sites database audit will continue in 2016.

### Historic Heritage

Conservation Management Plans (CMPs) have been, or will be, prepared for a number of historic sites at MTW. Protective maintenance and stabilisation of these sites, in line with the recommendations within the CMPs & the Project Approvals, will continue to be conducted throughout 2016, & an MTW complex-wide Historic HMP will be developed in accordance with the conditions of the Warkworth & Mount Thorley Project Approvals.

## 12.7 Water

Improvements to water management in 2016 will continue to focus in water security for MTW. This includes commissioning of the water transfer pipeline linking MTW to the HVO Riverview Void, to permit transfer of excess water from MTW and recovery of water where required. Work remains ongoing to improve secondary containment of pipelines and a review of the design containment criteria for water storage facilities on site.

The Water Management Plan will be reviewed in 2016 to meet the contemporary Consent requirements and reflect updated water quality triggers incorporating 2015 data for the surface water and groundwater monitoring programmes.

## 12.8 Rehabilitation

### Performance Criteria and Rehabilitation Monitoring

The rehabilitation monitoring programme will continue in 2016 for both grazing and native vegetation rehabilitation areas. Results from this and previous year's monitoring of reference sites and rehabilitation sites will be used to determine suitable target levels for the rehabilitation performance criteria. Target levels for MOP performance criteria will be determined by the end of 2016.

### Rehabilitation Maintenance

An air-assisted boom sprayer will be trialled to control weeds on rehabilitation areas and topsoil stockpiles. The spray nozzles are enclosed within a shroud and air is used to direct the herbicide out through the bottom of the shroud and onto the target weeds (see Figure 76). The air-assist design helps to minimise spray drift onto off-target areas and results in better leaf coverage with herbicide for a more effective kill of target species.

**Figure 76: Photo showing a spray rig boom fitted with air-assist shroud.**

### Habitat Augmentation

Guidelines for fauna habitat augmentation in rehabilitation areas will be developed during 2016. Data on the number of trees containing hollows and length of logs on the ground has been collected for the native vegetation reference sites established during the recent rehabilitation monitoring program. This information will be used to set targets for the habitat-related MOP performance criteria. Habitat augmentation measures, such as the construction of habitat ponds and the placement of salvaged logs in rehabilitation areas, will be undertaken during 2016.

### Native Grass Harvest Areas

The native grass seed harvesting properties at Mt Pleasant will not be available to C&A for future harvests due to the impending sale of the Mt Pleasant assets. Over the next couple of years C&A will prepare native grass pasture areas in rehabilitation areas to provide replacement harvest sites. In the interim, C&A have an inventory of harvested native grass seed from the Mt Pleasant properties to provide seed for rehabilitation activities while the native pastures in rehabilitation areas are being prepared.

### Native Grass Cover Crops

Trials will be undertaken in new rehabilitation areas that have been spread with topsoil to use native grasses as a cover crop rather than using exotic cereal and legume crops. The current use of annual exotic cover crops results in regular spraying out and replacing through re-sowing. Alternatively, the use of a perennial native pasture as a cover crop is planned to reduce this requirement and will begin the establishment of a component of the desired vegetation community. The weed wiper will provide a means of removing quick-growing exotic grasses from the native grass pasture during the early establishment phase.

### Hydroseeding Equipment

The focus for trials of spoil/compost as a growth medium replacement for topsoil will be on seeding methods that are suitable to be used on a rough spoil surface. The germination results from a spoil/compost trial at Wilton, where the surface was cleared of rock using rock windrowing and rock picking in preparation for using the direct-drill seeder, were not as impressive as previous trials where a rough spoil surface had been maintained. During 2016, a tanker will be trialled for hydroseeding spoil/compost areas with native seed mixes. The tanker can discharge the water/seed mixture through either splash plates fitted to the rear of the tanker; or through a water cannon that can be controlled from the cab of the tractor.

**Figure 77: Photo showing discharge capabilities of sludge tanker that will be trialled for hydroseeding rehabilitation areas.**

### Tailings Dam 2 Capping

Capping of Tailings Dam 2 will commence during 2016. Rehabilitation of this facility will be progressively completed during the period 2017 to 2019.

# Appendix 1

# 2015 Complaints Summary

# Mount Thorley Warkworth Complaints 2015

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Noise | January | 1/01/2015 | 22:28 | Hotline | Bulga |
| Noise | January | 1/01/2015 | 22:34 | Hotline | Bulga |
| Noise | January | 1/01/2015 | 23:54 | Hotline | Bulga |
| Noise | January | 1/01/2015 | 23:59 | Telephone | Unknown |
| Noise | January | 2/01/2015 | 21:25 | Telephone | Unknown |
| Noise | January | 2/01/2015 | 21:26 | Hotline | Bulga |
| Noise | January | 2/01/2015 | 23:50 | Hotline | Bulga |
| Noise | January | 3/01/2015 | 22:30 | Hotline | Bulga |
| Noise | January | 3/01/2015 | 22:33 | Hotline | Bulga |
| Noise | January | 3/01/2015 | 23:59 | Telephone | Unknown |
| Noise | January | 4/01/2015 | 21:04 | Hotline | Bulga |
| Noise | January | 4/01/2015 | 23:59 | Telephone | Unknown |
| Light | January | 5/01/2015 | 22:03 | Hotline | Bulga |
| Noise | January | 6/01/2015 | 21:06 | Hotline | Bulga |
| Noise | January | 6/01/2015 | 21:42 | Hotline | Bulga |
| Noise | January | 6/01/2015 | 21:57 | Hotline | Bulga |
| Noise | January | 7/01/2015 | 21:39 | Hotline | Bulga |
| Noise | January | 7/01/2015 | 21:43 | Hotline | Bulga |
| Noise | January | 7/01/2015 | 22:21 | Hotline | Bulga |
| Noise | January | 7/01/2015 | 22:38 | Hotline | Bulga |
| Dust | January | 9/01/2015 | 15:16 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 19:06 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 19:20 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 19:21 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 19:27 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 19:31 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 19:32 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 19:33 | Hotline | Bulga |
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| Noise | January | 9/01/2015 | 22:28 | Hotline | Bulga |
| Noise | January | 9/01/2015 | 22:49 | Hotline | Bulga |
| Noise | January | 10/01/2015 | 17:54 | Hotline | Bulga |
| Noise | January | 10/01/2015 | 18:19 | Hotline | Bulga |
| Light | January | 11/01/2015 | 21:10 | Hotline | Bulga |
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| Noise | January | 13/01/2015 | 20:57 | Hotline | Bulga |
| Noise | January | 13/01/2015 | 21:35 | Hotline | Bulga |
| Noise | January | 13/01/2015 | 21:55 | Hotline | Bulga |
| Noise | January | 13/01/2015 | 22:09 | Hotline | Bulga |
| Blast | January | 15/01/2015 | 13:13 | Hotline | Bulga |
| Dust | January | 17/01/2015 | 10:34 | Hotline | Glenridding |
| Noise | January | 19/01/2015 | 10:00 | Telephone | Unknown |
| Noise | January | 19/01/2015 | 19:48 | Hotline | Bulga |
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| Noise | January | 19/01/2015 | 22:21 | Hotline | Bulga |
| Noise | January | 19/01/2015 | 22:31 | Hotline | Bulga |

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| Noise | January | 20/01/2015 | 22:14 | Hotline | Bulga |
| Noise | January | 20/01/2015 | 22:42 | Hotline | Bulga |
| Noise | January | 20/01/2015 | 22:51 | Hotline | Bulga |
| Noise | January | 21/01/2015 | 7:18 | Hotline | Bulga |
| Noise | January | 21/01/2015 | 19:59 | Hotline | Bulga |
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| Noise | January | 23/01/2015 | 4:55 | Hotline | Bulga |
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| Noise | February | 7/02/2015 | 21:43 | Hotline | Bulga |
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| Noise | March | 4/03/2015 | 22:03 | Hotline | Bulga |
| Noise | March | 4/03/2015 | 22:16 | Hotline | Bulga |
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| Dust | March | 7/03/2015 | 9:06 | Hotline | Bulga |
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| Noise | March | 9/03/2015 | 21:53 | Hotline | Bulga |
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| Noise | March | 14/03/2015 | 0:42 | Hotline | Bulga |
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| Noise | March | 15/03/2015 | 9:11 | Hotline | Gowrie |
| Noise | March | 15/03/2015 | 9:34 | Hotline | Gowrie |
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| Noise | March | 16/03/2015 | 21:56 | Hotline | Bulga |
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| Noise | March | 19/03/2015 | 21:12 | Hotline | Bulga |
| Noise | March | 19/03/2015 | 21:13 | Hotline | Bulga |
| Noise | March | 19/03/2015 | 22:07 | Hotline | Bulga |
| Noise | March | 19/03/2015 | 22:31 | Hotline | Bulga |
| Noise | March | 21/03/2015 | 23:19 | Hotline | Bulga |
| Noise | March | 21/03/2015 | 23:37 | Hotline | Bulga |
| Noise | March | 22/03/2015 | 7:50 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Noise | March | 22/03/2015 | 9:17 | Hotline | Bulga |
| Noise | March | 22/03/2015 | 9:33 | Hotline | Bulga |
| Noise | March | 22/03/2015 | 21:15 | Hotline | Bulga |
| Noise | March | 22/03/2015 | 21:15 | Hotline | Bulga |
| Noise | March | 22/03/2015 | 22:49 | Hotline | Bulga |
| Noise | March | 22/03/2015 | 22:52 | Hotline | Bulga |
| Noise | March | 22/03/2015 | 23:12 | Hotline | Bulga |
| Noise | March | 23/03/2015 | 0:32 | Hotline | Bulga |
| Noise | March | 23/03/2015 | 7:55 | Hotline | Bulga |
| Noise | March | 23/03/2015 | 22:12 | Hotline | Bulga |
| Noise | March | 23/03/2015 | 23:42 | Hotline | Bulga |
| Noise | March | 25/03/2015 | 21:36 | Hotline | Bulga |
| Noise | March | 25/03/2015 | 22:35 | Hotline | Bulga |
| Noise | March | 25/03/2015 | 22:55 | Hotline | Bulga |
| Noise | March | 26/03/2015 | 0:04 | Hotline | Bulga |
| Noise | March | 26/03/2015 | 7:04 | Hotline | Gowrie |
| Dust | March | 26/03/2015 | 14:14 | Telephone | Glenridding |
| Dust | March | 26/03/2015 | 19:12 | Hotline | Glenridding |
| Blast | March | 27/03/2015 | 13:48 | Hotline | Bulga |
| Blast | March | 27/03/2015 | 13:51 | Hotline | Bulga |
| Dust | March | 27/03/2015 | 15:32 | Hotline | Bulga |
| Noise | March | 28/03/2015 | 21:05 | Hotline | Bulga |
| Noise | March | 29/03/2015 | 6:28 | Hotline | Bulga |
| Noise | March | 29/03/2015 | 20:41 | Hotline | Bulga |
| Noise | March | 29/03/2015 | 23:53 | Hotline | Bulga |
| Noise | March | 31/03/2015 | 0:04 | Hotline | Bulga |
| Noise | March | 31/03/2015 | 7:47 | Hotline | Bulga |
| Noise | March | 31/03/2015 | 21:44 | Hotline | Bulga |
| Noise | March | 31/03/2015 | 22:00 | Hotline | Bulga |
| Noise | March | 31/03/2015 | 22:04 | Hotline | Bulga |
| Noise | March | 31/03/2015 | 22:37 | Hotline | Bulga |
| Noise | April | 1/04/2015 | 21:02 | Hotline | Bulga |
| Noise | April | 5/04/2015 | 18:36 | Hotline | Gowrie |
| Noise | April | 8/04/2015 | 22:43 | Hotline | Long Point |
| Noise | April | 8/04/2015 | 23:21 | Hotline | Gowrie |
| Blast | April | 10/04/2015 | 11:19 | Hotline | Bulga |
| Blast | April | 10/04/2015 | 11:19 | Telephone | Bulga |
| Blast | April | 10/04/2015 | 11:52 | Hotline | Bulga |
| Noise | April | 11/04/2015 | 20:23 | Hotline | Bulga |
| Noise | April | 11/04/2015 | 20:39 | Hotline | Bulga |
| Noise | April | 12/04/2015 | 5:17 | Hotline | Gowrie |
| Noise | April | 13/04/2015 | 22:09 | Hotline | Bulga |
| Noise | April | 14/04/2015 | 20:18 | Hotline | Bulga |
| Noise | April | 14/04/2015 | 20:42 | Hotline | Bulga |
| Noise | April | 14/04/2015 | 20:54 | Hotline | Bulga |
| Noise | April | 15/04/2015 | 19:43 | Hotline | Bulga |
| Noise | April | 15/04/2015 | 19:47 | Hotline | Bulga |
| Noise | April | 15/04/2015 | 20:38 | Hotline | Bulga |
| Blast | April | 16/04/2015 | 13:23 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Blast | April | 16/04/2015 | 13:24 | Hotline | Bulga |
| Blast | April | 16/04/2015 | 13:30 | Hotline | Bulga |
| Blast | April | 16/04/2015 | 19:32 | Hotline | Bulga |
| Noise | April | 16/04/2015 | 20:55 | Hotline | Bulga |
| Noise | April | 16/04/2015 | 22:35 | Hotline | Bulga |
| Blast | April | 17/04/2015 | 7:44 | Telephone | Bulga |
| Noise | April | 17/04/2015 | 19:56 | Hotline | Bulga |
| Noise | April | 17/04/2015 | 22:03 | Hotline | Bulga |
| Noise | April | 18/04/2015 | 0:34 | Hotline | Bulga |
| Noise | April | 19/04/2015 | 7:42 | Hotline | Bulga |
| Blast | April | 20/04/2015 | 11:11 | Hotline | Bulga |
| Blast | April | 20/04/2015 | 11:27 | Hotline | Bulga |
| Noise | April | 23/04/2015 | 19:43 | Hotline | Bulga |
| Noise | April | 23/04/2015 | 20:32 | Hotline | Bulga |
| Noise | April | 23/04/2015 | 21:06 | Hotline | Bulga |
| Noise | April | 23/04/2015 | 21:20 | Hotline | Bulga |
| Noise | April | 26/04/2015 | 6:17 | Hotline | Gowrie |
| Noise | April | 26/04/2015 | 8:48 | Hotline | Gowrie |
| Noise | April | 26/04/2015 | 19:05 | Hotline | Gowrie |
| Noise | April | 29/04/2015 | 21:16 | Hotline | Bulga |
| Noise | April | 29/04/2015 | 21:22 | Hotline | Bulga |
| Noise | April | 29/04/2015 | 21:38 | Hotline | Bulga |
| Noise | April | 29/04/2015 | 22:41 | Hotline | Bulga |
| Noise | April | 29/04/2015 | 23:24 | Hotline | Bulga |
| Noise | April | 30/04/2015 | 5:23 | Hotline | Bulga |
| Noise | April | 30/04/2015 | 7:29 | Hotline | Bulga |
| Noise | April | 30/04/2015 | 14:36 | Hotline | Bulga |
| Noise | April | 30/04/2015 | 20:55 | Hotline | Bulga |
| Noise | April | 30/04/2015 | 20:57 | Hotline | Bulga |
| Noise | April | 30/04/2015 | 21:56 | Hotline | Bulga |
| Noise | May | 1/05/2015 | 1:47 | Hotline | Bulga |
| Noise | May | 1/05/2015 | 8:45 | Hotline | Bulga |
| Other | May | 1/05/2015 | 12:23 | Hotline | Bulga |
| Noise | May | 1/05/2015 | 19:57 | Hotline | Bulga |
| Noise | May | 1/05/2015 | 21:17 | Hotline | Bulga |
| Noise | May | 1/05/2015 | 21:32 | Hotline | Bulga |
| Noise | May | 4/05/2015 | 23:20 | Hotline | Bulga |
| Dust | May | 6/05/2015 | 15:09 | Hotline | Bulga |
| Dust | May | 8/05/2015 | 14:31 | Hotline | Bulga |
| Noise | May | 9/05/2015 | 6:40 | Telephone | Bulga |
| Dust | May | 10/05/2015 | 12:42 | Hotline | Glenridding |
| Blast | May | 12/05/2015 | 13:15 | Hotline | Bulga |
| Light | May | 12/05/2015 | 20:37 | Hotline | Bulga |
| Dust | May | 13/05/2015 | 15:05 | Telephone | Glenridding |
| Noise | May | 13/05/2015 | 22:42 | Hotline | Gowrie |
| Noise | May | 14/05/2015 | 8:03 | Hotline | Unknown |
| Blast | May | 14/05/2015 | 12:21 | Hotline | Bulga |
| Noise | May | 15/05/2015 | 3:13 | Hotline | Gowrie |
| Noise | May | 17/05/2015 | 8:09 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Noise | May | 17/05/2015 | 20:14 | Hotline | Bulga |
| Noise | May | 17/05/2015 | 20:38 | Hotline | Bulga |
| Noise | May | 17/05/2015 | 20:43 | Hotline | Bulga |
| Noise | May | 17/05/2015 | 20:52 | Hotline | Bulga |
| Noise | May | 17/05/2015 | 20:57 | Hotline | Bulga |
| Noise | May | 17/05/2015 | 20:58 | Hotline | Bulga |
| Noise | May | 17/05/2015 | 21:55 | Hotline | Bulga |
| Noise | May | 17/05/2015 | 22:53 | Hotline | Bulga |
| Noise | May | 18/05/2015 | 8:06 | Hotline | Bulga |
| Noise | May | 18/05/2015 | 18:31 | Hotline | Bulga |
| Noise | May | 18/05/2015 | 19:42 | Hotline | Bulga |
| Noise | May | 18/05/2015 | 20:06 | Hotline | Bulga |
| Noise | May | 18/05/2015 | 22:01 | Hotline | Bulga |
| Noise | May | 18/05/2015 | 23:58 | Hotline | Bulga |
| Noise | May | 20/05/2015 | 19:20 | Hotline | Unknown |
| Noise | May | 20/05/2015 | 20:21 | Hotline | Gowrie |
| Noise | May | 23/05/2015 | 20:16 | Hotline | Bulga |
| Noise | May | 24/05/2015 | 22:02 | Hotline | Bulga |
| Noise | May | 25/05/2015 | 2:57 | Hotline | Bulga |
| Dust | May | 25/05/2015 | 10:44 | Hotline | Bulga |
| Light | May | 25/05/2015 | 19:37 | Hotline | Glenridding |
| Noise | May | 25/05/2015 | 21:58 | Hotline | Gowrie |
| Dust | May | 27/05/2015 | 18:00 | Hotline | Bulga |
| Light | May | 27/05/2015 | 19:49 | Hotline | Bulga |
| Noise | May | 27/05/2015 | 23:44 | Hotline | Bulga |
| Dust | May | 28/05/2015 | 10:45 | Telephone | Putty Rd |
| Blast | May | 28/05/2015 | 13:07 | Hotline | Bulga |
| Dust | May | 28/05/2015 | 15:11 | Hotline | Bulga |
| Noise | May | 29/05/2015 | 17:24 | Hotline | Gowrie |
| Noise | May | 31/05/2015 | 21:54 | Hotline | Gowrie |
| Noise | June | 2/06/2015 | 5:50 | Hotline | Gowrie |
| Light | June | 2/06/2015 | 17:43 | Hotline | Glenridding |
| Light | June | 3/06/2015 | 17:22 | Hotline | Glenridding |
| Noise | June | 3/06/2015 | 20:43 | Hotline | Bulga |
| Noise | June | 4/06/2015 | 8:05 | Hotline | Bulga |
| Blast | June | 5/06/2015 | 11:29 | Hotline | Bulga |
| Blast | June | 5/06/2015 | 11:29 | Hotline | Bulga |
| Noise | June | 5/06/2015 | 22:40 | Hotline | Unknown |
| Noise | June | 6/06/2015 | 1:47 | Hotline | Bulga |
| Noise | June | 6/06/2015 | 17:39 | Hotline | Bulga |
| Dust | June | 7/06/2015 | 10:30 | Hotline | Bulga |
| Noise | June | 9/06/2015 | 21:04 | Hotline | Bulga |
| Noise | June | 10/06/2015 | 8:32 | Hotline | Bulga |
| Noise | June | 10/06/2015 | 21:47 | Hotline | Bulga |
| Noise | June | 10/06/2015 | 22:15 | Hotline | Bulga |
| Noise | June | 10/06/2015 | 22:27 | Hotline | Bulga |
| Noise | June | 10/06/2015 | 23:48 | Hotline | Bulga |
| Noise | June | 11/06/2015 | 0:00 | Hotline | Bulga |
| Noise | June | 11/06/2015 | 22:20 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Noise | June | 12/06/2015 | 7:22 | Hotline | Bulga |
| Noise | June | 12/06/2015 | 8:31 | Hotline | Bulga |
| Noise | June | 12/06/2015 | 8:33 | Hotline | Bulga |
| Noise | June | 12/06/2015 | 19:34 | Hotline | Bulga |
| Noise | June | 12/06/2015 | 21:46 | Hotline | Bulga |
| Noise | June | 12/06/2015 | 22:15 | Hotline | Bulga |
| Noise | June | 12/06/2015 | 22:26 | Hotline | Bulga |
| Noise | June | 13/06/2015 | 2:30 | Hotline | Bulga |
| Noise | June | 13/06/2015 | 8:47 | Hotline | Bulga |
| Noise | June | 13/06/2015 | 18:43 | Hotline | Bulga |
| Noise | June | 13/06/2015 | 20:32 | Hotline | Bulga |
| Noise | June | 14/06/2015 | 18:59 | Hotline | Bulga |
| Noise | June | 14/06/2015 | 19:52 | Hotline | Bulga |
| Noise | June | 14/06/2015 | 20:56 | Hotline | Bulga |
| Noise | June | 14/06/2015 | 22:31 | Hotline | Bulga |
| Noise | June | 14/06/2015 | 23:37 | Hotline | Bulga |
| Noise | June | 15/06/2015 | 8:05 | Hotline | Bulga |
| Noise | June | 16/06/2015 | 7:37 | Hotline | Bulga |
| Blast | June | 16/06/2015 | 13:17 | Hotline | Bulga |
| Noise | June | 18/06/2015 | 22:48 | Hotline | Gowrie |
| Noise | June | 21/06/2015 | 9:20 | Hotline | Gowrie |
| Blast | June | 22/06/2015 | 13:45 | Hotline | Bulga |
| Blast | June | 22/06/2015 | 13:48 | Hotline | Bulga |
| Noise | June | 22/06/2015 | 20:20 | Hotline | Bulga |
| Noise | June | 22/06/2015 | 20:51 | Hotline | Bulga |
| Noise | June | 22/06/2015 | 21:05 | Hotline | Bulga |
| Noise | June | 22/06/2015 | 21:37 | Hotline | Bulga |
| Noise | June | 22/06/2015 | 22:07 | Hotline | Bulga |
| Noise | June | 23/06/2015 | 4:54 | Hotline | Bulga |
| Noise | June | 23/06/2015 | 7:26 | Hotline | Gowrie |
| Noise | June | 23/06/2015 | 9:32 | Hotline | Bulga |
| Noise | June | 23/06/2015 | 18:16 | Hotline | Bulga |
| Noise | June | 23/06/2015 | 19:00 | Hotline | Bulga |
| Blast | June | 26/06/2015 | 12:50 | Hotline | Bulga |
| Dust | June | 26/06/2015 | 12:56 | Hotline | Gouldsville |
| Dust | June | 26/06/2015 | 14:10 | Hotline | Bulga |
| Noise | June | 26/06/2015 | 18:01 | Hotline | Bulga |
| Noise | June | 26/06/2015 | 21:40 | Hotline | Bulga |
| Noise | June | 26/06/2015 | 22:09 | Hotline | Bulga |
| Noise | June | 27/06/2015 | 4:08 | Hotline | Bulga |
| Noise | June | 27/06/2015 | 5:42 | Hotline | Bulga |
| Noise | June | 27/06/2015 | 19:17 | Hotline | Bulga |
| Noise | June | 27/06/2015 | 19:42 | Hotline | Bulga |
| Blast | July | 1/07/2015 | 13:11 | Hotline | Bulga |
| Noise | July | 3/07/2015 | 22:25 | Hotline | Bulga |
| Noise | July | 3/07/2015 | 23:45 | Hotline | Bulga |
| Dust | July | 4/07/2015 | 17:09 | Hotline | Glenridding |
| Noise | July | 6/07/2015 | 4:19 | Hotline | Bulga |
| Blast | July | 8/07/2015 | 13:26 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Blast | July | 8/07/2015 | 13:29 | Hotline | Bulga |
| Noise | July | 8/07/2015 | 21:05 | Hotline | Bulga |
| Noise | July | 8/07/2015 | 23:20 | Hotline | Bulga |
| Noise | July | 8/07/2015 | 23:42 | Hotline | Bulga |
| Noise | July | 9/07/2015 | 21:56 | Hotline | Bulga |
| Light | July | 12/07/2015 | 19:02 | Hotline | Glenridding |
| Light | July | 13/07/2015 | 17:38 | Hotline | Glenridding |
| Noise | July | 14/07/2015 | 5:16 | Hotline | Gowrie |
| Noise | July | 15/07/2015 | 21:08 | Hotline | Bulga |
| Noise | July | 15/07/2015 | 21:28 | Hotline | Bulga |
| Noise | July | 15/07/2015 | 22:47 | Hotline | Bulga |
| Light | July | 17/07/2015 | 17:49 | Hotline | Glenridding |
| Noise | July | 19/07/2015 | 16:22 | Hotline | Gowrie |
| Noise | July | 19/07/2015 | 22:30 | Hotline | Bulga |
| Noise | July | 20/07/2015 | 4:58 | Hotline | Bulga |
| Light | July | 20/07/2015 | 17:22 | Telephone | Glenridding |
| Noise | July | 20/07/2015 | 21:11 | Hotline | Bulga |
| Noise | July | 20/07/2015 | 21:50 | Hotline | Bulga |
| Noise | July | 20/07/2015 | 22:41 | Hotline | Bulga |
| Noise | July | 20/07/2015 | 23:44 | Hotline | Bulga |
| Noise | July | 21/07/2015 | 19:27 | Hotline | Bulga |
| Noise | July | 21/07/2015 | 22:36 | Hotline | Bulga |
| Noise | July | 22/07/2015 | 4:34 | Hotline | Bulga |
| Noise | July | 22/07/2015 | 9:39 | Hotline | Bulga |
| Noise | July | 22/07/2015 | 10:48 | Hotline | Bulga |
| Light | July | 22/07/2015 | 18:24 | Hotline | Glenridding |
| Noise | July | 22/07/2015 | 20:05 | Hotline | Bulga |
| Noise | July | 23/07/2015 | 6:15 | Hotline | Bulga |
| Noise | July | 24/07/2015 | 0:23 | Hotline | Bulga |
| Light | July | 27/07/2015 | 18:12 | Hotline | Glenridding |
| Noise | July | 27/07/2015 | 22:03 | Hotline | Unknown |
| Noise | July | 28/07/2015 | 21:59 | Hotline | Bulga |
| Light | July | 29/07/2015 | 18:19 | Hotline | Glenridding |
| Noise | July | 29/07/2015 | 18:36 | Hotline | Bulga |
| Noise | July | 29/07/2015 | 23:00 | Hotline | Bulga |
| Noise | August | 1/08/2015 | 0:47 | Hotline | Bulga |
| Light | August | 4/08/2015 | 21:44 | Hotline | Bulga |
| Other | August | 5/08/2015 | 8:43 | Hotline | Milbrodale |
| Noise | August | 6/08/2015 | 8:11 | Hotline | Gowrie |
| Light | August | 6/08/2015 | 18:34 | Hotline | Glenridding |
| Noise | August | 6/08/2015 | 21:42 | Hotline | Gowrie |
| Blast | August | 7/08/2015 | 13:51 | Telephone | Bulga |
| Blast | August | 7/08/2015 | 22:44 | Telephone | Bulga |
| Noise | August | 9/08/2015 | 20:41 | Hotline | Bulga |
| Noise | August | 9/08/2015 | 23:44 | Hotline | Bulga |
| Dust | August | 10/08/2015 | 13:16 | Hotline | Bulga |
| Light | August | 11/08/2015 | 19:39 | Telephone | Glenridding |
| Noise | August | 12/08/2015 | 9:23 | Hotline | Bulga |
| Dust | August | 12/08/2015 | 14:31 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Blast | August | 13/08/2015 | 12:30 | Telephone | Long Point |
| Dust | August | 13/08/2015 | 12:32 | Hotline | Bulga |
| Blast | August | 13/08/2015 | 12:37 | Hotline | Bulga |
| Dust | August | 13/08/2015 | 12:43 | Hotline | Bulga |
| Noise | August | 15/08/2015 | 22:24 | Hotline | Bulga |
| Dust | August | 17/08/2015 | 16:11 | Hotline | Bulga |
| Noise | August | 18/08/2015 | 22:45 | Hotline | Bulga |
| Noise | August | 19/08/2015 | 8:19 | Hotline | Bulga |
| Noise | August | 19/08/2015 | 8:38 | Hotline | Bulga |
| Noise | August | 19/08/2015 | 10:02 | Hotline | Bulga |
| Light | August | 19/08/2015 | 18:30 | Telephone | Glenridding |
| Noise | August | 19/08/2015 | 20:13 | Hotline | Bulga |
| Noise | August | 19/08/2015 | 20:54 | Hotline | Bulga |
| Noise | August | 19/08/2015 | 22:59 | Hotline | Bulga |
| Noise | August | 19/08/2015 | 23:39 | Hotline | Bulga |
| Blast | August | 20/08/2015 | 10:39 | Hotline | Bulga |
| Dust | August | 20/08/2015 | 14:00 | Hotline | Bulga |
| Blast | August | 20/08/2015 | 14:00 | Hotline | Bulga |
| Noise | August | 20/08/2015 | 22:27 | Hotline | Bulga |
| Noise | August | 20/08/2015 | 23:22 | Hotline | Bulga |
| Noise | August | 21/08/2015 | 5:19 | Hotline | Bulga |
| Noise | August | 21/08/2015 | 23:23 | Hotline | Bulga |
| Noise | August | 25/08/2015 | 22:55 | Hotline | Gowrie |
| Noise | August | 25/08/2015 | 22:58 | Hotline | Unknown |
| Noise | August | 26/08/2015 | 8:10 | Hotline | Unknown |
| Light | August | 26/08/2015 | 16:15 | Telephone | Glenridding |
| Noise | August | 26/08/2015 | 22:18 | Hotline | Unknown |
| Noise | August | 26/08/2015 | 22:21 | Hotline | Unknown |
| Noise | August | 27/08/2015 | 7:56 | Hotline | Unknown |
| Noise | August | 27/08/2015 | 8:02 | Hotline | Unknown |
| Noise | August | 27/08/2015 | 8:18 | Hotline | Unknown |
| Noise | August | 27/08/2015 | 21:54 | Hotline | Unknown |
| Noise | August | 28/08/2015 | 7:37 | Hotline | Gowrie |
| Light | August | 28/08/2015 | 20:47 | Hotline | Glenridding |
| Light | August | 29/08/2015 | 19:09 | Hotline | Glenridding |
| Noise | August | 30/08/2015 | 22:34 | Hotline | Bulga |
| Noise | August | 31/08/2015 | 19:56 | Hotline | Bulga |
| Noise | August | 31/08/2015 | 19:57 | Hotline | Bulga |
| Noise | August | 31/08/2015 | 23:08 | Hotline | Gowrie |
| Dust | September | 1/09/2015 | 14:50 | Hotline | Bulga |
| Dust | September | 1/09/2015 | 15:00 | Hotline | Glenridding |
| Dust | September | 1/09/2015 | 16:52 | Hotline | Bulga |
| Noise | September | 2/09/2015 | 8:06 | Hotline | Bulga |
| Noise | September | 2/09/2015 | 22:58 | Hotline | Bulga |
| Light | September | 5/09/2015 | 18:14 | Hotline | Glenridding |
| Noise | September | 5/09/2015 | 22:55 | Hotline | Bulga |
| Noise | September | 6/09/2015 | 19:11 | Hotline | Bulga |
| Noise | September | 6/09/2015 | 21:58 | Hotline | Bulga |
| Noise | September | 6/09/2015 | 22:49 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Light | September | 7/09/2015 | 20:32 | Hotline | Glenridding |
| Light | September | 8/09/2015 | 18:11 | Hotline | Glenridding |
| Dust | September | 9/09/2015 | 17:14 | Hotline | Bulga |
| Dust | September | 9/09/2015 | 17:29 | Hotline | Bulga |
| Dust | September | 9/09/2015 | 17:52 | Hotline | Bulga |
| Dust | September | 9/09/2015 | 18:17 | Hotline | Bulga |
| Other | September | 9/09/2015 | 18:35 | Hotline | Bulga |
| Noise | September | 9/09/2015 | 19:15 | Hotline | Bulga |
| Light | September | 9/09/2015 | 21:22 | Hotline | Glenridding |
| Noise | September | 11/09/2015 | 8:08 | Hotline | Bulga |
| Noise | September | 11/09/2015 | 9:11 | Hotline | Bulga |
| Dust | September | 12/09/2015 | 9:10 | Hotline | Bulga |
| Light | September | 12/09/2015 | 18:17 | Hotline | Bulga |
| Dust | September | 13/09/2015 | 9:06 | Hotline | Bulga |
| Noise | September | 13/09/2015 | 21:38 | Hotline | Bulga |
| Dust | September | 15/09/2015 | 13:56 | Hotline | Bulga |
| Blast | September | 16/09/2015 | 13:55 | Hotline | Bulga |
| Blast | September | 16/09/2015 | 13:56 | Hotline | Unknown |
| Dust | September | 16/09/2015 | 16:00 | Telephone | Bulga |
| Noise | September | 19/09/2015 | 22:51 | Hotline | Bulga |
| Noise | September | 20/09/2015 | 19:25 | Hotline | Bulga |
| Noise | September | 20/09/2015 | 20:25 | Hotline | Bulga |
| Noise | September | 20/09/2015 | 20:54 | Hotline | Bulga |
| Noise | September | 20/09/2015 | 21:41 | Hotline | Bulga |
| Noise | September | 20/09/2015 | 22:50 | Hotline | Bulga |
| Noise | September | 20/09/2015 | 23:12 | Hotline | Bulga |
| Dust | September | 21/09/2015 | 15:57 | Hotline | Bulga |
| Noise | September | 21/09/2015 | 21:55 | Hotline | Unknown |
| Noise | September | 21/09/2015 | 22:09 | Hotline | Gowrie |
| Dust | September | 27/09/2015 | 17:13 | Hotline | Bulga |
| Light | September | 27/09/2015 | 20:30 | Hotline | Glenridding |
| Noise | September | 28/09/2015 | 19:41 | Hotline | Bulga |
| Noise | September | 28/09/2015 | 23:14 | Hotline | Bulga |
| Noise | September | 29/09/2015 | 7:52 | Hotline | Bulga |
| Dust | September | 29/09/2015 | 14:22 | Hotline | Bulga |
| Noise | September | 29/09/2015 | 20:53 | Hotline | Bulga |
| Noise | September | 30/09/2015 | 20:14 | Hotline | Bulga |
| Noise | September | 30/09/2015 | 21:07 | Hotline | Bulga |
| Noise | September | 30/09/2015 | 21:26 | Hotline | Bulga |
| Noise | September | 30/09/2015 | 23:28 | Hotline | Bulga |
| Blast | October | 1/10/2015 | 13:48 | Hotline | Bulga |
| Dust | October | 1/10/2015 | 17:36 | Hotline | Bulga |
| Noise | October | 2/10/2015 | 20:52 | Hotline | Bulga |
| Noise | October | 2/10/2015 | 23:06 | Hotline | Bulga |
| Dust | October | 4/10/2015 | 11:28 | Hotline | Bulga |
| Dust | October | 6/10/2015 | 8:25 | Hotline | Bulga |
| Dust | October | 6/10/2015 | 10:22 | Hotline | Bulga |
| Dust | October | 7/10/2015 | 9:45 | Hotline | Bulga |
| Noise | October | 8/10/2015 | 9:00 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Dust | October | 9/10/2015 | 13:01 | Hotline | Bulga |
| Light | October | 11/10/2015 | 20:11 | Hotline | Bulga |
| Noise | October | 11/10/2015 | 20:29 | Hotline | Bulga |
| Blast | October | 12/10/2015 | 13:52 | Hotline | Bulga |
| Light | October | 13/10/2015 | 19:39 | Hotline | Glenridding |
| Noise | October | 13/10/2015 | 20:37 | Hotline | Bulga |
| Noise | October | 13/10/2015 | 22:33 | Hotline | Bulga |
| Noise | October | 14/10/2015 | 22:43 | Hotline | Bulga |
| Light | October | 15/10/2015 | 19:25 | Hotline | Glenridding |
| Noise | October | 15/10/2015 | 22:31 | Hotline | Bulga |
| Blast | October | 16/10/2015 | 10:38 | Hotline | Bulga |
| Noise | October | 16/10/2015 | 20:49 | Hotline | Bulga |
| Dust | October | 19/10/2015 | 14:38 | Hotline | Long Point |
| Noise | October | 21/10/2015 | 20:18 | Hotline | Bulga |
| Noise | October | 21/10/2015 | 22:13 | Hotline | Bulga |
| Noise | October | 21/10/2015 | 22:28 | Hotline | Bulga |
| Blast | October | 23/10/2015 | 13:22 | Hotline | Bulga |
| Blast | October | 23/10/2015 | 13:27 | Hotline | Bulga |
| Noise | October | 24/10/2015 | 1:41 | Hotline | Bulga |
| Noise | October | 24/10/2015 | 8:16 | Hotline | Bulga |
| Noise | October | 24/10/2015 | 20:22 | Hotline | Bulga |
| Noise | October | 24/10/2015 | 20:41 | Hotline | Bulga |
| Noise | October | 24/10/2015 | 21:41 | Hotline | Bulga |
| Noise | October | 25/10/2015 | 7:47 | Hotline | Bulga |
| Noise | October | 25/10/2015 | 22:46 | Hotline | Bulga |
| Noise | October | 28/10/2015 | 7:45 | Hotline | Bulga |
| Noise | October | 28/10/2015 | 7:57 | Hotline | Bulga |
| Noise | October | 28/10/2015 | 8:14 | Hotline | Bulga |
| Noise | October | 28/10/2015 | 21:48 | Hotline | Bulga |
| Noise | October | 29/10/2015 | 5:17 | Hotline | Bulga |
| Noise | October | 29/10/2015 | 20:48 | Hotline | Bulga |
| Noise | October | 29/10/2015 | 21:00 | Hotline | Bulga |
| Blast | October | 30/10/2015 | 12:42 | Hotline | Bulga |
| Dust | October | 30/10/2015 | 17:53 | Hotline | Bulga |
| Dust | November | 1/11/2015 | 11:43 | Hotline | Putty Rd |
| Light | November | 1/11/2015 | 20:49 | Hotline | Bulga |
| Blast | November | 2/11/2015 | 13:24 | Hotline | Bulga |
| Blast | November | 2/11/2015 | 13:29 | Hotline | Bulga |
| Light | November | 2/11/2015 | 20:32 | Hotline | Bulga |
| Light | November | 4/11/2015 | 12:27 | Hotline | Wambo Rd |
| Blast | November | 4/11/2015 | 12:55 | Hotline | Bulga |
| Noise | November | 5/11/2015 | 20:27 | Hotline | Bulga |
| Light | November | 7/11/2015 | 21:47 | Hotline | Bulga |
| Light | November | 9/11/2015 | 19:09 | Hotline | Glenridding |
| Noise | November | 9/11/2015 | 21:27 | Hotline | Bulga |
| Noise | November | 9/11/2015 | 21:43 | Hotline | Bulga |
| Noise | November | 9/11/2015 | 21:55 | Hotline | Bulga |
| Noise | November | 10/11/2015 | 6:29 | Hotline | Bulga |
| Noise | November | 10/11/2015 | 6:34 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Blast | November | 10/11/2015 | 13:28 | Hotline | Bulga |
| Light | November | 12/11/2015 | 19:10 | Hotline | Glenridding |
| Noise | November | 15/11/2015 | 19:36 | Hotline | Bulga |
| Noise | November | 15/11/2015 | 20:22 | Hotline | Bulga |
| Noise | November | 16/11/2015 | 8:10 | Hotline | Bulga |
| Noise | November | 16/11/2015 | 21:50 | Hotline | Bulga |
| Dust | November | 17/11/2015 | 16:49 | Hotline | Bulga |
| Dust | November | 20/11/2015 | 16:25 | Hotline | Bulga |
| Light | November | 21/11/2015 | 21:14 | Hotline | Glenridding |
| Noise | November | 24/11/2015 | 7:20 | Hotline | Bulga |
| Noise | November | 24/11/2015 | 7:30 | Hotline | Bulga |
| Noise | November | 24/11/2015 | 19:51 | Hotline | Bulga |
| Noise | November | 24/11/2015 | 19:58 | Hotline | Bulga |
| Noise | November | 24/11/2015 | 20:17 | Hotline | Bulga |
| Noise | November | 24/11/2015 | 20:35 | Hotline | Bulga |
| Noise | November | 24/11/2015 | 20:40 | Hotline | Bulga |
| Noise | November | 24/11/2015 | 21:00 | Hotline | Bulga |
| Dust | November | 26/11/2015 | 8:37 | Hotline | Bulga |
| Light | November | 28/11/2015 | 19:42 | Hotline | Glenridding |
| Noise | November | 28/11/2015 | 22:57 | Hotline | Bulga |
| Noise | November | 29/11/2015 | 0:13 | Hotline | Bulga |
| Noise | November | 29/11/2015 | 3:52 | Hotline | Bulga |
| Noise | December | 1/12/2015 | 7:40 | Hotline | Bulga |
| Blast | December | 1/12/2015 | 13:32 | Hotline | Bulga |
| Noise | December | 3/12/2015 | 21:10 | Hotline | Bulga |
| Noise | December | 4/12/2015 | 4:56 | Hotline | Bulga |
| Noise | December | 4/12/2015 | 8:16 | Hotline | Bulga |
| Noise | December | 4/12/2015 | 8:30 | Hotline | Bulga |
| Noise | December | 4/12/2015 | 8:54 | Hotline | Bulga |
| Blast | December | 4/12/2015 | 11:27 | Hotline | Bulga |
| Noise | December | 4/12/2015 | 22:18 | Hotline | Bulga |
| Noise | December | 7/12/2015 | 6:25 | Hotline | Bulga |
| Light | December | 7/12/2015 | 20:09 | Hotline | Glenridding |
| Noise | December | 8/12/2015 | 8:00 | Hotline | Bulga |
| Noise | December | 8/12/2015 | 21:35 | Hotline | Bulga |
| Noise | December | 8/12/2015 | 22:18 | Hotline | Bulga |
| Dust | December | 9/12/2015 | 13:55 | Hotline | Bulga |
| Dust | December | 9/12/2015 | 20:32 | Hotline | Bulga |
| Light | December | 9/12/2015 | 20:36 | Hotline | Glenridding |
| Dust | December | 9/12/2015 | 20:38 | Hotline | Bulga |
| Dust | December | 10/12/2015 | 14:26 | Hotline | Glenridding |
| Noise | December | 10/12/2015 | 17:17 | Hotline | Long Point |
| Noise | December | 10/12/2015 | 19:21 | Hotline | Bulga |
| Noise | December | 10/12/2015 | 20:10 | Hotline | Bulga |
| Noise | December | 10/12/2015 | 20:24 | Hotline | Bulga |
| Noise | December | 10/12/2015 | 21:37 | Hotline | Bulga |
| Noise | December | 10/12/2015 | 22:06 | Hotline | Bulga |
| Noise | December | 10/12/2015 | 22:10 | Hotline | Bulga |
| Dust | December | 11/12/2015 | 13:07 | Hotline | Bulga |

| Type | Month | Date | Time | Method | Location |
|---|---|---|---|---|---|
| Dust | December | 12/12/2015 | 12:04 | Hotline | Bulga |
| Noise | December | 13/12/2015 | 20:29 | Hotline | Bulga |
| Noise | December | 13/12/2015 | 21:12 | Hotline | Bulga |
| Noise | December | 13/12/2015 | 21:21 | Hotline | Bulga |
| Noise | December | 13/12/2015 | 21:47 | Hotline | Bulga |
| Dust | December | 14/12/2015 | 8:24 | Hotline | Bulga |
| Noise | December | 14/12/2015 | 23:50 | Hotline | Bulga |
| Noise | December | 17/12/2015 | 5:38 | Hotline | Bulga |
| Noise | December | 18/12/2015 | 21:14 | Hotline | Bulga |
| Noise | December | 18/12/2015 | 21:59 | Hotline | Bulga |
| Noise | December | 18/12/2015 | 23:29 | Hotline | Bulga |
| Blast | December | 19/12/2015 | 10:37 | Hotline | Bulga |
| Blast | December | 19/12/2015 | 14:49 | Hotline | Bulga |
| Noise | December | 19/12/2015 | 22:19 | Hotline | Bulga |
| Blast | December | 21/12/2015 | 8:56 | Hotline | Bulga |
| Dust | December | 21/12/2015 | 15:38 | Hotline | Bulga |
| Noise | December | 22/12/2015 | 22:03 | Hotline | Bulga |
| Noise | December | 23/12/2015 | 4:26 | Hotline | Bulga |
| Noise | December | 31/12/2015 | 7:10 | Hotline | Bulga |
| Noise | December | 31/12/2015 | 7:26 | Hotline | Bulga |
| Noise | December | 31/12/2015 | 8:22 | Hotline | Bulga |

# Appendix 2

# Rehabilitation Tables

Annual Rehabilitation Report Form – Mines
Year Ending: 2015
Mine: Mt Thorley Warkworth
Company: Rio Tinto Coal Australia – Coal and Allied
Plans Attached:
Mt Thorley Warkworth – AEMR 2015
Approved Mining Operations Plan:
MTW MOP (2015 – 2021) – Approval Date 21/01/2016
Total Area Covered by Mining Operations Plan:
MTW MOP – 6,185ha
Total Area Covered by Mining Lease for This Mine: 6,185ha

Table 1: Rehabilitation Progress 2015

| 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 | 320.7 | 138.96 |
| | 1C | Final Void | Rehabilitation Area - Grassland | 0 | 0 |
| | 2A | Water Management Areas | Final Void | 0 | 0 |
| | 2B | Water Management Areas | Water Management Areas | 0 | 0 |
| | 2C | Water Management Areas | Rehabilitation Area - Grassland | 24.3 | 34.97 |
| | 2D | Water Management Areas | Rehabilitation Area - Woodland | 28.9 | 26.17 |
| | 2E | Water Management Areas | Rehabilitation Area - Woodland EEC | 0 | 0 |
| | 3B | Infrastructure Area | Water Management Areas | 0 | 0 |
| | 3C | Infrastructure Area | Rehabilitation Area - Grassland | 84 | 100.65 |
| | 3D | Infrastructure Area | Rehabilitation Area - Woodland | 69 | 69.04 |
| | 3E | Infrastructure Area | Rehabilitation Area - Woodland EEC | 0 | 0 |
| | 4C | Tailings Storage Facility | Rehabilitation Area - Grassland | 45.5 | 75.74 |

| | | | | | |
|---|---|---|---|---|---|
| | 4D | Tailings Storage Facility | Rehabilitation Area - Woodland | 92.0 | 95.38 |
| | 4E | Tailings Storage Facility | Rehabilitation Area - Woodland EEC | 0 | 11.74 |
| | 5A | Overburden Emplacement Area | Final Void | 0 | 0 |
| | 5B | Overburden Emplacement Area | Water Management Areas | 0 | 0.00 |
| | 5C | Overburden Emplacement Area | Rehabilitation Area - Grassland | 397.5 | 332.01 |
| | 5D | Overburden Emplacement Area | Rehabilitation Area - Woodland | 1419.5 | 1296.29 |
| | 5E | Overburden Emplacement Area | Rehabilitation Area - Woodland EEC | 32.2 | 297.86 |
| | Bulga Sublease Area | N/A - Outside Domain Boundary | N/A - Outside Domain Boundary | 12.8 | 12.8 |
| | Outside Domain Area | N/A - Outside Domain Boundary | N/A - Outside Domain Boundary | 0.0 | 1.35 |
| | Total Active | | | 2526.4 | 2493.0 |
| 1.2 Decommissioning | Total - Decommissioning | | | 0.0 | 0 |
| 1.3 Landform Establishment | Total - Landform Establishment | | | 10.6 (Included in 1.1) | 9.96 (Included in 1.1) |
| 1.4 Growth Medium Development | Total - Growth Medium Development | | | 0 | 29.73 (Included in 1.1) |
| 1.5 Ecosystem and Land Use Establishment | 5C | Overburden Emplacement Area | Rehabilitation Area - Grassland | 5.6 | 3.22 |
| | 5D | Overburden Emplacement Area | Rehabilitation Area - Woodland | 98.6 | 68.42 |
| | 5E | Overburden Emplacement Area | Rehabilitation Area - Woodland EEC | 0 | 0 |
| | Total - Ecosystem and Land Use Establishment | | | 104.2 | 71.64 |

| | | | | | |
|---|---|---|---|---|---|
| 1.6 Ecosystem and Land Use Development | 1A | Final Void | Final Void | 0 | 0 |
| | 2B | Water Management Areas | Water Management Areas | 0 | 0 |
| | 2C | Water Management Areas | Rehabilitation Area - Grassland | 0 | 0 |
| | 5B | Overburden Emplacement Area | Water Management Areas | 0 | 0 |
| | 5C | Overburden Emplacement Area | Rehabilitation Area - Grassland | 541.72 | 573.99 |
| | 5D | Overburden Emplacement Area | Rehabilitation Area - Woodland | 263.12 | 348.16 |
| | 5E | Overburden Emplacement Area | Rehabilitation Area - Woodland EEC | 0 | 13.76 |
| | Total - Ecosystem and Land Use Development | | | 804.8 | 935.91 |

| Rehabilitation Activity Type | Domain Identifier | Primary Domain | Secondary Domain | Total Area Last Reported (ha) | Total Area to date (ha) |
|---|---|---|---|---|---|
| 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 | 321.44 | 138.96 |
| | 2A | Water Management Areas | Final Void | 0 | 0 |
| | 2B | Water Management Areas | Water Management Areas | 0 | 0 |
| | 2C | Water Management Areas | Rehabilitation Area - Grassland | 28.11 | 34.97 |
| | 2D | Water Management Areas | Rehabilitation Area - Woodland | 28.92 | 26.17 |
| | 2E | Water Management Areas | Rehabilitation Area - Woodland EEC | 0 | 0 |
| | 3B | Infrastructure Area | Water Management Areas | 0 | 0 |
| | 3C | Infrastructure Area | Rehabilitation Area - Grassland | 84 | 100.65 |
| | 3D | Infrastructure Area | Rehabilitation Area - Woodland | 69 | 69.04 |
| | 3E | Infrastructure Area | Rehabilitation Area - Woodland EEC | 0 | 0 |
| | 4C | Tailings Storage Facility | Rehabilitation Area - Grassland | 45.77 | 75.74 |
| | 4D | Tailings Storage Facility | Rehabilitation Area - Woodland | 92.04 | 95.38 |

| | | | | |
|---|---|---|---|---|
| 4E | Tailings Storage Facility | Rehabilitation Area - Woodland EEC | 0 | 11.74 |
| 5A | Overburden Emplacement Area | Final Void | 0 | 0 |
| 5B | Overburden Emplacement Area | Water Management Areas | 0 | 0.00 |
| 5C | Overburden Emplacement Area | Rehabilitation Area - Grassland | 941.44 | 909.22 |
| 5D | Overburden Emplacement Area | Rehabilitation Area - Woodland | 1779.75 | 1712.87 |
| 5E | Overburden Emplacement Area | Rehabilitation Area - Woodland EEC | 32.15 | 311.62 |
| Bulga Sublease Area | N/A - Outside Domain Boundary | N/A - Outside Domain Boundary | 12.82 | 12.8 |
| Outside Domain Area | N/A - Outside Domain Boundary | N/A - Outside Domain Boundary | 0 | 1.35 |
| Total Footprint | | | 3435.44 | 3500.51 |

Table 2: Soil Management and Erosion, 2015

| Soil Stockpiling/ Use | Soil Used This Period (m3) | Soil Pre-stripped This Period (m3) | Soil Stockpiled to Date (m3) | Soil Stockpiled Last Report (m3) |
|---|---|---|---|---|
| | 43,800 | 32,880 | 760,061 | 1,174,066 |
| 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 | Not Available | 0.6 | 0.6 |

| | |
|---|---|
| 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 | 365.1 |
| 3.3 Give summary of control strategies used and verification by approval agency(s) | |
| Species targeted in rehabilitation areas during 2015 included: galenia, Acacia Saligna, African boxthorn, mother of millions, opuntia species (pear), castor oil, green cestrum and lantana. | |

Table 4: Management of Rehabilitation Areas

| | |
|---|---|
| 4.1 Area treated with maintenance fertiliser | 78ha |
| 4.2 Area treated by rotational grazing, cropping or slashing | 90ha |
| Give Summary | 90ha Warkworth rehabilitation area licence agreement in place for grazing. |

Table: 5 Variations to Rehabilitation Program

| | |
|---|---|
| Has rehabilitation work proceeded generally in accordance with the conditions of an accepted Mining Operations Plan? | Yes |

| | |
|---|---|
| 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. | NA |

Table 6: Planned Operations During the Next Repot Period

| | |
|---|---|
| 6.1 Area estimated to be disturbed | 149.1ha |
| 6.2 Area estimated to be rehabilitated | 82.6ha |

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# Appendix 3

## Rehabilitation and Disturbance Summary and Maps

### Table A: Rehabilitation Summary

| Rehabilitation Site Name | Type | Coordinates (GDA94) | Area (ha) | Rehabilitation Summary |
|---|---|---|---|---|
| **West Pit North** | Woodland & Pasture | 309,542.3 E<br>6,410,422.8 N | 35.5 | ▪ The landform was constructed from a waste emplacement.<br>▪ The north-eastern area of the landform (~8ha) is predominantly sloping (10 degrees) with north-eastern aspect while the remainder of the area is flat plateau with localised variation and without dominant aspect.<br>▪ North-eastern area drainage is via northerly draining contours to an engineered rock chute which reports to the established downstream drainage network. Slope crests and near areas report to upper contours. Plateau drainage is overland flow to small drainage swales and drainage depressions.<br>▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material.<br>▪ Silty clay loam topsoils from a combination of West Pit North topsoil stripping and existing topsoil stockpiles was spread at a nominal thickness of 100mm.<br>▪ Mixed waste compost was applied at a rate of 100t/ha.<br>▪ Gypsum was applied at a rate of 10t/ha.<br>▪ Growth medium preparation included windrowing, rock picking and aerating as required.<br>▪ Seasonal cover crops comprising Autumn Winter Cereal (barley/ryegrass, 8.7ha, 35kg/ha), Spring Summer Rehab Blend (millet/legumes/herbs, 21.8ha, 33kg/ha), and Summer Cereal (millet, 5.0ha, 30kg/ha) were drilled into an aerated pattern across successive releases. |
| **West Pit South** | Pasture | 308,142.4 E<br>6,408,251.0 N | 29.2 | ▪ The landform was constructed from a waste emplacement.<br>▪ The area is flat plateau without dominant aspect.<br>▪ The southern portion of the area drains overland to a drainage depression and then to an engineered rock chute. The chute reports to the existing lower contour drainage network. Overland drainage of the northern portion currently reports to adjacent mine areas via low lying drainage swales and drainage depressions. Integrated drainage of this area will be formalised with rehabilitation of adjacent areas.<br>▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material.<br>▪ Silty Clay Loam topsoils from a combination of West Pit Centre topsoil stripping and existing topsoil stockpiles was spread at a nominal thickness of 100mm.<br>▪ Mixed waste compost was applied at a rate of 100t/ha.<br>▪ Gypsum was applied at a rate of 10t/ha.<br>▪ Growth medium preparation included windrowing, rock picking and aerating as required.<br>▪ Seasonal cover crops comprising Spring Summer Rehab Blend (millet/legumes/herbs, 9.6ha, 33kg/ha), and Summer Cereal (millet, 19.6ha, 30kg/ha) were drilled into an aerated pattern across successive releases. |

| Rehabilitation Site Name | Type | Coordinates (GDA94) | Area (ha) | Rehabilitation Summary |
|---|---|---|---|---|
| **CD RL160** | Woodland | 319,432.7 E<br>6,389,893.7 N | 6.7 | ▪ The landform was constructed from a waste emplacement. Topsoil stockpile overlies 5.0ha of the landform surface.<br>▪ The area is a flat plateau and without dominant aspect.<br>▪ Drainage is to local low lying areas or via overland flow to adjacent active mine and rehabilitation areas. Areas adjacent to the South Pit North slope crest drain to slope contours and then to the engineered rock chute.<br>▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material.<br>▪ Clay loam topsoil from an existing topsoil stockpile was spread at a nominal thickness of 100mm across 1.7ha. Relocated clay loam topsoil from forward mine areas is stockpiled to 3m across the 5.0ha.<br>▪ Mixed waste compost was applied at a rate of 100t/ha.<br>▪ Gypsum was applied at a rate of 10t/ha.<br>▪ Growth medium preparation included windrowing, rock picking, and aerating as required.<br>▪ Autumn Winter Cereal was drilled into an aerated pattern at 35kg/ha across 1.7ha.<br>▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 36kg/ha across 5.0ha (topsoil stockpile). |
| **CD RL160 West** | Woodland | 319,053.9 E<br>6,389,938.9 N | 7.2 | ▪ The landform was constructed from a waste emplacement.<br>▪ The area is a flat plateau with localised slope variation and without dominant aspect.<br>▪ Drainage is via overland flow and contour swales reporting to local drainage depressions and dams.<br>▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material.<br>▪ A substrate of mine spoil was used for 4.6ha of the area. Clay loam topsoil from an existing topsoil stockpile was spread on the spoil base at a nominal thickness of 100mm across 2.6ha.<br>▪ Mixed Waste Compost (6.3ha) and Green Waste (0.9ha) were applied at a rate of 100t/ha.<br>▪ Gypsum was applied at a rate of 10t/ha.<br>▪ Growth medium preparation included rock rolling, rock picking and aerating as required.<br>▪ Diverse Native Woodland Mix was drilled to 6.4ha of spoil/compost area at 17kg/ha. Autumn Winter cereal (barley/ryegrass) was drilled to topsoil areas at 35kg/ha. Spring Summer Rehab Blend (millet/legume/herb) was broadcast to 0.8ha of spoil/compost at 36kg/ha. All seeding was to an aerated surface pattern. |

| Rehabilitation Site Name | Type | Coordinates (GDA94) | Area (ha) | Rehabilitation Summary |
|---|---|---|---|---|
| **NOOP** | Grassland | 320,357.6 E<br>6,392,179.0 N | 6.7 | ▪ The landform is *in-situ* natural subsoil (5.9ha) with a small adjacent area of waste emplacement toe (0.8ha).<br>▪ The area predominantly comprises flat to gentle sloping natural ground with minor slopes associated with the emplacement toe. All areas have easterly aspect.<br>▪ Drainage is via overland flow to adjacent dams.<br>▪ Landform surface preparation comprised bulk shaping and shallow ripping of the natural soil area, and bulk shaping, deep ripping, rock raking and removal of oversize rock material from the emplacement toe.<br>▪ A clay loam substrate of stockpiled topsoil was spread on the emplacement toe to a nominal depth of 100mm. Substrate of *in-situ* clay subsoil was retained in the area occurring.<br>▪ Green Waste was applied at a rate of 100t/ha.<br>▪ Gypsum was applied at a rate of 10t/ha.<br>▪ Growth medium preparation included rock windrowing, rock picking, and aerating as required.<br>▪ Native Grass Mix was drilled into an aerated pattern at 20kg/ha. |
| **South Pit North** | | 320,625.9 E<br>6,389,909.3 N | 13.8 | ▪ The landform was constructed from a waste emplacement.<br>▪ The area generally slopes to the east and north-east at 10 degrees with concave top upper slope areas of lesser steepness transitioning to the landform plateau adjacent west.<br>▪ The area is drained by contours which flow to a centrally located engineered rock chute. The chute traverses the full slope length and reports to basal dams.<br>▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material.<br>▪ Clay loam topsoil from an existing topsoil stockpile was spread at a nominal thickness of 100mm across the slope.<br>▪ Mixed Waste Compost was applied at a rate of 100t/ha.<br>▪ Gypsum was applied at a rate of 10t/ha.<br>▪ Growth medium preparation included windrowing, rock picking, and aerating as required.<br>▪ Summer Cereal (millet) was broadcast into an aerated pattern at 36kg/ha. |
| **Tailings Dam 1** | | 319,648.1 E<br>6,392,392.8 N | 41.0 | ▪ The landform is predominantly the engineered waste rock capping layer of a decommissioned Tailings Storage Facility (TSF). The capping landform extends into adjacent waste emplacement areas to the south and west, and onto the TSF embankment in the north and east.<br>▪ The area slopes gently (0.5-1.5% fall) to a central drainage channel (20% batter slopes fall, 0.8% longitudinal channel grade) which reports to dams external to the TSF footprint. Slopes at outer edges steepen to tie-in with the adjacent emplacement (concave slope tie-in) and embankment (convex slope tie-in) features.<br>▪ Drainage is via overland flow to the central drainage channel which reports to storage |

| Rehabilitation Site Name | Type | Coordinates (GDA94) | Area (ha) | Rehabilitation Summary |
|---|---|---|---|---|
| | | | | dams located to the south-east of the rehab area.<br>▪ Landform surface preparation comprised waste emplacement in two 2m layers, bulk shaping, deep ripping, rock raking, and removal of oversize rock material.<br>▪ A substrate of mine spoil was used for the 29.9ha comprising the substantive central areas of the former TSF.<br>▪ Clay loam topsoil from an existing topsoil stockpile was spread at a nominal thickness of 100mm across the remaining 11.1ha which comprised edge areas and the central drainage channel.<br>▪ Mixed Waste Compost (37ha) and Green Waste (4ha) was applied at a rate of 100t/ha.<br>▪ Gypsum was applied at a rate of 10t/ha.<br>▪ Growth medium preparation included rock rolling, windrowing, rock picking, and aerating as required.<br>▪ Native Woodland Mix was drilled to 29.9ha of spoil/compost area at 17kg/ha. Spring Summer Rehab Blend (millet/legume/herb) was broadcast on topsoil areas at 36kg/ha. All seeding was to an aerated surface pattern. |
| **Woodlands** | | 319,890.7 E<br><br>6,388,349.3 N | 0.4 | ▪ This area of rehab is an engineered rock chute only.<br>▪ The landform was constructed from a waste emplacement.<br>▪ The chute slopes to the south-east at 10 degrees.<br>▪ The chute receives runoff from south and east flowing contours located to the north and west respectively, and conveys waters to a basal surge dam which spills to South Pit South void.<br>▪ Landform surface preparation comprised bulk shaping, bulk and detailed excavation, surface compaction, geofabric installation and rock placement. |

| Autumn Winter Cereal Mix 1 | Composition (%) |
| --- | --- |
| Oats | 75 |
| Italian Ryegrass | 25 |

| Autumn Winter Cereal Mix 2 | Composition (%) |
| --- | --- |
| **Schooner Barley** | **75** |
| **Italian Ryegrass** | **25** |

| Autumn Winter Rehab Blend | Composition (%) |
| --- | --- |
| **Yarran Oats** | **68** |
| **Italian Ryegrass** | **22** |
| **L91 Lucerne** | **5** |
| **Arrowleaf Clover** | **5** |

| Spring Summer Cereal | Composition (%) |
| --- | --- |
| **Rebound Millet** | **100** |

| Spring Summer Rehab Blend | Composition (%) |
| --- | --- |
| **Rebound Millet** | **58** |
| **Balance Chicory** | **5** |
| **Renegade Red Clover** | **8** |
| **L70 Lucerne** | **21** |
| **Burgundy Bean** | **8** |

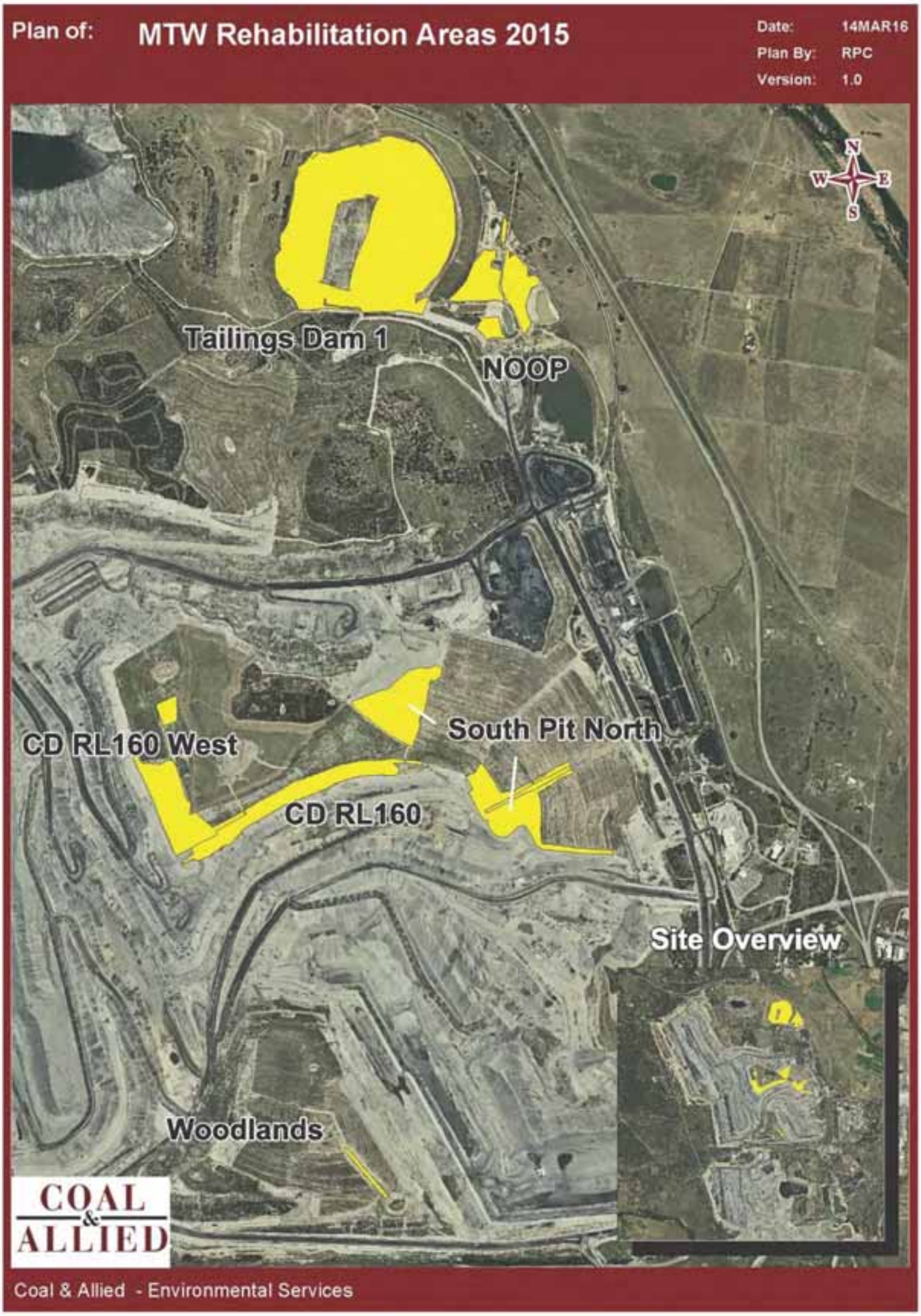



**Figure A: Rehabilitation Areas 2015**

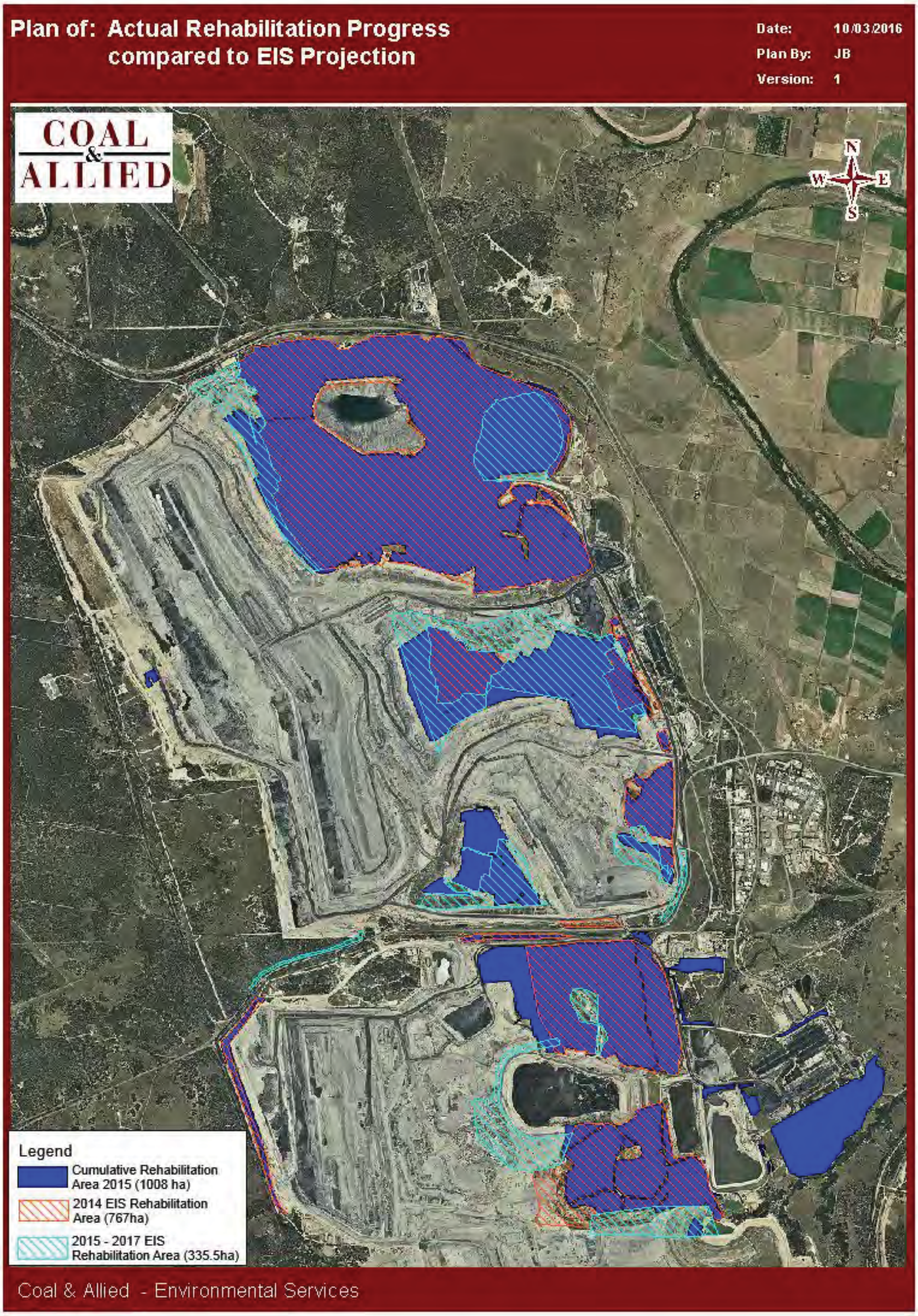
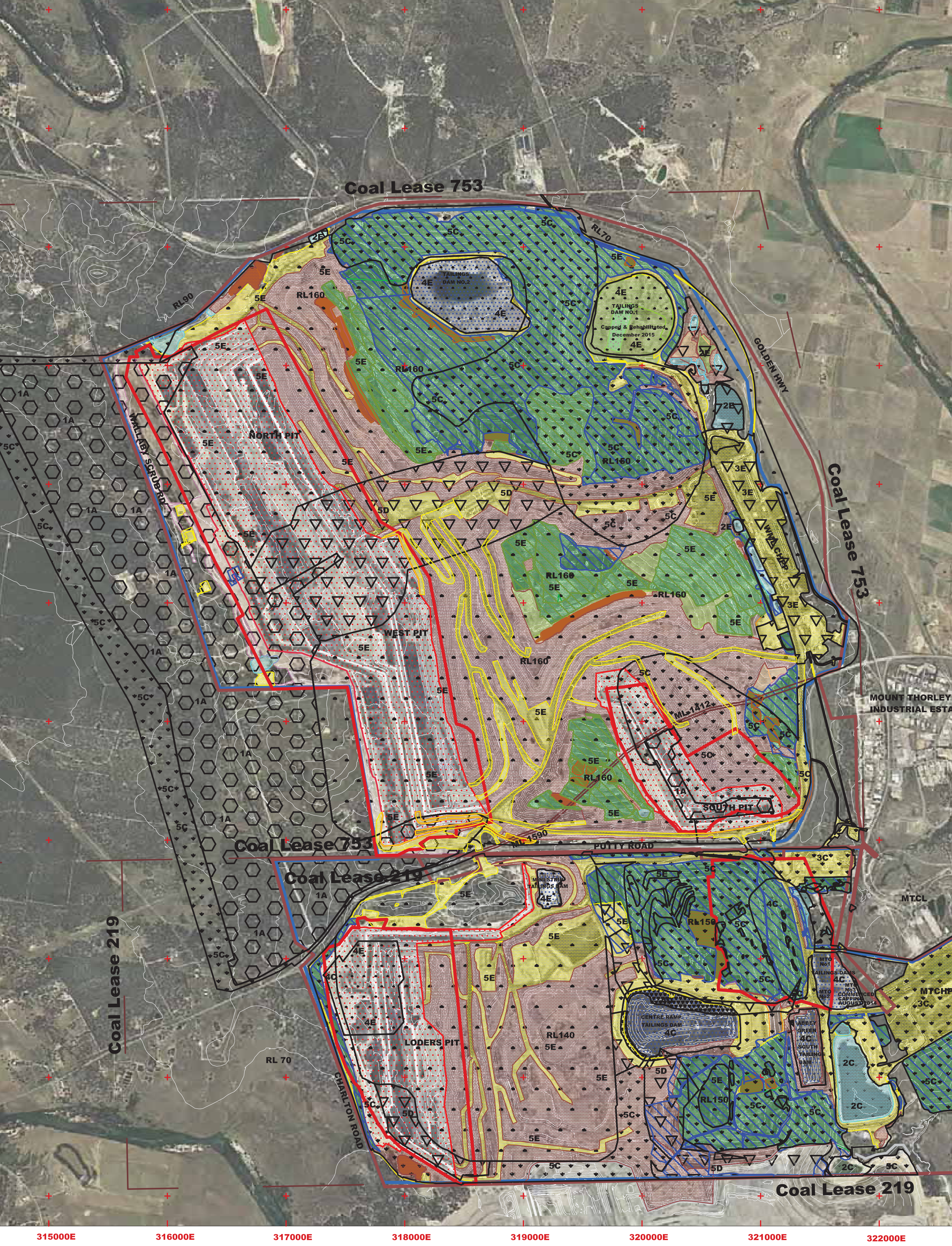



**Figure B: Cumulative Rehabilitation compared to EIS Prediction**




Primary Domains

1 – Final Void

2 – Water Management Area

3 – Infrastructure Area

AEMR 2015 Areas

Active Mining

Shaped Spoils

Unshaped Spoils

Sub–Lease Area

Appendix 4

Rehabilitation Monitoring Report

# Native Vegetation Rehabilitation Monitoring 2016

## Mount Thorley Warkworth and Hunter Valley Operations

**Prepared for Coal and Allied**

**29 March 2016**

## Document control

| | |
|---|---|
| Project no.: | 2766 |
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| Project office: | Mudgee |
| Document description: | Monitoring of native vegetation within rehabilitation areas at Mt Thorley Warkworth Operations (MTW) and Hunter Valley Operations (HVO) as part of the Rehabilitation Monitoring Program. |
| Project Director: | Dr Rhidian Harrington |
| Project Manager: | Vivien Howard |
| Authors: | Vivien Howard and Luke Baker |
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| Vivien Howard, Luke Baker | Draft 1 | Rhidian Harrington | 7 March 2016 | RH |
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| Vivien Howard | Rev2 | Vivien Howard | 29 March 2016 | VH |


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*Cover photograph: Native rehabilitation at monitoring site MTWMTO2000*

# Executive summary

### Context

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Coal and Allied Operations Pty Ltd (C&A) to undertake the first year of native rehabilitation post-mining monitoring sites 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 across 19 individual HVO rehabilitation areas, and 17 individual MTW rehabilitation areas.

### Methods

This monitoring report provides the results of the progress of the native vegetation in accordance with the methodology detailed in AECOM (2012) Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites.

### Aims

The aim of the monitoring program is to undertake monitoring in accordance with AECOM (2012) and establish permanent monitoring sites across the rehabilitation areas, and 12 reference sites in unmined areas aimed at capturing the two target Biometric Vegetation Types (BVTs) specified in the respective Mining Operations Plans (MOP) for MTW and HVO:

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 to assist C&A in setting target levels for the performance criteria for the native vegetation rehabilitation which have not been finalised in the MOP's for MTW, HVO North and HVO South.

### Results

A total of 35 rehabilitation monitoring sites were established across HVO and MTW native vegetation rehabilitation areas. Twelve reference sites were established in target vegetation types in a number of locations.

Key findings include the following:

- There is significant variation in the types and ages of the rehabilitation sites which were part of the monitoring project, and therefore there is a high degree of variability in monitoring results - this includes native plant species richness, exotic cover, percentage cover, and projected cover of all strata.
- Data was collected from each reference site and compared to the NSW Office of Environment and Heritage (OEH) benchmarks for the two target BVTs. Notable differences include low values for native mid-storey, native ground cover (shrubs), and number of trees with hollows within the local reference sites. The low reference site values for these attributes may not provide C&A with a performance indicator suitable to measure rehabilitation progress.
- Generally the rehabilitation sites fell below reference site and benchmark values for both of the target communities. This means that management should aim to increase those attributes for each rehabilitation site for which it is lacking.
- Rehabilitation sites were achieving local benchmark values for some of the ten Biobanking site attribute values.

- Weed abundance was high across all monitoring sites. This is to be expected for some sites given they were still in the early phases of weed clean-up prior to sowing native seed mixes.
- Generally there was limited variation in regards to the ground cover assessment scores between different soil treatments.
- Landscape Function Analysis (LFA) scores (Landscape Organisation Index (LOI) and soil surface indicators) were high for reference sites, and variable for rehabilitation sites.
- The Landscape Organisation Index (LOI) averages show that the sites treated with Spoil/ Compost have a lower average LOI than the reference sites or other soil treatments. Topsoil/ Compost contained the greatest average LOI (0.93), which was similar to that at Reference sites (0.97).
- 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), including sites HVORIV201405 and HVORIV201406.
- Sites which achieved relatively low LOI were sites that had only recently been established and exhibited little grass or plant cover. These sites had been seeded with native seed mix but the sites were still in the early phases of seed germination and vegetation establishment.
- The Spoil/ Compost site contained the lowest average stability score, whilst the remaining soil treatments were quite similar.
- The Reference sites contained the highest average infiltration scores. Both Subsoil/ Compost and Topsoil treatments had similar results, with Topsoil/ Compost having s slightly higher infiltration score. Spoil/ Compost was relatively low compared to the other soil treatments.
- The variability in values at the rehabilitation sites is likely to be influenced by the seed treatments applied to sites and the age of the rehabilitation.

### Recommendations

Key recommendations from monitoring presented in this report include the following:

- Amend the monitoring methodology to allow the collection of more meaningful data that would assist in management of the rehabilitation sites. Potential changes may include:
    - Replacing the groundcover assessment with a nested 20 x 20 m floristic plot. Recording all species (native and exotic) and recording cover abundance scores for each.
    - Ceasing the use of AECOM's 'Groundcover Assessment' and only rely on LFA for information on surface cover (plants, rocks and litter) and use the cover abundance scores (recommended above) to provide information on the proportion of weed and native cover.
    - Ceasing the use of the AECOM's 'Species Composition Assessment' and rely on a 20 x 20 m floristic plot data instead. This would provide a more robust list of species present (i.e. every species in the plot). Dominant species could be discerned via the cover abundance scores. Eliminating this assessment would reduce field and data management time by reducing duplication with the Biobanking methodology.
    - Stipulating in the methodology that Diameter at Breast Height (DBH) and tree height is recorded for ten canopy trees at each sample site, and replicating this process at reference sites. Data from the reference sites is needed to inform performance criteria setting as tree maturity is not reflected in BioBanking benchmark data.
    - Undertaking monitoring during spring and/or autumn to increase opportunities for more thorough identification. Species identification at early stage rehabilitation sites is limited by the maturity of the plants present.
- Consider using OEH benchmark data for native mid-storey cover, native ground cover (shrubs), and number of trees with hollows, as the local reference sites had values ranging to zero for these attributes.

It is noted that without more accurate data on the rehabilitation measures implemented (i.e. seed mixes used and seeding rate), it is difficult to discern accurate information regarding the efficacy of particular

rehabilitation techniques. It is recommended that C&A compile data on the particular rehabilitation techniques implemented at each site and target aspect of the monitoring program to enable the efficacy of rehabilitation techniques to be better determined.

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# Abbreviations

| Acronym | Term/Definition |
|---|---|
| BBAM | BioBanking Assessment Methodology |
| BVT | Biometric Vegetation Type |
| C&A | Coal & Allied Operations |
| Dbh | Diameter at breast height |
| EPC | Exotic Plant Cover |
| FL | Fallen logs |
| ha | Hectare/s |
| HVO | Hunter Valley Operations |
| Km | Kilometre |
| LFA | Landscape Function Analysis |
| LOI | 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 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 |
| TSC Act | Threatened Species Conservation Act 1995 (NSW) |

# 1. Introduction

## 1.1 Overview

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Coal and Allied Operations Pty Ltd (C&A) to undertake the first year of native rehabilitation post-mining monitoring sites at the Mt Thorley-Warkworth (MTW) and Hunter Valley Operations (HVO) mine sites (Figure 1 to Figure 12). The monitoring forms part of the MTW and HVO monitoring program, which aims to assess the recovery of native rehabilitation across 19 individual HVO rehabilitation areas, and 17 individual MTW rehabilitation areas.

This monitoring report provides the results of the progress of the native vegetation in accordance with the methodology detailed in Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites (AECOM 2012).

To date, the performance criteria targets for the native vegetation rehabilitation have not been finalised in the Mining Operations Plan (MOP) for MTW, HVO North or HVO South. The results of this monitoring report will assist C&A in determining suitable targets for performance criteria against which rehabilitation areas can be assessed.

## 1.2 Background to the rehabilitation monitoring

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

- Schedule 4 – Condition 70(h) of Development Consent DA-300-9-2002i (Warkworth Mine)
- Schedule 3 – Condition 42(g) of Development Consent DA 34/95 (Mount 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 are generally divided into areas of post-mined lands being returned to either a native ecosystem or a grazing pasture (or grassland) final land use. 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 these EEC communities is 2,114ha at MTW and 4ha at HVO. Other native ecosystem rehabilitation undertaken at MTW and HVO will produce trees over grassland areas, but not necessarily conforming to any particular known or existing vegetation type.

This assessment marks the first round of native vegetation monitoring and site establishment at MTW and HVO. Biobanking benchmark site data and data obtained from monitoring of reference sites will be used by C&A to determine appropriate target values for the performance criteria for native vegetation rehabilitation as detailed in the MOPs.

## 1.3 Project scope and objectives

This rehabilitation monitoring report documents the 2016 survey results and subsequent data analysis.

The monitoring program has been undertaken in accordance with the methodology detailed in AECOM (2012).

The monitoring involved the following key objectives:

- Establish permanent monitoring sites within each of the rehabilitation area (19 at HVO and 17 at MTW).
- Establish permanent reference sites within target EECs (Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest) to assist with target setting for MOP performance criteria.
- Complete BioBanking plots at all reference sites, and older (> 4 years) rehabilitation sites with sufficient native vegetation establishment (four sites at HVO North and five sites 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.
- Complete ground cover assessment for those monitoring sites where BioBanking plots were not completed.
- Provide an analysis of results against reference sites.
- Provide an analysis of results from those rehabilitation sites with different soil treatment.
- Provide recommendations to assist with the improvement of future monitoring and performance indicators.

## 1.4 Monitoring team

Data collection for the first monitoring period was undertaken on 1st to 5th and 8th to 12th of February 2016. Ecologists involved with the completion of field monitoring tasks and reporting are listed as follows:

| | |
|---|---|
| Vivien Howard | Senior Ecologist (Field survey and reporting) |
| Luke Baker | Senior Botanist (Field survey and reporting) |
| Dr Ross Jenkins | GIS |

## 2. Rehabilitation areas

### 2.1 HVO rehabilitation areas

HVO rehabilitation consists of 19 individual areas (Figure 2) comprised of different rehabilitation establishment conditions. The desired outcome of the rehabilitation is to achieve a native woodland community, or native pasture/ light wooded vegetation community. Details regarding the establishment and treatment for each site, including the desired vegetation type are provided in Table 1.

**Table 1. HVO rehabilitation areas, establishment conditions and derived vegetation type**

| Rehabilitation area name | Area (ha) | Establishment date | Soil and seeding information[1] | Desired vegetation type |
|---|---|---|---|---|
| HVO WES200801 | 3.4 | 2008 | Topsoil | Native woodland |
| HVO WES201101 | 4.4 | 2011 | Compost (with spoil), native seed hydroseeded | Native woodland |
| HVO WES201301 | 3.7 | 2013 | Compost (with spoil), native seed drilled | Native woodland |
| HVO WES201302 | 12.7 | 2013 | Compost (with topsoil), natives not sown | Native woodland |
| HVO CAR200901 | 14.2 | 2009 | Topsoil, native seed broadcast | Native woodland |
| HVO CAR200902 | 7.7 | 2009 | Topsoil, native seed broadcast | Native woodland |
| HVO CAR201401 | 25.6 | 2014 | Compost (with topsoil), natives not sown | Native woodland |
| HVO RIV201406 | 3.1 | 2014 | Compost (with topsoil), natives not sown | Pasture/ light Wooded |
| HVO RIV201405 | 14.3 | 2014 | Compost (with subsoil), native seed drilled | Pasture/ light Wooded |
| HVO RIV201404 | 8.4 | 2014 | Compost (with subsoil), seed has been drilled | Pasture/ light Wooded |
| HVO RIV201403 | 4.8 | 2014 | Compost (with subsoil), seed has been drilled | Pasture/ light Wooded |
| HVO RIV201402 | 10 | 2014 | Compost (with subsoil), seed has been drilled | Pasture/ light Wooded |
| HVO RIV201401 | 5.8 | 2014 | Compost (with spoil), seed has been drilled | Pasture/ Light Wooded |
| HVO RIV201301 | 10 | 2013 | Compost (with topsoil), natives not sown | Pasture/ Light Wooded |
| HVO CHE201201 | 20.8 | 2012 | Compost (with topsoil), native seed drilled | Native woodland |
| HVO CHE201202 | 6.1 | 2012 | Topsoil (with spoil), native grass sown | Native woodland |
| HVO CHE201203 | 26.6 | 2012 | Compost (with topsoil), natives not sown | Native woodland |

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

| Rehabilitation area name | Area (ha) | Establishment date | Soil and seeding information[1] | Desired vegetation type |
|---|---|---|---|---|
| HVO CHE201301 | 12.6 | 2013 | Compost (with topsoil), natives not sown | Native woodland |
| HVO CHE201401 | 9.8 | 2014 | Compost (with topsoil), natives not sown | Native woodland |

## 2.2 MTW rehabilitation areas

The MTW rehabilitation area consists of 17 individual areas (Figure 7) comprised of different rehabilitation establishment conditions listed below in Table 2.

The desired outcome of the rehabilitation is to achieve a native woodland community, or native pasture/ light wooded vegetation community.

**Table 2. MTW rehabilitation areas, establishment and derived vegetation type**

| Rehabilitation area name | Area (ha) | Establishment date | Soil and seeding information[2] | Desired vegetation type |
|---|---|---|---|---|
| MTWNPN201301 | 23.1 | 2013 | Compost (with topsoil), natives drilled Winter 2015 | Native woodland |
| MTWNPN201402 | 1.9 | 2014 | Compost (with fresh sand topsoil), natives drilled 2014 | Native woodland |
| MTWNPN201401 | 7.1 | 2014 | Compost (with topsoil), natives drilled 2014 | Native woodland |
| MTWNPN201403 | 5.5 | 2014 | Compost (with subsoil), natives drilled 2014 | Native woodland |
| MTWNPN201101 | 43.3 | 2011 | Topsoil, natives hydroseeded 2011 | Native woodland |
| MTWNPN200901 | 21.8 | 2009 | Topsoil, using an ‘old seed mix’ | Native woodland |
| MTWCDD201101 | 8.1 | 2011 | Topsoil, native seed hydroseeded | Native woodland |
| MTWCDD201301 | 9.1 | 2013 | Compost (with topsoil), natives not sown | Native woodland |
| MTWCDD201501 | 6.4 | 2015 | Compost (with spoil), natives drilled | Native woodland |
| MTWSPN201401 | 37.7 | 2014 | Compost (with topsoil), natives not sown | Native woodland |
| MTWWDL201401 | 4.7 | 2014 | Compost (with topsoil), natives drilled 2015 | Native woodland |
| MTWWDL201402 | 8.9 | 2014 | Compost (with topsoil), natives not sown | Native woodland |
| MTWMTO200001 | 6.3 | 2000 | Topsoil | Pasture/ light wooded |
| MTWTD1201501 | 20.6 | 2015 | Compost (with spoil), native seed drilled 2015 | Native woodland |
| MTWNPN200501 | 13.2 | 2005 | Topsoil | Pasture/ light wooded |

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

| Rehabilitation area name | Area (ha) | Establishment date | Soil and seeding information[2] | Desired vegetation type |
|---|---|---|---|---|
| MTWNPN200502 | 4.8 | 2005 | Topsoil | Pasture/ light wooded |
| MTWMTO200503 | 11.7 | 2005 | Topsoil | Native woodland |

## 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 (Coal & Allied 2012a and 2012b), however, target values for some of the criteria are yet to be developed. The data provided from the reference sites established during this monitoring program will assist C&A in assessing rehabilitation against the performance criteria targets and triggers. In the absence of performance criteria targets this monitoring report will provide a comparison of results for rehabilitation sites against reference site and Biobanking benchmark values, where available).

# 3. Monitoring methodology

## 3.1 Monitoring dates

Monitoring was undertaken on 1st to 5th and 8th to 12th of February 2016.

Details regarding the dates, personnel and sites completed for each day during the monitoring is provided in Appendix 1.

## 3.2 Design

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

### 3.2.1 Rehabilitation monitoring sites

A total of 35 rehabilitation monitoring sites were established:

- 18 monitoring sites at HVO North (Figure 2, and Figures 3 to 6)
- 17 monitoring sites within rehabilitation sites at MTW (Figure 7, and Figures 8-12).

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 2).

Monitoring at each rehabilitation site included the collection of the following data: photo points, visual assessment, Landscape Function Analysis (LFA) and soil analysis. Those sites with native vegetation established also required the collection of BioBanking data.

The locations of the monitoring sites, along with their associated descriptions and coordinates have been provided in Appendix 2.

### 3.2.2 Reference monitoring sites

The project resulted in the establishment of 12 reference monitoring sites, aimed at capturing the two BVTs specified in the MOP:

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

The selection of the reference sites for the monitoring program was undertaken with consideration of the following:

- The rehabilitation objectives and commitments – to ensure that the reference sites are representative of what is trying to be achieved on post-mined rehabilitated lands (i.e. the same vegetation types).
- To ensure that the suite of reference sites making up the monitoring programme appropriately capture the range of environmental and biophysical conditions occurring in the region.

A preliminary assessment of potential reference sites was undertaken based on regional vegetation mapping and based on discussions with staff from OEH, and environmental staff from C&A and other mine sites.  A larger (based on range and number) list of potential sites was developed and then reduced based largely on access limitations.

Three of the Central Hunter Ironbark-Spotted Gum-Grey Box Forest sites were established at Belford National Park (Figure 13) and another three established within land managed by Wambo Coal Mine (Figure 14).

Two of the Central Hunter Grey Box-Ironbark Woodland reference sites were established within land managed by Wambo Coal (Figure 14), with another four established in land managed by C&A (Figure 15).

The coordinates for the location of each reference site is provided in Appendix 2.

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.

## 3.3 Sampling techniques

### 3.3.3 Landscape Function Analysis (LFA)

LFA is a monitoring procedure developed by the CSIRO (Tongway & 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 3), 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 3. 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 sites attributes which are measured along a transect or within a survey plot, and assessed against benchmarks values (Table 4). A minimum number of plots are required based on the area of the site being assessed. Given this is the first year of monitoring, it was thought to be more valuable to present results for each of the Biobanking criteria rather than just the site value score. The results for the rehabilitation areas have been compared to the reference site benchmarks.

BioBanking plots were undertaken at all reference sites, and those sites with native vegetation established (four sites at HVO North and five sites at MTW as identified in Appendix 1).

**Table 4. 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 for a specific vegetation community. In rehabilitation areas, this allowed confirmation that the species establishing conformed to the 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.

#### 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 weather 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 Ground cover assessment

Ground cover assessment was undertaken at sites where native vegetation is not yet well established (i.e. where the BioBanking monitoring was not undertaken). The ground cover assessment involved a plot based assessment, conducted at 5-metre intervals along the 50 m transect line (for a total of 10 sampling points per transect). The following information was visually assessed and recorded in 1 x 1 m quadrats:

- The percentage cover of protective ground cover components (dead and live plant material, rocks and logs)
- The percentage cover of bare ground
- The percentage cover of weeds
- The number of ground cover species present.

At each sampling point, percentage cover is visually estimated to the nearest 10% using a 1 x 1 m frame divided into a 0.1 x 0.1 m grid. The overall percentage cover for the site is calculated by averaging results from all ten sampling points.

### 3.3.7 Soil analyses

Soil characterisation and analyses are 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 m apart was collected within a 20 m 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 SESL Australia for analysis.

The following soil parameters were determined:

- pH
- Sodicity
- Electrical conductivity (EC)
- Electrochemical Stability Index (ESI)
- Plant available nutrients
- Cation balance
- Soil organic matter content
- Soil texture including clay content
- Fertiliser application rates as relevant for the proposed plant community.

Soil analysis was undertaken by SESL Australia, results were analysed and tabulated by them and included comparisons of soil parameters based on soil treatment and the rehabilitation outcome trying to be achieved at each site.

At a further 36 sites, soil microbial testing was also undertaken, to gain a relative measure of microbial fungal associations. This was undertaken at all 12 reference sites and 18 rehabilitation sites. Appendix 1 identifies those monitoring sites where soil microbial testing was undertaken. Appendix 6 includes the raw soil data.

### 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. Photographs were taken to allow a panorama of each end of the transects to be established. This included:

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

### 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 m spacing across the slope.

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

### 3.3.10 Weather

Temperatures and rainfall in the four months preceding the field monitoring period are listed in

Table 5.

Conditions during the field surveys were dry and hot, with high humidity levels. Low rainfall occurred overnight and intermittent throughout the 4th and 6th of February (approximately 4 mm) during the field survey. Daily temperatures ranged from 17°C to 34°C.

Most plants had just finished their flowering growth phase at the time of monitoring.

**Table 5. Weather conditions preceding and during the monitoring period (BoM Station # 061397)**

| | Monthly mean | | | 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 | 839 | 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

Given this round of monitoring will inform the native rehabilitation performance criteria, no discussion or analysis in regards to the performance objectives detailed in the MOP was undertaken.

Soil slake and texture test was not able to be conducted for some sites (MTWD1201501, MTWCDD201301, MTWNPN2009, MTWCDD201501) due to wet weather during the 4th and 6th of February.

A site value assessment using the BBAM, as per the AECOM (2012), was not undertaken during this round of monitoring as MOP performance criteria targets have not been finalised by C&A. Analysis of each benchmark attribute is a far more beneficial assessment tool in this instance, as it provides greater detail on how sites scored for each attribute.

Whilst monitoring of HVOCHE201202 was anticipated as part of the monitoring project, it was advised by C&A during the survey period that monitoring at this site was no longer required.

Many of the flora recorded in the rehabilitation monitoring sites were in a juvenile or seedling state. 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 within a good condition and within the general region of the study they have been impacted by historic clearing, and thus old growth forms of these BVTs were not able to be sampled as reference sites.

Data analysis was limited to comparison of rehabilitation sites with 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.

# 4. Results

## 4.1 Reference sites

### 4.1.1 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 the Table 6

Based on the two OEH benchmark values, the following can be concluded:

- Grey-Box Ironbark Woodland has higher NPS compared to Ironbark Spotted Gum-Grey Box Forest.
- NOS cover differed slightly between the two communities.
- Ironbark Spotted Gum-Grey Box Forest has a greater NMS range compared to Grey-Box Ironbark Woodland.
- Grey-Box Ironbark Woodland has a greater NGCG and a greater range compared to Ironbark Spotted Gum-Grey Box Forest.
- Both communities had the same NGCS.
- 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 6. 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 |
| Average | ≥33 | 17.5 | 45 | 7.5 | 40 | 17.5 | 33 | 5 | 10 | 12.5 | 27.5 | 0 | 2 | 1 | ≥35.5 |

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, .

### 4.1.2 Reference site and OEH Benchmark values

The OEH Benchmarks values have been compared to the reference values in Table 7.

Based on the results, the following can be concluded:

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

- Reference sites have a lower limit for most attributes (except NGCG).

- NPS for the reference site benchmark had a total of ten species less than OEH benchmark.
- NOS for reference site benchmark has a smaller range than the OEH benchmark. 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 5 percent.
- NGCG for the reference site benchmark is higher compared to the OEH benchmark.
- NGCS for the reference site benchmark has a lower value of zero and a higher upper value compared to OEH benchmark.
- NGCO for the reference site benchmark has a lower value of zero and a higher upper value compared to OEH benchmark.
- FL has a greater reference site benchmark than the OEH benchmark.

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

- NPS for the local benchmark had a total of nine species more than OEH benchmark.
- NOS for reference site benchmark has a smaller range than the OEH benchmark. 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 10. 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 OEH benchmark.
- NGCS for the reference site benchmark has a lower low value and high value compared to OEH benchmark.
- NGCO for the reference site benchmark has a higher low value and a significantly higher upper value compared to OEH benchmark.
- FL has a lower reference site benchmark than the OEH benchmark.

## Table 7. OEH Benchmarks and Rehabilitation sites

| 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 |

### 4.1.3 Landscape Function Analysis

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 8. Key results include the following:

- Most sites scored a LOI of 1.0.
- WARKGB03 had the lowest LOI (0.84) across all reference sites.
- The average LOI for Ironbark-Spotted Gum-Grey Box Forest was similar to the average for Grey Box-Ironbark Woodland.
- Stability ranged from 57.9 to 72.5 for Grey Box-Ironbark Woodland. WAMBOGB2 and WARKGB04 both had the highest stability score at 72.5.
- Stability ranged from 66.7 to 81.8 for Ironbark-Spotted Gum-Grey Box Forest.
- BELSPOT2 had the highest stability scores (81.8) across all Reference sites.
- The average stability for Ironbark-Spotted Gum-Grey Box Forest was similar to the average for Grey Box-Ironbark Woodland.
- Infiltration ranged from 48.4 to 57.6 for the Grey Box-Ironbark Woodland Reference sites. Most of the sites scored below 50.
- Infiltration ranged from 51.6 to 69.9 for the Ironbark-Spotted Gum-Grey Box Forest.
- The average infiltration for Ironbark-Spotted Gum-Grey Box Forest was higher than the average for Grey Box-Ironbark Woodland.
- Nutrient cycling ranged from 38.7 to 52.1 for the Grey Box-Ironbark Woodland Reference sites. Only WARKGB02 scored above 50.
- Nutrient cycling ranged from 43.6 to 65.6 for Ironbark-Spotted Gum-Grey Box Forest. WAMBOSPOT1 had the highest score.
- The average nutrient cycling value for Ironbark-Spotted Gum-Grey Box Forest was higher than the average for Grey Box-Ironbark Woodland.

**Table 8. LFA for Reference sites**

| Site name | Landscape Organisation Index (LOI) | Stability | Infiltration | Nutrient Cycling |
|---|---|---|---|---|
| Central Hunter Grey Box-Ironbark Woodland | | | | |
| WAMBOGB1 | 1 | 58.3 | 56.2 | 46.3 |
| WAMBOGB2 | 1 | 72.5 | 48.4 | 48.4 |
| WARKGB01 | 1 | 69.8 | 49.7 | 43.2 |
| WARKGB02 | 1 | 70 | 57.6 | 52.1 |
| WARKGB03 | 0.84 | 57.9 | 49.8 | 38.7 |
| WARKGB04 | 0.97 | 72.5 | 48.4 | 48.4 |
| Average | 0.96 | 66.8 | 51.7 | 46.2 |
| Central Hunter Ironbark-Spotted Gum-Grey Box Forest | | | | |
| BELSPOT1 | 1 | 66.7 | 51.6 | 43.6 |
| BELSPOT2 | 0.94 | 81.8 | 69.9 | 54.2 |
| BELSPOT3 | 1 | 63.9 | 65.3 | 54.9 |
| WAMBOSPOT1 | 1 | 62.5 | 74 | 65.6 |
| WAMBOSPOT2 | 0.96 | 72.7 | 64.2 | 62.1 |
| WAMBOSPOT3 | 1 | 69.7 | 67.2 | 59.7 |

| | | | | |
|---|---|---|---|---|
| Average | 1.0 | 69.6 | 65.4 | 56.7 |
| Average scores for both Grey Box-Ironbark Woodland and Ironbark-Spotted Gum-Grey Box Forest | 0.98 | 68.19 | 58.53 | 51.43 |

### 4.1.4 Visual monitoring, photo monitoring

The results of the visual monitoring, DBH and photo monitoring area provided in Appendix 4.

### 4.1.5 Soil analysis

The results of the soil analyses for key soil chemistry parameters for the reference sites are summarised in Table 9. This table includes a summary of the most significant indicators of soil condition.

Maximum, minimum and mean values for core soil attributes at the reference sites is provided in Table 10 , below. For reference, the detailed results as provided by SESL are included in Appendix 6.

**Table 9. Summary of soil condition indicators at Reference Sites**

| Site | Texture | Soil Infiltration Rate | pH CaCl 2 | EC (dS/ m) | Ece (dS/ m) | ECEC (Meq) | Ca (%) | Mg (%) | K (%) | Na (%) | NO3 (mg/k g) | PO4 (mg/k g) | K (mg/ kg) | Ca (mg/ kg) | Mg (mg/k g) | SO4 (mg/k g) | Na (mg/k g) | B (mg/ kg) | Cu (mg/ kg) | Fe (mg/ kg) | Mng (mg/k g) | Zn (mg/ kg) | OM (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bel1 | Loam Fine Sandy | Rapid | 4.64 | 0.05 | 0.5 | 12 | 15.2 | 21.6 | 3.3 | 2.1 | 8.82 | 8.3 | 156 | 365 | 315 | 10 | 57.6 | 0.1 | 0.64 | 293 | 30 | 5.6 | 6.4 |
| Bel2 | Loam Fine Sandy | Rapid | 5.72 | 0.07 | 0.7 | 10.3 | 73.7 | 20.8 | 3.8 | 1.5 | 18 | 6.4 | 152 | 1522 | 260 | 11 | 34.9 | 0.4 | 0.64 | 198 | 39 | 5.2 | 7.1 |
| Bel3 | Loam Fine Sandy | Rapid | 5.03 | 0.07 | 0.7 | 17 | 31.2 | 22.4 | 2.6 | 2.9 | 6.93 | 6.4 | 170 | 1064 | 463 | 11 | 116 | 0.3 | 0.64 | 257 | 24 | 6.6 | 9.3 |
| WarkGB01 | Fine Sandy Clay Loam | Moderate | 5.06 | 0.05 | 0.4 | 15.6 | 43.1 | 16 | 3.7 | 1 | 3.51 | 10 | 226 | 1346 | 303 | 14 | 34.1 | 0.2 | 0.6 | 196 | 43 | 6.1 | 6.8 |
| WarkGB02 | Light Sandy Clay Loam | Rapid | 4.6 | 0.04 | 0.4 | 8.7 | 20.8 | 16 | 3.8 | 1.7 | 1.96 | 6.8 | 130 | 363 | 169 | 11 | 33.7 | 0.1 | 0.64 | 254 | 29 | 1.7 | 2.9 |
| WarkGB04 | Sandy Clay Loam | Moderate | 5.14 | 0.06 | 0.6 | 13.2 | 23.4 | 25 | 2.4 | 2 | 1.4 | 13.2 | 125 | 619 | 401 | 11 | 62.9 | 0.1 | 0.64 | 241 | 21 | 2.5 | 3.9 |
| WAMBO GB01 | Clay Loam | Moderate | 5.22 | 0.05 | 0.4 | 15.7 | 30.7 | 27.5 | 3.5 | 2.3 | 1.94 | 6.3 | 216 | 967 | 525 | 9.7 | 83.3 | 0.1 | 0.64 | 188 | 28 | 4 | 4.6 |
| WAMBO GB 02 | Clay Loam | Moderate | 6.06 | 0.06 | 0.5 | 14.2 | 44.9 | 46.7 | 5.6 | 3.2 | 2.58 | 3.3 | 309 | 1277 | 806 | 8.2 | 104 | 0.2 | 0.64 | 130 | 37 | 4.6 | 5.3 |
| WAMBO SPOT 1 | Sandy Loam | Rapid | 5.08 | 0.04 | 0.6 | 10.7 | 38.4 | 11.8 | 3.3 | 0.2 | 10.1 | 8.3 | 138 | 823 | 154 | 9.4 | 4.5 | 0.1 | 0.64 | 173 | 138 | 3 | 4.6 |
| WAMBO SPOT 2 | Clay Loam | Moderate | 5.6 | 0.12 | 1 | 17.9 | 47 | 40.6 | 3.6 | 8.7 | 0.942 | 4.1 | 256 | 1688 | 884 | 12 | 359 | 0.2 | 0.64 | 162 | 22 | 2.3 | 4.9 |
| WAMBO SPOT 3 | Sandy Loam | Rapid | 5.52 | 0.03 | 0.4 | 5.2 | 64.8 | 27.3 | 7.1 | 0.6 | 2.18 | 12.6 | 143 | 674 | 173 | 7.6 | 6.5 | 0.1 | 0.64 | 129 | 138 | 2.2 | 2.8 |
| WarkGB03 | Sandy Loam | Rapid | 4.72 | 0.12 | 1.7 | 7.4 | 14.9 | 15.6 | 3.2 | 6.6 | 0.265 | 4.2 | 94.4 | 220 | 140 | 12 | 113 | 0.1 | 0.64 | 237 | 27 | 0.9 | 2.8 |

**Table 10.Minimum, maximum and average values for measured soil parameters.**

| Vegetation community | | pH ($H_2O$) | pH $CaCl_2$ | Ece (dS/m) | ECEC (Meq) | Ca (%) | Mg (%) | K (%) | Na (%) | H (%) | OM (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Central Hunter Ironbark-Spotted Gum-Grey Box Forest | AVERAGE | 6.10 | 5.27 | 0.65 | 12.2 | 45.1 | 24.1 | 3.9 | 2.7 | 23.8 | 5.9 |
| | MAX | 6.60 | 5.72 | 1.00 | 17.9 | 73.7 | 40.6 | 7.1 | 8.7 | 55.8 | 9.3 |
| | MIN | 5.60 | 4.64 | 0.40 | 5.2 | 15.2 | 11.8 | 2.6 | 0.2 | 0.0 | 2.8 |
| | AVERAGE | 5.78 | 5.13 | 0.67 | 12.47 | 29.6 | 24.5 | 3.7 | 2.8 | 39.1 | 4.4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Central Hunter Grey Box-Ironbark Woodland** | **MAX** | 6.60 | 6.06 | 1.70 | 15.70 | 44.9 | 46.7 | 5.6 | 6.6 | 58.8 | 6.8 |
| | **MIN** | 5.40 | 4.60 | 0.40 | 7.40 | 14.9 | 15.6 | 2.4 | 1.0 | 0.0 | 2.8 |

## 4.2 Rehabilitation monitoring sites

A total of 18 HVO rehabilitation monitoring sites, and 17 MTW monitoring site were established as described in Section 2.1.

BioBanking plots were undertaken at the following sites: MTWNPN2005-01, MTWNPN2005-02, MTWNPN2009-01, MTWCDD2011-01, MTWMTO2005-03, MTWMTO2000-01, HVOCAR200901, HVOCAR200902, HVOWES200801 and HVOWES201101.

The remainder of the sites were assessed by a Ground Cover Assessment as per the methodology discussed in Section 3.3.6.

### 4.2.1 Vegetation and condition

Descriptions for each site, including structure, dominant species and site photographs have been provided in Appendix 5.

Based on the BioBanking data collection, a total of 104 flora species across 30 families were recorded (Appendix 3). Of the 104 flora recorded, 31 were introduced species (30%).

Common native species across both MTW and HVO included:

- Trees: *Corymbia maculata*, *Eucalyptus crebra*, *Eucalyptus punctata.*
- Shrubs: *Acacia longifolia*, *Acacia amblygona*, *Acacia dealbata*, *Acacia falcata*, *Acacia mearnsii*.
- Grasses: *Bothriochloa macra*, *Chloris truncata*, *Cynodon dactylon*, *Austrodanthonia racemosa.*
- Forbs/herbaceous/other: *Oxalis perennans*, *Glycine tabacina*, *Eremophila debilis*, *Portulaca oleracea*, *Vittadinia cuneata*, *Einadia nutans*, *Dichondra repens*, *Sida corrugata*, *Cheilanthes sieberi*, *Calotis lappulacea*, *Enchylaena tomentosa*, *Cyperus gracilis*, *Chrysocephalum apiculatum*, *Vittadinia sulcata*, *Wahlenbergia gracilis*, *Wahlenbergia stricta*, *Einadia trigonos*, *Carex inversa*, *Fimbristylis dichotoma*, *Hardenbergia violacea*, *Indigofera australis.*
- Common introduced species include: *Galenia pubescens*, *Gomphocarpus fruticosus*, *Bidens pilosa*, *Cirsium vulgare*, *Conyza bonariensis*, *Senecio madagascariensis*, *Medicago arabica*, *Acacia saligna*, *Mimosa pudica*, *Sida rhombifolia*, *Plantago lanceolata*, *Chloris gayana*, *Panicum maximum*, *Paspalum dilatatum*, *Pennisetum clandestinum*, *Polygonum aviculare and Verbena bonariensis.*

### 4.2.2 BioBanking attribute data

The BioBanking attribute data collected from the rehabilitation sites, along with the average reference site local benchmarks, have been provided in Section 5 .

## Table 11. BioBanking attribute data at rehabilitation sites and average local benchmarks

| Plot name | Soil treatment | NPS | NOS | NMS | NGCG | NGCS | NGCO | EPC | NTH | OR | FL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HVOCAR200901 | Topsoil | 9 | 12 | 23 | 0 | 0 | 2 | 38 | 0 | 0 | 1 |
| HVOCAR200902 | Topsoil | 15 | 3 | 8 | 0 | 0 | 8 | 86 | 0 | 0 | 0 |
| HVOWES200801 | Topsoil | 22 | 9 | 15 | 22 | 2 | 14 | 30 | 0 | 0 | 0 |
| HVOWES201101 | Spoil/ Compost | 21 | 19 | 0 | 50 | 0 | 20 | 24 | 0 | 0 | 0 |
| MTWCDC201101 | Topsoil | 20 | 0 | 18 | 26 | 18 | 22 | 34 | 0 | 0 | 0 |
| MTWMTO200001 | Topsoil | 19 | 7.5 | 0 | 36 | 0 | 10 | 26 | 0 | 0 | 0 |
| MTWMTO200503 | Topsoil | 21 | 5.5 | 0 | 10 | 0 | 6 | 14 | 0 | 0 | 28 |
| MTWNPN200501 | Topsoil | 15 | 4 | 0 | 18 | 2 | 6 | 65 | 0 | 0 | 1.5 |
| MTWNPN200502 | Topsoil | 15 | 8 | 9 | 4 | 0 | 0 | 36 | 0 | 0 | 1 |
| MTWNPN200901 | Topsoil | 14 | 57.5 | 0 | 8 | 6 | 0 | 12 | 0 | 0 | 0 |
| Grey Box-Ironbark Woodland Lower and Upper Average Local Benchmarks | - | ≥31 | 7.5 18.8 | 0 15.0 | 44.0 67.0 | 0 20.0 | 14.0 50.0 | 0 | ≥0 | 1 | ≥15 |
| Ironbark-Spotted Gum-Grey Box Forest Lower and Upper Average Local Benchmarks | - | ≥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 |

### 4.2.3 Ground Cover Assessment

The average ground cover assessment for all the HVO and MTW sites is provided in Table 12, with the raw data provided in Appendix 5.

No benchmark data was collected to allow for comparison.

Based on the data, on average the HVO North sites contain 71.1 percent Protective Cover. The sites with the highest average Protective Cover included HVO WES2013-01 (97 percent), HVO CHE2013-01 (93 percent), and HVO WES2013-02 (91 percent). This is attributed to cover crops (i.e. millet) that were used for initial stabilisation and volunteer introduced grass species (i.e. Green Panic) germinating from seeds in the topsoil.

The average ground cover assessment for all the MTW sites is provided in Table 12 and raw data provided in Appendix 5. Based on the data, on average the MTW sites contain 75.9 percent Protective Cover. The sites with the highest average Protective Cover included MTWCDD2013-01 (98 percent), MTWNPN2014-03 (93 percent) and MTWNPN2011-01 (84 percent). This is attributed to cover crops (i.e. millet) that were used for initial stabilisation and volunteer introduced grass species (i.e. Green Panic (*Panicum maximum*) germinating from seeds in the topsoil.

Sites containing the highest average amount of bare cover included MTWNPN2014-01 (51 percent) and MTWCDD2015-01 (44 percent).

Generally, a high average percentage weed cover made up the Protective Cover. Sites that contain high weed cover included MTWCDD2013-01 (97 percent), MTWSPN2014-01 (94 percent) and MTWNPN2014-03 (88 percent).

The average number of species recorded across all sites was four species (3.5 species).

**Table 12. Ground cover assessment data for HVO and MTW sites**

| Site name | Soil treatment | Protective cover (%) | Bare (%) | Weeds (%) of Protective Cover | Number of species |
|---|---|---|---|---|---|
| HVO RIV2013-01 | Topsoil/ Compost | 81 | 19 | 100 | 2 |
| HVO RIV2014-01 | Spoil/ Compost | 47 | 53 | 94 | 3 |
| HVO RIV2014-02 | Subsoil/ Compost | 27 | 73 | 26 | 3 |
| HVO RIV2014-03 | Spoil/ Compost | 39 | 61 | 97 | 6 |
| HVO RIV2014-04 | Subsoil/ Compost | 74 | 26 | 70 | 5 |
| HVO RIV2014-05 | Subsoil/Compos t | 77 | 23 | 100 | 2 |
| HVO RIV2014-06 | Topsoil/ Compost | 73 | 27 | 70 | 5 |
| HVO WES2013-01 | Spoil/ Compost | 97 | 3 | 55 | 5 |
| HVO WES2013-02 | Topsoil/ Compost | 91 | 9 | 13 | 3 |
| HVO CAR2014-01 | Topsoil/ Compost | 54 | 45 | 55 | 2 |
| HVO CHE2012-01 | Topsoil/ Compost | 87 | 13 | 84 | 4 |

| Site name | Soil treatment | Protective cover (%) | Bare (%) | Weeds (%) of Protective Cover | Number of species |
|---|---|---|---|---|---|
| HVO CHE2013-01 | Topsoil/ Compost | 93 | 7 | 46 | 4 |
| HVO CHE2014-01 | Topsoil/ Compost | 74 | 26 | 81 | 3 |
| HVO CHE2012-03 | Topsoil/ Compost | 81 | 19 | 63 | 3.7 |
| MTWNPN2011-01 | Topsoil | 84 | 16 | 68 | 4 |
| MTWTDI2015-01 | Spoil/ Compost | 77 | 23 | 5 | 2 |
| MTWSPN2014-01 | Topsoil/ Compost | 81 | 19 | 94 | 2 |
| MTWNPN2014-01 | Topsoil/ Compost | 49 | 51 | 42 | 4.6 |
| MTWNPN2014-03 | Subsoil/ Compost | 93 | 7 | 88 | 7 |
| MTWNPN2013-01 | Topsoil/ Compost | 76 | 24 | 74 | 2.6 |
| MTWWDL2014-01 | Topsoil/ Compost | 71 | 29 | 73 | 5 |
| MTWWDL2014-02 | Topsoil/ Compost | 74 | 26 | 51 | 3 |
| MTWCDD2015-01 | Spoil/ Compost | 56 | 44 | 9 | 2.3 |
| MTWCDD2013-01 | Topsoil/ Compost | 98 | 2 | 97 | 1.1 |
| **Average** | | **73.1** | **26.9** | **61.9** | **3.5** |

### 4.2.1 Landscape Function Analysis

The raw data and average LFA scores for all the HVO and MTW sites is provided in Table 13.

#### HVO rehabilitation sites

Based on the data, LFA scores across all indices were fairly consistent for all sites, with no conspicuous outliers. The average LOI score was .89, across all the sites. High LOI scores, particularly at younger rehabilitation sites was generally driven by extensive grass cover, rather than development of leaf litter or shrub species.

#### MTW rehabilitation sites

The raw data and average LFA scores for all MTW sites is provided in Table 13.

Results include the following:

- LOI ranged from 0.14 to 1.0.
- Stability ranged from 47.8 to 85.4.
- Infiltration was highly variable and ranged from 10.3 to 71.4
- Like Infiltration, nutrient cycling was also variable and ranged from 10.3 to 77.8.
- MTWCDD201501 had the lowest LFA score. It was an outlier in the dataset. The cause for this low score is likely due to the site being in the early stages of rehabilitation, with foliage cover at the site being extremely low. This is evident from the photo monitoring results provided in Appendix 4.

### Table 13. LFA for HVO and MTW Rehabilitation sites

| Site name | LOI | Stability | Infiltration | Nutrient Cycling |
|---|---|---|---|---|
| HVO RIV201406 | 1 | 74.4 | 63.3 | 75.6 |
| MTWWDL201401 | 0.97 | 63.7 | 40.6 | 36.8 |
| MTWWDL201402 | 0.98 | 66.5 | 71.4 | 67.2 |
| HVO RIV201301 | 0.94 | 73.1 | 48.7 | 52.4 |
| HVO CHE201301 | 1 | 64.2 | 46.3 | 67 |
| 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 WES200801 | 0.61 | 58.8 | 47.1 | 46 |
| HVO WES201302 | 0.93 | 55 | 33.8 | 25.5 |
| HVO CHE201203 | 0.91 | 64.3 | 57.3 | 57.5 |
| HVO CHE201401 | 0.82 | 55.6 | 40.2 | 34.1 |
| HVO CHE201201 | 0.98 | 65.4 | 56.1 | 76.5 |
| HVO RIV201405 | 1 | 73.1 | 64.1 | 77.8 |
| HVO RIV201404 | 0.96 | 56 | 21.3 | 15.9 |
| HVO RIV201403 | 0.86 | 50.8 | 22 | 16 |
| HVO RIV201402 | 0.77 | 53.9 | 22.1 | 13.5 |
| HVO RIV201401 | 0.69 | 49 | 33.2 | 22.6 |
| HVO WES201101 | 0.95 | 61.4 | 35.9 | 25.7 |
| HVO WES201301 | 0.88 | 50.4 | 27 | 18.8 |
| MTWWDL201401 | 0.97 | 63.7 | 40.6 | 36.8 |
| MTWWDL201402 | 0.98 | 66.5 | 71.4 | 67.2 |
| MTWNPN200901 | 0.93 | 66.2 | 40.5 | 45.8 |
| MTWCDD201101 | 0.98 | 85.4 | 65.2 | 72.1 |
| MTWCDD201301 | 1 | 78.7 | 77.8 | 64.6 |
| MTWSPN201401 | 1 | 73.7 | 40.7 | 37.2 |
| MTWNPN200502 | 0.95 | 61.3 | 37 | 32.4 |
| MTWNPN201301 | 1 | 63.5 | 57.1 | 53.3 |
| MTWNPN201402 | 0.96 | 59.8 | 39.5 | 47 |
| MTWNPN201401 | 0.67 | 61.9 | 32.8 | 21.4 |
| MTWNPN201101 | 1 | 58.7 | 57.1 | 53.5 |
| MTWNPN200501 | 0.92 | 63.3 | 43.3 | 39.9 |
| MTWMTO200001 | 0.89 | 58.2 | 31.8 | 33.9 |
| MTWMTO200503 | 0.54 | 54 | 28.5 | 21.4 |
| MTWCDD201501 | 0.14 | 47.8 | 10.3 | 10.3 |
| MTWNPN201403 | 0.98 | 74.6 | 66.8 | 65.5 |
| MTWTD1201501 | 0.61 | 54.4 | 24 | 22 |

### 4.2.2 Visual monitoring, photo monitoring

The results of the visual monitoring and photo monitoring for the HVO North sites area provided in Appendix 5.

### 4.2.3 Soil analysis

The results of the soil analyses for key soil chemistry parameters for the HVO site MTW sites are summarised in Table 14. This table includes a summary of the most significant indicators of soil condition. For reference, the detailed results provided by SESL Australia are included in Appendix 6.

## Table 14. Summary of soil condition indicators at MTW and HVO rehabilitation sites

| Site | Texture | Soil Infiltration Rate | pH (H2O) | pH CaCl2 | EC (dS/m) | Ece (dS/m) | ECEC (Meq) | Ca (%) | Mg (%) | K (%) | Na (%) | NO3 (mg/kg) | PO4 (mg/kg) | K (mg/kg) | Ca (mg/kg) | Mg (mg/kg) | SO4 (mg/kg) | Na (mg/kg) | B (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | Mng (mg/kg) | Zn (mg/kg) | OM (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MTWCDC2 01301 | Clay Loam | Moderate | 7.8 | 7.3 | 0.32 | 2.8 | 19.9 | 75.3 | 18.7 | 3.5 | 2.7 | 9.7 | 110.4 | 269 | 3002 | 452 | 210 | 123 | 0.8 | 5.1 | 247 | 50 | 30 | 6 |
| MTWCDD2 01101 | Clay Loam | Moderate | 7.3 | 6.59 | 0.09 | 0.8 | 12.1 | 50.6 | 38.4 | 5.5 | 5.7 | 9.68 | 1 | 262 | 1225 | 564 | 15 | 159 | 0.3 | 1.3 | 265 | 42 | 4.5 | 3.7 |
| MTWCDD2 01501 | Clay Loam | Moderate | 8 | 7.55 | 0.21 | 1.8 | 14.8 | 70.3 | 24.5 | 3.2 | 2.1 | 13.4 | 153 | 186 | 2087 | 441 | 83 | 72 | 0.5 | 5.7 | 237 | 16 | 30 | 3.7 |
| MTWMTO2 00503 | Sandy Clay Loam | Moderate | 7.8 | 7.38 | 0.26 | 2.5 | 12.3 | 44.5 | 44.8 | 2.2 | 8.6 | 2.24 | 6 | 104 | 1095 | 670 | 96 | 244 | 0.1 | 0.64 | 131 | 27 | 1.8 | 3.3 |
| MTWNPN2 00501 | Clay Loam | Moderate | 7.4 | 7.05 | 0.08 | 0.7 | 10.9 | 47.7 | 44.6 | 6.8 | 1.3 | 13.7 | 2.7 | 289 | 1042 | 591 | 9.9 | 33.3 | 0.3 | 0.9 | 166 | 41 | 2.4 | 2.7 |
| MTWNPN2 00502 | Sandy Clay Loam | Moderate | 6.6 | 6.19 | 0.08 | 0.8 | 10.7 | 46.4 | 47.4 | 5.2 | 1.2 | 13.1 | 1.8 | 220 | 994 | 616 | 15 | 30.1 | 0.3 | 0.9 | 227 | 26 | 5.6 | 6 |
| MTWNPN2 00901 | Clay Loam | Moderate | 6.8 | 6.36 | 0.08 | 0.7 | 12.6 | 59 | 35.5 | 4.4 | 1 | 2.7 | 0.9 | 220 | 1490 | 543 | 17 | 26.7 | 0.3 | 1.7 | 221 | 31 | 4.6 | 4 |
| MTWNPN2 01101 | Clay Loam | Moderate | 7.9 | 7.39 | 0.07 | 0.6 | 12.9 | 63.5 | 32.2 | 3.6 | 0.4 | 2.01 | 1.2 | 184 | 1641 | 505 | 11 | 11.7 | 0.4 | 1.8 | 129 | 65 | 6 | 3.4 |
| MTWNPN2 01301 | Sandy Clay Loam | Moderate | 7 | 6.96 | 0.16 | 1.5 | 8.9 | 73.9 | 19.8 | 4.6 | 1.3 | 1.07 | 28.7 | 159 | 1319 | 214 | 66 | 27.3 | 0.3 | 1.7 | 291 | 19 | 10 | 3 |
| MTWNPN2 01401 | Fine Sandy Clay Loam | Moderate | 6.9 | 6.55 | 0.18 | 1.5 | 11.4 | 59 | 33.3 | 4.1 | 3.9 | 0.9 | 31.2 | 184 | 1348 | 462 | 54 | 102 | 0.3 | 3.3 | 263 | 44 | 11 | 3.8 |
| MTWNPN2 01403 | Clay Loam | Moderate | 7.6 | 7.3 | 0.17 | 1.5 | 16.6 | 70.9 | 23.2 | 4.7 | 1.3 | 3.72 | 148 | 304 | 2359 | 468 | 51 | 47.5 | 0.7 | 4.8 | 251 | 52 | 24 | 6.1 |
| MTWNPN2 01405 | Loamy Sand | Very Rapid | 6.7 | 6.27 | 0.03 | 0.7 | 4.2 | 83.1 | 13 | 3.3 | 0.5 | 0.157 | 25.4 | 55.5 | 700 | 66 | 7.6 | 3.6 | 0.1 | 1 | 115 | 27 | 6.9 | 3.8 |
| MTWSPN2 01401 | Clay Loam | Moderate | 8.1 | 7.27 | 0.11 | 0.9 | 13.8 | 67.8 | 26.5 | 3.8 | 2 | 2.09 | 29.7 | 208 | 1877 | 444 | 21 | 62.3 | 0.5 | 3.7 | 226 | 42 | 17 | 4.8 |
| MTWTDI201501 | Clay Loam | Moderate | 9.6 | 8.66 | 0.49 | 4.2 | 16.5 | 24.1 | 28 | 4.2 | 43.6 | 0.05 | 7.5 | 268 | 795 | 560 | 124 | 1654 | 0.4 | 9.3 | 262 | 7.9 | 26 | 8.3 |
| MTWTO200001 | Sandy Clay | Slow | 7.6 | 7.02 | 0.13 | 1.1 | 12 | 39.9 | 47.7 | 2.7 | 9.6 | 4.67 | 15.7 | 126 | 959 | 696 | 20 | 263 | 0.1 | 1.1 | 186 | 21 | 18 | 2.4 |
| MTWWDL2 01401 | Clay Loam | Moderate | 7.1 | 7.08 | 0.37 | 3.2 | 14.3 | 59.4 | 29.4 | 5.3 | 5.9 | 3.74 | 90.5 | 298 | 1702 | 510 | 167 | 196 | 0.3 | 2.2 | 307 | 23 | 18 | 6.1 |
| MTWWDL2 01402 | Clay Loam | Moderate | 8 | 7.43 | 0.27 | 2.3 | 17.9 | 59.1 | 31.9 | 4.1 | 5 | 8.65 | 67.2 | 284 | 2118 | 693 | 127 | 205 | 0.6 | 4.7 | 310 | 55 | 21 | 8.7 |

| Site | Texture | Soil Infiltration Rate | pH (H2O) | pH CaCl2 | EC (dS/m) | Ece (dS/m) | ECEC (Meq) | Ca (%) | Mg (%) | K (%) | Na (%) | NO3 (mg/kg) | PO4 (mg/kg) | K (mg/kg) | Ca (mg/kg) | Mg (mg/kg) | SO4 (mg/kg) | Na (mg/kg) | B (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | Mng (mg/kg) | Zn (mg/kg) | OM (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HVOCAR200901 | Light Clay | Slow | 7.7 | 6.98 | 0.07 | 0.6 | 15.9 | 35.7 | 53.6 | 5 | 5.8 | 1.79 | 2.8 | 314 | 1137 | 1035 | 8.8 | 213 | 0.5 | 1.7 | 143 | 95 | 2 | 2.1 |
| HVOCAR200902 | Light Medium Clay | Slow | 7.9 | 7.53 | 0.14 | 1.1 | 1.9 | 61.1 | 33 | 4.2 | 3.2 | 2.18 | 3.4 | 32.1 | 232 | 76 | 3.2 | 14.2 | 0.1 | 0.64 | 18.5 | 13 | 1.1 | 1.5 |
| HVOCAR201401 | Clay Loam | Moderate | 7.5 | 6.76 | 0.17 | 1.5 | 20.1 | 59.5 | 32.1 | 4.6 | 3.8 | 1.3 | 42.2 | 361 | 2398 | 783 | 50 | 177 | 1.4 | 3.3 | 192 | 122 | 10 | 5.4 |
| HVOCHE 201201 | Clay Loam | Moderate | 7.9 | 7.13 | 0.13 | 1.1 | 15.2 | 67.2 | 23.7 | 4.5 | 4.5 | 10.9 | 69.4 | 267 | 2047 | 438 | 15 | 157 | 0.5 | 4 | 234 | 64 | 20 | 3.8 |
| HVOCHE2014-01 | Sandy Clay | Slow | 7.8 | 7.32 | 0.13 | 1.1 | 15.5 | 55.5 | 35.7 | 3.9 | 4.6 | 3.32 | 29.3 | 238 | 1723 | 672 | 32 | 166 | 0.5 | 1.7 | 141 | 47 | 6.8 | 3.4 |
| HVOCHES2012-03 | Sandy Loam | Rapid | 8.2 | 7.63 | 0.12 | 1.7 | 15.5 | 73.5 | 19.4 | 3.4 | 3.7 | 3.99 | 117.1 | 203 | 2283 | 366 | 21 | 132 | 1.2 | 5.6 | 199 | 31 | 35 | 4.5 |
| HVORIV201301 | Clay Loam | Moderate | 8.6 | 7.79 | 0.24 | 2.1 | 22.4 | 48.5 | 37.9 | 3.4 | 10 | 11.6 | 18.3 | 300 | 2177 | 1031 | 30 | 518 | 0.9 | 3 | 162 | 91 | 6.4 | 3.1 |
| HVORIV201401 | Clay Loam | Moderate | 9 | 8.23 | 0.37 | 3.2 | 28.1 | 43.7 | 41.3 | 3.2 | 11.7 | 6.71 | 71.4 | 354 | 2463 | 1409 | 65 | 755 | 1.1 | 4.1 | 119 | 93 | 17 | 3.6 |
| HVORIV201402 | Clay Loam | Moderate | 9.1 | 8.15 | 0.29 | 2.5 | 27.1 | 50.7 | 38.7 | 2.3 | 8.5 | 3.07 | 62.3 | 239 | 2752 | 1274 | 75 | 529 | 1 | 4.6 | 131 | 119 | 22 | 4.8 |
| HVORIV201403 | Clay Loam | Moderate | 8.7 | 7.89 | 0.15 | 1.3 | 22.2 | 49.7 | 42 | 3 | 5.3 | 2.27 | 90.9 | 258 | 2212 | 1134 | 29 | 272 | 0.9 | 6.8 | 250 | 52 | 24 | 3.2 |
| HVORIV201404 | Clay Loam | Moderate | 8.5 | 7.93 | 0.31 | 2.7 | 22.1 | 62.2 | 27.6 | 3.8 | 6.3 | 6.18 | 85.2 | 330 | 2754 | 740 | 112 | 321 | 1.2 | 5.9 | 210 | 51 | 25 | 5.8 |
| HVORIV201405 | Sandy Clay Loam | Moderate | 8.4 | 7.65 | 0.11 | 1 | 13.4 | 70 | 19.7 | 6.6 | 3.7 | 4.01 | 123 | 346 | 1880 | 320 | 13 | 115 | 0.6 | 4.4 | 197 | 67 | 28 | 4.8 |
| HVORIV201406 | Clay Loam | Moderate | 8.1 | 7.48 | 0.13 | 1.1 | 23.2 | 63.8 | 28.8 | 3.6 | 3.6 | 6.67 | 93.6 | 326 | 2966 | 812 | 22 | 194 | 0.8 | 4.5 | 262 | 57 | 33 | 7 |
| HVOWES2008-01 | Clay Loam | Moderate | 7.2 | 6.72 | 0.08 | 0.7 | 12.3 | 55.4 | 38.1 | 5 | 1.1 | 4.46 | 2.9 | 237 | 1367 | 569 | 11 | 32.1 | 0.4 | 1.7 | 127 | 58 | 3.7 | 4.6 |
| HVOWES2011-01 | Light Clay | Slow | 8.4 | 7.74 | 0.19 | 1.6 | 22.6 | 46.7 | 49.1 | 2.1 | 2.2 | 2.04 | 25.8 | 186 | 2115 | 1349 | 58 | 114 | 0.2 | 4 | 88.8 | 30 | 17 | 5.5 |
| HVOWES2013-01 | Clay Loam | Moderate | 8.6 | 7.92 | 0.15 | 1.3 | 19 | 62.8 | 32 | 2.8 | 2.1 | 3.44 | 62.3 | 210 | 2391 | 739 | 22 | 92.9 | 0.5 | 4.8 | 116 | 45 | 20 | 2.1 |
| HVOWES2013-02 | Clay Loam | Moderate | 8 | 7.45 | 0.15 | 1.3 | 13.6 | 61.8 | 32.1 | 4.2 | 2.2 | 2.07 | 23 | 222 | 1684 | 531 | 26 | 69.7 | 0.8 | 4 | 188 | 31 | 15 | 4.6 |

# 5. Discussion

## 5.1 Rehabilitation sites compared to Central Hunter Grey Box – Ironbark Woodland Reference Site Benchmarks

Rehabilitation sites have been compared to reference site benchmarks for Central Hunter Grey Box – Ironbark Woodland in Table 15.

The following conclusions can be made from comparing the reference site benchmarks for Central Hunter Grey Box-Ironbark Woodland against the rehabilitation sites:

- All sites are lower than benchmark for NPS.
- Sites HVO CAR200901, HVO WES200801 and MTWMTO200001 are within benchmark for NOS.
- MTWNPN200901 contains a high NOS (above benchmark). This is attributed to the close stands of eucalypts present at the site. Details are provided in Appendix 5.
- MTWCDC201101 did not have any NOS. This is likely due to juvenile trees not occurring in the canopy stratum.
- HVO CAR200902, HVO WES200801 and MTWNPN200502 are within benchmark for NMS, whilst HVO CAR200901 and MTWCDC201101 are above benchmark. It should be noted that the lower benchmark value for NMS is zero.
- HVO WES201101 and MTWMTO200001 are within benchmark for NGCG.
- HVO WES200801, MTWCDC201101, MTWNPN200501 and MTWNPN200901 were within benchmark for NGCS. It should be noted that the lower benchmark value for NGCS is zero, and thus any low shrub cover will put the site into benchmark for this attribute.
- HVO WES200801, HVO WES201101 and MTWCDC201101 are within benchmark for NGCO.
- All sites have a high percentage of weed cover.
- None of the sites contain evidence of native regeneration (e.g. young eucalypts regenerating naturally).
- All sites meet benchmark for NTH. However, this is due to the benchmark value being zero.
- Only site MTWMTO200503 is within benchmark for FL. Most sites did not contain any FL, although this is to be expected given the age of the canopy.
- It cannot be concluded that the older sites are trending closer to benchmark compared with younger sites, as there is a range of results for each of the attributes when comparing establishment years. For example, MTWNPN200901 has a high NOS (57.5 percent) compared to older years. This would largely be attributed to the management that has occurred at each rehabilitation area, including the seeding mix and seeding methods used.

Table 15. Rehabilitation sites compared to Central Hunter Grey Box – Ironbark Woodland benchmarks

| Plot name | Soil treatment | NPS | NOS | | NMS | | NGCG | | NGCS | | NGCO | | EPC | NTH | OR | FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Central Hunter Grey Box-Ironbark Woodland benchmark | - | ≥31 | 7.5 | 18.8 | 0 | 15.0 | 44.0 | 67.0 | 0 | 20.0 | 14.0 | 50.0 | 0 | ≥0 | 1 | ≥15 |
| HVO CAR200901 | Topsoil | 9 | 12 | | 23 | | 0 | | 0 | | 2 | | 38 | 0 | 0 | 1 |
| HVO CAR200902 | Topsoil | 15 | 3 | | 8 | | 0 | | 0 | | 8 | | 86 | 0 | 0 | 0 |
| HVO WES200801 | Topsoil | 22 | 9 | | 15 | | 22 | | 2 | | 14 | | 30 | 0 | 0 | 0 |
| HVO WES201101 | Topsoil | 21 | 19 | | 0 | | 50 | | 0 | | 20 | | 24 | 0 | 0 | 0 |
| MTWCDC201101 | Topsoil | 20 | 0 | | 18 | | 26 | | 18 | | 22 | | 34 | 0 | 0 | 0 |
| MTWMTO200001 | Topsoil | 19 | 7.5 | | 0 | | 36 | | 0 | | 10 | | 26 | 0 | 0 | 0 |
| MTWMTO200503 | Topsoil | 21 | 5.5 | | 0 | | 10 | | 0 | | 6 | | 14 | 0 | 0 | 28 |
| MTWNPN200501 | Topsoil | 15 | 4 | | 0 | | 18 | | 2 | | 6 | | 65 | 0 | 0 | 1.5 |
| MTWNPN200502 | Topsoil | 15 | 8 | | 9 | | 4 | | 0 | | 0 | | 36 | 0 | 0 | 1 |
| MTWNPN200901 | Topsoil | 14 | 57.5 | | 0 | | 8 | | 6 | | 0 | | 12 | 0 | 0 | 0 |

| | |
|---|---|
| | 0-10% of reference site benchmark |
| | 10-50% of reference site benchmark |
| | 50-100% of reference site benchmark |
| | within reference site benchmark |

Include OEH Benchmark scores as well for reference. Leave colour-coding as a comparison with reference site benchmarks

## 5.2 Rehabilitation sites compared to Central Hunter Ironbark-Spotted Gum-Grey Box Forest Reference Site Benchmarks

Rehabilitation sites have been compared to reference site benchmarks for Central Hunter Ironbark-Spotted Gum-Grey Box in Table 16.

The following conclusions can be made from comparing the reference site benchmarks for Central Hunter Ironbark-Spotted Gum-Grey Box against the rehabilitation sites:

- All sites are lower than benchmark for NPS.
- Only HVO WES201101 is within benchmark for NOS.
- MTWNPN200901 contains a high NOS (above benchmark). This is attributed to the close stands of eucalypts present at the site. Details are provided in Appendix 5.
- MTWCDC201101 did not have any NOS. This is likely due to juvenile trees not occurring in the canopy stratum.
- HVO CAR200902 and MTWNPN200502 are within benchmark for NMS, whilst HVO CAR200901, HVO WES200801 and MTWCDC201101 are above benchmark. It should be noted that the lower benchmark value for NMS is zero.
- HVO WES201101 and MTWMTO200001 are within benchmark for NGCG.
- HVO WES200801, MTWNPN200501 and MTWNPN200901 were in benchmark for NGCS. MTWCDC201101 is above benchmark. It should be noted that the lower benchmark value for NGCS is zero, and thus any shrub cover will put the site into benchmark for this attribute.
- HVO WES200801, HVO WES201101 and MTWCDC201101 are within benchmark for NGCO.
- All sites have a high percentage of weed cover.

- None of the sites contain evidence of native regeneration (e.g. young eucalypts regenerating naturally).
- All sites meet benchmark for NTH. However, this is attributed to the benchmark value being zero.
- All sites are below benchmark for FL. Most sites did not contain any FL, although this is to be expected given the age of the canopy.
- It cannot be concluded that the older sites are trending closer to benchmark compared to younger sites, as there is a range of results for each attribute when comparing establishment years. For example, MTWNPN200901 has a high NOS (57.5 percent) compared to older years. This would largely be attributed to the management that has occurred at each rehabilitation area, including the seeding mix and seeding methods used.

**Table 16. Rehabilitation sites compared to Central Hunter Ironbark-Spotted Gum-Grey Box Forest benchmarks**

| Plot name | Soil treat | NPS | NOS | | NMS | | NGCG | | NGCS | | NGCO | | EPC | NTH | OR | FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Central Hunter Ironbark-Spotted Gum-Grey Box Forest reference site benchmark | - | ≥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 |
| HVO CAR200901 | Topsoil | 9 | 12 | | 23 | | 0 | | 0 | | 2 | | 38 | 0 | 0 | 1 |
| HVO CAR200902 | Topsoil | 15 | 3 | | 8 | | 0 | | 0 | | 8 | | 86 | 0 | 0 | 0 |
| HVO WES200801 | Topsoil | 22 | 9 | | 15 | | 22 | | 2 | | 14 | | 30 | 0 | 0 | 0 |
| HVO WES201101 | Topsoil | 21 | 19 | | 0 | | 50 | | 0 | | 20 | | 24 | 0 | 0 | 0 |
| MTWCDC201101 | Topsoil | 20 | 0 | | 18 | | 26 | | 18 | | 22 | | 34 | 0 | 0 | 0 |
| MTWMTO200001 | Topsoil | 19 | 7.5 | | 0 | | 36 | | 0 | | 10 | | 26 | 0 | 0 | 0 |
| MTWMTO200503 | Topsoil | 21 | 5.5 | | 0 | | 10 | | 0 | | 6 | | 14 | 0 | 0 | 28 |
| MTWNPN200501 | Topsoil | 15 | 4 | | 0 | | 18 | | 2 | | 6 | | 65 | 0 | 0 | 1.5 |
| MTWNPN200502 | Topsoil | 15 | 8 | | 9 | | 4 | | 0 | | 0 | | 36 | 0 | 0 | 1 |
| MTWNPN200901 | Topsoil | 14 | 57.5 | | 0 | | 8 | | 6 | | 0 | | 12 | 0 | 0 | 0 |

0-10% of reference site benchmark

10-50% of reference site benchmark

50-100% of reference site benchmark

within reference site benchmark

Include OEH Benchmark scores as well for reference. Leave colour-coding as a comparison with reference site benchmarks

## 5.3 Weed cover across rehabilitation sites

Based on the results of the BioBanking attribute data (Table 15 and Table 16), ground cover assessment and visual assessment (Appendix 5), weed cover was relatively high across all rehabilitation sites.

A high weed cover is expected given many of the sites were seeded with introduced cover crop species for initial stabilisation and the topsoil being used generally contains a high weed seed load.

A breakdown of the percentage of native vegetation cover compared to protective cover was not achievable, given such data collection was not specified in the AECOM (2012). A recommendation to include collection of this data in future survey has been provided in Section 6.

## 5.4 Comparison of ground cover assessment for compost and topsoil sites

A comparison of the ground cover assessment scores for four different soil treatment (Soil/Compost, Topsoil/Compost, Topsoil, Subsoil/Compost) at HVO North and MTW sites has been provided in Charts 1-3.

Significant findings include the following:

**Protective Cover (%)**

- Most of the sites had greater than 50 percent Protective Cover.
- Generally there was not a great deal of variation between different soil treatments.
- There were individual sites within each soil treatment which had high protective cover. For example, MTWCDD2013-01 (topsoil/Compost 98 percent), MTWNPN2014-02 (Spoil/Compost 97 percent), MTWNPN2011-01 (topsoil 84 percent) and MTWNPN2014-03 (subsoil/compost 93 percent).
- The site with the lowest Protective Cover was HVORIV2014-02.
- As mentioned above, a breakdown on the percentage of native vegetation cover compared to protective cover was not achievable, given such data collection was not specified in AECOM (2012). Furthermore, difference in scores may be attributed to weed management and seed establishment, but methodologies used at each site to enable these comparisons was not available.

**Weed Cover (%) of Protective Cover**

- High weed cover was present at all sites.
- The site with the lowest weed cover percentage was MTWCDD2015-01 and MTWTDI2015-01 however, this is likely due to the Protective Cover consisting more of rocks rather than vegetation cover.
- Generally there was not a great deal of variation between different soil treatments.

**Number of native species**

- The number of native species ranged from one to seven species.
- The site with the highest number of native species was MTWNPN2014-03 (seven species) and HVORIV2014-03 (six species).

**Chart 1. Ground cover assessment – Protective Cover across rehabilitation sites**

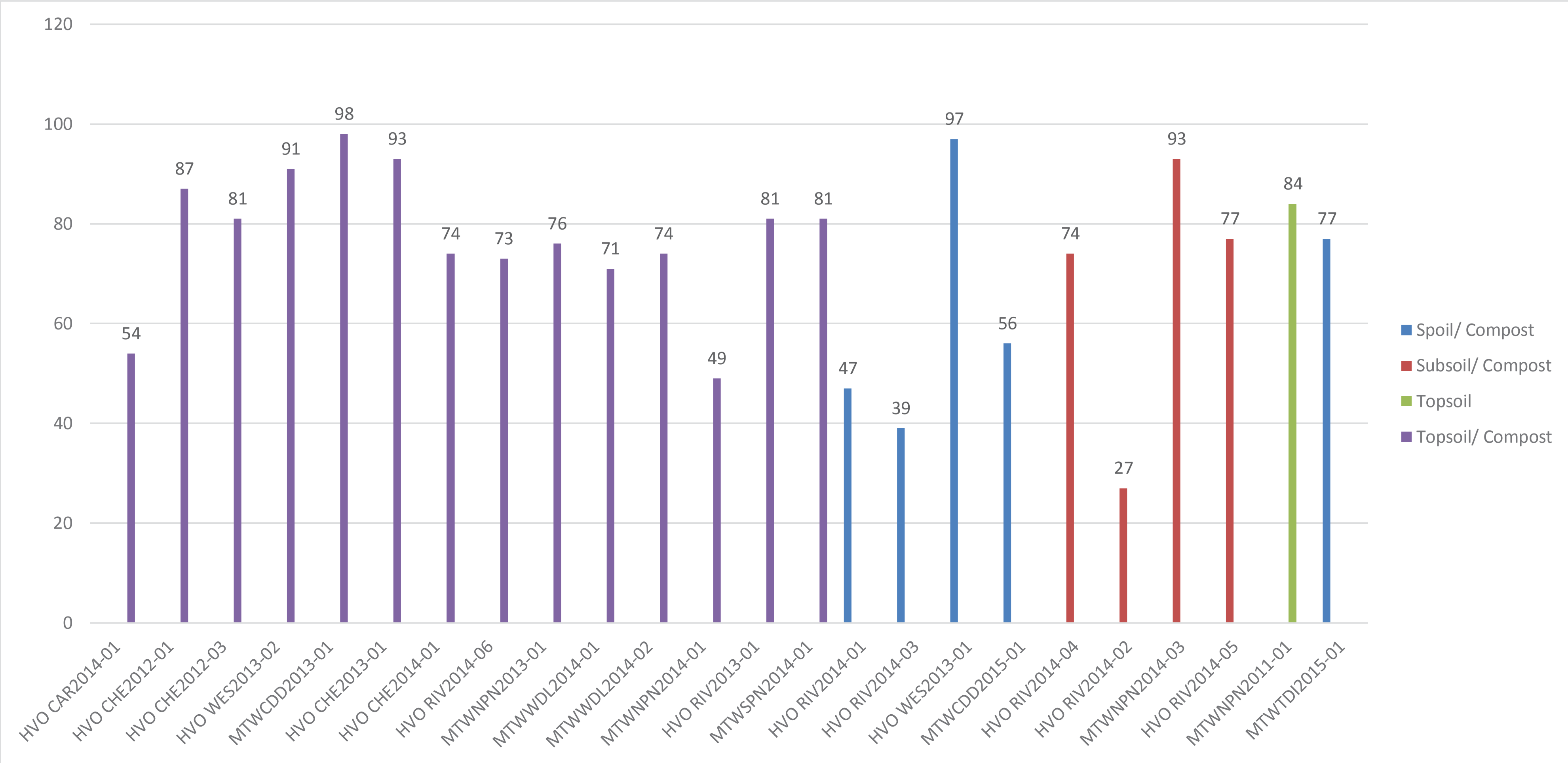


**Chart 2**. Weed cover percentage of the Protective Cover across rehabilitation sites.

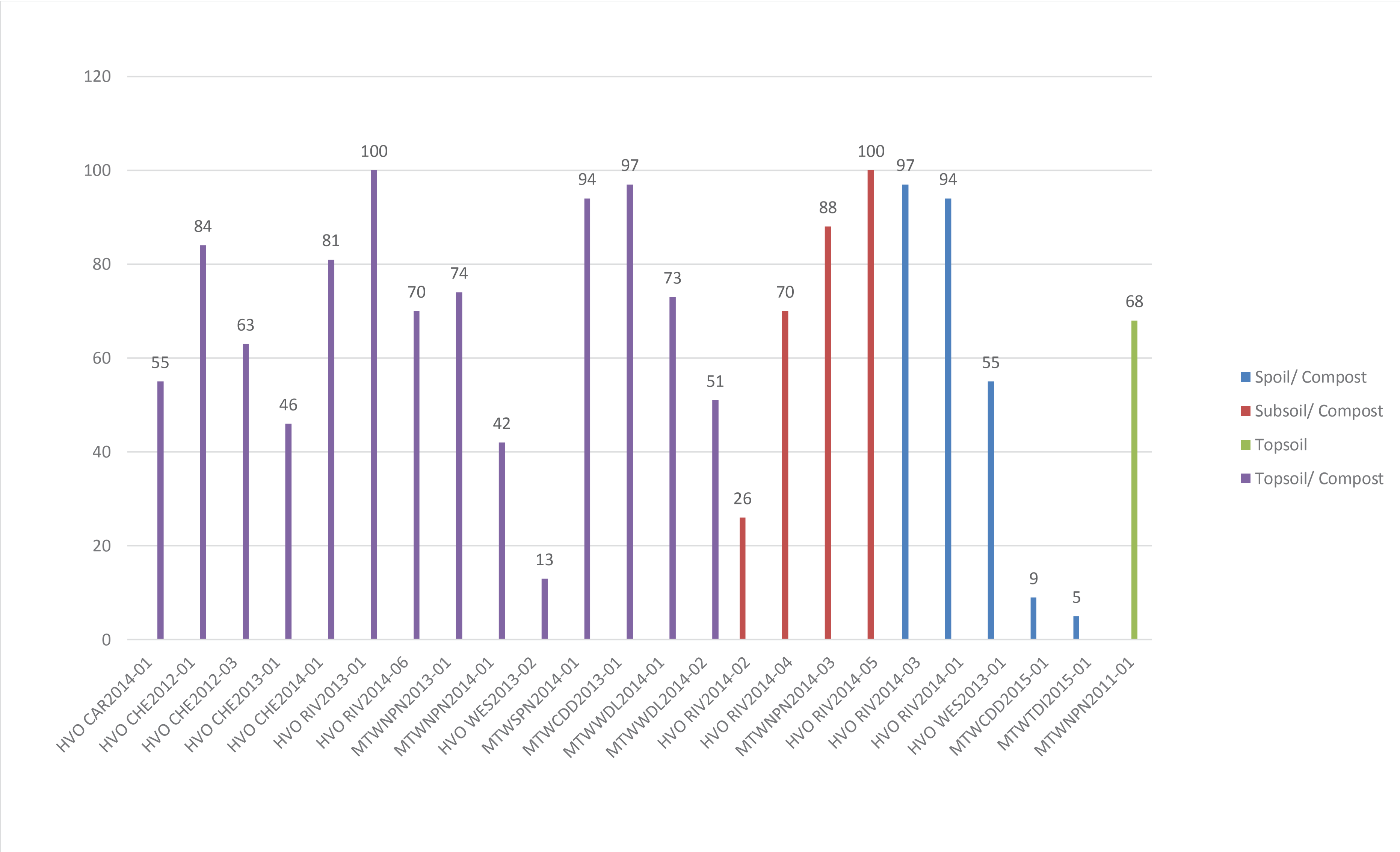
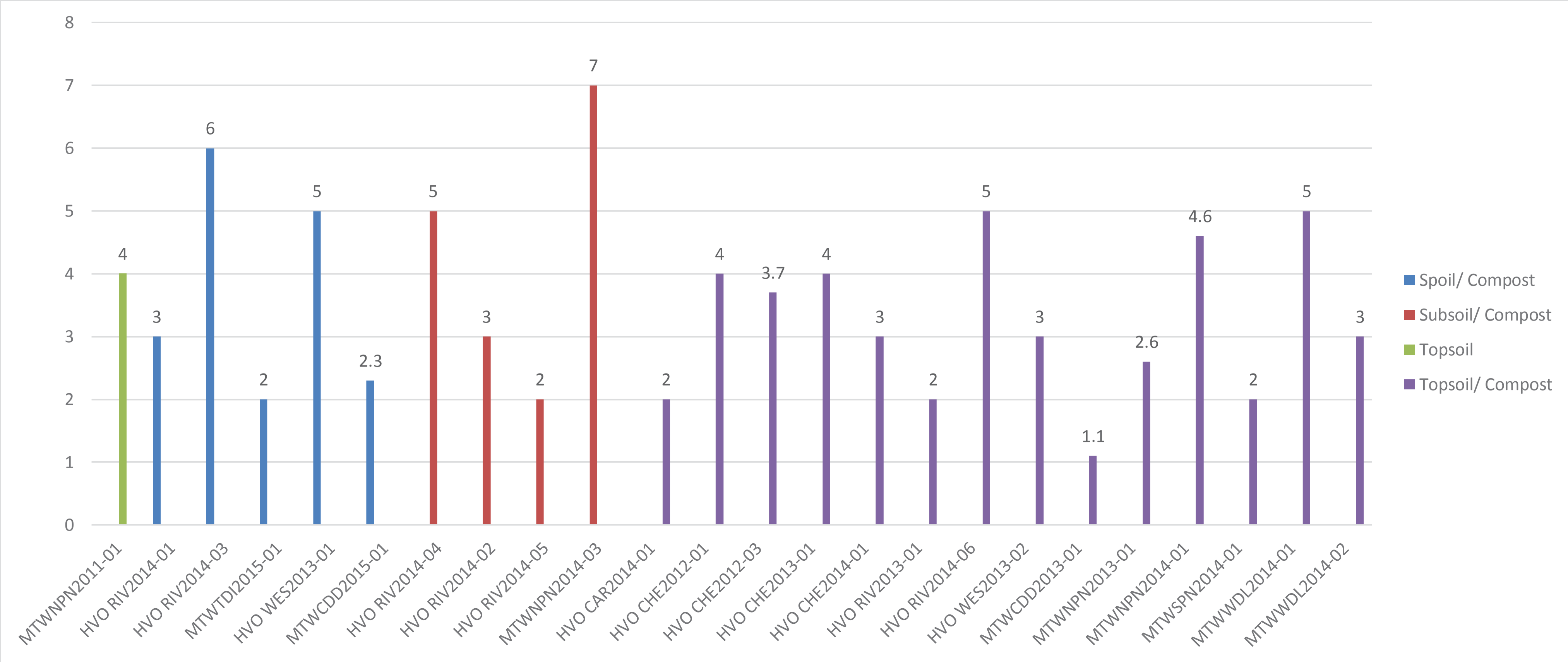


**Chart 3**. Number of native species across the rehabilitation sites



## 5.5 Landscape Function Analysis comparison to reference sites

### 5.5.1 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 0.87 for the rehabilitation sites (see Table 17 ). The variability in the range of scores however was greater at the rehabilitation sites than at 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). Examples of these sites include HVORIV201405 and HVORIV201406. 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 (ie MTW CDD201501, MTW TD1201501 and HVO RIV201401).

**Table 17. Provides the LOI and soil surface indicators for all sites.**

| Site name | Soil treatment | LOI | Stability | Infiltration | Nutrient Cycling |
|---|---|---|---|---|---|
| BELLSPOT1 | Reference | 1 | 66.7 | 51.6 | 43.6 |
| BELLSPOT2 | Reference | 0.94 | 81.8 | 69.9 | 54.2 |
| BELLSPOT3 | Reference | 1 | 63.9 | 65.3 | 54.9 |
| WAMBOGB1 | Reference | 1 | 58.3 | 56.2 | 46.3 |
| WAMBOGB2 | Reference | 1 | 72.5 | 48.4 | 48.4 |
| WAMBOSPOT1 | Reference | 1 | 62.5 | 74 | 65.6 |
| WAMBOSPOT2 | Reference | 0.96 | 72.7 | 64.2 | 62.1 |
| WAMBOSPOT3 | Reference | 1 | 69.7 | 67.2 | 59.7 |
| WARKGB01 | Reference | 1 | 69.8 | 49.7 | 43.2 |
| WARKGB02 | Reference | 1 | 70 | 57.6 | 52.1 |
| WARKGB03 | Reference | 0.84 | 57.9 | 49.8 | 38.7 |
| WARKGB04 | Reference | 0.97 | 72.5 | 48.4 | 48.4 |
| | Average | 0.98 | 68.19 | 58.53 | 51.43 |
| HVO RIV201401 | Spoil/ Compost | 0.69 | 49 | 33.2 | 22.6 |
| HVO RIV201403 | Spoil/ Compost | 0.86 | 50.8 | 22 | 16 |
| HVO WES201101 | Spoil/ Compost | 0.95 | 61.4 | 35.9 | 25.7 |
| HVO WES201301 | Spoil/ Compost | 0.88 | 50.4 | 27 | 18.8 |
| MTWCDD201501 | Spoil/ Compost | 0.14 | 47.8 | 10.3 | 10.3 |
| MTWTDI201501 | Spoil/ Compost | 0.61 | 54.4 | 24 | 22 |
| HVO RIV201402 | Subsoil/ Compost | 0.77 | 53.9 | 22.1 | 13.5 |
| HVO RIV201404 | Subsoil/ Compost | 0.96 | 56 | 21.3 | 15.9 |
| HVO RIV201405 | Subsoil/ Compost | 1 | 73.1 | 64.1 | 77.8 |
| MTWNPN201403 | Subsoil/ Compost | 0.98 | 74.6 | 66.8 | 65.5 |
| HVO CAR200901 | Topsoil | 0.83 | 66.5 | 47.4 | 44.2 |
| HVO CAR200902 | Topsoil | 0.99 | 68 | 46.2 | 40.1 |
| HVO WES200801 | Topsoil | 0.61 | 58.8 | 47.1 | 46 |
| MTWCDD201101 | Topsoil | 0.98 | 85.4 | 65.2 | 72.1 |
| MTWMTO200001 | Topsoil | 0.89 | 58.2 | 31.8 | 33.9 |
| MTWNPN200501 | Topsoil | 0.92 | 63.3 | 43.3 | 39.9 |

| Site name | Soil treatment | LOI | Stability | Infiltration | Nutrient Cycling |
|---|---|---|---|---|---|
| MTWNPN200502 | Topsoil | 0.95 | 61.3 | 37 | 32.4 |
| MTWNPN200901 | Topsoil | 0.93 | 66.2 | 40.5 | 45.8 |
| MTWNPN201101 | Topsoil | 1 | 58.7 | 57.1 | 53.5 |
| MTWMTO200503 | Topsoil | 0.54 | 54 | 28.5 | 21.4 |
| HVO CAR201401 | Topsoil/ Compost | 0.86 | 61.4 | 43.3 | 50.2 |
| HVO CHE201201 | Topsoil/ Compost | 0.98 | 65.4 | 56.1 | 76.5 |
| HVO CHE201203 | Topsoil/ Compost | 0.91 | 64.3 | 57.3 | 57.5 |
| HVO CHE201301 | Topsoil/ Compost | 1 | 64.2 | 46.3 | 67 |
| HVO CHE201401 | Topsoil/ Compost | 0.82 | 55.6 | 40.2 | 34.1 |
| HVO RIV201301 | Topsoil/ Compost | 0.94 | 73.1 | 48.7 | 52.4 |
| HVO RIV201406 | Topsoil/ Compost | 1 | 74.4 | 63.3 | 75.6 |
| HVO WES201302 | Topsoil/ Compost | 0.93 | 55 | 33.8 | 25.5 |
| MTWCDD201301 | Topsoil/ Compost | 1 | 78.7 | 77.8 | 64.6 |
| MTWNPN201301 | Topsoil/ Compost | 1 | 63.5 | 57.1 | 53.3 |
| MTWNPN201401 | Topsoil/ Compost | 0.67 | 61.9 | 32.8 | 21.4 |
| MTWNPN201402 | Topsoil/ Compost | 0.96 | 59.8 | 39.5 | 47 |
| MTWSPN201401 | Topsoil/ Compost | 1 | 73.7 | 40.7 | 37.2 |
| MTWWDL201401 | Topsoil/ Compost | 0.97 | 63.7 | 40.6 | 36.8 |
| MTWWDL201402 | Topsoil/ Compost | 0.98 | 66.5 | 71.4 | 67.2 |
| | Average | 0.87 | 62.66 | 43.42 | 42.39 |

### 5.5.2 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 68.7 and the rehabilitation sites obtaining an average score of 68.2. As with the results from the LOI (above), stability indicators across all the sites show greater consistency than the stability indicators for the rehabilitation sites. This is likely due to the variation in the age of the rehabilitation sites and the variation in the nature of the rehabilitation works undertaken at each site. The stability indicators for the rehabilitation scores had a range of 36.4, whilst the range of indices for the reference sites was 23.9.

***Infiltration***

There’s a greater difference in the averages infiltration indices between reference and rehabilitation sites than for the soil surface condition indices (stability and nutrient cycling). The average value for the reference sites was 58.32, whilst the rehabilitation sites had an average of 43.42. The range of scores was greater for the rehabilitation scores than the reference sites. The range for the reference sites was 25.6, whilst the range value of the rehabilitation sites was 68.19.

***Nutrient enrichment***

The difference in the range of values for the nutrient enrichment is less than the average difference for the Infiltration indices. The average index for reference sites was 51.43, whilst the average index for rehabilitation sites was 42.39.

### 5.6 Landscape Function Analysis comparison to soil treatments

The results of the LFA showed a consistency across monitoring and rehabilitation sites, and between rehabilitation treatments. The LOI showed a large range (between 0.14 and 1), although the bulk of the sites exceeded 0.9.

Based on a preliminary evaluation of the data, sites have also been split for the purpose of this discussion into three broadly distinct categories of soil treatment:

1. Sites without treatment (reference/reference sites)
2. Spoil/ Compost
3. Subsoil/ Compost
4. Topsoil
5. Topsoil/ Compost

Sections 5.6.3 and 1.1.1 below provide a discussion of the LOI results and soil surface assessment indicators (stability, infiltration and nutrient cycling).

#### 5.6.3 Landscape Organisation Index (LOI)

Whilst to a large extent the LOI scores were consistent across the sites and the relevant treatments, there is variation in the averages across the soil treatments. Table 18 shows the average LOI for the different soil treatments as well as the relevant range. Chart 4 provides the results of the LOI across all sites.

The averages show that the sites treated with Spoil/Compost have a lower average LOI, than the reference sites or other soil treatments. Topsoil/ Compost contained the greatest average LOI (0.93) which was close to Reference sites (0.97).

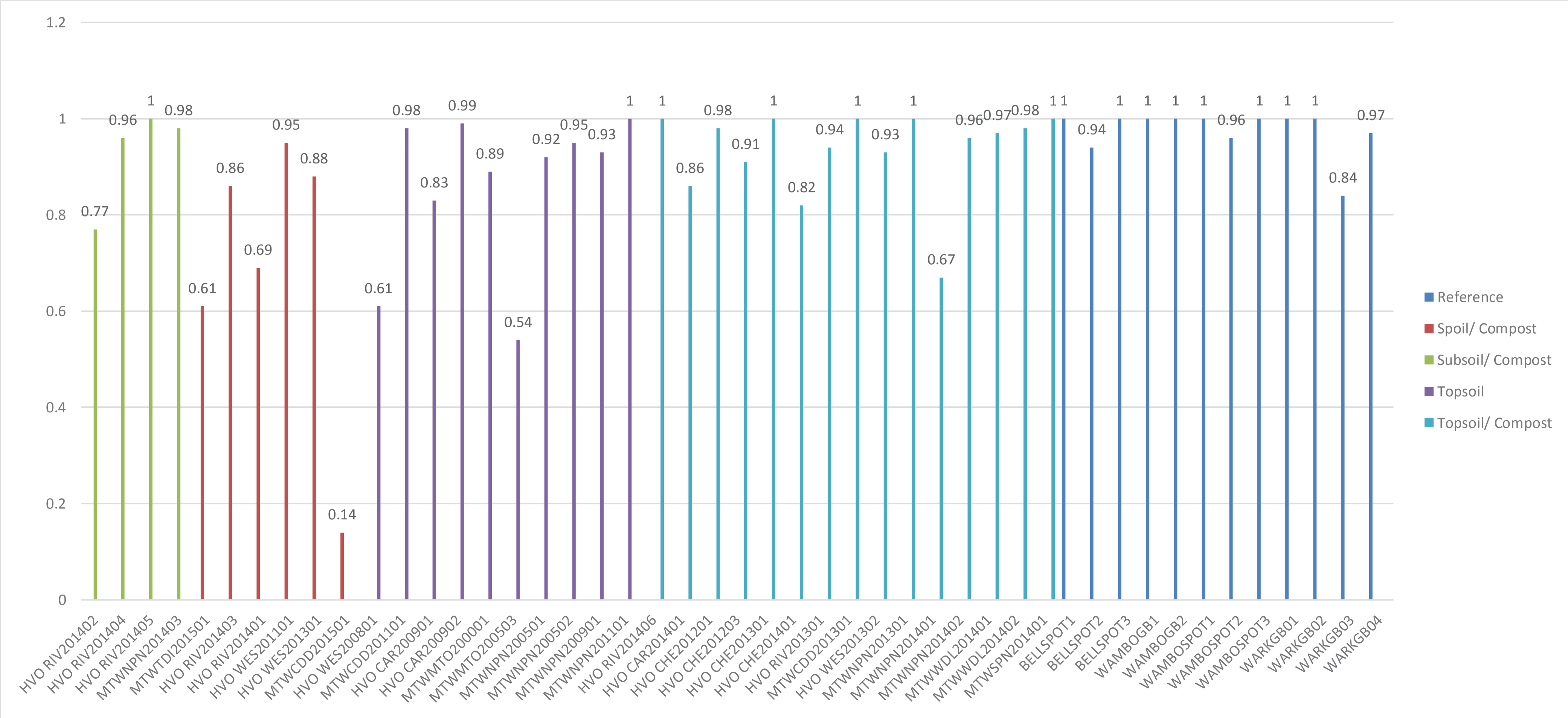
One outlier in the dataset is MTWCDD201501 which achieved a LOI of only 0. MTWDD201501 was a relatively new site, with a lack of plant cover and litter accumulation being the likely reason for the low LOI.

LOI is a measure of the total length of all measured ‘patches’ as a proportion of the length of the transect, which for this study was 50 m. A patch is a defined as a zone of resource accumulation and in the field was largely represented by vegetation and leaf litter. These parameters in a rehabilitation context would be expected to change with time, and are likely to be influenced by the revegetation techniques used. It is also valuable to note in this context that LOI is not a measure of native diversity, and in this regard successful rehabilitation. For example, WARKGB04 by comparison with other sites has a relatively low LOI, but still exhibits a high species richness score. By comparison, HVO RIV201301, with a LOI of 94, is comprised entirely of exotic vegetation.

**Table 18. Average LOI scores across reference sites, and different soil treatment sites.**

| Treatment | Average scores across rehabilitation and reference sites |
|---|---|
| Reference site | 0.97 |
| Spoil/ Compost | 0.69 |
| Subsoil/ Compost | 0.93 |
| Topsoil | 0.86 |
| Topsoil/ Compost | 0.94 |

**Chart 4. Comparison of LOI across soil treatments**



### 5.6.4 Soil surface condition

The ten soil surface indicators collected during LFA monitoring, feed into soil assessments; stability, infiltration and nutrient cycling. The results of these and some of the core outcomes of the results are provided below.

#### *Stability*

The averages for stability across all soil treatments are provided in Table 19. Chart 5 provide the results from all sites.

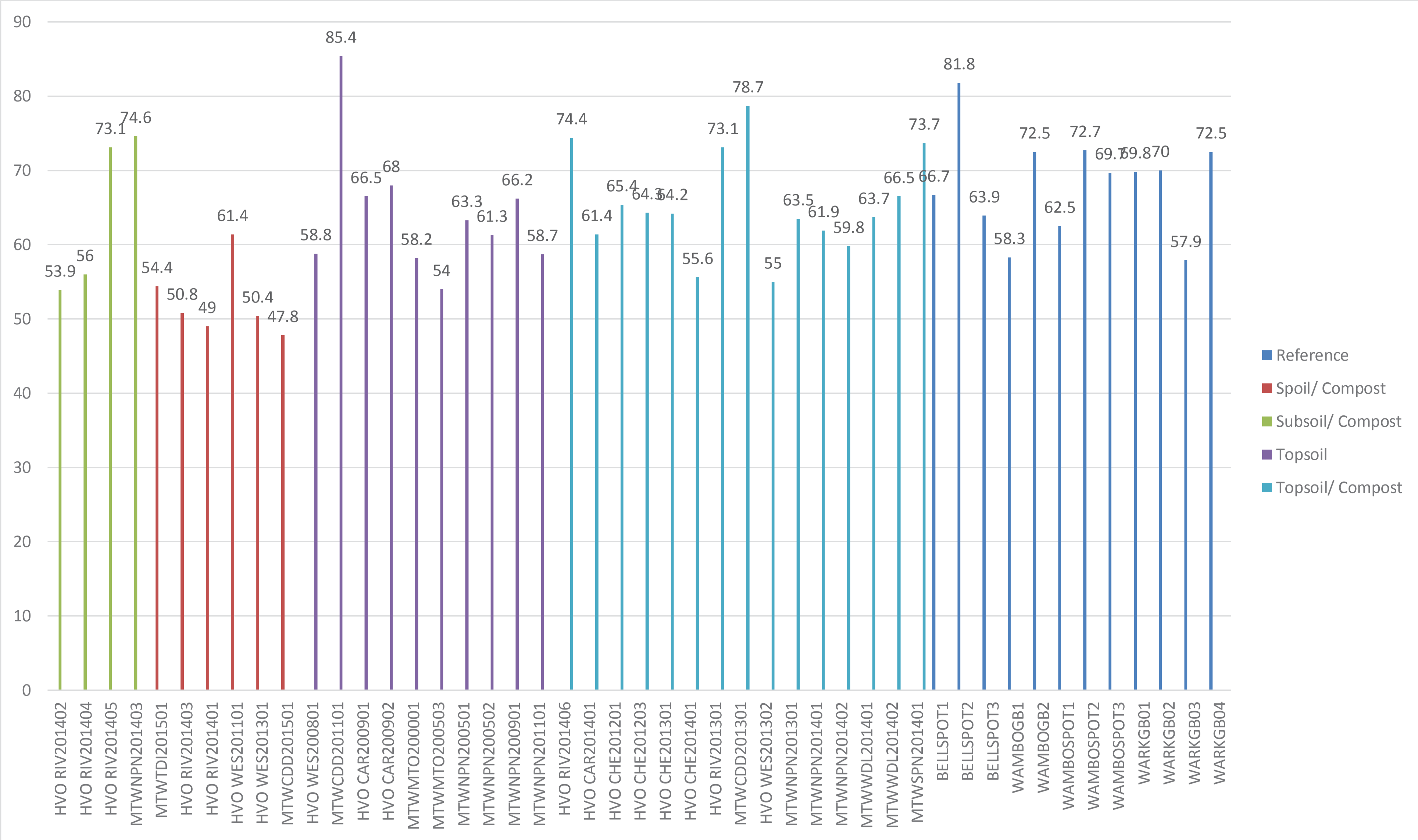
When the averages for each treatment are tabulated, the average of the reference sites have the highest stability score. The Spoil/Compost site contained the lowest average stability score, whilst the remaining soil treatments were similar.

Soil/plant cover is an indicator of stability, the variable cover at some of the compost sites may have influenced the lower average stability score at the compost sites. This parameter could be expected to increase with time, as the rehabilitation develops. It may also be the case, that the age of the rehabilitation and the rehabilitation technique has a greater influence on the stability value than the soil treatment. The range of values for the stability across the soil treatments can be seen in Chart 5.

**Table 19. Averages of the stability values for the soil treatments.**

| Treatment | Average scores across rehabilitation and reference sites |
|---|---:|
| Reference site | 68.19 |
| Spoil/ Compost | 52.30 |
| Subsoil/ Compost | 64.40 |
| Topsoil | 64.04 |
| Topsoil/ Compost | 65.41 |

**Chart 5. Comparison of the stability index against the soil treatments.**



### *Infiltration*

The average infiltration scores for the soil treatments are detailed in Table 20.

The Reference sites contained the highest average infiltration scores.

Both Subsoil/Compost and Topsoil treatments had similar results, with Topsoil/Compost being slightly higher. Spoil/Compost was quite low compared to the other soil treatments.

Whilst all rehabilitation sites scored lower than the reference site, this finding is consistent with Tongway and Hindley (2004) who found that whilst the stability index was consistent between rehabilitation areas and remnant woodland, infiltration index (and nutrient index) were lower in rehabilitation areas when compared with remnant woodland.

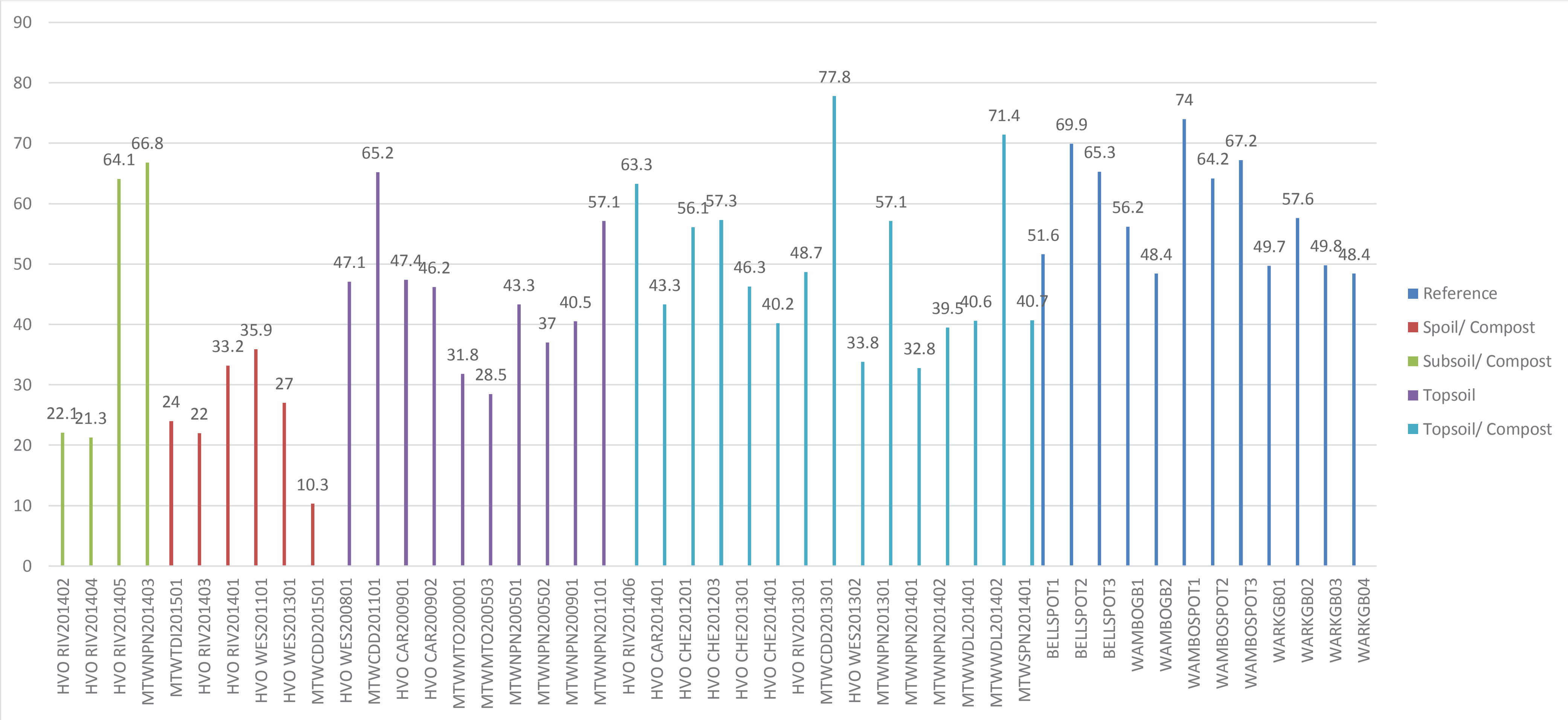
The range of infiltration values is presented in Chart 6.

The range of infiltration values were high, between 10.3 at MTWCDD201501 and 77.8 at MTWCDD201301. The infiltration index is driven by soil surface indicators, including leaf litter and surface roughness, which could be reasonably assumed to increase with the development of the rehabilitation.

**Table 20. Average of the infiltration values for the Reference Sites and rehabilitation sites**

| Treatment | Average scores across rehabilitation and reference sites |
|---|---:|
| Reference site | 58.52 |
| Spoil/ Compost | 25.40 |
| Subsoil/ Compost | 43.58 |
| Topsoil | 44.41 |
| Topsoil/ Compost | 49.93 |

**Chart 6. Comparison of the infiltration index against soil treatments.**



### *Nutrient cycling*

The average infiltration scores for the soil treatments are detailed in Table 21.

The Reference sites contained the greatest average score, with the average Topsoil/Compost score being a similar value.

Both Spoil/Compost and Subsoil/Compost treatment presented similar average results.

The Spoil/Compost treatment had the lowest average score.

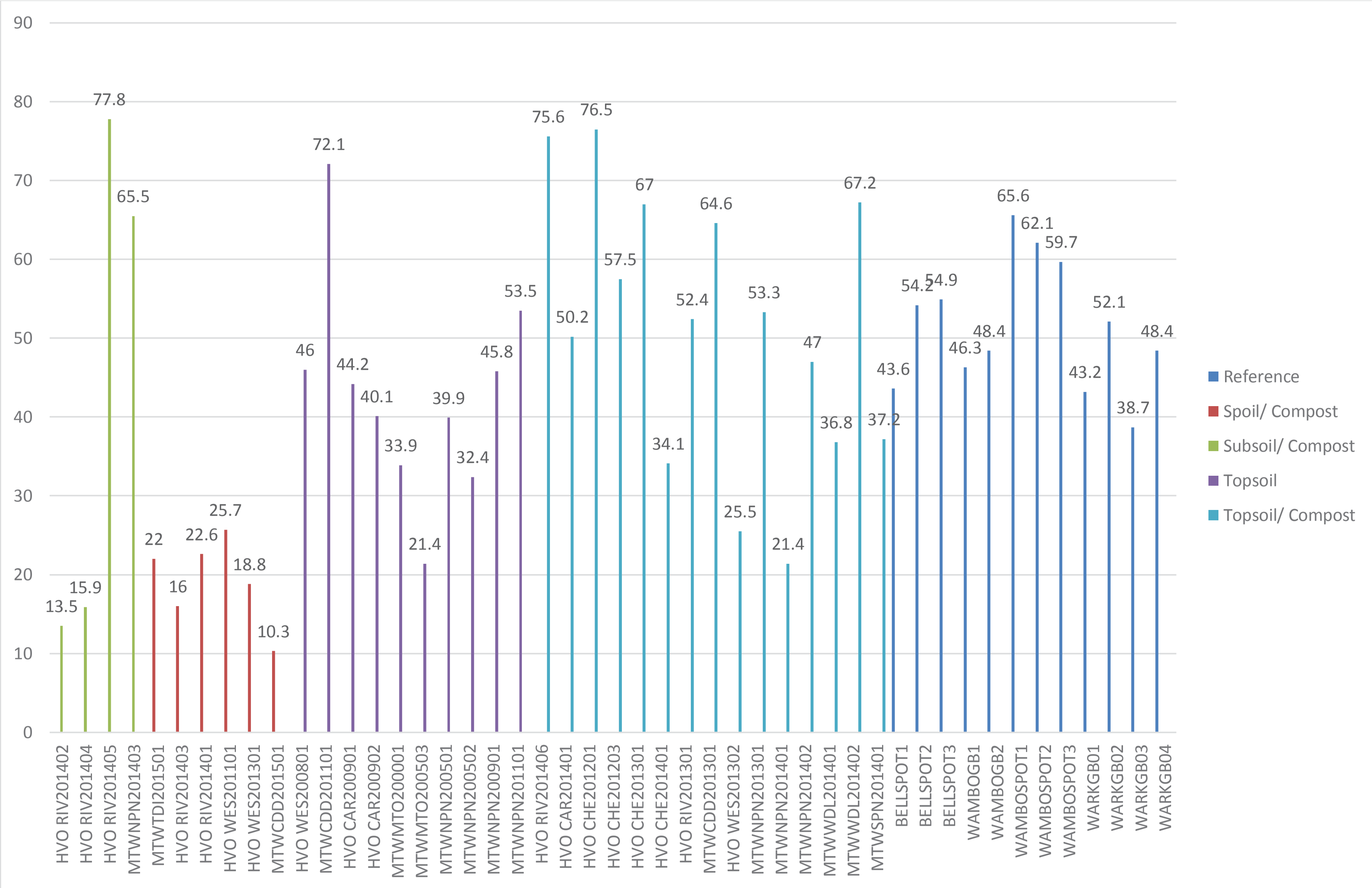
The range of values is presented in Chart 7.

The range of values was high, with the range of values being 10.3 for MTWCD201501 and 75.6 for HVRIV201406.

**Table 21. Average values for the nutrient cycling index for Reference Sites and soil treatments.**

| Treatment | Average scores across rehabilitation and reference sites |
|---|---|
| Reference site | 51.43 |
| Spoil/ Compost | 19.23 |
| Subsoil/ Compost | 43.18 |
| Topsoil | 42.93 |
| Topsoil/ Compost | 51.09 |

**Chart 7. Comparison of the nutrient cycling index for each soil treatment.**



# 6. Conclusions and recommendations

## 6.1 Conclusions

There is significant variation in the types and ages of the rehabilitation sites which were part of the monitoring project, thus there is a high degree of variability in monitoring results, this includes native plant species richness, exotic cover, percentage cover, LOI and projected cover of all strata. Provided below are some core outcomes of the monitoring undertaken. These outcomes have been provided below and summarised based on type of monitoring outcomes undertaken.

### 6.1.1 BioBanking assessment

Aspects of the BioBanking methodology have been used as part of this monitoring program to make comparisons with the target EECs, through the establishment of reference sites. A total of 12 reference sites were established, six representing the Central Hunter Ironbark-Spotted Gum-Grey Box EEC and six representing the Central Hunter Grey Box-Ironbark Woodland EEC. BioBanking plots were undertaken at a total of ten rehabilitation sites, enabling the comparison of 10 of 35 rehabilitation sites against the reference sites for the parameters collected. Results were generally positive, with some sites achieving the reference site benchmark for some of the ten attribute values. Some of the core outcomes included:

- All rehabilitation sites fall below benchmark in at least one attribute for both of the target communities. This means that management should aim to increase the number of native species present at the rehabilitation sites.
- Due to the density of regenerating shrub species, three sites are within benchmark for NMS (HVO CAR200902, HVO WES200801 and MTWNPN200502), whilst HVO CAR200901 and MTWCDC201101 are above benchmark. This is the case for benchmark data from both EECs.
- HVO WES200801, MTWNPN200501 and MTWNPN200901 were in benchmark for NGCS. MTWCDC201101 was above benchmark. It should be noted that the lower benchmark value for NGCS is zero, and thus any shrub cover would put the site into benchmark for this attribute.
- Three sites are within benchmark for NOS; HVO CAR200901, HVO WES200801 and MTWMTO200001 are within benchmark for NOS for Central Hunter Grey Box-Ironbark Woodland, and HVO WES200801 for Central Hunter Ironbark-Spotted Gum-Grey Box.

This report has noted differences between the published OEH benchmarks and the reference site benchmark data collected. Recommendations have been provided below where the lower benchmark values, obtained from reference site data, may not be suitable for setting performance criteria targets for rehabilitation areas.

### 6.1.2 Landscape function analysis

LFA was undertaken at all the sites surveyed, including the reference and rehabilitation sites. LFA scores (LOI and soil surface indicators) were high for reference sites, and variable for rehabilitation sites. It may be poignant to consider the efficacy of LFA assessment at all sites. A number of core outcomes of the LFA assessment include:

- LOI at the reference and rehabilitation sites was generally high, with an average LOI of .93 for the reference sites and .87 at the rehabilitation sites.
- The variability in the range of scores however was greater at the rehabilitation sites when compared with the reference sites. The variability in values at the rehabilitation sites is likely to be influenced by the seed treatments applied to sites and the age of the rehabilitation.

- 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), including HVORIV201405 and HVORIV201406.
- Sites which achieved relatively low LOI indices (MTWCDD201501 and MTWTD201501) were sites that had only recently been established and exhibited little grass or plant cover. These sites were typically spoil/compost sites that had only recently been established and exhibited little grass or plant cover.
- It is also valuable to note in this context that LAI is not a measure of native diversity, and in this regard not a measure of successful rehabilitation of native vegetation. For example, WARKGB04 by comparison with other reference sites has a relatively low LOI, but still exhibits a high species richness score. By comparison, HVO RI201301, with a LOI of 94, is comprised entirely of exotic vegetation.
- Whilst to a large extent the LOI scores were consistent across the sites and the relevant treatments, there is variation in the averages across the soil treatments. The averages show that the sites treated with Spoil/ Compost have a lower average LOI than the reference sites or other soil treatments. Topsoil/ Compost contained the greatest average LOI (0.93), which was close to that of Reference sites (0.97).
- The Spoil/ Compost site contained the lowest average stability score, whilst the remaining soil treatments were quite similar.
- The Reference sites contained the highest average infiltration scores. Both Subsoil/ Compost and Topsoil treatments had similar infiltration scores, with Topsoil/ Compost being slightly higher. Infiltration for Spoil/ Compost sites was relatively low when compared to the other soil treatments.

### 6.1.3 Groundcover assessment

The groundcover assessment was limited to rehabilitation sites and thus there is no reference data available for comparison. A comparison with soil treatments was undertake, with the key outcomes of the groundcover assessment being:

- Generally there was little variation in the ground cover assessment scores between different soil treatments.
- High weed cover was present at all sites.
- Most sites had greater than 50 percent Protective Cover.
- There were individual sites within each soil treatment which had high protective cover. For example, MTWCDD2013-01 (topsoil/ Compost 98 percent), MTWNPN2014-02 (Spoil/ Compost 97 percent), MTWNPN2011-01 (topsoil 84 percent) and MTWNPN2014-03 (subsoil/ compost 93 percent).
- The site with the lowest Protective Cover was HVORIV2014-02.
- The number of native species ranged from one to seven species.
- The site with the highest number of native species was MTWNPN2014-03 (seven species) and HVORIV2014-03 (six species).

## 6.2 Recommendations

Based on the results and conclusions above, and implementation of the monitoring protocols, a number of recommendations have been developed pertaining to site results and the monitoring protocols (Table 22). The following recommendations are proposed:

**Table 22. Recommendations for improving monitoring protocols**

| Component | Issue | Recommendation |
|---|---|---|
| Ground cover assessment | The ground cover assessment does not capture a comprehensive list of the regenerating species. The assessment is part of the visual | Replace the groundcover assessment with a nested 20 x 20 m floristic plot. Record all species (native and exotic) and record cover abundance scores for each. This is the same process as that undertaken at sites where |

| Component | Issue | Recommendation |
|---|---|---|
| | assessment, which only requires recording of dominant species. | BioBanking plots are conducted. The traditional groundcover assessment may have more utility if used by C&A staff (or other field staff) to measure the efficacy of targeted weed treatment, in areas where herbaceous weeds are abundant. Utilising this process before, and a number of times after, treatments may improve the efficacy of measuring the actions undertaken. |
| Ground cover assessment | The assessment records information which is substantially covered by the LFA assessment. This includes plant cover, litter cover, rock and bare ground. The assessment adds field time and data management time to the process. | Cease the use of the groundcover assessment. Rely on LFA for information on surface cover (plants, rocks and litter) and use the cover abundance scores (recommended above) to provide information on the proportion of weed and native cover. |
| Visual Assessment - Species composition | The species composition assessment requires the dominant species in each strata to be recorded. This information is recorded automatically at sites where biometric plots are undertaken via cover abundance scores – and thus is a duplication. It is also difficult to quantify within the reporting. | Cease using the species conservation assessment and rely on a 20 x 20 m floristic plot instead. This would provide a more robust list of species present (i.e. every species in the plot). Dominant species could be discerned via the cover abundance scores. Eliminating the Visual Assessment at BioBanking sites would reduce field and data management time by reducing duplication. |
| Visual Assessment - Species composition | The capture of information regarding tree maturity (height and DBH) is not undertaken in a qualitative sense (i.e. the methodology does not stipulate a sample size or how the information should be reflected in the report). | Stipulate in the methodology that DBH and tree height is recorded for 10 canopy tree at each sample site. Replicate this process at reference sites. Tree maturity is not reflected in BioBanking data or benchmarks. |
| Monitoring timing | Species identification is always assisted by the presence of flowers or fruit, and undertaking monitoring when these features are not present may inhibit data collection. | Undertake monitoring during spring and/or autumn to increase opportunities for more thorough identification. Identification at rehabilitation sites will be limited by the maturity of the plants present. |
| Local Benchmark data - Central Hunter Grey Box-Ironbark Woodland | Lower benchmark for NGCS is zero. A midstorey of zero for this community may not provide a suitable performance criteria. | Consideration to use the OEH benchmark for NGCS (Lower = five percent, Upper = 10 percent) as the lower benchmark more likely reflects the BVT. |
| Local Benchmark data - Central Hunter Grey Box-Ironbark Woodland | NTH is zero, which may not reflect a true benchmark for this attribute. | Consideration to use the OEH benchmark for NTH (three) as this benchmark more likely reflects the BVT. |

| Component | Issue | Recommendation |
|---|---|---|
| Local Benchmark data - Central Hunter Ironbark-Spotted Gum-Grey Box Forest | Lower benchmark for NMS is zero. A midstorey of zero for this community and may not provide a suitable performance criteria. | Consideration to use the OEH benchmark for NMS (Lower = 10 percent, Upper = 60 percent) as the lower benchmark more likely reflects the BVT. |
| Local Benchmark data - Central Hunter Ironbark-Spotted Gum-Grey Box Forest | NTH is zero, which may not reflect a true benchmark for this attribute. | Consideration to use the OEH benchmark for NTH (one) as this benchmark more likely reflects the BVT. |
| Scope of the analysis | It is noted that without more accurate data on the rehabilitation measures implemented (seed mixes used and yield), it is difficult to discern accurate information regarding the efficacy of particular rehabilitation techniques. | Compile data on the particular rehabilitation techniques implemented and target aspect of the monitoring program to establish the efficacy of rehabilitation outcomes. |

# 7. References

AECOM (2012) Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites, Prepared for Coal and Allied.

Coal and Allied (2015a) Mining Operations Plan – HVO North – Draft edition.

Coal and Allied (2015b) Mining Operations Plan - Mount Thorley Warkworth - Draft edition.

OEH (2014) BioBanking Assessment Methodology, Prepared by Office of Environment and Heritage for the NSW Government

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.

# Figures

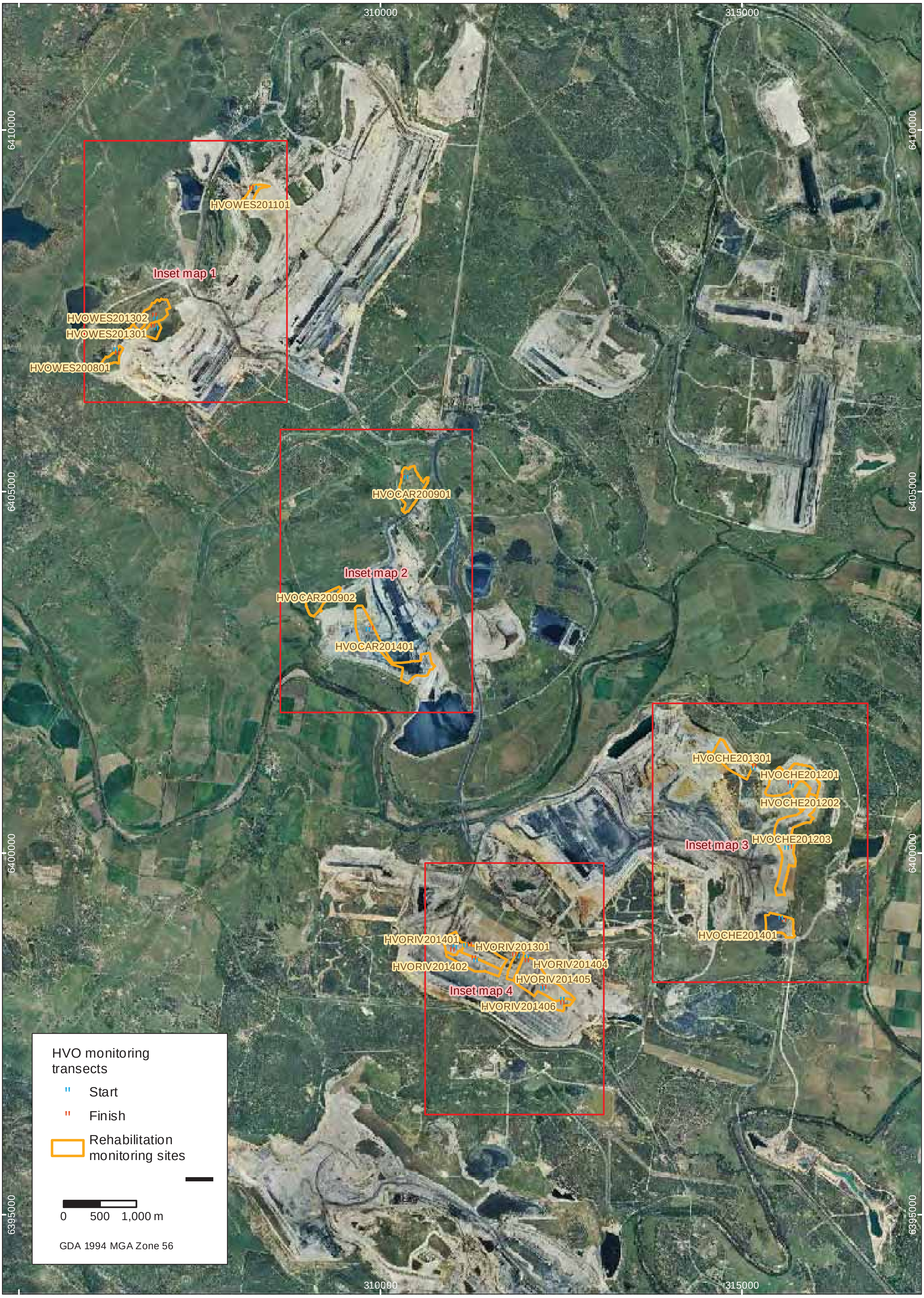

Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

Project location

Coal and Allied Rehabilitation Monitoring

**FIGURE 1**

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_1_StudyArea.mxd




HVO survey locations overview

Coal and Allied Rehabilitation Monitoring

niche Environment and Heritage

**FIGURE 2**

Imagery: (c) RTCA 2010-12-31

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_2_HVO.mxd


HVO survey locations - Inset map 1

Coal and Allied Rehabilitation Monitoring

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**FIGURE 3**

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_3_HVO.mxd

Imagery: (c) RTCA 2010-12-31


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

HVO survey locations - Inset map 2

Coal and Allied Rehabilitation Monitoring

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**FIGURE 4**

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_4_HVO.mxd

Imagery: (c) RTCA 2010-12-31


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

HVO survey locations - Inset map 3

Coal and Allied Rehabilitation Monitoring

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**FIGURE 5**

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_5_HVO.mxd

Imagery: (c) RTCA 2010-12-31


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

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HVO survey locations - Inset map 4

Coal and Allied Rehabilitation Monitoring

**FIGURE 6**

Imagery: (c) RTCA 2010-12-31

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_6_HVO.mxd


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

MTW survey locations overview

Coal and Allied Rehabilitation Monitoring

niche Environment and Heritage

**FIGURE 7**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_7_MTW.mxd


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

MTW survey locations overview - Inset map 1

Coal and Allied Rehabilitation Monitoring

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**FIGURE 8**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_8_MTW.mxd


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

MTW survey locations overview - Inset map 2

Coal and Allied Rehabilitation Monitoring

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**FIGURE 9**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_9_MTW.mxd


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

MTW survey locations overview - Inset map 3

Coal and Allied Rehabilitation Monitoring

**FIGURE 10**

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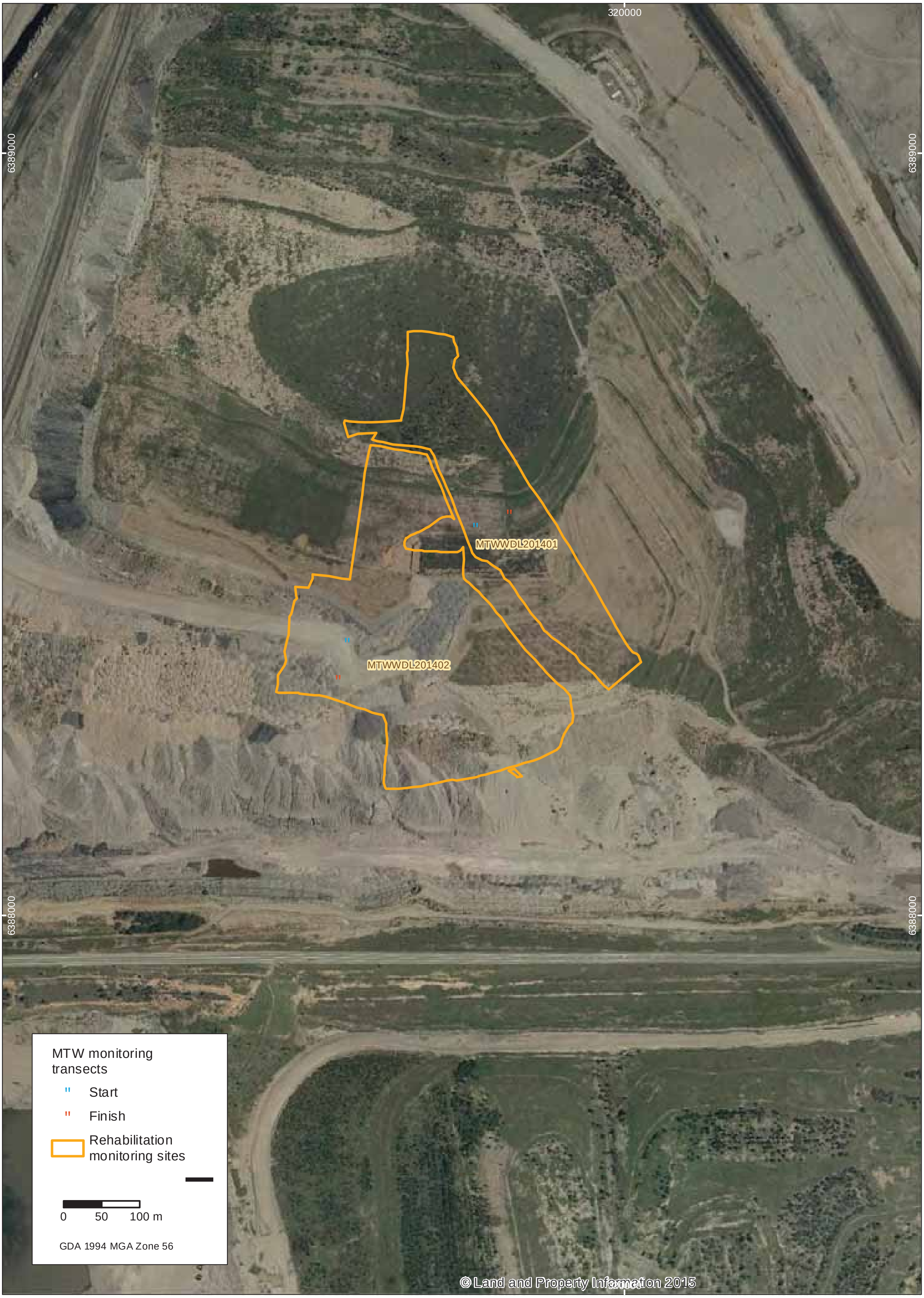
Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_10_MTW.mxd

Imagery: (c) LPI 2008-12-17




Drawn by: RJ    Project Manager: VH    Project Number: 2766    Date: 08/03/2016

MTW survey locations overview - Inset map 4

Coal and Allied Rehabilitation Monitoring

niche Environment and Heritage

**FIGURE 11**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_11_MTW.mxd


Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

MTW survey locations overview - Inset map 5

Coal and Allied Rehabilitation Monitoring

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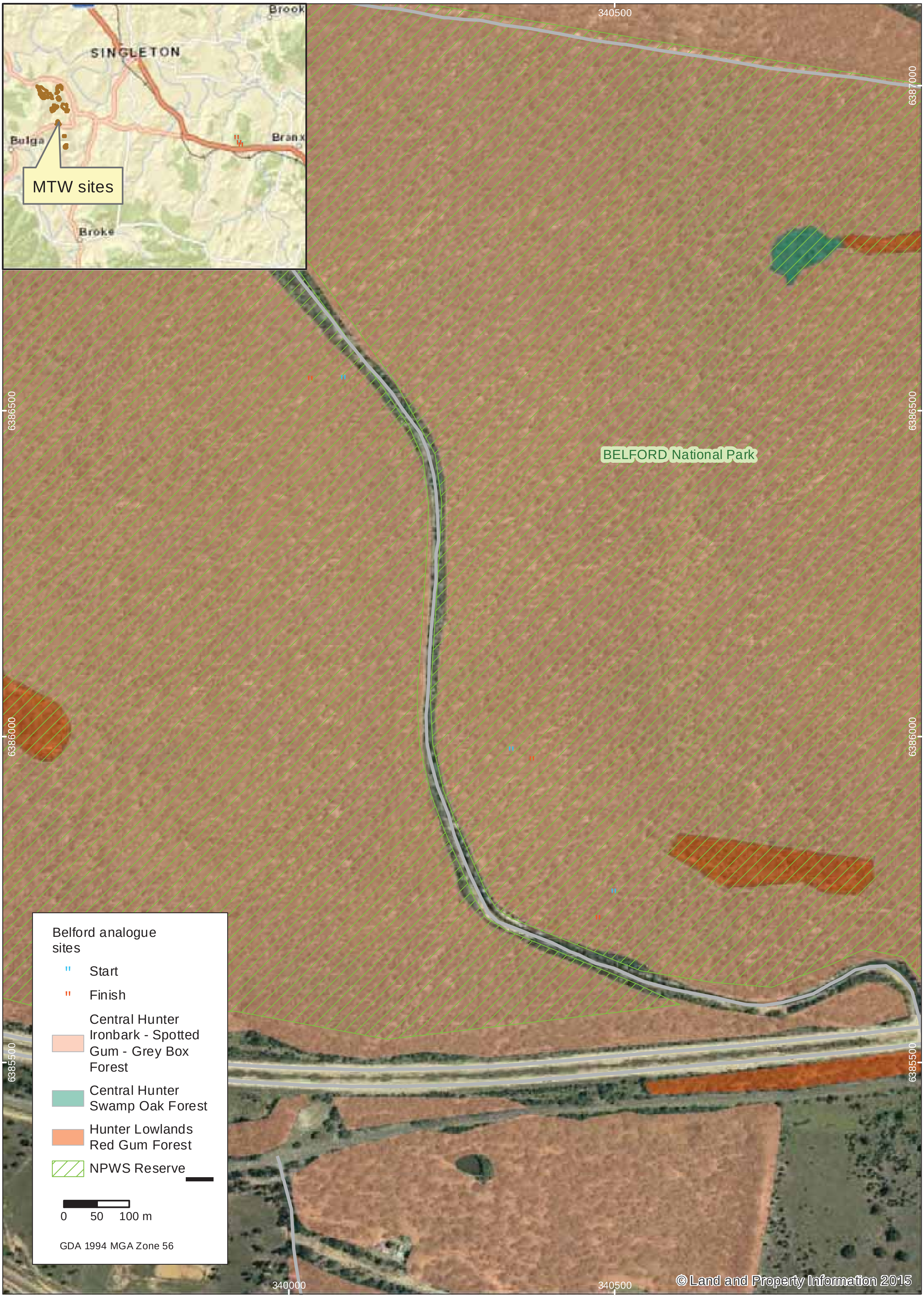
**FIGURE 12**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_12_MTW.mxd




Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

Analogue sites – Belford National Park

Coal and Allied Rehabilitation Monitoring

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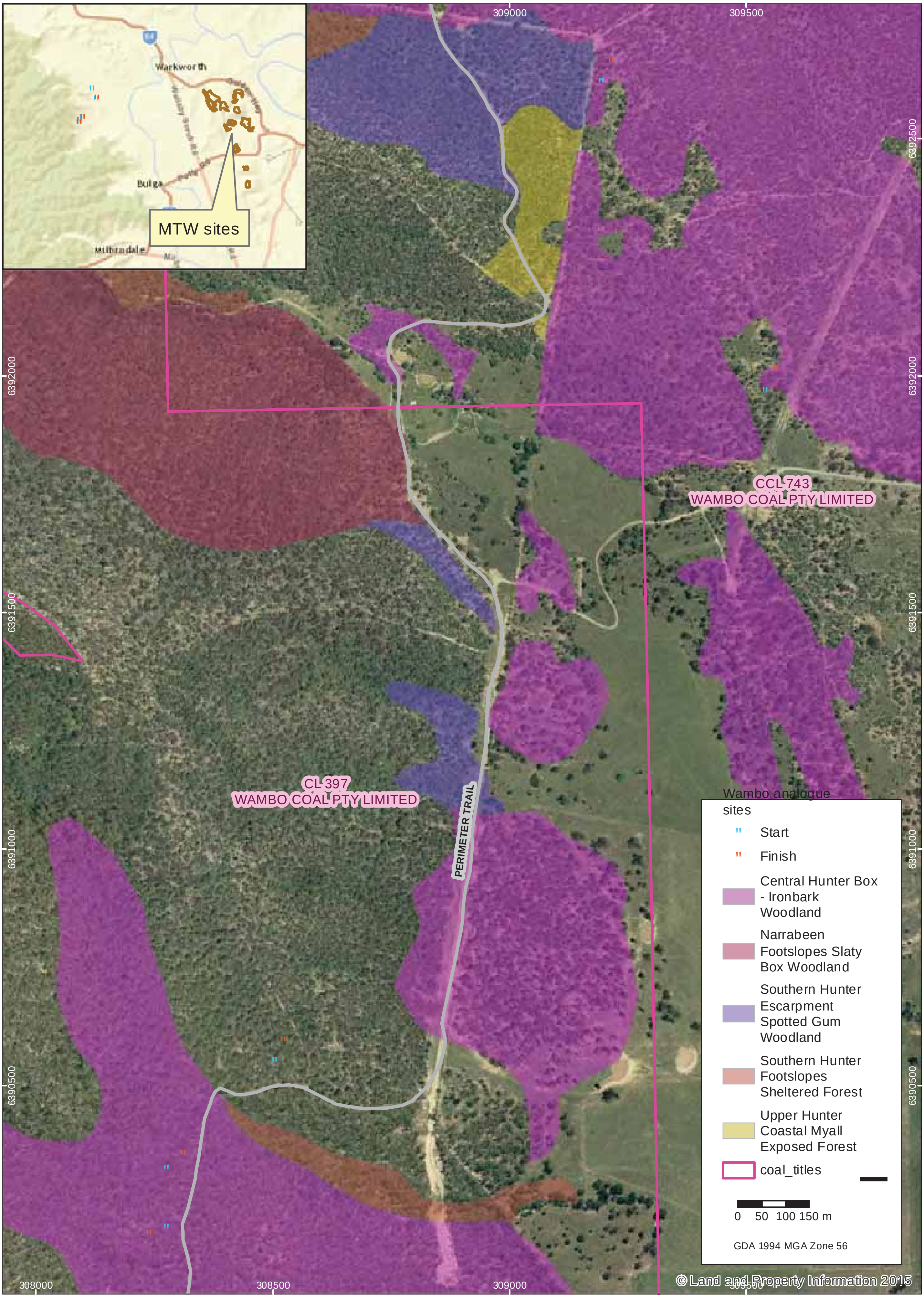
**FIGURE 13**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_13_AnalogBELL.mxd

Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016




Analogue sites – Wambo Colliery Land

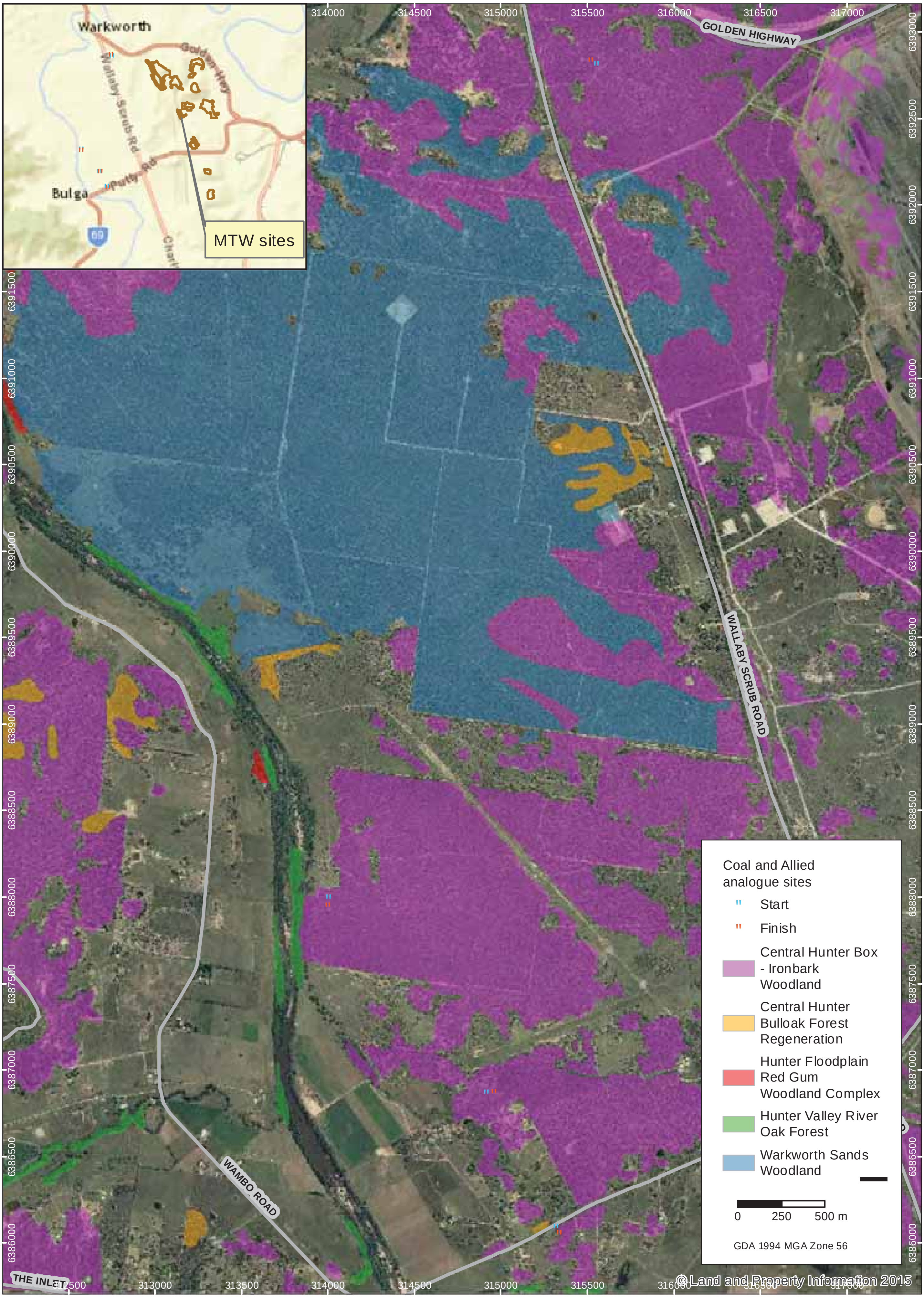
Coal and Allied Rehabilitation Monitoring

niche Environment and Heritage

**FIGURE 14**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_14_AnalogWAMBO.mxd




Drawn by: RJ Project Manager: VH Project Number: 2766 Date: 08/03/2016

Analogue sites – Coal and Allied managed land

Coal and Allied Rehabilitation Monitoring

niche Environment and Heritage

**FIGURE 15**

Imagery: (c) LPI 2008-12-17

Path: T:\spatial\projects\a2700\a2766_MTW_HVO\Maps\report\2766_Figure_15_AnalogCNA.mxd

# Appendix 1 – Monitoring dates

| Location | Survey personnel | Date | BioBanking completed |
|---|---|---|---|
| BELLSPOT1 | Luke Baker and Vivien Howard | 01/02/2016 | Completed |
| HVO RIV201406 | Luke Baker, Vivien Howard and Robert Carter | 02/02/2016 | Not required |
| HVO RIV201405 | Luke Baker, Vivien Howard and Robert Carter | 02/02/2016 | Not required |
| HVO RIV201404 | Luke Baker, Vivien Howard and Robert Carter | 02/02/2016 | Not required |
| HVO RIV201403 | Luke Baker, Vivien Howard and Robert Carter | 02/02/2016 | Not required |
| BELSPOT2 | Luke Baker and Vivien Howard | 02/02/2016 | Completed |
| MTWWDL201401 | Luke Baker, Vivien Howard and Robert Carter | 03/02/2016 | Not required |
| MTWWDL201402 | Luke Baker, Vivien Howard and Robert Carter | 03/02/2016 | Not required |
| HVO RIV201402 | Luke Baker, Vivien Howard and Bill Baxter | 03/02/2016 | Not required |
| HVO RIV201401 | Luke Baker, Vivien Howard and Bill Baxter | 03/02/2016 | Not required |
| HVO RIV201301 | Luke Baker, Vivien Howard and Bill Baxter | 03/02/2016 | Not required |
| HVO CHE201201 | Luke Baker, Vivien Howard and Bill Baxter | 03/02/2016 | Not required |
| HVO CHE201202 | Luke Baker, Vivien Howard and Bill Baxter | 03/02/2016 | Not required |
| HVO CHE201301 | Luke Baker, Vivien Howard and Bill Baxter | 03/02/2016 | Not required |
| MTWNPN200901 | Luke Baker, Vivien Howard and Robert Carter | 04/02/2016 | Completed |
| MTWCDD201101 | Luke Baker, Vivien Howard and Jess Blair | 04/02/2016 | Not required |
| MTWCDD201301 | Luke Baker, Vivien Howard and Jess Blair | 04/02/2016 | Not required |
| MTWCDD201501 | Luke Baker, Vivien Howard and Jess Blair | 04/02/2016 | Not required |
| MTWSPN201401 | Luke Baker, Vivien Howard and Robert Carter | 04/02/2016 | Not required |
| MTWNPN200502 | Luke Baker, Vivien Howard and Robert Carter | 04/02/2016 | Completed |
| MTWNPN201301 | Luke Baker, Vivien Howard and Jess Blair | 05/02/2016 | Not required |
| MTWNPN201402 | Luke Baker, Vivien Howard and Jess Blair | 05/02/2016 | Not required |
| MTWNPN201401 | Luke Baker, Vivien Howard and Jess Blair | 05/02/2016 | Not required |
| MTWNPN201403 | Luke Baker, Vivien Howard and Jess Blair | 05/02/2016 | Not required |
| MTWNPN201101 | Luke Baker, Vivien Howard and Robert Carter | 05/02/2016 | Not required |
| MTWTD1201501 | Luke Baker, Vivien Howard and Bill Baxter | 05/02/2016 | Not required |
| MTWNPN200501 | Luke Baker, Vivien Howard and Bill Baxter | 05/02/2016 | Completed |
| MTWMTO200001 | Luke Baker, Vivien Howard and Bill Baxter | 08/02/2016 | Completed |
| MTWMTO200503 | Luke Baker, Vivien Howard and Bill Baxter | 08/02/2016 | Completed |
| HVO CAR200901 | Luke Baker, Vivien Howard and Robert Carter | 08/02/2016 | Completed |
| HVO CAR200902 | Luke Baker, Vivien Howard and Robert Carter | 08/02/2016 | Completed |
| HVO CAR201401 | Luke Baker, Vivien Howard and Robert Carter | 08/02/2016 | Not required |
| HVO WES200801 | Luke Baker, Vivien Howard and Bill Baxter | 09/02/2016 | Completed |
| HVO WES201101 | Luke Baker, Vivien Howard and Bill Baxter | 09/02/2016 | Completed |
| HVO WES201301 | Luke Baker, Vivien Howard and Bill Baxter | 09/02/2016 | Not required |
| HVO WES201302 | Luke Baker, Vivien Howard and Bill Baxter | 09/02/2016 | Not required |
| HVO CHE201203 | Luke Baker, Vivien Howard and Robert Carter | 09/02/2016 | Not required |

| Location | Survey personnel | Date | BioBanking completed |
|---|---|---|---|
| HVO CHE201401 | Luke Baker, Vivien Howard and Robert Carter | 09/02/2016 | Not required |
| BELSPOT3 | Luke Baker and Vivien Howard | 09/02/2016 | Completed |
| SBOAGB1 | Luke Baker and Vivien Howard | 10/02/2016 | Completed |
| WAMBOSPOT1 | Luke Baker and Vivien Howard | 11/02/2016 | Completed |
| WAMBOSPOT2 | Luke Baker and Vivien Howard | 12/02/2016 | Completed |
| SBOAGB2 | Luke Baker and Vivien Howard | 12/02/2016 | Completed |
| WAMBOSPOT3 | Luke Baker and Vivien Howard | 13/02/2016 | Completed |
| SBOAGB3 | Luke Baker and Vivien Howard | 13/02/2016 | Completed |
| WAMBOGB1 | Luke Baker and Vivien Howard | 14/02/2016 | Completed |
| SBOAGB4 | Luke Baker and Vivien Howard | 14/02/2016 | Completed |
| WAMBOGB2 | Luke Baker and Vivien Howard | 15/02/2016 | Completed |

# Appendix 2 – Monitoring locations

| Monitoring site | Position on transection | GDA94 MGA Zone 56 | |
|---|---|---|---|
| | | Northing | Easting |
| HVO North rehabilitation monitoring sites | | | |
| 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 CHE201203 | Start | 6400040 | 315617 |
| HVO CHE201203 | Finish | 6400044 | 315667 |
| HVO CHE201301 | Start | 6401135 | 315159 |
| HVO CHE201301 | Finish | 6401172 | 315170 |
| HVO CHE201401 | Start | 6399065 | 315541 |
| HVO CHE201401 | Finish | 6399040 | 315582 |
| HVO RIV201301 | Start | 6398690 | 311184 |
| HVO RIV201301 | Finish | 6398695 | 311233 |
| 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 |
| 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 |
| MTW Rehabilitation monitoring sites | | | |

| Monitoring site | Position on transection | GDA94 MGA Zone 56 | |
|---|---|---|---|
| | | 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 |
| MTWMPN201401 | Start | 6392128 | 317619 |
| MTWMPN201401 | Finish | 6392128 | 317619 |
| 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 | 6391981 | 319682 |
| MTWNPN200901 | Start | 6391524 | 319069 |
| MTWNPN200901 | Finish | 6391535 | 319027 |
| MTWNPN201101 | Start | 6392138 | 318166 |
| MTWNPN201301 | Finish | 6391519 | 317995 |
| MTWNPN201301 | Start | 6391551 | 318047 |
| MTWNPN201401 | Start | 6392098 | 317646 |
| MTWNPN201401 | Finish | 6392098 | 317646 |
| MTWNPN201403 | Start | 6391212 | 318079 |
| MTWNPN201403 | Finish | 6391213 | 318131 |
| MTWSPN201401 | Start | 6390161 | 320170 |
| MTWSPN201401 | Finish | 6390304 | 319574 |
| MTWTDI201501 | Start | 6392186 | 319688 |
| MTWTDI201501 | Finish | 6392236 | 319692 |
| MTWWDL201401 | Start | 6388508 | 319805 |
| MTWWDL201401 | Finish | 6388526 | 319849 |
| MTWWDL201402 | Start | 6388357 | 319636 |
| MTWWDL201402 | Finish | 6388309 | 319624 |
| Reference sites | | | |
| BEL1 | Start | 6386547 | 340083 |
| BEL1 | Finish | 6386546 | 340033 |
| BEL2 | Start | 6386551 | 340072 |
| BEL2 | Finish | 6385962 | 340373 |
| BEL3 | Start | 6385760 | 340498 |
| BEL3 | Finish | 6385719 | 340474 |

| Monitoring site | Position on transection | GDA94 MGA Zone 56 | |
|---|---|---|---|
| | | Northing | Easting |
| 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 3 – Flora species list

## Flora two-way table: Rehabilitation sites

| Family | Species | Common Name | Exotic * | HVOCAR 200901 | HVOCAR 200902 | HVOWES 200801 | HVOWES 201101 | MTWCDC 201101 | MTWMTO 200001 | MTWMTO 200503 | MTWNPN 200501 | MTWNPN 200502 | MTWNPN 200901 | Wambo GB01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acanthaceae | Brunoniella australis | Blue Trumpet | | | | | | | | | | | | 4 |
| Adiantaceae | Cheilanthes sieberi | Rock Fern | | | | | | | 2 | | | 3 | | 2 |
| Aizoaceae | Galenia pubescens | Galenia | * | 3 | | 3 | 2 | 2 | 3 | 3 | 3 | 2 | | |
| Anthericaceae | Tricoryne spp. | | | | | | | | | | | | | 1 |
| Apocynaceae | Gomphocarpus fruticosus | Narrow-leaved Cotton Bush | * | 3 | | | | 4 | 2 | | 3 | 2 | 2 | |
| Asteraceae | Bidens pilosa | Cobbler's Pegs | * | | 3 | 3 | 2 | 3 | | 2 | 3 | 3 | | 1 |
| Asteraceae | Calotis lappulacea | Yellow Burr-daisy | | | | | | | 2 | 2 | | | | |
| Asteraceae | Chrysocephalum apiculatum | Common Everlasting | | | | | | | | | 3 | | | 2 |
| Asteraceae | Cirsium vulgare | Spear Thistle | * | 3 | | | | 3 | | | | | | |
| Asteraceae | Conyza bonariensis | Flaxleaf Fleabane | * | 3 | | | 3 | 4 | 4 | 3 | 3 | 2 | | |
| Asteraceae | Lactuca serriola | Prickly Lettuce | * | | | | | 3 | | | | | | |
| Asteraceae | Olearia elliptica | Sticky Daisy-bush | | | | | | | | | | | | 5 |
| Asteraceae | Senecio madagascariensis | Fireweed | * | 3 | | | 2 | 3 | 3 | 3 | 3 | 2 | | 1 |
| Asteraceae | Sonchus oleraceus | Common Sowthistle | * | | | | | | | | | 1 | | |
| Asteraceae | Vittadinia cuneata | A Fuzzweed | | | | | | | | 1 | 2 | 2 | | 2 |
| Asteraceae | Vittadinia sulcata | | | | | 2 | | | 2 | | | | | |
| Boraginaceae | Heliotropium amplexicaule | Blue Heliotrope | * | | | 3 | | | | | | | | |
| Brassicaceae | Brassica spp. | Brassica | * | | | | 3 | | | | | | | |
| Brassicaceae | Lepidium campestre | Field Cress | * | | | | | | 2 | | | | | |
| Cactaceae | Opuntia aurantiaca | Tiger Pear | * | | | | | | 2 | 2 | | | | 1 |

| Family | Species | Common Name | Exotic * | HVOCAR 200901 | HVOCAR 200902 | HVOWES 200801 | HVOWES 201101 | MTWCDC 201101 | MTWMTO 200001 | MTWMTO 200503 | MTWNPN 200501 | MTWNPN 200502 | MTWNPN 200901 | Wambo GB01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Campanulaceae | Wahlenbergia gracilis | Sprawling Bluebell | | | | | | | | 2 | | | | 2 |
| Campanulaceae | Wahlenbergia stricta | Tall Bluebell | | | 1 | | | | | | 2 | | | |
| Casuarinaceae | Allocasuarina littoralis | Black She-Oak | | | | | 1 | | | | | | | |
| Casuarinaceae | Casuarina cunninghamiana | River Oak | | | | | | | | | | | | 6 |
| Chenopodiaceae | Einadia nutans | Climbing Saltbush | | | | | | | 2 | 2 | 1 | | | 3 |
| Chenopodiaceae | Einadia trigonos | Fishweed | | | | | | 2 | | | | | | |
| Chenopodiaceae | Enchylaena tomentosa | Ruby Saltbush | | | | 2 | 3 | | 2 | 3 | | | | |
| Convolvulaceae | Convolvulus arvensis | Field Bindweed | * | | | | | 1 | | | | | | |
| Convolvulaceae | Dichondra repens | Kidney Weed | | 3 | 2 | 2 | 2 | 2 | | | 3 | | 2 | 3 |
| Cyperaceae | Carex inversa | Knob Sedge | | | | | | 1 | | | | | | |
| Cyperaceae | Cyperus gracilis | Slender Flat-sedge | | | 1 | | | | | 2 | | | 1 | 3 |
| Cyperaceae | Fimbristylis dichotoma | Common Fringe-sedge | | | | | | 2 | | | | | | |
| Ericaceae | Lissanthe strigosa | Peach Heath | | | | | | | | | | | | 2 |
| Fabaceae (Faboideae) | Desmodium brachypodum | Large Tick-trefoil | | | | | | | | | | | | 2 |
| Fabaceae (Faboideae) | Glycine tabacina | Variable Glycine | | | 2 | 2 | | 3 | | 2 | 2 | 1 | | 2 |
| Fabaceae (Faboideae) | Hardenbergia violacea | False Sarsaparilla | | | | | 2 | 2 | | | | | | |
| Fabaceae (Faboideae) | Indigofera australis | Australian Indigo | | | | | 2 | 2 | | | | | | |
| Fabaceae (Faboideae) | Medicago arabica | Spotted Burr Medic | * | | 2 | 2 | | | | | | | | |
| Fabaceae (Faboideae) | Swainsona galegifolia | Smooth Darling Pea | | | | | 2 | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia amblygona | Fan Wattle | | 3 | | 4 | | 5 | | | 3 | 2 | 3 | |
| Fabaceae (Mimosoideae) | Acacia binervata | Two-veined Hickory | | | | | 1 | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia cultriformis | Knife-leaved Wattle | | | | | | 3 | | | | | | |

| Family | Species | Common Name | Exotic * | HVOCAR 200901 | HVOCAR 200902 | HVOWES 200801 | HVOWES 201101 | MTWCDC 201101 | MTWMTO 200001 | MTWMTO 200503 | MTWNPN 200501 | MTWNPN 200502 | MTWNPN 200901 | Wambo GB01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fabaceae (Mimosoideae) | Acacia dealbata | Silver Wattle | | | 2 | 4 | | 1 | 2 | | | | 2 | |
| Fabaceae (Mimosoideae) | Acacia falcata | | | 3 | | | 2 | | | | | | 2 | |
| Fabaceae (Mimosoideae) | Acacia longifolia | | | 3 | 3 | | 3 | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia mearnsii | Black Wattle | | 4 | 2 | | | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia paradoxa | Kangaroo Thorn | | | | 2 | | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia parvipinnula | Silver-stemmed Wattle | | | | 4 | | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia saligna | Golden Wreath Wattle | * | 5 | | 3 | | 2 | | 1 | 5 | 3 | | |
| Fabaceae (Mimosoideae) | Acacia spp. | Wattle | | | 3 | 1 | | | 1 | | | | | 1 |
| Fabaceae (Mimosoideae) | Mimosa pudica | Common Sensitive Plant | * | | 2 | | | | | 1 | | | | |
| Gentianaceae | Centaurium spicatum | Spike Centaury | | | | | | | | | 2 | | | |
| Lomandraceae | Lomandra filiformis | Wattle Matt-rush | | | | 1 | | | | | | | | |
| Lomandraceae | Lomandra multiflora | Many-flowered Mat-rush | | | | 1 | | | | | | | | 2 |
| Malvaceae | Malvastrum americanum | Spiked Malvastrum | * | | | 2 | | | | | | | | |
| Malvaceae | Sida corrugata | Corrugated Sida | | 3 | 2 | | | 2 | 3 | | | | 2 | 2 |
| Malvaceae | Sida rhombifolia | Paddy's Lucerne | * | 3 | | 3 | 1 | 4 | 3 | 3 | | 2 | 3 | |
| Myoporaceae | Eremophila debilis | Amulla | | | | 3 | | | 2 | 2 | 1 | 2 | | |
| Myoporaceae | Myoporum montanum | Western Boobialla | | | | | 2 | | | | | | | |
| Myrsinaceae | Anagallis arvensis | Scarlet Pimpernel | * | | | | | | | | 1 | 1 | | |
| Myrtaceae | Corymbia citriodora | Lemon-scented Gum | * | | | | | | | | | 2 | | |
| Myrtaceae | Corymbia maculata | Spotted Gum | | | 3 | 6 | 4 | 3 | | | 3 | 4 | 6 | |
| Myrtaceae | Eucalyptus crebra | Narrow-leaved Ironbark | | | 2 | | 3 | | | | | 3 | 3 | 5 |
| Myrtaceae | Eucalyptus maculata | Spotted Gum | | 5 | | | | | | | | | | |

| Family | Species | Common Name | Exotic * | HVOCAR 200901 | HVOCAR 200902 | HVOWES 200801 | HVOWES 201101 | MTWCDC 201101 | MTWMTO 200001 | MTWMTO 200503 | MTWNPN 200501 | MTWNPN 200502 | MTWNPN 200901 | Wambo GB01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Myrtaceae | Eucalyptus punctata | Grey Gum | | | | 6 | 2 | | 2 | 5 | 4 | 3 | | |
| Myrtaceae | Eucalyptus spp. | | | | | | | | 1 | | | | | |
| Oleaceae | Notelaea longifolia | Large Mock-olive | | | | | | | | | | | | 1 |
| Orchidaceae | Acianthus spp. | Mosquito Orchid | | | | | | | | | | | | 1 |
| Oxalidaceae | Oxalis perennans | | | | 2 | 2 | | | 2 | 2 | 2 | 2 | 2 | 2 |
| Phormiaceae | Dianella revoluta | Blueberry Lily | | | | | | | | | | | | 2 |
| Phyllanthaceae | Breynia oblongifolia | Coffee Bush | | | | | | | | | | | 2 | |
| Phyllanthaceae | Phyllanthus gunnii | | | | | | | | | | | | | 2 |
| Phyllanthaceae | Phyllanthus spp. | | * | | | | | | 1 | 1 | | | | |
| Pittosporaceae | Bursaria spinosa | Native Blackthorn | | | | | | | | | | | 1 | |
| Plantaginaceae | Plantago debilis | Shade Plantain | | | | 1 | | | | | | | | |
| Plantaginaceae | Plantago lanceolata | Lamb's Tongues | * | | 2 | 3 | | 3 | | 2 | 3 | 2 | | |
| Poaceae | Aristida ramosa | Purple Wiregrass | | | | | | | | 2 | | 2 | | 3 |
| Poaceae | Aristida vagans | Threeawn Speargrass | | | | | | | | | | | | 2 |
| Poaceae | Austrodanthonia racemosa | Wallaby Grass | | | | 4 | | | | | | | | 5 |
| Poaceae | Austrostipa scabra | Speargrass | | | | | 2 | | | 2 | | | | 3 |
| Poaceae | Bothriochloa decipiens | Red Grass | | | | | | 3 | | | | | | |
| Poaceae | Bothriochloa macra | Red Grass | | 3 | 2 | 3 | 3 | | | 2 | | 2 | 3 | 3 |
| Poaceae | Capillipedium spicigerum | Scented-top Grass | | | | | 3 | 6 | | | | | | |
| Poaceae | Chloris gayana | Rhodes Grass | * | 6 | 6 | | 3 | 3 | | | 3 | 4 | 3 | |
| Poaceae | Chloris truncata | Windmill Grass | | | 2 | | 2 | | 2 | 3 | 3 | | | |
| Poaceae | Chloris ventricosa | Tall Chloris | | | | 3 | | | | 3 | | | | 3 |
| Poaceae | Cymbopogon refractus | Barbed Wire Grass | | | | | | | | | 3 | | | 6 |
| Poaceae | Cynodon dactylon | Common Couch | | 3 | | 3 | | 3 | | 2 | | 3 | | |

| Family | Species | Common Name | Exotic * | HVOCAR 200901 | HVOCAR 200902 | HVOWES 200801 | HVOWES 201101 | MTWCDC 201101 | MTWMTO 200001 | MTWMTO 200503 | MTWNPN 200501 | MTWNPN 200502 | MTWNPN 200901 | Wambo GB01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Poaceae | Echinochloa crusgalli | Barnyard Grass | * | | | | | | | | | | 3 | |
| Poaceae | Echinopogon caespitosus | Bushy Hedgehog-grass | | | | | | 3 | | | | | | |
| Poaceae | Ehrharta erecta | Panic Veldtgrass | * | | | | | | | | | 2 | | |
| Poaceae | Eragrostis curvula | African Lovegrass | * | | | | | | | 2 | 4 | | 2 | |
| Poaceae | Eriochloa pseudoacrotricha | Early Spring Grass | | | | | | 3 | 4 | 4 | | | 2 | |
| Poaceae | Melinis repens | Red Natal Grass | * | | | | | | | | | 2 | | |
| Poaceae | Microlaena stipoides | Weeping Grass | | | | | 2 | | | | | | | |
| Poaceae | Panicum effusum | Hairy Panic | | | 3 | | | | | 3 | | 2 | | 2 |
| Poaceae | Panicum maximum | Guinea Grass | * | 4 | 6 | 3 | | | | | 3 | | | |
| Poaceae | Panicum spp. | Panicum | | | | 1 | | | | | | | | |
| Poaceae | Paspalidium spp. | | | | | | | | 3 | | | | | |
| Poaceae | Paspalum dilatatum | Paspalum | * | 3 | | | | 5 | | | | | | |
| Poaceae | Pennisetum clandestinum | Kikuyu Grass | * | | | 3 | 2 | | | | | | | |
| Poaceae | Poa annua | Winter Grass | * | | | | | 2 | | | | 2 | | |
| Poaceae | Setaria gracilis | Slender Pigeon Grass | * | | | | | | | 3 | 4 | | | |
| Poaceae | Setaria parviflora | | * | | | | 3 | | | | | | | |
| Poaceae | Sporobolus creber | Slender Rat's Tail Grass | | | | 2 | | 3 | 3 | 2 | 3 | 4 | | 3 |
| Poaceae | Sporobolus fertilis | Giant Parramatta Grass | * | | | | | | | | | 3 | | |
| Poaceae | Themeda australis | Kangaroo Grass | | | | | 1 | | 3 | 2 | | 1 | | |
| Poaceae | Themeda avenacea | Native Oatgrass | | | | | 1 | | | | | | | |
| Poaceae | Themeda triandra | | | | | | | 2 | | | | | | |
| Polygonaceae | Polygonum aviculare | Wireweed | * | | | | 3 | | | 2 | | | | |
| Portulacaceae | Portulaca oleracea | Pigweed | | | | | | 2 | 3 | 2 | | | 2 | |

| Family | Species | Common Name | Exotic * | HVOCAR 200901 | HVOCAR 200902 | HVOWES 200801 | HVOWES 201101 | MTWCDC 201101 | MTWMTO 200001 | MTWMTO 200503 | MTWNPN 200501 | MTWNPN 200502 | MTWNPN 200901 | Wambo GB01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Proteaceae | Hakea sericea | Needlebush | | | | | 1 | | | | | | | |
| Rubiaceae | Asperula conferta | Common Woodruff | | | | | | | | | | | | 2 |
| Solanaceae | Solanum nigrum | Black-berry Nightshade | * | | | | | 3 | | | | | | |
| Solanaceae | Solanum prinophyllum | Forest Nightshade | | | | | | | 2 | | | | | |
| Sterculiaceae | Lasiopetalum spp. | | | | | | | | | | | | | 3 |
| Verbenaceae | Verbena bonariensis | Purpletop | * | | | 3 | | 4 | | | 4 | 2 | 3 | |

## Flora two-way table: Reference sites

| Family | Species | Common Name | Exotic * | BEL 1 | BEL 2 | BEL 3 | Wambo GB01 | Wambo GB02 | Wambo Spot1 | Wambo Spot2 | Wambo Spot3 | WARK GB01 | WARK GB02 | Wark GB03 | Wark GB04 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acanthaceae | Brunoniella australis | Blue Trumpet | | | 2 | | 4 | 3 | 3 | 2 | | | | | |
| Acanthaceae | Pseuderanthemum variabile | Pastel Flower | | 3 | 2 | 2 | | 2 | | 2 | 2 | 2 | | | |
| Adiantaceae | Cheilanthes sieberi | Rock Fern | | 3 | 4 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 |
| Aizoaceae | Galenia pubescens | Galenia | * | | | | | | | | | | | | 2 |
| Amaranthaceae | Alternanthera spp. | Joyweed | | | | | | | | | | | | 1 | |
| Anthericaceae | Dichopogon spp. | Chocolate Lily | | | | 1 | | | | | | | 2 | | |
| Anthericaceae | Laxmannia gracilis | Slender Wire Lily | | 3 | 2 | | | | | | | | | 4 | |
| Anthericaceae | Thysanotus tuberosus | Common Fringe-lily | | | 2 | 2 | | | | | | | | | |
| Anthericaceae | Tricoryne spp. | | | | | | 1 | | | | | | | | |
| Asteraceae | Bidens pilosa | Cobbler's Pegs | * | | 2 | | 1 | 1 | 2 | | | | 1 | 2 | |
| Asteraceae | Calotis lappulacea | Yellow Burr-daisy | | 1 | 2 | | | 2 | | | | | | | 2 |
| Asteraceae | Chrysocephalum apiculatum | Common Everlasting | | | | | 2 | 2 | | | | | | 2 | |
| Asteraceae | Conyza bonariensis | Flaxleaf Fleabane | * | | | | | 1 | | | | | | | |
| Asteraceae | Crassocephalum spp. | | | | | | | | | | | | 1 | | |
| Asteraceae | Hypochaeris radicata | Catsear | * | | 1 | | | | | | | | | 2 | |
| Asteraceae | Olearia elliptica | Sticky Daisy-bush | | 3 | | | 5 | | 4 | 4 | 5 | | 2 | | |
| Asteraceae | Senecio linearifolius | Fireweed Groundsel | | 1 | 1 | | | | 1 | 2 | | | 2 | | |
| Asteraceae | Senecio madagascariensis | Fireweed | * | | | | 1 | 1 | | | | | | 2 | |
| Asteraceae | Vittadinia cuneata | A Fuzzweed | | 2 | 2 | 2 | 2 | | | | | 2 | 3 | | |
| Asteraceae | Vittadinia sulcata | | | 1 | | | | | | | | | | | |
| Brassicaceae | Lepidium spp. | A Peppercress | * | | | | | | | | | | | | 2 |
| Cactaceae | Opuntia aurantiaca | Tiger Pear | * | | | | 1 | 1 | 1 | 2 | | 2 | 2 | 2 | 2 |
| Campanulaceae | Wahlenbergia gracilis | Sprawling Bluebell | | | | 2 | 2 | 2 | | | | | | | 2 |
| Campanulaceae | Wahlenbergia stricta | Tall Bluebell | | | | | | | | | | | | 2 | |
| Casuarinaceae | Allocasuarina luehmannii | Bulloak | | | | | | | | | | 5 | 5 | 4 | 4 |

| Family | Species | Common Name | Exotic * | BEL 1 | BEL 2 | BEL 3 | Wambo GB01 | Wambo GB02 | Wambo Spot1 | Wambo Spot2 | Wambo Spot3 | WARK GB01 | WARK GB02 | Wark GB03 | Wark GB04 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Casuarinaceae | Allocasuarina torulosa | Forest Oak | | | | 1 | | | | | | | | | |
| Casuarinaceae | Casuarina cunninghamiana | River Oak | | | | | 6 | 2 | | | | | | | |
| Chenopodiaceae | Einadia hastata | Berry Saltbush | | | | | | | | | | 1 | | | |
| Chenopodiaceae | Einadia nutans | Climbing Saltbush | | | | | 3 | | | | | | | | |
| Chenopodiaceae | Enchylaena tomentosa | Ruby Saltbush | | | | | | | | | | | 2 | | |
| Commelinaceae | Commelina cyanea | Native Wandering Jew | | | | | | 4 | | 2 | 3 | 3 | 4 | 4 | 3 |
| Convolvulaceae | Dichondra repens | Kidney Weed | | 2 | 3 | 2 | 3 | 3 | | 1 | | 3 | 3 | | 2 |
| Cyperaceae | Cyperus gracilis | Slender Flat-sedge | | | | | 3 | 2 | | | 2 | | 2 | 2 | 2 |
| Cyperaceae | Fimbristylis ferruginea | | | | | | | 2 | | | | | | | |
| Cyperaceae | Fimbristylis tristachya | | | | | | | | | | | | 2 | 2 | 2 |
| Cyperaceae | Gahnia aspera | Rough Saw-sedge | | | 2 | 2 | | 2 | | | 2 | | 3 | | |
| Cyperaceae | Lepidosperma latens | | | | | | | | | | | | | | |
| Cyperaceae | Lepidosperma laterale | Variable Sword-sedge | | 3 | 6 | | | | | | | | | | |
| Dilleniaceae | Hibbertia spp. | | | | 3 | | | | | 3 | 2 | | | | |
| Ericaceae | Lissanthe strigosa | Peach Heath | | 2 | 3 | | 2 | 3 | | | | | | | |
| Fabaceae (Faboideae) | Daviesia ulicifolia | Gorse Bitter Pea | | | | | | | | | | 2 | | | 2 |
| Fabaceae (Faboideae) | Desmodium brachypodum | Large Tick-trefoil | | | | 2 | 2 | 4 | 3 | | | | 3 | | |
| Fabaceae (Faboideae) | Desmodium gunnii | Slender Tick-trefoil | | | | | | | 2 | 2 | 2 | 2 | | | |
| Fabaceae (Faboideae) | Desmodium varians | Slender Tick-trefoil | | 2 | 2 | 2 | | | 2 | | | | 3 | 2 | |
| Fabaceae (Faboideae) | Glycine clandestina | Twining glycine | | | | | | | 2 | | | | | | |
| Fabaceae (Faboideae) | Glycine microphylla | Small-leaf Glycine | | 1 | | | | 2 | | | | | | | |
| Fabaceae (Faboideae) | Glycine tabacina | Variable Glycine | | 3 | 3 | 3 | 2 | 3 | | 2 | 2 | 1 | | 2 | 3 |
| Fabaceae (Faboideae) | Hardenbergia violacea | False Sarsaparilla | | 2 | | | | | | | 2 | | | | 2 |
| Fabaceae (Faboideae) | Hovea linearis | | | | | | | | 3 | | | | | | |

| Family | Species | Common Name | Exotic * | BEL 1 | BEL 2 | BEL 3 | Wambo GB01 | Wambo GB02 | Wambo Spot1 | Wambo Spot2 | Wambo Spot3 | WARK GB01 | WARK GB02 | Wark GB03 | Wark GB04 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fabaceae (Faboideae) | Pultenaea spinosa | A Bush Pea | | 4 | 3 | | | | | | | | | | |
| Fabaceae (Faboideae) | Viminaria juncea | Native Broom | | | | | | | | 1 | | | | | |
| Fabaceae (Mimosoideae) | Acacia amblygona | Fan Wattle | | | | | | 3 | | 3 | | | | 2 | 3 |
| Fabaceae (Mimosoideae) | Acacia binervata | Two-veined Hickory | | | | | | | 1 | | | | | | |
| Fabaceae (Mimosoideae) | Acacia bulgaensis | Bulga Wattle | | | | | | | 5 | | | | | | |
| Fabaceae (Mimosoideae) | Acacia dealbata | Silver Wattle | | | | | | 2 | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia decurrens | Black Wattle | | | | | | | | | | | 3 | | |
| Fabaceae (Mimosoideae) | Acacia falcata | | | 3 | 3 | | | 2 | | | | 2 | | | 3 |
| Fabaceae (Mimosoideae) | Acacia longifolia | | | | | | | | 2 | | 3 | | | | |
| Fabaceae (Mimosoideae) | Acacia mearnsii | Black Wattle | | 4 | 3 | 2 | | | | | | | | | |
| Fabaceae (Mimosoideae) | Acacia spp. | Wattle | | | | | 1 | | | | | | | | |
| Goodeniaceae | Goodenia hederacea | Ivy Goodenia | | | | | | | | | | | | 3 | |
| Goodeniaceae | Goodenia rotundifolia | | | 2 | | | | | 3 | | | | 2 | | 2 |
| Goodeniaceae | Goodenia spp. | | | | | | | | 1 | | | | | | |
| Lobeliaceae | Pratia purpurascens | Whiteroot | | 3 | 4 | 3 | | | | | 3 | | | | |
| Lomandraceae | Lomandra filiformis | Wattle Matt-rush | | | | | | 2 | | | 2 | | | | |
| Lomandraceae | Lomandra longifolia | Spiny-headed Mat-rush | | 2 | 2 | | | | | | | | | | |
| Lomandraceae | Lomandra multiflora | Many-flowered Mat-rush | | 2 | 3 | 3 | 2 | | | | 2 | | | 2 | |
| Luzuriagaceae | Geitonoplesium cymosum | Scrambling Lily | | | | | | | 2 | 2 | | | | | |
| Malvaceae | Hibiscus heterophyllus | | | | | | | | | | 2 | | | | |
| Malvaceae | Sida corrugata | Corrugated Sida | | | | | 2 | | | | | | 1 | | |
| Malvaceae | Sida rhombifolia | Paddy's Lucerne | * | | | | | | | | | | | | 2 |
| Myoporaceae | Eremophila debilis | Amulla | | | | 2 | | 3 | | 2 | | 2 | | 2 | 2 |
| Myrsinaceae | Rapanea howittiana | Brush Muttonwood | | | | | | | | | 2 | | | | |

| Family | Species | Common Name | Exotic * | BEL 1 | BEL 2 | BEL 3 | Wambo GB01 | Wambo GB02 | Wambo Spot1 | Wambo Spot2 | Wambo Spot3 | WARK GB01 | WARK GB02 | Wark GB03 | Wark GB04 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Myrtaceae | Corymbia maculata | Spotted Gum | | 6 | 4 | 3 | | | 5 | 5 | 5 | | | | |
| Myrtaceae | Eucalyptus crebra | Narrow-leaved Ironbark | | 3 | | | 5 | | 1 | | 5 | 5 | 5 | 5 | 5 |
| Myrtaceae | Eucalyptus fibrosa | Red Ironbark | | | | 3 | | | | | | | | | |
| Myrtaceae | Eucalyptus moluccana | Grey Box | | | 3 | 3 | | 5 | | 5 | | 2 | | | |
| Myrtaceae | Eucalyptus punctata | Grey Gum | | | | | | | 5 | | 5 | | | | |
| Myrtaceae | Eucalyptus tereticornis | Forest Red Gum | | | | | | | | | | | | 3 | |
| Myrtaceae | Melaleuca decora | | | | | | | | | | | | | 3 | |
| Oleaceae | Notelaea longifolia | Large Mock-olive | | | | | 1 | | | 2 | | 2 | | | |
| Oleaceae | Notelaea microcarpa | Native Olive | | | | | | 2 | | | | | 3 | | |
| Orchidaceae | Acianthus spp. | Mosquito Orchid | | | | | 1 | | | | | | | | |
| Oxalidaceae | Oxalis perennans | | | | | 3 | 2 | | | | | 2 | | 2 | 2 |
| Phormiaceae | Dianella caerulea | Blue Flax-lily | | | | 2 | | | | | | | | 3 | |
| Phormiaceae | Dianella revoluta | Blueberry Lily | | 3 | | 3 | 2 | | 2 | | | | | | |
| Phyllanthaceae | Breynia oblongifolia | Coffee Bush | | 2 | 5 | 2 | | | 3 | 2 | 2 | 3 | 3 | 3 | |
| Phyllanthaceae | Phyllanthus gunnii | | | | | | 2 | 2 | | | 2 | 3 | | | |
| Phyllanthaceae | Phyllanthus hirtellus | Thyme Spurge | | | | 2 | | | | | | | | | |
| Pittosporaceae | Billardiera scandens | Hairy Apple Berry | | 2 | | | | | | | | | | | |
| Pittosporaceae | Bursaria spinosa | Native Blackthorn | | 3 | | 2 | | | | 3 | 5 | | 4 | 4 | |
| Plantaginaceae | Plantago debilis | Shade Plantain | | | | | | 2 | | | | | | | |
| Poaceae | Aristida ramosa | Purple Wiregrass | | | 3 | 3 | 3 | | | | | 3 | | | 2 |
| Poaceae | Aristida vagans | Threeawn Speargrass | | 5 | 2 | | 2 | | | | | | 2 | | |
| Poaceae | Austrodanthonia racemosa | Wallaby Grass | | 4 | | | 5 | | | | | | | 5 | |
| Poaceae | Austrostipa scabra | Speargrass | | | | | 3 | 3 | | | | | | 4 | 3 |
| Poaceae | Bothriochloa macra | Red Grass | | | | | 3 | 4 | | | | 4 | | | 3 |
| Poaceae | Chloris truncata | Windmill Grass | | | | | | | | | | | | | 3 |
| Poaceae | Chloris ventricosa | Tall Chloris | | | | 1 | 3 | 3 | | | | | 3 | | 2 |
| Poaceae | Cymbopogon refractus | Barbed Wire Grass | | 4 | 3 | 2 | 6 | 6 | 4 | 3 | 2 | 3 | 4 | 5 | 3 |

| Family | Species | Common Name | Exotic * | BEL 1 | BEL 2 | BEL 3 | Wambo GB01 | Wambo GB02 | Wambo Spot1 | Wambo Spot2 | Wambo Spot3 | WARK GB01 | WARK GB02 | Wark GB03 | Wark GB04 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Poaceae | Cynodon dactylon | Common Couch | | | | | | | | | | | | 4 | 2 |
| Poaceae | Dichelachne micrantha | Shorthair Plumegrass | | | 2 | | | 2 | | | | 3 | 3 | | |
| Poaceae | Digitaria spp. | A Finger Grass | * | 2 | | | | | | | | | | | |
| Poaceae | Echinopogon caespitosus | Bushy Hedgehog-grass | | | | 3 | | | | | | 2 | 2 | | |
| Poaceae | Entolasia marginata | Bordered Panic | | 4 | | | | | | | | | | | |
| Poaceae | Entolasia stricta | Wiry Panic | | | 5 | | | | 3 | 2 | | | | | |
| Poaceae | Eragrostis brownii | Brown's Lovegrass | | | | | | | | | | | | 2 | 3 |
| Poaceae | Eragrostis curvula | African Lovegrass | * | | | | | | | | | | | | 2 |
| Poaceae | Eragrostis elongata | Clustered Lovegrass | | | | | | | | | | | | 2 | |
| Poaceae | Eriochloa pseudoacrotricha | Early Spring Grass | | | | | | 3 | | | | | | | |
| Poaceae | Melinis repens | Red Natal Grass | * | | | | | | | | | | | 2 | 2 |
| Poaceae | Microlaena stipoides | Weeping Grass | | 4 | 5 | 3 | | | 2 | | 2 | 3 | 3 | 3 | |
| Poaceae | Oplismenus aemulus | | | | | | | | | | 3 | | | | |
| Poaceae | Panicum effusum | Hairy Panic | | | 3 | | 2 | 4 | | 3 | 3 | 1 | | | 3 |
| Poaceae | Paspalidium spp. | | | | | | | | 2 | 1 | 2 | | 3 | | 2 |
| Poaceae | Pennisetum clandestinum | Kikuyu Grass | * | | | | | | | | | | | 2 | |
| Poaceae | Poa sieberiana | Snowgrass | | | | | | | | | | | | 3 | |
| Poaceae | Setaria gracilis | Slender Pigeon Grass | * | | | | | 1 | 1 | | | | | | |
| Poaceae | Sporobolus creber | Slender Rat's Tail Grass | | | 5 | 3 | 3 | 4 | | | | | 3 | | |
| Poaceae | Themeda australis | Kangaroo Grass | | | 3 | 2 | | | 3 | 3 | | 3 | | 4 | 3 |
| Proteaceae | Persoonia linearis | Narrow-leaved Geebung | | | | | | | 2 | | 2 | | | | |
| Ranunculaceae | Clematis aristata | Old Man's Beard | | | | | | | | | 1 | | | | |
| Rhamnaceae | Pomaderris ferruginea | | | | | | | | 2 | | | | | | |
| Rubiaceae | Asperula conferta | Common Woodruff | | | | | 2 | 2 | | | | | | | |
| Rubiaceae | Pomax umbellata | Pomax | | | 3 | 2 | | | | | 2 | | | | |

| Family | Species | Common Name | Exotic * | BEL 1 | BEL 2 | BEL 3 | Wambo GB01 | Wambo GB02 | Wambo Spot1 | Wambo Spot2 | Wambo Spot3 | WARK GB01 | WARK GB02 | Wark GB03 | Wark GB04 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Santalaceae | Exocarpos cupressiformis | Cherry Ballart | | | | | | | 2 | | 3 | 3 | | | |
| Sapindaceae | Dodonaea pinnata | | | | | | | | | 3 | | | | | |
| Sapindaceae | Dodonaea viscosa | Sticky Hop-bush | | | | | | 2 | | 4 | 5 | | | | |
| Solanaceae | Lycium ferocissimum | African Boxthorn | * | | 2 | | | | | | | | | | |
| Solanaceae | Solanum prinophyllum | Forest Nightshade | | 2 | | | | | 2 | | | 3 | 2 | | 3 |
| Solanaceae | Solanum spp. | | * | | | | | 1 | | | | | | | |
| Sterculiaceae | Brachychiton populneus | Kurrajong | | | | | | | 1 | | 1 | | | | |
| Sterculiaceae | Lasiopetalum spp. | | | | | | 3 | | | | | | | | |
| Thymelaeaceae | Pimelea neo-anglica | Poison Pimelea | | | | | | | 3 | | | | | | |
| Verbenaceae | Lantana camara | Lantana | * | | | | | | | | | 2 | | | |
| Zamiaceae | Macrozamia flexuosa | | | | | | | | 3 | 2 | 2 | | | | |

# Appendix 4 –Visual and Photo Monitoring

## Belford Site 01 (Bell1)

| Bellford Site 01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 340083 | 6386547 |
| End transect | 340031 | 6386548 |

**Description**: The Belford Site 01 occurs in Belford National Park. The site was established in an area that aligns to the native vegetation community Central Hunter Ironbark – Spotted Gum – Grey Box Forest, which is listed as an EEC under the NSW TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the  trees is approximately 28 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species, evidence of foot traffic and bike use. Feral animals including the dog (*Canis familiaris familiaris*), European red fox (*Vulpes vulpes*), rabbit (*Oryctolagus cuniculus*), cat (*Felis catus*), black rat (*Rattus rattus*) and Indian mynah (*Acridotheres tristis*) are considered to be impacting the Reserve (DECCW 2010).

Historically the site has been logged, with the majority of trees within the reserve being regrowth from past logging (DECCW 2010).

The following weed species have been identified in DECCW (2010) as a threat to the native vegetation of the reserve; African olive (*Olea europaea subsp. cuspidata*), Prickly Pear and Tiger Pear (*Opuntia* spp.) and Mother of Millions (*Brophyllum* sp.). The Analogue site was set up where little disturbance from these weeds occurred.

**Table. Dominant species and structure at Belford Site 01**

| Stratum | Height (m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 30 | 40 | *Eucalyptus moluccana* and *Corymbia maculata* |
| Midstorey layer | 6 - 13 | 30 - 40 | *Acacia falcate* and *Acacia mearnsii* |
| Shrub layer | 2 | 35 - 40 | *Breynia oblongifolia, Bursaria spinosa, Lissanthe strigosa* and *Pultenaea spinosa.* |
| Ground layer | 1 | 20 - 30 | *Aristida vagans, Austrodanthonia racemosa, Billardiera scandens, Bursaria spinosa, Calotis lappulacea, Cheilanthes sieberi, Cymbopogon refractus, Desmodium varians, Dianella revoluta, Dichondra repens, Entolasia marginata, Glycine tabacina, Hardenbergia violacea, Laxmannia gracilis, Lepidosperma laterale* and *Pratia purpurascens.* |

*Projected foliage cover

**Site photographs at Belford Site 01 (left to right)**

Start position

End position

## Belford Site 02 (Bell2)

| Belford Site 02 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 340332 | 6385942 |
| End transect | 340373 | 6385962 |

**Description**: Belford Site 02 occurs in Belford National Park. The site was established in an area that aligns to the native vegetation community Central Hunter Ironbark – Spotted Gum – Grey Box Forest, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 30 cm.

**Disturbance:**

Disturbance present at the site consisted of a few weed species, evidence of foot traffic and bike use.

Historically the site has been logged, with the majority of trees within the reserve consisting of regrowth from past logging (DECCW 2010).

The following weed species have been identified in DECCW (2010) as a threat to the native vegetation of the reserve; African olive (*Olea europaea subsp. cuspidata*), Prickly Pear and Tiger Pear (*Opuntia* spp.) and Mother of Millions (*Brophyllum* sp.). The analogue site was set up where little disturbance from these weeds occurred, however few indivuals of *Olea europaea* subsp. *cuspidata* and *Opuntia* spp. were recorded in at the site.

**Table. Dominant species and structure at Belford Site 02**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 30 | 40 | *Eucalyptus moluccana* and *Corymbia maculata* |
| Midstorey layer | 6 - 13 | 30 - 40 | *Acacia falcata* |
| Shrub layer | 2 | 35 - 40 | *Breynia oblongifolia, Bursaria spinosa, Lissanthe strigosa* and *Pultenaea spinosa.* |
| Ground layer | 1 | 20 - 30 | *Aristida vagans, Austrodanthonia racemosa, Billardiera scandens, Bursaria spinosa, Calotis lappulacea, Cheilanthes sieberi, Cymbopogon refractus, Desmodium varians, Dianella revoluta, Dichondra repens, Entolasia marginata, Glycine tabacina, Hardenbergia violacea, Laxmannia gracilis, Lepidosperma laterale* and *Pratia purpurascens.* |

*Projected foliage cover

## Site photographs at Belford Site 02 (left to right)

Start position



End position



## Bellford Site 03 (Bell03)

| Bellford Site 03 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 340498 | 6385760 |
| End transect | 340474 | 6385719 |

**Description**: Belford Site 03 occurs in Belford National Park. The site was established in an area that aligns to the native vegetation community Central Hunter Ironbark – Spotted Gum – Grey Box Forest, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 29 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species, evidence of foot traffic and bike use.

Historically the site has been logged, with the majority of trees within the reserve consisting of regrowth from past logging (DECCW 2010).

The following weed species have been identified in DECCW (2010) as a threat to the native vegetation of the reserve; African olive (*Olea europaea subsp. cuspidata*), Prickly Pear and Tiger Pear (*Opuntia* spp.) and Mother of Millions (*Brophyllum* sp.). The analogue site was set up where little disturbance from these weeds occurred, however few indivuals of *Olea europaea* subsp. *cuspidata* and *Opuntia* spp. were recorded in at the site.

**Table. Dominant species and structure at Belford Site 03**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 40 | *Eucalyptus crebra, Eucalyptus moluccana* and *Corymbia maculata* |
| Midstorey layer | 6 - 13 | 30 - 40 | *Acacia mearnsii* and *Acacia falcata* |
| Shrub layer | 2 | 35 - 40 | *Breynia oblongifolia, Bursaria spinosa, Lissanthe strigosa and Pultenaea spinosa.* |
| Ground layer | 1 | 20 - 30 | *Aristida vagans, Austrodanthonia racemosa, Billardiera scandens, Bursaria spinosa, Calotis lappulacea, Cheilanthes sieberi, Cymbopogon refractus, Desmodium varians, Dianella revoluta, Dichondra repens, Entolasia marginata, Glycine tabacina, Hardenbergia violacea, Laxmannia gracilis, Lepidosperma laterale* and *Pratia purpurascens.* |

*Projected foliage cover

## Site photographs at Belford Site 03 (left to right)

Start position

End position

## WAMBOSPOT1

| WamboSpottedGum 01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 308275 | 6390324 |
| End transect | 308311 | 6390355 |

**Description**: WAMBOSPOT1 occurs in land currently managed by Wambo Coal. The site was established in an area that has been previously mapped as a native vegetation community, consistent with Central Hunter Ironbark – Spotted Gum – Grey Box Forest, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 34 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp and *Bidens pilosa.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

**Table. Dominant species and structure at Wambo Spotted Gum 01**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 40-50 | *Eucalyptus crebra, Eucalyptus punctate* and *Corymbia maculata* |
| Midstorey layer | 6 - 13 | 50-60 | *Acacia binervata, Acacia bulgaensis,* and *Acacia longifolia* |
| Shrub layer | 2 | 30-50 | *Breynia oblongifolia, Exocarpos cupressiformis, Pimelea neo-angelica* and *Macrozamia flexuosa.* |
| Ground layer | 1 | 20 - 30 | *Brunoniella australis, Cheilanthes sieberi, Cymbopogon refractus, Desmodium brachypodum, Dianella revoluta, Entolasia stricta, Geitonoplesium cymosum, Glycine clandestina, Goodenia rotundifolia, Hovea linearis, Microlaena stipoides, Olearia elliptica, Solanum prinophyllum,* and *Themeda australis.* |

*Projected foliage cover

**Site photographs Wambo Spotted Gum 01 (left to right)**

Start position



End position



## WAMBOSPOT2

| WAMBOSPOT2 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 308504 | 6390550 |
| End transect | 308522 | 6390593 |

**Description**: WAMBOSPOT2 occurs in land currently managed by Wambo Coal. The site was established in an area that has been previously mapped as a native vegetation community consistent with Central Hunter Ironbark – Spotted Gum – Grey Box Forest, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 34 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

**Table. Dominant species and structure at Wambo Spotted Gum 02**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 40-50 | *Eucalyptus moluccana* and *Corymbia maculata* |
| Midstorey layer | 5-10 | 50-60 | *Acacia mearnsii* |
| Shrub layer | 2 | 40-60 | *Bursaria spinosa, Dodonaea viscosa, Breynia oblongifolia, Pimelea neo-angelica* and *Macrozamia flexuosa.* |
| Ground layer | 1 | 20 - 30 | *Austrodanthonia racemosa, Brunoniella australis, Cheilanthes sieberi, Cymbopogon refractus, Desmodium brachypodum, Desmodium gunnii, Desmodium varians, Dianella revoluta, Entolasia stricta, Geitonoplesium cymosum, Glycine clandestina, Hovea linearis, Microlaena stipoides, Solanum prinophyllum* and *Themeda australis.* |

*Projected foliage cover

Site photographs at Wambo Spotted Gum 02 (left to right)

Start position



End position



## WAMBOSPOT3

| WAMBOSPOT3 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 308276 | 6390200 |
| End transect | 308238 | 6390185 |

**Description**: WAMBOSPOT3 occurs in land currently managed by Wambo Coal. The site was established in an area that has been previously mapped as a native vegetation community consistent with Central Hunter Ironbark – Spotted Gum – Grey Box Forest, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 40 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

**Table. Dominant species and structure at Wambo Spotted Gum 03**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 40-50 | *Eucalyptus crebra, Eucalyptus punctate* and *Corymbia maculata* |
| Midstorey layer | 5-10 | 50-60 | *Acacia longifolia* |
| Shrub layer | 2 | 30-50 | *Bursaria spinosa, Dodonaea viscosa, Olearia elliptica,* and *Exocarpous cupressiformis* |
| Ground layer | 1 | 20 - 30 | *Austrodanthonia racemosa, Brunoniella australis, Cheilanthes sieberi, Cymbopogon refractus, Desmodium brachypodum, Desmodium gunnii, Desmodium varians, Dianella revoluta, Entolasia stricta, Geitonoplesium cymosum, Glycine clandestina, Hovea linearis, Microlaena stipoides, Solanum prinophyllum* and *Themeda australis.* |

*Projected foliage cover

## Site photographs at Wambo Spotted Gum 03 (left to right)

Start position



End position



## WAMBOGB01

| WAMBOGB01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 309194 | 6392618 |
| End transect | 309215 | 6392661 |

**Description**: WAMBOGB01 occurs in land currently managed by Wambo Coal. The site was established in an area that has been previously mapped as a native vegetation community consistent with Central Hunter Grey-Box – Ironbark Woodland, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 30 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

The site has been historically cleared in areas. The site generally lacks mature trees.

**Table. Dominant species and structure at Wambo Grey Box 01**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 30-40 | *Eucalyptus crebra* and *Eucalyptus moluccana* |
| Midstorey layer | 5-10 | 10-20 | *Casuarina cunninghamiana* |
| Shrub layer | 2 | 10-20 | *Olearia elliptica* and *Lissanthe strigosa* |
| Ground layer | 1 | 30-40 | *Brunoniella australis, Cheilanthes sieberi, Chrysocephalum apiculatum, Vittadinia cuneata, Wahlenbergia gracilis, Einadia nutans, Dichondra repens, Cyperus gracilis, Desmodium brachypodum, Glycine tabacina, Lomandra multiflora, Sida corrugata, Notelaea longifolia, Acianthus spp. Oxalis perennans, Dianella revoluta, Phyllanthus gunnii, Aristida ramosa Aristida vagans, Austrodanthonia racemosa, Austrostipa scabra Bothriochloa macra, Chloris ventricosa, Cymbopogon refractus, Panicum effusum, Sporobolus creber* and *Asperula conferta.* |

*Projected foliage cover

**Site photographs at Wambo Grey Box 01 (left to right)**

Start position

End position

## WAMBOGB02

| WAMBOGB02 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 309539 | 6391965 |
| End transect | 309561 | 6392010 |

**Description**: WAMBOGB02 occurs in land currently managed by Wambo Coal. The site was established in an area that has been previously mapped as a native vegetation community consistent with Central Hunter Grey-Box – Ironbark Woodland, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 30 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

The site has been historically cleared in areas. The site generally lacks mature trees.

**Table. Dominant species and structure at Wambo Grey Box 02**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 10-20 | *Eucalyptus moluccana* |
| Midstorey layer | 5-10 | 10-20 | *Acacia amblygona, Acacia dealbata* and *Acacia falcata.* |
| Shrub layer | 2 | 10-20 | *Olearia elliptica and Lissanthe strigosa* |
| Ground layer | 1 | 30-40 | *Brunoniella australis, Cheilanthes sieberi, Chrysocephalum apiculatum, Vittadinia cuneata, Wahlenbergia gracilis, Einadia nutans, Dichondra repens, Cyperus gracilis, Desmodium brachypodum, Glycine tabacina, Lomandra multiflora, Sida corrugata, Notelaea longifolia, Acianthus spp. Oxalis perennans, Dianella revoluta, Phyllanthus gunnii, Aristida ramosa Aristida vagans, Austrodanthonia racemosa, Austrostipa scabra Bothriochloa macra, Chloris ventricosa, Cymbopogon refractus, Panicum effusum, Sporobolus creber* and *Asperula conferta.* |

*Projected foliage cover

**Site photographs at Wambo Grey Box 02 (left to right)**

Start position



End position



# WARKGB01

| WARKGB01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 315553 | 6392801 |
| End transect | 315517 | 6392823 |

**Description**: WarkGB01 occurs in land currently managed by Coal and Allied. The site was established in an area that has been previously mapped (Niche 2015a) as a native vegetation community consistent with Central Hunter Grey-Box – Ironbark Woodland, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 29 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

The site has been historically cleared in areas. The site generally lacks mature trees.

**Table. Dominant species and structure at Warkworth Grey Box 01**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 10-20 | *Eucalyptus crebra* and *Eucalyptus moluccana*, |
| Midstorey layer | 5-10 | 10-20 | *Acacia falcata, Allocasuarina luehmannii* and *Exocarpos cupressiformis*, |
| Shrub layer | 2 | 10-20 | *Breynia oblongifolia, Daviesia ulicifolia, Notelaea longifolia* |
| Ground layer | 1 | 30-40 | *Aristida ramosa, Bothriochloa macra, Cheilanthes sieberi, Commelina cyanea, Cymbopogon refractus, Desmodium gunnii, Dichelachne micrantha, Dichondra repens, Echinopogon caespitosus, Einadia hastata, Eremophila debilis, Glycine tabacina, Lantana camara*<br>*Microlaena stipoides, Oxalis perennans, Panicum effusum, Phyllanthus gunnii, Pseuderanthemum variabile, Solanum prinophyllum, Themeda australis* and *Vittadinia cuneata.* |

*Projected foliage cover

**Site photographs at Warkworth Grey Box 01 (left to right)**

Start position

End position

## WARKGB02

| WARKGB02 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 314003 | 6387985 |
| End transect | 313998 | 6387939 |

**Description**: WarkGB02 occurs in land currently managed by Coal and Allied. The site was established in an area that has been previously mapped as the native vegetation community Central Hunter Grey-Box – Ironbark Woodland, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 26  cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

The site has been historically cleared in areas. The site generally lacks mature trees.

**Table. Dominant species and structure at Warkworth Grey Box 02**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 10-20 | *Eucalyptus crebra,* |
| Midstorey layer | 5-10 | 10-20 | *Acacia decurrens* and *Allocasuarina luehmannii,* |
| Shrub layer | 2 | 10-20 | *Breynia oblongifolia, Bursaria spinosa, Notelaea microcarpa,* and *Olearia elliptica,* |
| Ground layer | 1 | 30-40 | *Aristida vagans, Cheilanthes sieberi, Chloris ventricosa, Commelina cyanea, Crassocephalum spp., Cymbopogon refractus, Cyperus gracilis, Desmodium brachypodum, Desmodium varians, Dichelachne micrantha, Dichondra repens, Dichopogon spp., Echinopogon caespitosus, Enchylaena tomentosa, Fimbristylis tristachya, Gahnia aspera, Goodenia rotundifolia, Microlaena stipoides, Sida corrugata, Solanum prinophyllum, Sporobolus creber* and *Vittadinia cuneata.* |

*Projected foliage cover

**Site photographs at Warkworth Grey Box 02 (left to right)**

Start position



End position



# WARKGB03

| WARKGB03 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 314917 | 6386859 |
| End transect: | 314960 | 6386864 |

**Description**: WARKGB03 occurs in land currently managed by Coal and Allied. The site was established in an area that has been previously mapped as a native vegetation community constituting Central Hunter Grey-Box – Ironbark Woodland, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 28 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

The site has been historically cleared in areas. The site generally lacks mature trees.

**Table. Dominant species and structure at Warkworth Grey Box 03**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 10-20 | *Eucalyptus tereticornis* and *Eucalyptus crebra,* |
| Midstorey layer | 5-10 | 10-20 | *Allocasuarina luehmannii* |
| Shrub layer | 2 | 10-20 | *Acacia amblygona Breynia oblongifolia* and *Bursaria spinosa,* |
| Ground layer | 1 | 30-40 | *Alternanthera spp., Austrodanthonia racemosa, Austrostipa scabra, Cheilanthes sieberi, Chrysocephalum apiculatum, Commelina cyanea, Cymbopogon refractus, Cynodon dactylon, Cyperus gracilis, Desmodium varians, Dianella caerulea, Eragrostis brownii, Eragrostis elongata, Eremophila debilis, Fimbristylis tristachya, Glycine tabacina, Goodenia hederacea, Hypochaeris radicata, Laxmannia gracilis, Lomandra multiflora, Melaleuca decora, Melinis repens, Microlaena stipoides, Oxalis perennans, Pennisetum clandestinum, Poa sieberiana, Themeda australis* and *Wahlenbergia stricta.* |

*Projected foliage cover

**Site photographs at Warkworth Grey Box 03 (left to right)**

Start position

End position

## WARKGB04

| WARKGB04 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 315316 | 6386087 |
| End transect: | 315336 | 6386046 |

**Description**: WarkGB04 occurs in land currently managed by Coal and Allied. The site was established in an area that has been previously mapped as a native vegetation community constituting Central Hunter Grey-Box – Ironbark Woodland, which is listed as an EEC under the TSC Act.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 30 cm.

**Disturbance:**

Disturbance present at the site consisted of few weed species. Weeds recorded include *Melinus repens, Eragrostis curvula, Opuntia* spp., *Bidens pilosa* and *Senecio madagascariensis.*

No damage from fire activity was observed at the site.

No access tracks, or evidence of trail bikes or foot traffic was observed at the site.

The site has been historically cleared in areas. The site generally lacks mature trees.

**Table. Dominant species and structure at Warkworth Grey Box 04**

| Stratum | Height(m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 25 | 10-20 | *Eucalyptus crebra,* |
| Midstorey layer | 5-10 | 10-20 | *Acacia amblygona, Acacia falcate* and *Allocasuarina luehmannii,* |
| Shrub layer | 2 | 10-20 | *Daviesia ulicifolia,* |
| Ground layer | 1 | 30-40 | *Aristida ramosa, Austrostipa scabra, Bothriochloa macra, Calotis lappulacea, Cheilanthes sieberi, Chloris truncata, Chloris ventricosa, Commelina cyanea, Cymbopogon refractus, Cynodon dactylon, Cyperus gracilis, Dichondra repens, Eragrostis brownii, Eremophila debilis, Fimbristylis tristachya, Galenia pubescens, Glycine tabacina, Goodenia rotundifolia, Hardenbergia violacea, Oxalis perennans, Panicum effusum, Paspalidium spp., Sida rhombifolia, Solanum prinophyllum, Themeda australis* and *Wahlenbergia gracilis.* |

*Projected foliage cover

**Site photographs at Warkworth Grey Box 04 (left to right)**

Start position



End position



## HVOCAR2009-01

| HVOCAR2009-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 310310 | 6405170 |
| End transect | 310358 | 6405167 |

**Description:**

The HVOCAR2009-01 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 14 cm.

**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 *Galea pubescens, Plantago lanceolata*, *Conyza bonariensis*, *Chloris gayana*, *Sida rhombifolia*, and *Verbena bonariensis.*

**Table. Dominant species and structure at HVOCAR2009-01**

| Stratum | Height | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 15 - 30 | 15 | *Eucalyptus moluccana* |
| Midstorey layer | 6 - 13 | 25 | *Acacia longifolia*, *Acacia falcata*, and *Acacia mearnsii* |
| Shrub layer | 2 | 5 | *Acacia amblygona.* |
| Ground layer | 1 | 40 | *Cynodon dactylon*, *Dichondra repens*, *Sida corrugata*, and *Bothriochloa macra.* |

*Projected foliage cover

### Site photographs at HVOCAR2009-01 (left to right)

Start position



End position



## HVOCAR2009-02

| HVOCAR2009-02 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 309114 | 6403453 |
| End transect | 309076 | 6403430 |

**Description:**

HVOCAR2009-02 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 10 cm.

**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 *Galea pubescens, Plantago lanceolata, Conyza bonariensis, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis*.

**Table. Dominant species and structure at HVOCAR2009-02**

| Stratum | Height (m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | - | - | - |
| Midstorey layer | 6 | 10 | *Eucalyptus crebra, Corymbia maculata, Acacia mearnsii,* and *Acacia longifolia,* |
| Shrub layer | - | - | - |
| Ground layer | 1 | 50 | *Bothriochloa macra, Dichondra repens, Panicum effusum, Oxalis perennans,* and *Wahlenbergia gracilis,* |

*Projected foliage cover

## Site photographs at HVOCAR2009-02 (left to right)

Start position



End position



## HVOWES2008-01

| HVOWES2008-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 306340 | 6406920 |
| End transect | 306364 | 6406877 |

**Description:**

The HVOWES2008-01 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 15 cm.

**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 *Heliotronium amplexicaule, Malvastrum americanum, Galea pubescens, Plantago lanceolata, Chloris gayana, Cymbopogon refractus, Sida rhombifolia* and *Verbena bonariensis*.

**Table. Dominant species and structure at HVOWES2008-01**

| Stratum | Height (m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 5 | 20 | *Eucalyptus punctate* and *Corymbia maculata* |
| Midstorey layer | 2 – 4 | 30 | *Acacia parvipula, Acacia mearnsii, Acacia dealbata* and *Acacia amblygona,* |
| Shrub layer | 2 | 25 | *Acacia paradoxa, Acacia mearnsii, Acacia dealbata* and *Acacia amblygona* |
| Ground layer | 1 | 40 | *Austrostipa ramossisima, Bothriochloa macra, Plantago debilis, Dichondra repens, Sporobolous creber, Chloris ventricosa, Enchylaena tomentose* and *Glycine tabacina.* |

*Projected foliage cover

## Site photographs at HVOWES2008-01 (left to right)

Start position



End position



# HVOWES2011-01

| HVOWES2011-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 308265 | 6409164 |
| End transect | 308223 | 6409171 |

**Description:**

The HVOWES2011-01 rehabilitation area occurs on spoil with compost. Native seed has been hydroseeded in the rehabilitation area.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 13 cm.

**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.

Pig scats were recorded at the site during the monitoring.

Common weeds recorded at the site included *Galea pubescens, Plantago lanceolata, Conyza bonariensis, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis.*

**Table. Dominant species and structure at HVOWES2011-01**

| Stratum | Height | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | - | - | - |
| Midstorey layer | 5-6 | 50 | *Eucalyptus crebra, Eucalyptus punctata, Corymbia maculata, Acacia longifolia, Allocasuarina littoralis, Acacia implexa, Acacia binervata,* and *Acacia falcata.* |
| Shrub layer | 2 | 5 | *Indigofera australis* and *Hakea sericea.* |
| Ground layer | 1 | 60 | *Austrostipa ramossisima, Bothriochloa macra, Dichondra repens, Sporobolous creber, Chloris truncata, Hardenbergia violacea, Microlaeana stipoides, Enchylaena tomentosa, Glycine tabacina* and *Themeda australis.* |

*Projected foliage cover

## Site photographs at HVOWES2011-01 (left to right)

Start position



End position



## MTWNPN2005-01

| MTWNPN2005-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319816 | 6391225 |
| End transect | 319842 | 6391183 |

**Description:**

The MTWNPN2005-01 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 22 cm.

**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 *Acacia saligna, Plantago lanceolata, Conyza bonariensis, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis.*

**Table. Dominant species and structure at MTWNPN2005-01**

| Stratum | Height (m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 10 | 5 | *Corymbia maculata* and *Eucalyptus punctata* |
| Midstorey layer | 4 | 20 | Dominanted by *Acacia saligna* |
| Shrub layer | 2 | 5 | *Acacia amblygona,* |
| Ground layer | 1 | 40 | *Bothriochloa macra, Dichondra repens, Hardenbergia violacea, Oxalis perennans, Enchylaena tomentosa, Sporobolus creber, Wahlenbergia stricta* and *Eremophila debilis* |

*Projected foliage cover

## Site photographs at MTWNPN2005-01 (left to right)

Start position

End position

## MTWNPN2005-02

| MTWNPN2005-02 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319682 | 6391980 |
| End transect | 319682 | 6391980 |

**Description:**

The MTWNPN2005-01 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 18 cm.

**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 *Acacia saligna, Plantago lanceolata, Conyza bonariensis, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis.*

**Table. Dominant species and structure at MTWNPN2005-02**

| Stratum | Height (m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 10 | 10 | *Corymbia maculata, Corymbia citriodora, Eucalyptus crebra,* and *Eucalyptus punctata* |
| Midstorey layer | 5 | 20 | Acacia spp (no flowers or seed pods to assist in identification). |
| Shrub layer | 2 | 5 | *Acacia amblygona,* |
| Ground layer | 1 | 40 | *Bothriochloa macra, Dichondra repens, Oxalis perennans, Enchylaena tomentosa, Sporobolus creber, Vittadinia cuneata, Eremophila debilis, Themeda australis,* and *Panicum effusum.* |

*Projected foliage cover

## Site photographs at MTWNPN2005-02 (left to right)

Start position

End position

## MTWNPN2009-01

| MTWNPN2009-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319069 | 6391524 |
| End transect | 319027 | 6391535 |

**Description:**

The MTWNPN2009-01 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The spacing between the eucalypts were noticeable densely compact compared to the other sites.

The average DBH of the trees is approximately 16 cm.

**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 *Galea pubescens, Plantago lanceolata, Conyza bonariensis, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis.*

Pig scats were found at the site during the monitoring.

**Table. Dominant species and structure at MTWNPN2009-01**

| Stratum | Height | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 7-8 | 60 | *Corymbia maculata* and *Eucalyptus crebra* |
| Midstorey layer | 3 | 10 | *Acacia amblygona* and *Acacia falciformis* |
| Shrub layer | 2 | 10 | Small acacias, *Bursaria spinulosa* and *Breynia oblongifolia.* |
| Ground layer | 1 | 20 | *Bothriochloa macra, Dichondra repens, Hardenbergia violacea,* and *Oxalis perennans.* |

*Projected foliage cover

## Site photographs at MTWNPN2009-01 (left to right)

Start position



End position



## MTWCDD2011-01

| MTWCDC2011-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319599 | 6390304 |
| End transect | 319552 | 6390312 |

**Description:**

The MTWCDD2011-01 rehabilitation area occurs on imported topsoil with native seeds hydroseeded into the soil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 13 cm.

**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 *Acacia saligna, Bidens pilosa, Solanum nigrum, Galea pubescens, Plantago lanceolata, Chloris gayana, Cymbopogon refractus, Sida rhombifolia* and *Verbena bonariensis.*

**Table. Dominant species and structure at MTWCDC2011-01**

| Stratum | Height (m) | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | - | - | - |
| Midstorey layer | 4 | 10 | *Corymbia maculata, Acacia cultriformis, Acacia amblygona,* and *Acacia falcata,* |
| Shrub layer | 1 | 10 | *Indigofera australis,* |
| Ground layer | 0.5 | 40 | *Dichondra repens, Cynodon dactylon, Bothriochloa macra, Einadia nutans, Echinopogon caespiotsis, Themeda australis, Fimbristylis dicholoma* and *Capillipedium spicigerum* |

*Projected foliage cover

## Site photographs at MTWCDC2011-01 (left to right)

Start position



## MTWMTO2005-03

| MTWMTO2005-03 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 320678 | 6385782 |
| End transect | 320640 | 6385756 |

**Description:**

The MTWMTO2005-03 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the average trees is approximately 17 cm.

**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 *Acacia saligna, Eragrostis curvula, Bidens pilosa, Plantago lanceolata, Conyza bonariensis, Chloris gayana, Sida rhombifolia, Verbena bonariensis.*

**Table. Dominant species and structure at MTWMTO2005-03**

| Stratum | Height | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 10 | 10 | *Eucalyptus punctata* |
| Midstorey layer | - | - | - |
| Shrub layer | - | - | - |
| Ground layer | 1 | 20 | *Einadia nutans, Sporobolus creber, Chloris truncata, Chloris ventricosa, Calotis lappulacea, Bothriochloa macra, Dichondra repens, Oxalis perennans, Enchylaena tomentosa, Cyperus gracilis, Eremophila debilis,* and *Aristida vagans.* |

*Projected foliage cover

## MTWMTO2000-01

| MTWMTO2000-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 320551 | 6386940 |
| End transect | 320531 | 6386982 |

**Description:**

The MTWMTO2000-01 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site is provided in the table below.

The average DBH of the trees is approximately 23 cm.

**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 *Opuntia stricta, Senecio madagascariensis, Bidens pilosa, Plantago lanceolata, Conyza bonariensis, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis.*

**Table. Dominant species and structure at MTWMTO2000-01**

| Stratum | Height | % cover* | Dominant native species |
|---|---|---|---|
| Tree layer | 10 | 10 | *Eucalyptus punctata* and *E. moluccana* |
| Midstorey layer | - | - | - |
| Shrub layer | 2 | 20 | *Acacia* spp., |
| Ground layer | 1 | 20 | *Solanum prinophyllum, Einadia nutans, Cheilanthes sieberi, Themeda australis, Chloris truncata, Dichondra repens, Oxalis perennans, Enchylaena tomentosa*, and *Eremophila debilis.* |

*Projected foliage cover

**Site photographs at MTWMTO2000-01 (left to right)**

Start position



End position



# HVORIV2013-01

| HVORIV2013-01 | MGA 84 Zone 56 | |
|---|---|---|
| Position | Easting | Northing |
| Start transect: | 311184 | 6398689 |
| End transect | 311232 | 6398695 |

**Description:**

HVORIV2013-01 rehabilitation area occurs on a combination of topsoil and compost at HVO West. The rehabilitation site is dominated by the following species; *Chloris gayana, Bidens pilosa, Echinochloa crus-galli, Galenia pubescens, Plantago lanceolata, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Plantago lanceolata, Portulacca olearea, Sida rhombifolia* and *Solanum nigrum.*

**Disturbance:**

Disturbance present at rehabilitation site HVORIV2013-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVORIV2013-01 has an average 81 percent Protective cover. The percentage of weeds occupy an average of 100 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to three species. The average number of species per 1 x 1 metre plot is two species.

**Table. Ground cover assessment percentage cover at HVORIV2013-01**

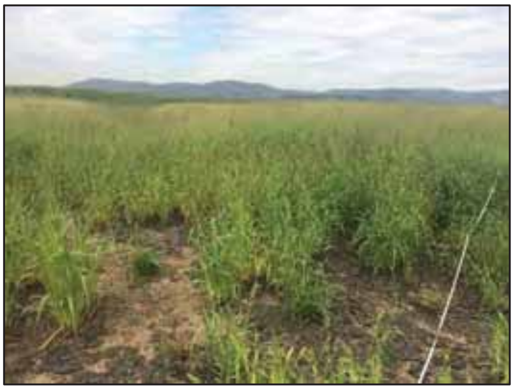
| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 100 | 0 | 100 | 3 |
| 10m | 100 | 0 | 100 | 2 |
| 15m | 100 | 0 | 100 | 3 |
| 20m | 90 | 10 | 100 | 3 |
| 25m | 90 | 10 | 100 | 2 |
| 30m | 80 | 20 | 100 | 2 |
| 35m | 100 | 0 | 100 | 3 |
| 40m | 80 | 20 | 100 | 1 |
| 45m | 60 | 40 | 100 | 3 |
| 50m | 10 | 90 | 100 | 1 |
| Average | 81 | 19 | 100 | 2 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at HVORIV2013-01 (left to right)**

Start position

End position



## HVORIV2014-01

| HVORIV2014-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 311033 | 6398662 |
| End transect | 310993 | 6398633 |

### Description:

HVORIV2014-01 rehabilitation area occurs on a comination of spoil and compost at HVO West. The rehabilitation site is dominated by *Conyza bonariensis.* Other species include *Chloris gayana, Bidens pilosa, Bothriochloa macra, Galenia pubescens, Plantago lanceolata, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Plantago lanceolata, Nicotiana glauca* and *Solanum nigrum.* It should be noted that a number of regenerating eucalypts (thin leaves – likely *E. crebra*), and small acacias and *Enchylaena tomentosa* were also recorded regenerating in the plot.

### Disturbance:

Disturbance present at rehabilitation site HVORIV2014-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

### Ground cover assessment:

HVORIV2014-01 has an average 47 percent Protective cover.  The percentage of weeds occupy an average of 94 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to six species. The average number of species per 1 x 1 metre plot is three species.

**Table. Ground cover assessment percentage cover at HVORIV2014-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 20 | 80 | 100 | 3 |
| 10m | 70 | 30 | 90 | 6 |
| 15m | 30 | 70 | 100 | 1 |
| 20m | 10 | 90 | 70 | 3 |
| 25m | 20 | 80 | 100 | 2 |
| 30m | 30 | 70 | 100 | 1 |
| 35m | 70 | 30 | 80 | 4 |
| 40m | 70 | 30 | 100 | 3 |
| 45m | 80 | 20 | 100 | 3 |
| 50m | 70 | 30 | 100 | 3 |
| Average | 47 | 53 | 94 | 3 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at HVORIV2014-01 (left to right)

Start position



End position



## HVORIV2014-02

| HVORIV2014-02 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 311293 | 6398516 |
| End transect | 311320 | 6398476 |

**Description:**

HVORIV2014-02 rehabilitation area occurs on a comination of subsoil and compost at HVO West. The rehabilitation site is dominated by *Conyza bonariensis.* Other species include *Chloris gayana, Chloris truncata, Bidens pilosa, Bothriochloa macra, Galenia pubescens, Hypochaeria radicata, Plantago lanceolata, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Plantago lanceolata, Sida rhombifolia, Solanum nigrum* and *Polymeiria aviculare.* It should be noted that a number of regenerating eucalypts (thin leaves – likely *E. crebra*), small acacias (*Acacia decora, Acacia implexa), Salsola tragus* and *Enchylaena tomentosa* were also recorded regenerating in the plot.

**Disturbance:**

Disturbance present at rehabilitation site HVORIV2014-02 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVORIV2014-02 has an average 27 percent Protective cover. The percentage of weeds occupy an average of 26 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to four species. The average number of species per 1 x 1 metre plot is three species.

**Table. Ground cover assessment percentage cover at HVORIV2014-02**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 20 | 80 | 20 | 3 |
| 10m | 30 | 70 | 30 | 2 |
| 15m | 40 | 60 | 20 | 4 |
| 20m | 30 | 70 | 30 | 2 |
| 25m | 30 | 70 | 30 | 1 |
| 30m | 10 | 90 | 10 | 3 |
| 35m | 40 | 60 | 30 | 4 |
| 40m | 30 | 70 | 20 | 2 |
| 45m | 30 | 70 | 60 | 2 |
| 50m | 10 | 90 | 10 | 2 |
| Average | 27 | 73 | 26 | 3 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at HVORIV2014-02 (left to right)**

Start position



End position



## HVORIV2014-03

| HVORIV2014-03 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 311900 | 6398539 |
| End transect | 311853 | 6398557 |

**Description:**

HVORIV2014-03 rehabilitation area occurs on a comination of spoil and compost at HVO West. The rehabilitation site consisted predominantly of the following introduced species; *Bidens pilosa, Panicum maximum, Echinochloa crus-gali, Chloris gayana,* and *Conyza bonariensis.* Native species included *Chloris truncata, Austrodanthonia spp.,* and *Persicaria decipiens.*

**Disturbance:**

Disturbance present at rehabilitation site HVORIV2014-03 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVORIV2014-03 has an average 39 percent Protective cover. The percentage of weeds occupy an average of 97 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from four to eight species. The average number of species per 1 x 1 metre plot is 6 species.

**Table. Ground cover assessment percentage cover at HVORIV2014-03**

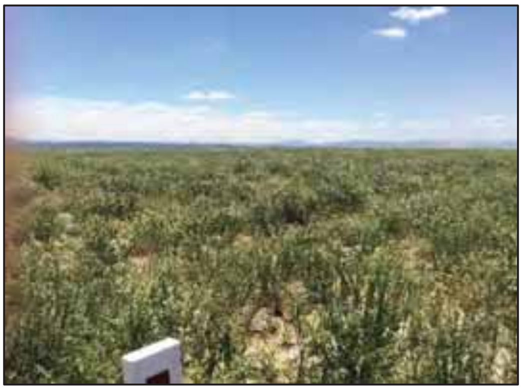
| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 20 | 80 | 100 | 8 |
| 10m | 10 | 90 | 100 | 7 |
| 15m | 30 | 70 | 100 | 9 |
| 20m | 20 | 80 | 100 | 5 |
| 25m | 20 | 80 | 100 | 4 |
| 30m | 30 | 70 | 80 | 6 |
| 35m | 30 | 70 | 100 | 5 |
| 40m | 30 | 70 | 100 | 5 |
| 45m | 100 | 0 | 90 | 7 |
| 50m | 100 | 0 | 100 | 4 |
| Average | 39 | 61 | 97 | 6 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

### Site photographs at HVORIV2014-03 (left to right)

Start position





End position



## HVORIV2014-04

| HVORIV2014-04 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 311900 | 6398539 |
| End transect | 311853 | 6398557 |

**Description:**

HVORIV2014-04 rehabilitation area occurs on a comination of subsoil and compost at HVO West. The rehabilitation site consisted predominantly of the following introduced species: *Panicum maximum, Echinochloa crus-gali, Cynodon dactylon, Eriochloa pseudoastrotrica, Chloris gayana, Solanum nigrum* and *Conyza bonariensis.*

**Disturbance:**

Disturbance present at rehabilitation site HVORIV2014-04 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVORIV2014-04 has an average 74 percent Protective cover. The percentage of weeds occupy an average of 70 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to six species. The average number of species per 1 x 1 metre plot is 5 species.

**Table. Ground cover assessment percentage cover at HVORIV2014-04**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 80 | 20 | 10 | 4 |
| 10m | 10 | 90 | 40 | 9 |
| 15m | 80 | 20 | 20 | 6 |
| 20m | 40 | 60 | 100 | 6 |
| 25m | 80 | 20 | 100 | 6 |
| 30m | 90 | 10 | 80 | 4 |
| 35m | 100 | 0 | 100 | 1 |
| 40m | 80 | 20 | 80 | 6 |
| 45m | 90 | 10 | 80 | 5 |
| 50m | 90 | 10 | 90 | 4 |
| Average | 74 | 26 | 70 | 5 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at HVORIV2014-04 (left to right)

Start position



End position



## HVORIV2014-05

| HVORIV2014-05 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 312242 | 6398088 |
| End transect | 312268 | 6398113 |

**Description:**

HVORIV2014-05 is rehabilitation area occurs on a comination of subsoil and compost at HVO West. The rehabilitation site consisted predominantly of the following introduced species: *Panicum maximum, Echinochloa crus-gali, Chloris gayana, Solanum nigrum* and *Conyza bonariensis.*

**Disturbance:**

Disturbance present at rehabilitation site HVORIV2014-05 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVORIV2014-05 has an average 77 percent Protective cover.  The percentage of weeds occupy an average of 100 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to three species. The average number of species per 1 x 1 metre plot is 2 species.

**Table. Ground cover assessment percentage cover at HVORIV2014-05**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 90 | 10 | 100 | 2 |
| 10m | 90 | 10 | 100 | 1 |
| 15m | 80 | 20 | 100 | 1 |
| 20m | 70 | 30 | 100 | 1 |
| 25m | 80 | 20 | 100 | 3 |
| 30m | 70 | 30 | 100 | 2 |
| 35m | 60 | 40 | 100 | 1 |
| 40m | 60 | 40 | 100 | 2 |
| 45m | 90 | 10 | 100 | 2 |
| 50m | 80 | 20 | 100 | 2 |
| Average | 77 | 23 | 100 | 2 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at HVORIV2014-05 (left to right)

Start position



End position



## HVORIV2014-06

| HVORIV2014-06 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 312521 | 6397946 |
| End transect | 312521 | 6397895 |

**Description:**

HVORIV2014-06 rehabilitation area occurs on a comination of topsoil and compost at HVO West. The rehabilitation site consisted predominantly of the following introduced species: *Chloris gayana, Bidens pilosa, Bothriochloa macra, Galenia pubescens, , Plantago lanceolata, Senecio madagascariensis, Panicum maximum, Solanum nigrum* and *Conyza bonariensis. Solanum prinophyllum* and *Enchylaena tomentosa* were also recorded regenerating in the plot.

**Disturbance:**

Disturbance present at rehabilitation site HVORIV2014-06 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVORIV2014-06 has an average 73 percent Protective cover. The percentage of weeds occupy an average of 70 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from four to seven species. The average number of species per 1 x 1 metre plot is five species.

**Table. Ground cover assessment percentage cover at HVORIV2014-06**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 90 | 10 | 30 | 6 |
| 10m | 70 | 30 | 40 | 6 |
| 15m | 70 | 30 | 60 | 5 |
| 20m | 60 | 40 | 100 | 6 |
| 25m | 90 | 10 | 60 | 4 |
| 30m | 90 | 10 | 60 | 5 |
| 35m | 90 | 10 | 70 | 7 |
| 40m | 50 | 50 | 80 | 5 |
| 45m | 90 | 10 | 100 | 4 |
| 50m | 30 | 70 | 100 | 6 |
| Average | 73 | 27 | 70 | 5 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

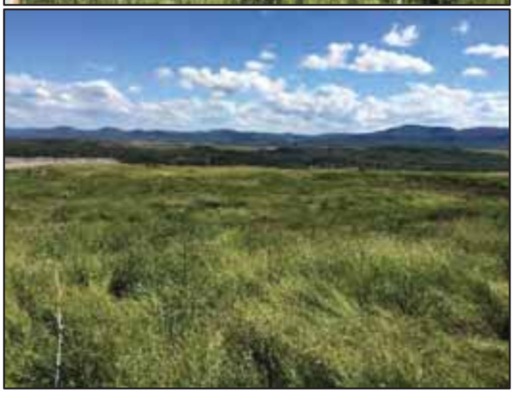
## Site photographs at HVORIV2014-06 (left to right)

Start position



End position





# HVOWES2013-01

| HVOWES2013-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 306899 | 6407222 |
| End transect | 306858 | 6407251 |

**Description:**

HVOWES2013-01 rehabilitation area occurs on a comination of spoil and compost at HVO West. The rehabilitation site includes the following grasses: Bothriochloa macra, Austrodanthonia spp. (lack of seed head), *Eragstristis curvula, Chloris gayana* and *Chloris truncata.*

A number of eucalypts were observed within the rehabilitation area. It is likely that the eucalypts regenerating included *Eucalyptus crebra* and *Corymbia maculata.*

**Disturbance:**

Disturbance present at rehabilitation site HVOWES2013-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

Rehabilitation site HVOWES2013-01 has a high percentage of Protective cover (97 percent). Weed occupied 55 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots was relatively high compared to other sites, ranging from three to eight species, with an average of five species.

**Table. Ground cover assessment percentage cover at HVOWES2013-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 100 | 0 | 50 | 6 |
| 10m | 100 | 0 | 50 | 8 |
| 15m | 90 | 10 | 80 | 5 |
| 20m | 90 | 10 | 100 | 5 |
| 25m | 90 | 10 | 70 | 7 |
| 30m | 100 | 0 | 50 | 4 |
| 35m | 100 | 0 | 50 | 3 |
| 40m | 100 | 0 | 50 | 4 |
| 45m | 100 | 0 | 20 | 4 |
| 50m | 100 | 0 | 30 | 4 |
| Average | 97 | 3 | 55 | 5 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at HVOWES2013-01 (left to right)

Start position



End position



## HVOWES2013-02

| HVOWES2013-02 | | MGA 84 Zone 56 |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 306889 | 6407365 |
| End transect | 306879 | 6407409 |

**Description:**

HVOWES2013-02 rehabilitation area occurs on a comination of topsoil and compost at HVO West. The rehabilitation site includes the following grasses: *Eriochloa pseudoastritrica, Panicum maximum, Chloris gayana* and *Sporobolus creber.* Herbaceous weeds including *Verbena bonariensis, Conyza bonariensis* and *Brassica* spp. were recorded in the monitoring plot. All three of these herbaceous weeds were flowering at the time of the survey.

**Disturbance:**

Disturbance present at rehabilitation site HVOWES2013-02 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVOWES2013-02 has a high percentage of Protective cover (91 percent). Weed occupied 13 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots was low, ranging from one to three species, with an average of three species.

**Table. Ground cover assessment percentage cover at HVOWES2013-02**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 100 | 0 | 10 | 3 |
| 10m | 90 | 10 | 10 | 3 |
| 15m | 90 | 10 | 10 | 3 |
| 20m | 80 | 20 | 20 | 3 |
| 25m | 70 | 30 | 10 | 2 |
| 30m | 90 | 10 | 0 | 1 |
| 35m | 100 | 0 | 10 | 3 |
| 40m | 100 | 0 | 20 | 3 |
| 45m | 90 | 10 | 40 | 3 |
| 50m | 100 | 0 | 0 | 2 |
| Average | 91 | 9 | 13 | 3 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at HVOWES2013-02 (left to right)**

Start position

End position

## HVOCAR2014-01

| HVOCAR2014-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 6403083 | 309872 |
| End transect | 6403057 | 309832 |

**Description:**

HVOCAR2014-01 rehabilitation area occurs on a comination of topsoil and compost at HVO West. Rehabilitation site includes the following grasses: *Panicum maximum, Echinochloa crus-galli* and *Chloris gayana.* Herbaceous weeds including *Verbena bonariensis, Solanum nigrum, Senecio madagascariensis, Conyza bonariensis* and *Brassica* spp. were recorded in the monitoring plot.

**Disturbance:**

Disturbance present at rehabilitation site HVOCAR2014-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVOCAR2014-01 just a relatively higher percentage of Protective cover (54 percent) compared to Bare earth cover (45 percent). Weed dominanted the cover occupying an average of 55 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots was low, and ranged from one to six species, with an average of two species.

**Table. Ground cover assessment percentage cover at HVOCAR2014-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 40 | 60 | 40 | 6 |
| 10m | 50 | 50 | 40 | 3 |
| 15m | 80 | 20 | 80 | 3 |
| 20m | 50 | 50 | 50 | 3 |
| 25m | 40 | 60 | 40 | 2 |
| 30m | 50 | 60 | 50 | 1 |
| 35m | 60 | 40 | 60 | 2 |
| 40m | 80 | 20 | 80 | 1 |
| 45m | 30 | 50 | 50 | 1 |
| 50m | 60 | 40 | 60 | 1 |
| Average | 54 | 45 | 55 | 2 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at HVOCAR2014-01 (left to right)**

Start position



End position



## HVOCHE2012-01

| HVOCHE2012-01 | MGA 84 Zone 56 |
|---|---|

| Position | Easting | Northing |
|---|---|---|
| Start transect: | 315694 | 6400898 |
| End transect | 315660 | 6400932 |

**Description:**

HVOCHE2012-01 rehabilitation area occurs on a comination of topsoil and compost at HVO West. The rehabilitation site is dominated by the following species: *Chloris gayana, Chloris truncata, Conyza bonariensis, Echinochloa crus-galli, Eriochloa pseudoastrotricha, Hypochaeria radicata, Plantago lanceolata, Senecio madagascariensis, Panicum maximum, Plantago lanceolata, Sida rhombifolia,* and *Solanum nigrum.*

**Disturbance:**

Disturbance present at rehabilitation site HVOCHE2012-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVOCHE2012-01 has an average 87 percent Protective cover.  The percentage of weeds occupy an average of 84 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from two to seven species. The average number of species per 1 x 1 metre plot is four species.

**Table. Ground cover assessment percentage cover at HVOCHE2012-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 90 | 10 | 100 | 4 |
| 10m | 50 | 50 | 80 | 5 |
| 15m | 100 | 0 | 100 | 2 |
| 20m | 80 | 20 | 60 | 4 |
| 25m | 60 | 40 | 80 | 7 |
| 30m | 100 | 0 | 80 | 6 |
| 35m | 100 | 0 | 100 | 4 |
| 40m | 90 | 10 | 40 | 4 |
| 45m | 100 | 0 | 100 | 3 |
| 50m | 100 | 0 | 100 | 3 |
| Average | 87 | 13 | 84 | 4 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at HVOCHE2012-01 (left to right)**

Start position



End position



## HVOCHE2013-01

| HVOCHE2013-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 315159 | 6401135 |
| End transect | 315170 | 6401172 |

**Description:**

HVOCHE2013-01 rehabilitation area occurs on a comination of topsoil and compost at HVO West. The rehabilitation site is dominated by the following species: Chloris *gayana, Chloris truncata, Conyza bonariensis, Echinochloa crus-galli, Eriochloa pseudoastrotricha, Hypochaeria radicata, Plantago lanceolata, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Plantago lanceolata, Sida rhombifolia* and *Solanum nigrum.*

**Disturbance:**

Disturbance present at rehabilitation site HVOCHE2013-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVOCHE2013-01 has an average 93 percent Protective cover. The percentage of weeds occupy an average of 46 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from two to five species. The average number of species per 1 x 1 metre plot is four species.

**Table. Ground cover assessment percentage cover at HVOCHE2013-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 70 | 30 | 40 | 5 |
| 10m | 100 | 0 | 40 | 5 |
| 15m | 100 | 0 | 40 | 4 |
| 20m | 100 | 0 | 90 | 3 |
| 25m | 100 | 0 | 30 | 4 |
| 30m | 80 | 20 | 60 | 3 |
| 35m | 100 | 0 | 80 | 4 |
| 40m | 100 | 0 | 20 | 3 |
| 45m | 100 | 0 | 30 | 2 |
| 50m | 80 | 20 | 30 | 3 |
| Average | 93 | 7 | 46 | 4 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at HVOCHE2013-01 (left to right)

Start position



End position



## HVOCHE2014-01

| HVOCHE2014-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 315581 | 6399040 |
| End transect | 315541 | 6399065 |

**Description:**

HVOCHE2014-01 rehabilitation area occurs on a comination of topsoil and compost at HVO West. The rehabilitation site includes the following grasses: *Echinochloa crus-gali, Panicum maximum, Eriochloa pseudoastritrica* and *Sporobolus creber.* Herbaceous weeds including *Verbena bonariensis, Conyza bonariensis* and *Brassica* spp. were recorded in the monitoring plot. All three of these herbaceous weeds were flowering at the time of the survey.

**Disturbance:**

Disturbance present at rehabilitation site HVOCHE2014-01consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVOCHE2014-01 has a high percentage of Protective cover (91 percent). The percentage of weed occupied 81 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots was relatively low, ranging from two to five species, with an average of three species.

**Table. Ground cover assessment percentage cover at HVOCHE2014-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 50 | 50 | 40 | 2 |
| 10m | 80 | 20 | 30 | 5 |
| 15m | 80 | 20 | 60 | 3 |
| 20m | 70 | 30 | 100 | 3 |
| 25m | 80 | 20 | 100 | 3 |
| 30m | 70 | 30 | 100 | 2 |
| 35m | 80 | 20 | 100 | 4 |
| 40m | 80 | 20 | 80 | 3 |
| 45m | 70 | 30 | 100 | 2 |
| 50m | 80 | 20 | 100 | 3 |
| Average | 74 | 26 | 81 | 3 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at HVOCHE2014-01 (left to right)**

Start position



End position



# HVOCHE2012-03

| HVOCHE2012-03 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 315667 | 6400043 |
| End transect | 315617 | 6400040 |

**Description:**

HVOCHE2012-03 rehabilitation area occurs on a comination of topsoil and compost at HVO West. The rehabilitation site includes the following grasses: *Eriochloa pseudoastritrica, Panicum maximum* and Chloris gayana. Herbaceous weeds including *Conyza bonariensis, Brassica* spp., *Lepidium spp.* and *Portulaca oleracea* were recorded in the monitoring plot. All three of these herbaceous weeds were flowering at the time of the survey.

**Disturbance:**

Disturbance present at rehabilitation site HVOCHE2012-03 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

HVOCHE2012-03 has a high percentage of Protective cover (81 percent). The percentage of weed occupied 63 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from three to five species, with an average of three species.

**Table. Ground cover assessment percentage cover at HVOCHE2012-03**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 70 | 30 | 50 | 4 |
| 10m | 80 | 20 | 70 | 4 |
| 15m | 70 | 30 | 60 | 4 |
| 20m | 90 | 10 | 70 | 3 |
| 25m | 90 | 10 | 90 | 3 |
| 30m | 50 | 50 | 50 | 3 |
| 35m | 100 | 0 | 50 | 4 |
| 40m | 90 | 10 | 50 | 3 |
| 45m | 80 | 20 | 60 | 5 |
| 50m | 90 | 10 | 80 | 4 |
| Average | 81 | 19 | 63 | 3.7 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at HVOCHE2012-03 (left to right)**

Start position



End position



# MTWNPN2011-01

| MTWNPN2011-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 318166 | 6392138 |
| End transect | 318115 | 6392138 |

**Description:**

MTWNPN2011-01 rehabilitation area occurs on a comination of topsoil and compost at Mount Thorley-Warkworth. The rehabilitation site includes the following regenerating native species: *Acacia amblygona, A. longifolia, A, decora, A. cultriformis* and *Themeda australis.* Introduced species included: *Acacia saligna, Eriochloa pseudoastritrica, Panicum maximum* and Chloris gayana. Herbaceous weeds including *Conyza bonariensis, Brassica* spp., *Gomphocarpus fruiticosis* and *Sida rhombifolia* were recorded in the monitoring plot. All three of these herbaceous weeds were flowering at the time of the survey.

**Disturbance:**

Disturbance present at rehabilitation site MTWNPN2011-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWNPN2011-01 has a high percentage of Protective cover (84 percent). The percentage of weed occupied 68 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from two to five species, with an average of four species.

**Table. Ground cover assessment percentage cover at MTWNPN2011-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 100 | 0 | 100 | 2 |
| 10m | 90 | 10 | 90 | 4 |
| 15m | 80 | 20 | 70 | 5 |
| 20m | 80 | 20 | 70 | 4 |
| 25m | 90 | 10 | 90 | 5 |
| 30m | 50 | 50 | 50 | 3 |
| 35m | 100 | 0 | 90 | 2 |
| 40m | 90 | 10 | 60 | 4 |
| 45m | 60 | 40 | 20 | 5 |
| 50m | 100 | 0 | 40 | 4 |
| Average | 84 | 16 | 68 | 4 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at MTWNPN2011-01 (left to right)**

Start position



## MTWTDI2015-01

| MTWTD12015-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319687 | 6392186 |
| End transect | 319691 | 6392236 |

**Description:**

MTWTDI2015-01 rehabilitation area occurs on a comination of spoil and compost at Mount Thorley-Warkworth. The rehabilitation site includes the following grasses: Chloris truncata, Digitaria sanguinalis, Panicum effusum, Setaria gracilis, *Eriochloa pseudoastritrica, Echinochloa crus-gali* and Chloris gayana. Herbaceous weeds including *Conyza bonariensis* and *Portulaca oleracea* were recorded in the monitoring plot. *Enchylaena tomentosa* and *Einadia hastata* were also recorded in the monitoring plot.

**Disturbance:**

Disturbance present at rehabilitation site MTWTDI2015-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWTD12015-01 has 77 percent Protective cover, of which most is attributed due to rock and stone throughout the site. The percentage of weed occupied 5 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to five species, with an average of two species.

**Table. Ground cover assessment percentage cover at MTWTDI2015-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 70 | 30 | 10 | 2 |
| 10m | 90 | 10 | 0 | 1 |
| 15m | 90 | 10 | 10 | 5 |
| 20m | 60 | 40 | 0 | 0 |
| 25m | 90 | 10 | 0 | 1 |
| 30m | 90 | 10 | 0 | 1 |
| 35m | 80 | 20 | 0 | 3 |
| 40m | 80 | 20 | 10 | 2 |
| 45m | 60 | 40 | 10 | 1 |
| 50m | 60 | 40 | 10 | 2 |
| Average | 77 | 23 | 5 | 2 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at MTWTDI2015-01 (left to right)

Start position



End position



## MTWSPN2014-01

| MTWSPN2014-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 320170 | 6390161 |
| End transect | 320186 | 6390201 |

**Description:**

MTWSPN2014-01 rehabilitation area occurs on a comination of topsoil and compost at Mount Thorley-Warkworth. The rehabilitation site was dominanted by the following species: *Conyza bonariensis, Chloris gayana, Eriochloa pseudoastritrica, Echinochloa crus-gali* and *Panicum maximum.*

**Disturbance:**

Disturbance present at rehabilitation site MTWSPN2014-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWSPN2014-01 has an average of 81 percent Protective cover. The percentage of weed occupied an average of 94 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to four species. The average number of species within a 1 x 1 plot is 2 species.

**Table. Ground cover assessment percentage cover at MTWSPN2014-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 60 | 40 | 100 | 3 |
| 10m | 70 | 30 | 100 | 2 |
| 15m | 70 | 30 | 100 | 2 |
| 20m | 90 | 10 | 100 | 2 |
| 25m | 90 | 10 | 100 | 3 |
| 30m | 90 | 10 | 100 | 2 |
| 35m | 80 | 20 | 50 | 4 |
| 40m | 80 | 20 | 90 | 1 |
| 45m | 90 | 10 | 100 | 1 |
| 50m | 90 | 10 | 100 | 2 |
| Average | 81 | 19 | 94 | 2 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at MTWSPN2014-01 (left to right)

Start position



End position



## MTWNPN2014-01

| MTWNPN2014-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 317645 | 6392097 |
| End transect | 317618 | 6392128 |

**Description:**

MTWNPN2014-01 rehabilitation area occurs on a comination of topsoil and compost at Mount Thorley-Warkworth. The rehabilitation site includes the following native species: Bothriochloa macra, *Chloris truncata, Cynodon dactylon, Dichondra repens, Hardenbergia violacea,* and *Acacia amblygona.* Weeds included: *Bidens pilosa, Conyza bonariensis, Lepidium spp. Pennisetum cladenstina, Senecio madagascariensis, Solanum nigrum,* and *Verbena bonariensis*.

**Disturbance:**

Disturbance present at rehabilitation site MTWNPN2014-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWNPN2014-01 has an average 49 percent Protective cover. The percentage of weeds occupy an average of 42 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from three to eight species. The average number of species per 1 x 1 metre plot is 5 specis.

**Table. Ground cover assessment percentage cover at MTWNPN2014-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 30 | 70 | 30 | 5 |
| 10m | 30 | 70 | 20 | 8 |
| 15m | 50 | 50 | 40 | 4 |
| 20m | 60 | 40 | 30 | 4 |
| 25m | 60 | 40 | 60 | 4 |
| 30m | 60 | 40 | 60 | 4 |
| 35m | 30 | 70 | 40 | 4 |
| 40m | 40 | 60 | 40 | 5 |
| 45m | 40 | 60 | 40 | 3 |
| 50m | 90 | 10 | 60 | 5 |
| Average | 49 | 51 | 42 | 4.6 |

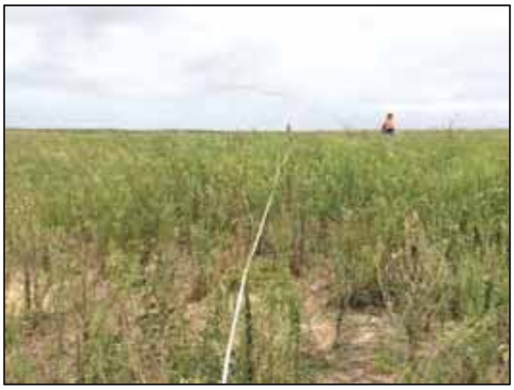
*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at MTWNPN2014-01 (left to right)**

Start position



End position


## MTWNPN2014-03

| MTWNPN2014-03 | MGA 84 Zone 56 | |
|---|---|---|
| Position | Easting | Northing |
| Start transect: | 318131 | 6391213 |
| End transect | 318131 | 6391213 |

**Description:**

MTWNPN2014-03 rehabilitation area occurs on a comination of subsoil and compost at Mount Thorley-Warkworth. The rehabilitation site includes the following grasses: Austrodanthonia spp., Chloris truncata, *Eriochloa pseudoastritrica* and *Pennisetum cladenstina.* Herbaceous weeds including *Bidens pilosa, Conyza bonariensis, Chenopodium spp.* and *Trifolium repens,* were recorded in the monitoring plot. *Acacia saligna* was recorded in the plot.

**Disturbance:**

Disturbance present at rehabilitation site MTWNPN2014-03 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWNPN2014-03 has 93 percent Protective cover. The percentage of weeds occupy an average of 88 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from two to eight species, with an average of 7 species.

**Table. Ground cover assessment percentage cover at MTWNPN2014-0**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 90 | 10 | 80 | 9 |
| 10m | 80 | 20 | 30 | 11 |
| 15m | 100 | 0 | 90 | 8 |
| 20m | 100 | 0 | 100 | 7 |
| 25m | 100 | 0 | 100 | 7 |
| 30m | 90 | 10 | 100 | 8 |
| 35m | 100 | 0 | 100 | 4 |
| 40m | 100 | 0 | 100 | 5 |
| 45m | 80 | 20 | 80 | 2 |
| 50m | 90 | 10 | 100 | 4 |
| Average | 93 | 7 | 88 | 7 |

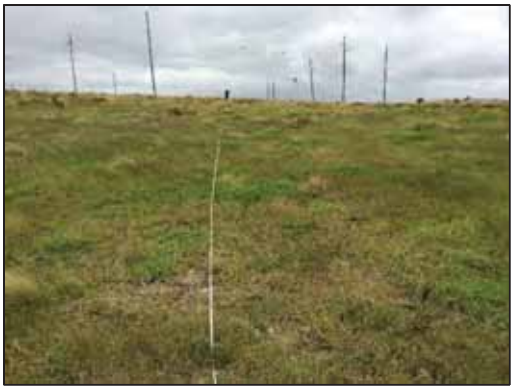
*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at MTWNPN2014-0 (left to right)

Start position



End position


# MTWNPN2013-01

| MTWNPN2013-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 318046 | 6391550 |
| End transect | 317995 | 6391518 |

**Description:**

MTWNPN2013-01 rehabilitation area occurs on a comination of topsoil and compost at Mount Thorley-Warkworth. The rehabilitation site includes the following native species: *Chloris truncata, Chloris ventricosa, Cynodon dactylon, Acacia amblygona, Acacia decora* and *Wahlenbergia stricta.* Herbaceous weeds including *Bidens pilosa, Conyza bonariensis, Lepidium spp. Solanum nigrum* and *Verbena bonariensis* were recorded in the monitoring plot.

**Disturbance:**

Disturbance present at rehabilitation site MTWNPN2013-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWNPN2013-01 has an average 76 percent Protective cover. The percentage of weeds occupy an average of 74 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from two to four species. The average number of species per 1 x 1 metre plot is three species.

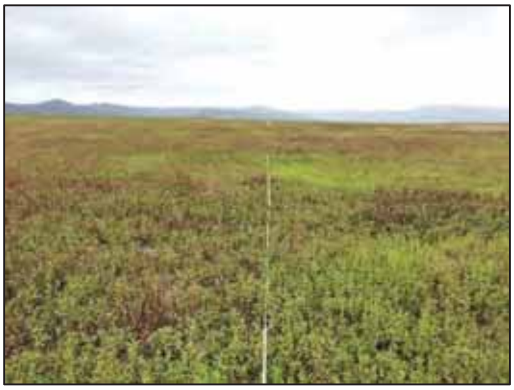
**Table. Ground cover assessment percentage cover at MTWNPN2013-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 70 | 30 | 80 | 4 |
| 10m | 60 | 40 | 80 | 2 |
| 15m | 100 | 0 | 80 | 2 |
| 20m | 80 | 20 | 80 | 2 |
| 25m | 90 | 10 | 90 | 3 |
| 30m | 50 | 50 | 50 | 3 |
| 35m | 50 | 50 | 50 | 4 |
| 40m | 80 | 20 | 70 | 2 |
| 45m | 90 | 10 | 70 | 2 |
| 50m | 90 | 10 | 90 | 2 |
| Average | 76 | 24 | 74 | 2.6 |

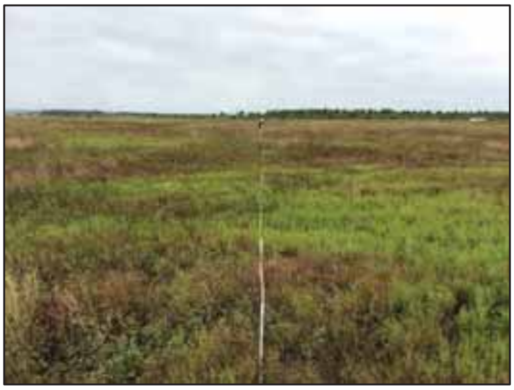
*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at MTWNPN2013-01 (left to right)**

Start position


End position


## MTWWDL2014-01

| MTWWDL2014-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319804 | 6388507 |
| End transect | 319849 | 6388525 |

**Description:**

MTWWDL2014-01 rehabilitation area occurs on a comination of topsoil and compost at Mount Thorley-Warkworth. The rehabilitation site included a number of regenerating species such as *Acacia amblygona, A. falciformis, Acacia (bipinate), Enchaleana tomentosa, Hardenbergia violacea, Indigofera australis*, *Chloris truncata* and *Bothriochloa macra*. Introduced species included *Conyza bonariensis, Digitaria sanguinalis*, *Eriochloa pseudoastritrica, Echinochloa crus-gali* and *Chloris gayana.*

**Disturbance:**

Disturbance present at rehabilitation site MTWWDL2014-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWWDL2014-01 has 71 percent Protective cover, of which most can be attributed to rock and stone throughout the site. The percentage of weed occupied 73 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from four to seven species, with an average of five species.

**Table. Ground cover assessment percentage cover at MTWWDL2014-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 70 | 30 | 100 | 4 |
| 10m | 60 | 40 | 100 | 4 |
| 15m | 100 | 0 | 50 | 6 |
| 20m | 50 | 50 | 40 | 4 |
| 25m | 80 | 20 | 70 | 5 |
| 30m | 90 | 10 | 90 | 5 |
| 35m | 70 | 30 | 80 | 7 |
| 40m | 70 | 30 | 40 | 8 |
| 45m | 30 | 70 | 90 | 5 |
| 50m | 90 | 10 | 70 | 5 |
| Average | 71 | 29 | 73 | 5 |

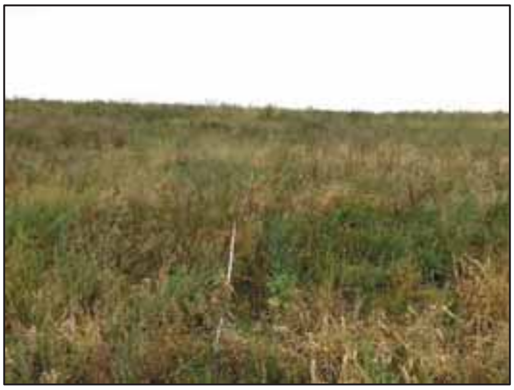
*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at MTWWDL2014-01 (left to right)**

Start position



End position


## MTWWDL2014-02

| MTWWDL2014-02 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319636 | 6388357 |
| End transect | 319624 | 6388309 |

**Description:**

MTWWDL2014-02 rehabilitation area occurs on a comination of topsoil and compost at Mount Thorley-Warkworth. The rehabilitation site includes the following introduced species: Chloris gayana, Panicum maximum, *Eriochloa pseudoastritrica* and *Echinochloa crus-galli.* Herbaceous weeds including *Conyza bonariensis* and *Portulaca oleracea* were recorded in the monitoring plot.

**Disturbance:**

Disturbance present at rehabilitation site MTWWDL2014-02 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWWDL2014-02 has an average 74 percent Protective cover. The percentage of weeds occupy an average of 51 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from two to five species. The average number of species per 1 x 1 metre plot is three species.

**Table. Ground cover assessment percentage cover at MTWWDL2014-02**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 70 | 30 | 40 | 3 |
| 10m | 80 | 20 | 20 | 3 |
| 15m | 80 | 20 | 30 | 3 |
| 20m | 70 | 30 | 40 | 2 |
| 25m | 60 | 40 | 50 | 4 |
| 30m | 70 | 30 | 80 | 3 |
| 35m | 70 | 30 | 80 | 2 |
| 40m | 80 | 20 | 70 | 5 |
| 45m | 80 | 20 | 60 | 4 |
| 50m | 80 | 20 | 40 | 3 |
| Average | 74 | 26 | 51 | 3 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at MTWWDL2014-02 (left to right)

Start position



End position



## MTWCDD2015-01

| MTWCDD2015-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319049 | 6390074 |
| End transect | 319081 | 6390034 |

**Description:**

MTWCDD2015-01 rehabilitation area occurs on a comination of spoil and compost at Mount Thorley-Warkworth. The rehabilitation site was dominanted by the following introduced species: *Conyza bonariensis*, *Chloris gayana*, *Echinochloa crus-gali*, *Senecio madagascariensis*, *Solanum nigrum* and *Panicum maximum.* Native species included *Eriochloa pseudoastritrica*, *Austrodanthonia spp.*, *Einadia nutans*, *Austrostipa scabra*, *Bothriochloa macra* and *Chloris truncata.*

It should be noted that a number of Eucalypts were regenerating in the area. Most of these are likely *Eucalyptus crebra* due to their narrow leaves.

**Disturbance:**

Disturbance present at rehabilitation site MTWCDD2015-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWCDD2015-01 has an average of 56 percent Protective cover. The percentage of weed occupied an average of 9 percent of the Protective cover. The remainder of the Protective cover generally consists of rocks. The number of species recorded in each of the 1 x 1 metre plots ranged from one to four species. The average number of species within a 1 x 1 plot is 2 species.

**Table. Ground cover assessment percentage cover at MTWCDD2015-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 40 | 60 | 0 | 2 |
| 10m | 60 | 40 | 10 | 3 |
| 15m | 60 | 40 | 10 | 1 |
| 20m | 60 | 40 | 10 | 4 |
| 25m | 60 | 40 | 10 | 2 |
| 30m | 60 | 40 | 10 | 2 |
| 35m | 40 | 60 | 10 | 3 |
| 40m | 60 | 40 | 10 | 3 |
| 45m | 60 | 40 | 10 | 1 |
| 50m | 60 | 40 | 10 | 2 |
| Average | 56 | 44 | 9 | 2.3 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

**Site photographs at MTWCDD2015-01 (left to right)**

Start position



End position



# MTWCDD2013-01

| MTWCDD2013-01 | MGA 84 Zone 56 | |
|---|---|---|
| **Position** | **Easting** | **Northing** |
| Start transect: | 319516 | 6390165 |
| End transect | 319535 | 6390212 |

**Description:**

MTWCDD2013-01 rehabilitation area occurs on topsoil at Mount Thorley-Warkworth. The rehabilitation site was dominanted by the following introduced species: *Chloris gayana, Echinochloa crus-gali, Senecio madagascariensis* and *Panicum maximum.*

**Disturbance:**

Disturbance present at rehabilitation site MTWCDD2013-01 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

**Ground cover assessment:**

MTWCDD2013-01 has an average of 98 percent Protective cover. The percentage of weed occupied an average of 97 percent of the Protective cover. The number of species recorded in each of the 1 x 1 metre plots ranged from one to two species. The average number of species within a 1 x 1 plot is one species.

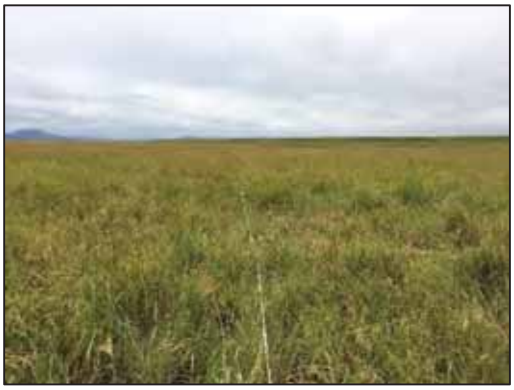
**Table. Ground cover assessment percentage cover at MTWCDD2013-01**

| Transect | % Protective cover* | % Bare | % Weeds | Number of species |
|---|---|---|---|---|
| 5m | 90 | 10 | 100 | 1 |
| 10m | 90 | 10 | 100 | 1 |
| 15m | 100 | 0 | 70 | 1 |
| 20m | 100 | 0 | 100 | 1 |
| 25m | 100 | 0 | 100 | 2 |
| 30m | 100 | 0 | 100 | 1 |
| 35m | 100 | 0 | 100 | 1 |
| 40m | 100 | 0 | 100 | 1 |
| 45m | 100 | 0 | 100 | 1 |
| 50m | 100 | 0 | 100 | 1 |
| Average | 98 | 2 | 97 | 1.1 |

*Protective cover includes dead and live vegetation, rocks, litter and logs

## Site photographs at MTWCDD2013-01 (left to right)

Start position


End position



## Appendix 5 –SESL report

SESL AUSTRALIA
Environment & Soil Sciences

# Mount Thorley Warkworth & Hunter Valley Operations

## Rehabilitation sites soil analysis and interpretation

**Prepared for:**

**Niche Environment and Heritage**

**March 2016**

**(Report: C8738.B38017.Q5236 FA)**

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## TABLES



## APPENDICES





WATER MINING SPORTS & RECREATION HORTICULTURE & AGRICULTURE ENVIRONMENTAL ENGINEERING & GEOTECH URBAN HORTICULTURE & LANDSCAPING

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QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006

**INTRODUCTION**

SESL Australia (SESL) was engaged by Niche Environment and Heritage (the client) to provide soil analysis and interpretation services for the Mount Thorley Warkworth (MTW) and Hunter Valley Operations (HVO) mine sites. The project involves revegetation by recreating woodland community and native pasture ecosystems.

The site has established 12 reference sites which are native vegetation communities and relatively undisturbed. The other sites are on mined land, which have been rehabilitated using one of the five different soil treatments listed below:

1. Subsoil / compost
2. Topsoil / compost
3. Topsoil
4. Spoil / compost
5. Fresh sand topsoil / compost

Table 1 below provides a summary of sample names, numbers, treatment and revegetation goals.

Samples were collected by the client and delivered to the SESL laboratory in February 2016. All samples were analysed for pH, salinity, cations, plant available nutrients, organic matter, and texture. Thirty-one samples were also analysed for microbiology including total microorganisms, total bacteria, total fungi, pseudomonas, actinomycetes, gram positive and gram negative bacteria, methane oxidisers, sulphur reducers, anaerobes, protozoa, mycorrhizal fungi and fungi:bacteria ratio.

Table 1 Summary of sample names, numbers, treatments and revegetation goals

| Sample # | Site | Sample Name | Treatment | Revegetation Goal |
|---|---|---|---|---|
| 8 | Reference | Bell 1 | - | - |
| 9 | Reference | Bell 2 | - | - |
| 20 | Reference | Bell 3 | - | - |
| 21 | Reference | GBREF 3 | - | - |
| 22 | Reference | GBREF 4 | - | - |
| 23 | Reference | GBREF 6 | - | - |
| 24 | Reference | WAMBOGB 01 | - | - |
| 25 | Reference | WAMBOGB 02 | - | - |
| 26 | Reference | WAMBOSPOT 1 | - | - |
| 27 | Reference | WAMBOSPOT 2 | - | - |
| 28 | Reference | WAMBOSPOT 3 | - | - |
| 29 | Reference | REF 05 | - | - |
| 1 | HVO | HVORIV201401 | Riverview RL145, spoil/compost, drilled | Pasture/ Light Wooded |


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| Sample # | Site | Sample Name | Treatment | Revegetation Goal |
|---|---|---|---|---|
| 3 | HVO | HVORIV201403 | Riverview RL155, spoil/compost, drilled | Pasture/ Light Wooded |
| 2 | HVO | HVORIV201402 | Riverview RL145, subsoil/compost, drilled | Pasture/ Light Wooded |
| 4 | HVO | HVORIV201404 | Riverview RL155, subsoil/compost, drilled | Pasture/ Light Wooded |
| 5 | HVO | HVORIV201405 | Riverview RL155, subsoil/compost, drilled | Pasture/ Light Wooded |
| 6 | HVO | HVORIV201406 | Riverview Ampitheatre, tospoil/compost, natives not sown | Pasture/ Light Wooded |
| 7 | HVO | HVORIV201301 | Riverview RL145, topsoil/compost, natives not sown | Pasture/ Light Wooded |
| 10 | HVO | HVOCHE201301 | Cheshunt Rim, topsoil/compost, natives not sown | Woodland |
| 11 | HVO | HVOCHE 201201 | Cheshunt Rim, topsoil/compost, drilled | Woodland |
| 30 | HVO | HVOCAR201401 | Carrington, topsoil/compost, natives not sown | Woodland |
| 42 | HVO | HVOWES2013-02 | Wilton dumps, topsoil/compost, natives not sown | Woodland |
| 43 | HVO | HVOCHES2012-03 | Cheshunt Rim, topsoil/compost, natives not sown | Woodland |
| 44 | HVO | HVOCHE2014-01 | Cheshunt Helipad, topsoil/compost, natives not sown | Woodland |
| 39 | HVO | HVOWES2008-01 | Wilton dumps, topsoil | Woodland |
| 45 | HVO | HVOCAR200901 | Carrington Western TSF Cell A, topsoil | Woodland |
| 46 | HVO | HVOCAR200902 | Carrington, topsoil | Woodland |
| 40 | HVO | HVOWES2011-01 | Dam 6W, spoil/compost, hydroseeded. | Woodland |
| 41 | HVO | HVOCHE2013-01 | Wilton dumps, spoil/compost, drilled | Woodland |
| 12 | MTW | MTWCDD201101 | CD RL160 2011, topsoil, native seed hydroseeded | Woodland |
| 15 | MTW | MTWWDL201401 | Woodlands N Slope 2014, topsoil/compost, natives drilled 2015 | Woodland |
| 32 | MTW | MTWCDD201301 | CD RL160 2013, topsoil/compost, natives not sown | Woodland |
| 35 | MTW | MTWNPN200901 | Swanlake 2009, topsoil, old seed mix | Woodland |
| 48 | MTW | MTWMTO200503 | MTO South Dump 2005, topsoil | Woodland |
| 13 | MTW | MTWCDD201501 | CD RL160 2015, spoil/compost, natives drilled | Woodland |
| 14 | MTW | MTWTDI201501 | TD1, spoil/compost, native seed drilled 2015 | Woodland |
| 16 | MTW | MTWNPN201403 | NPN 2014, subsoil/compost, | Woodland |


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| Sample # | Site | Sample Name | Treatment | Revegetation Goal |
|---|---|---|---|---|
| | | | natives drilled 2014 | |
| 17 | MTW | MTWNPN201301 | NPN 2013, topsoil/compost, natives drilled Winter 2015 | Woodland |
| 18 | MTW | MTWNPN201101 | NPN 2011, topsoil, natives hydroseeded 2011 | Woodland |
| 31 | MTW | MTWSPN201401 | SPN 2014, topsoil/compost, natives not sown | Woodland |
| 33 | MTW | MTWWDL201402 | Woodlands S Slope 2014, topsoil/compost, natives not sown | Woodland |
| 36 | MTW | MTWNPN201401 | NPN 2014, topsoil/compost, natives drilled 2014 | Woodland |
| 19 | MTW | MTWNPN200501 | NPN 2005, topsoil | Pasture/ Light Wooded |
| 34 | MTW | MTWNPN200502 | NPN 2005, topsoil | Pasture/ Light Wooded |
| 47 | MTW | MTWTO200001 | MTO North Dump 2000, topsoil | Pasture/ Light Wooded |
| 37 | MTW | MTWNPN201402 | NPN 2014, fresh sand topsoil/compost, natives drilled 2014 | Woodland |

*Notes: sample 10 renamed to HVOCHE 201301, and soil/compost treatment*
*Sample 38 deleted – not part of this project*

### *Objective*

This report discusses the soil properties at each site under different treatments, and compares the results to the reference sites. It also compares the soil in the reference sites under two different vegetation communities.

# 1 RESULTS

Table A in Appendix A provides data for each site, and includes maximum, minimum and average values for each treatment. The minimum to maximum values are called the ‘range’, and this section compares the values for the various soil treatments to the reference site ranges.

The reference sites have variable soil chemistry. pH range is acidic ranging from 5.4 to 6.6 in water, and the ECEC from 5.2 to 17.9. Lower ECEC is a feature of sandier soils, as they have less of an ability to retain cations. None of the samples are saline, with the maximum ECe 1.7 dS/m which is considered non-saline. One sample is sodic (ESP >6%), while the rest of the samples and the average are not sodic. Exchangeable hydrogen levels are highly variable ranging from 0 (for five samples) up to 59%, and reflects the variability in soil pH – exchangeable hydrogen levels increase as pH decreases. Organic matter levels range from 2.8 to 9.3%. Compared to a balanced agricultural soil, average cations are low in exchangeable calcium, and high in exchangeable magnesium. However, if this soil is


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'natural' for the environment, the revegetation species tolerate high levels of exchangeable hydrogen (stemming from a more acidic pH) and magnesium, and lower levels of exchangeable calcium.

The sites have good levels of microorganisms in total, however microbial diversity is below the ideal range set by Microbial Laboratories Australia. This simply indicates the reference sites naturally have high levels of only a few species of microorganisms.

Table 2 below presents a summary of key chemical parameters for the reference sites and each treatment. Table 3 presents a summary of microbial results.

Table 2 Summary of key parameters between sites

| Treatment | | pH ($H_2O$) | pH ($CaCl_2$) | ECe (dS/m) | ECEC (meq) | Ca (%) | Mg (%) | K (%) | Na (%) | H (%) | OM (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Reference Sites | Average | **5.9** | **5.2** | **0.7** | **12.3** | **37.3** | **24.3** | **3.8** | **2.7** | **31.4** | **5.1** |
| | Max | **6.6** | **6.1** | **1.7** | **17.9** | **73.7** | **46.7** | **7.1** | **8.7** | **58.8** | **9.3** |
| | Min | **5.4** | **4.6** | **0.4** | **5.2** | **14.9** | **11.8** | **2.4** | **0.2** | **0.0** | **2.8** |
| 1 Subsoil/ Compost | Average | 8.4 | 7.8 | 1.9 | 19.8 | 63.5 | 27.3 | 4.4 | 5.0 | 0.0 | 5.4 |
| | Max | 9.1 | 8.2 | 2.7 | 27.1 | 70.9 | 38.7 | 6.6 | 8.5 | 0.0 | 6.1 |
| | Min | 7.6 | 7.3 | 1.0 | 13.4 | 50.7 | 19.7 | 2.3 | 1.3 | 0.0 | 4.8 |
| 2 Topsoil/ Compost | Average | 7.8 | 7.3 | 1.5 | 16.2 | 63.7 | 28.6 | 3.9 | 3.7 | 0.0 | 4.7 |
| | Max | 8.6 | 7.8 | 2.8 | 23.2 | 75.3 | 37.9 | 4.6 | 10.0 | 0.0 | 8.7 |
| | Min | 6.9 | 6.6 | 0.6 | 8.9 | 48.5 | 18.7 | 3.4 | 0.4 | 0.0 | 3.0 |
| 3 Topsoil | Average | 7.3 | 6.9 | 1.2 | 11.5 | 50.0 | 41.3 | 4.6 | 4.3 | 0.0 | 3.6 |
| | Max | 7.9 | 7.5 | 3.2 | 15.9 | 61.1 | 53.6 | 6.8 | 9.6 | 0.0 | 6.1 |
| | Min | 6.6 | 6.2 | 0.6 | 1.9 | 35.7 | 29.4 | 2.2 | 1.0 | 0.0 | 1.5 |
| 4 Spoil/ Compost | Average | 8.7 | 8.0 | 2.2 | 20.5 | 49.6 | 36.2 | 3.1 | 11.2 | 0.0 | 4.4 |
| | Maximum | 9.6 | 8.7 | 4.2 | 28.1 | 70.3 | 49.1 | 4.2 | 43.6 | 0.0 | 8.3 |
| | Minimum | 8.0 | 7.6 | 1.3 | 14.8 | 24.1 | 24.5 | 2.1 | 2.1 | 0.0 | 2.1 |
| 5 Fresh Sand Topsoil/ Compost | | 6.7 | 6.1 | 0.7 | 3.9 | 79.7 | 14.9 | 3.8 | 0.5 | 0.0 | 3.1 |

*Note: there is only one data point for treatment 5, hence no maximum or minimum values are available*



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| | | | Bacteria | | | | | | | Eukaryotes, mg/Kg | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total microorganisms mg/kg | Total bacteria mg/kg | Total fungi mg/kg | Pseudomonas mg/kg | Actinomycetes mg/kg | Gram positive mg/kg | Gram negative mg/kg | Methane oxidisers mg/kg | Sulphur reducers mg/kg | True anaerobes mg/kg | Protozoa mg/kg | Mycorrhizal fungi mg/kg | Microbial diversity |
| *50* | *15* | *33.8* | *1* | *1* | *4* | *11* | *0.5* | *<0.005* | *<0.005* | *1.25* | *10* | *8* |
| 73.24 | 22.12 | 49.47 | 1.57 | 5.11 | 8.55 | 13.56 | 0.03 | 0.00 | 0.16 | 1.65 | 6.63 | 53.1 |
| 108.36 | 33.32 | 74.74 | 3.55 | 8.29 | 11.90 | 21.41 | 0.31 | 0.00 | 0.30 | 3.57 | 22.57 | 56.6 |
| 32.74 | 9.35 | 22.89 | 0.51 | 2.08 | 4.00 | 5.35 | 0.00 | 0.00 | 0.00 | 0.51 | 1.42 | 43.2 |
| 106.31 | 13.35 | 89.41 | 2.07 | 2.00 | 5.18 | 8.17 | 0.00 | 0.00 | 0.15 | 3.55 | 14.44 | 40.1 |
| 172.25 | 24.58 | 141.24 | 3.38 | 4.07 | 9.58 | 15.00 | 0.00 | 0.00 | 0.38 | 6.42 | 27.04 | 47.4 |
| 52.19 | 6.00 | 44.62 | 1.05 | 0.74 | 2.36 | 3.64 | 0.00 | 0.00 | 0.04 | 1.57 | 7.36 | 36.7 |
| 95.13 | 14.96 | 77.74 | 2.04 | 2.54 | 5.86 | 9.10 | 0.00 | 0.00 | 0.09 | 2.43 | 12.81 | 46.9 |
| 196.05 | 24.56 | 168.48 | 4.00 | 3.38 | 9.28 | 15.28 | 0.00 | 0.00 | 0.27 | 3.50 | 16.19 | 54.3 |
| 50.86 | 10.21 | 38.11 | 0.94 | 2.05 | 3.80 | 6.41 | 0.00 | 0.00 | 0.03 | 1.80 | 6.98 | 36.8 |
| 105.32 | 19.14 | 83.41 | 2.01 | 3.97 | 7.75 | 11.39 | 0.00 | 0.00 | 0.22 | 2.77 | 11.86 | 48.2 |
| 152.83 | 24.82 | 125.34 | 2.75 | 4.27 | 9.84 | 14.98 | 0.00 | 0.00 | 0.53 | 4.15 | 15.42 | 55.1 |
| 62.83 | 14.29 | 47.05 | 1.56 | 3.37 | 5.91 | 8.38 | 0.00 | 0.00 | 0.04 | 1.49 | 8.70 | 44.1 |
| 55.33 | 8.58 | 45.66 | 1.13 | 1.04 | 3.68 | 4.90 | 0.00 | 0.00 | 0.18 | 1.09 | 4.92 | 44.0 |
| 89.11 | 12.32 | 73.93 | 1.76 | 1.42 | 5.36 | 6.97 | 0.00 | 0.00 | 0.49 | 2.87 | 7.15 | 52.7 |
| 29.07 | 4.76 | 24.31 | 0.71 | 0.68 | 1.90 | 2.86 | 0.00 | 0.00 | 0.00 | 0.00 | 2.78 | 37.9 |

s undertaken on the treatment 5 sample.
d by Microbiology Laboratories Australia.

negative bacteria that are decomposers.
ia that grow hyphae like fungi. They are decomposers.
ethane as a fuel source. They can be either anaerobic or aerobic.
sulphur to hydrogen sulphide, and are active in anaerobic conditions.
e in anaerobic conditions.
organisms that feed on bacteria. They play a role in nutrient cycling.
e plant roots and can act as root extensions to access water and nutrients, and protect plant roots from predators and disease.

### *Treatment 1 Subsoil / compost*

Texture ranges from a sandy clay loam to a clay loam. The pH is alkaline ranging from 7.6 to 9.1 in water. Although all electrical conductivity (E.C.) values are above the reference sites maximum, the soil is not saline. The Effective Cation Exchange Capacity (ECEC) indicates a good nutrient holding capacity. Two samples have an Exchangeable Sodium Percentage (ESP) >6%, while two do not, and the soil is on average not sodic. For a soil to be considered sodic the ESP must be greater than 6%. Organic matter levels range from 4.8 – 6.1% and are considered good. Average microbial numbers generally exceed the guidelines except for total bacteria, gram negative bacteria and microbial diversity.

Compared to the reference sites, this treatment has a much higher pH. Salinity levels are higher however the soil is not considered saline. Exchangeable calcium (Ca), magnesium (Mg), sodium (Na) and hydrogen (H) fall within the reference range, however on average Ca, Mg, potassium (K) and Na are higher than the reference average. The ability to retain nutrients is higher. Except for nitrate (NO3) and iron (Fe), average plant available nutrient levels are higher than the reference site. Nitrate, iron and manganese (Mn) values fall within the reference value ranges. All phosphorus (P), calcium, boron (B), copper (Cu) and zinc (Zn) values are above the reference maximum. Potassium, magnesium, sulphate (SO4), and sodium results are within and above the reference range. Organic matter (%) average is similar and all results fall within the reference sites range.

Pseudomonas, methane oxidisers and sulphur reducers fall within the reference sites range. Numbers of actinomycetes, and microbial diversity are mostly below the reference minimum, while total fungi and fungi:bacteria ratio are above the reference maximum. Total microorganisms, total bacterial, gram positive and gram negative bacteria, true anaerobes and mycorrhizal fungi are all have one data point either above the reference maximum or below the reference minimum (see Table C, Appendix A).

### *Treatment 2 Topsoil / compost*

Soil textures range from sandy clay loam to sandy clay. The pH is neutral to alkaline ranging from 6.9 – 8.6 in water. The soil is, on average, not saline although three samples would be considered to have very slight salinity from an agricultural perspective. The ECEC indicates a good nutrient holding capacity. One sample has an ESP > 6% and is considered sodic, however on average the soil is not sodic. Organic matter levels range from 3.0 – 8.7% and are considered good. Average microbial numbers generally exceed the guidelines except for gram negative bacteria and microbial diversity.

Compared to the reference sites, this treatment has a higher pH. Salinity (ECe) values fall within the reference range, with five samples above the reference maximum. Overall the soil is not saline. The



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ECEC (ability to retain nutrients) is on average higher, with some values within the reference range and some above it. All exchangeable magnesium, potassium, and hydrogen values fall within the reference range. Most exchangeable sodium and calcium levels fall within the reference range. Apart from nitrate, with all values falling within the reference range, all other plant available nutrients are on average higher than the reference average. Except for one value, magnesium, sodium, iron and manganese fall within the reference range. Most phosphate, calcium, sulphate, boron, copper, and zinc values are above the reference maximum. All organic matter values fall within the reference range.

Total bacteria, gram negative bacteria, methane oxidisers, sulphur reducers, true anaerobes, protozoa, and mycorrhizal fungi fall within the reference sites range. Total microorganisms, total fungi, and pseudomonas have values within the reference range and above the reference maximum. Actinomycetes, gram positive bacteria, and microbial diversity have values within and below the reference range. The fungi:bacteria ratio values range from below the reference minimum to above the reference maximum.

### *Treatment 3 Topsoil*

Soil textures range from sandy clay loam to light clay. The pH is slightly acidic to alkaline, ranging from 6.6 to 7.9 in water. The soil is on average not saline. The ECEC indicates an average ability to retain nutrients. One sample has an ESP > 6% and is considered sodic, and on average the soil is not sodic. Organic matter levels range from 1.5 – 6.1% and are considered good. Average microbial numbers generally exceed the guidelines except microbial diversity.

Compared to the reference sites, this treatment has a higher pH, and higher average salinity however most values fall within the reference range and the soil is not considered saline. The ECEC is similar with all but one value falling within the reference range. All exchangeable calcium and hydrogen values fall within the reference range. Exchangeable magnesium, sodium and potassium are mostly within the reference range, with three Mg and one Na value above the reference maximum, and one K value below the reference minimum. All nitrate, phosphate, potassium, calcium, magnesium, sulphate, sodium, and boron values fall within the reference range. All copper levels are above the reference maximum. Iron, manganese and zinc are generally within the reference range. All organic matter values fall within the reference range.

Total fungi, pseudomonas, methane oxidisers and sulphur reducers fall within the reference sites range. Total microorganisms, total bacteria, gram positive and gram negative bacteria, protozoa and microbial diversity have values within and below the reference range. All actinomycetes values are below the reference minimum. The fungi: bacteria ratio ranges from within the reference range to above the reference maximum.


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### *Treatment 4   Spoil / compost*

Soil texture ranges from clay loam to light clay. The pH is very alkaline, ranging from 8.0 – 9.6 in water. The soil is on average very slightly saline. The ECEC indicates an excellent ability to retain nutrients. Two samples have an ESP > 6% and are considered highly sodic. The rest of the samples are not sodic. Organic matter levels range from 2.1 – 8.3%. Average microbial numbers are variable - total bacteria, gram positive and gram negative bacteria, protozoa, mycorrhizal fungi, and microbial diversity are below the guidelines. Total microorganisms, total fungi, pseudomonas, actinomycetes, and fungi:bacteria ratio are above the guidelines.

Compared to the reference sites, this treatment has a significantly higher pH. Salinity levels are higher and on average are considered very slightly saline. Two sites are causing this reading, with the remaining four sites considered not-saline. All exchangeable calcium and hydrogen values fall within the reference range. Exchangeable magnesium, sodium and potassium are mostly within the reference range, with two Mg and two Na values above the reference maximum, and one K value below the reference minimum. On average all plant available nutrients except for nitrate, iron and manganese are above the reference average.  All phosphorus, sulphate, copper and zinc levels are above the reference maximum. Most nitrate, potassium, sodium and manganese values fall within the reference range, with one nitrate and two manganese results below the reference minimum, and one potassium and two sodium values above the reference maximum. All organic matter values except one fall within the reference range.

Total bacteria, pseudomonas, actinomycetes, gram positive and gram negative bacteria, methane oxidisers, sulphur reducers, mycorrhizal fungi, and microbial diversity fall within the reference sites range. Total microorganisms, total fungi, true anaerobes, and protozoa have values within the reference range and above the reference maximum. The fungi:bacteria ratio values range from below the reference minimum to above the reference maximum.

### *Treatment 5   Fresh sand topsoil / compost*

There was only one soil sample taken for treatment five. This sandy soil has a slightly acidic pH, and is not saline. The ECEC is very low indicating a poor ability to retain nutrients. This is to be expected from a sand. The soil is not sodic. Organic matter is 3.1% which is considered moderate.

Compared to the reference sites, this soil has a similar pH and salinity level. The ECEC is lower. All exchangeable cations fall within the reference range. Nitrate, phosphorus, potassium, calcium, boron,


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copper, manganese and zinc fall within the reference range. Magnesium, sulphate, sodium, and iron are below the reference minimum. Organic matter levels are within the reference range.

Microbial analysis was not conducted on the treatment 5 sample.

### *Vegetation Communities*

Selected soil characteristics of the Central Hunter Ironbark/Spotted Gum/Grey-box forest, and the Central Hunter Grey-box/Ironbark woodland are compared in Table 4 below. All data is presented in Table B, Appendix A.

Table 4 Soil characteristics of different reference site vegetation communities

| Vege-tation | Sample Name | Texture | pH ($H_2O$) | pH $CaCl_2$ | Ece (dS/m) | ECEC (Meq) | Ca (%) | Mg (%) | K (%) | Na (%) | H (%) | OM (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Central Hunter Ironbark-Spotted Gum-Grey Box Forest | Bell 1 | Loam Fine Sandy | 5.6 | 4.64 | 0.5 | 12.0 | 15.2 | 21.6 | 3.3 | 2.1 | 55.8 | 6.4 |
| | Bell 2 | Loam Fine Sandy | 6.3 | 5.72 | 0.7 | 10.3 | 73.7 | 20.8 | 3.8 | 1.5 | 0 | 7.1 |
| | Bell 3 | Loam Fine Sandy | 5.9 | 5.03 | 0.7 | 17.0 | 31.2 | 22.4 | 2.6 | 2.9 | 40.2 | 9.3 |
| | WAMBO SPOT 1 | Sandy Loam | 5.9 | 5.08 | 0.6 | 10.7 | 38.4 | 11.8 | 3.3 | 0.2 | 46.5 | 4.6 |
| | WAMBO SPOT 2 | Clay Loam | 6.6 | 5.6 | 1 | 17.9 | 47 | 40.6 | 3.6 | 8.7 | 0 | 4.9 |
| | WAMBO SPOT 3 | Sandy Loam | 6.3 | 5.52 | 0.4 | 5.2 | 64.8 | 27.3 | 7.1 | 0.6 | 0 | 2.8 |
| | | **AVERAGE** | **6.10** | **5.27** | **0.65** | **12.2** | **45.1** | **24.1** | **3.9** | **2.7** | **23.8** | **5.9** |
| | | **MAX** | **6.60** | **5.72** | **1.00** | **17.9** | **73.7** | **40.6** | **7.1** | **8.7** | **55.8** | **9.3** |
| | | **MIN** | **5.60** | **4.64** | **0.40** | **5.2** | **15.2** | **11.8** | **2.6** | **0.2** | **0.0** | **2.8** |
| Central Hunter Grey Box-Ironbark Woodland | GBREF 3 | Fine Sandy Clay Loam | 5.7 | 5.06 | 0.4 | 15.6 | 43.1 | 16 | 3.7 | 1 | 36 | 6.8 |
| | GBREF 4 | Light Sandy Clay Loam | 5.4 | 4.6 | 0.4 | 8.7 | 20.8 | 16 | 3.8 | 1.7 | 56.7 | 2.9 |
| | GBREF 6 | Sandy Clay Loam | 5.7 | 5.14 | 0.6 | 13.2 | 23.4 | 25 | 2.4 | 2 | 47.1 | 3.9 |
| | WAMBO GB 01 | Clay Loam | 5.9 | 5.22 | 0.4 | 15.7 | 30.7 | 27.5 | 3.5 | 2.3 | 35.8 | 4.6 |
| | WAMBO GB 02 | Clay Loam | 6.6 | 6.06 | 0.5 | 14.2 | 44.9 | 46.7 | 5.6 | 3.2 | 0 | 5.3 |
| | REF 05 | Sandy Loam | 5.4 | 4.72 | 1.7 | 7.4 | 14.9 | 15.6 | 3.2 | 6.6 | 58.8 | 2.8 |
| | | **AVERAGE** | **5.78** | **5.13** | **0.67** | **12.47** | **29.6** | **24.5** | **3.7** | **2.8** | **39.1** | **4.4** |
| | | **MAX** | **6.60** | **6.06** | **1.70** | **15.70** | **44.9** | **46.7** | **5.6** | **6.6** | **58.8** | **6.8** |
| | | **MIN** | **5.40** | **4.60** | **0.40** | **7.40** | **14.9** | **15.6** | **2.4** | **1.0** | **0.0** | **2.8** |



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The Ironbark-spotted gum-grey box forest has an acidic ph. The soil is not saline. The ECEC suggests an average ability to retain nutrients. Exchangeable cations, particularly calcium, are highly variable. Organic matter levels are also highly variable, ranging from 2.8 – 9.3%.

The Grey box-ironbark woodland has an acidic pH. The soil is not saline. The ECEC suggests an average ability to retain nutrients. Exchangeable cations, particularly calcium, are highly variable. Organic matter levels are also highly variable, ranging from 2.8 – 6.8%.

# 2 DISCUSSION

### *Treatments*

The various soil treatments have produced growth mediums with different soil properties compared to the reference sites. The following conclusions have been drawn by comparing the average, maximum and minimum soil chemical data from treatments 1 – 5, with the average, maximum and minimum reference sites data. Neither target plant species nor site (MTW vs HVO) have been included in this assessment. Table 1 provides a summary of the average, maximum and minimum values per treatment. Table 3 provides microbial data. Tables A and C in Appendix A present all the data.

Treatment 1 subsoil / compost, has higher pH, ECEC, and salinity levels than the reference sites. Nitrogen, iron and manganese values are within the reference range, and all other plant available nutrients have increased compared to the reference data. Phosphorus levels are significantly higher than the reference average and range. Organic matter levels fall within the reference range. Microbes are variable, ranging from below the reference minimum to above the reference maximum.

Treatment 2 topsoil/compost, has higher pH, ECEC, salinity, and on average all plant available nutrient levels except for nitrate. Phosphorus levels are significantly higher than the reference average and range. Organic matter levels fall within the reference range. Microbes are variable, ranging from below the reference minimum to above the reference maximum, however in general results are within the reference range.

Treatment 3 topsoil, has slightly higher pH and salinity, however the soil is not considered saline. On average, all plant available nutrients except iron and manganese have increased. Phosphorus levels are on average slightly higher than the reference average. Organic matter results are on average lower but all fall within the reference range. Microbial results are general within or above the reference range.


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Treatment 4 spoil / compost, has significantly higher pH and salinity compared to the reference sites. The ECEC in this treatment is greater than the other treatments. On average this treatment is sodic (ESP>6%), however this is caused by one result of 12%, and a second of 44%. This result suggests highly variable sodium content in the mine spoils that have been used on each of these rehabilitation sites. Phosphorus levels are significantly higher than the reference average and range. Organic matter levels fall within the reference range. Microbial results are generally within or below the reference range.

Treatment 5 fresh sand topsoil / compost, has lower OM and nutrients levels than the other treatments. The ECEC is lower, and salinity levels are the same as the reference sites. The one site sampled has high exchangeable calcium levels however having only one sample makes it difficult to determine trends. The available phosphorus level is higher than the reference average but still suitable for moderately P sensitive species. Organic matter % is the lowest of all the treatments, but still falls within the reference site range. No microbial data is available.

Comparing the reference site averages to the various treatments, it is clear the treatments substituting spoil and subsoil for topsoil as the growth medium are resulting in growth mediums with increased pH and salinity. Based on advice provided by the Client, the virgin (pre-ameliorant) spoil and subsoil material used on the rehabilitation sites typically ranges in pH from 8.4 – 10 and 6.6 – 9.6 respectively; and the compost from 5.5 – 8.5. The highly alkaline nature of the spoil is reflected in the treatment 4 results which have the highest pH of all the treatments. The source spoil and subsoil material is likely to be the main cause of the observed increase in pH, however the compost may also be causing an increase in pH. This effect is seen in the higher pH levels observed between the Treatment 2 results for topsoil/compost plots compared to the treatment 3 samples taken from topsoil areas without compost applied to them.

Given that the subsoils, associated with the duplex soils that are common on the site (information from Client), are alkaline and plant roots are accessing these subsoils, it is therefore likely that the vegetation communities tolerate this high pH. The spoil appears to have variable levels of exchangeable sodium, causing extreme sodicity in one sample, and moderate sodicity in a second.

Although salinity levels have increased, the treatments are still not-saline or only very slightly saline.

Plant available nutrients have increased in treatments 1, 2 and 4, and is likely caused by the compost additions. Compost contains many plant available nutrients which become more available as the compost breaks down. Nutrients are generally within the reference range in treatment 3, and are within the range / declining in treatment 5. Treatments 1, 2 and 4 have also significantly increased available


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phosphorus levels. It is expected that over time the topsoil will acidify as calcium and other base cations are removed, and the will P become less available.

Microbial diversity is generally within the reference range, except for treatment 4 where results are within or below the reference range. The lack of sulphur reducers and anaerobes indicate the treatments aren't causing anaerobic conditions.

***Vegetation communities***

The soils taken from reference sites within the Central Hunter Ironbark/Spotted Gum/Grey-box forest and the Central Hunter Grey-box/Ironbark woodland are very similar. Notable differences lie in exchangeable calcium levels, with the Ironbark/Spotted Gum/Grey-box forest having more variable levels. Nitrate, sodium, manganese and organic matter levels in the Ironbark/Spotted Gum/Grey-box forest are more variable, potassium in the Grey-box/Ironbark woodland are more variable, while phosphorus, calcium, magnesium, sulphate, boron, copper, iron and zinc have similar averages and ranges. The soil microbes have similar ranges and averages between the two communities.

Overall the soils in the two communities are similar.

# 3 Conclusions

The reference vegetation is growing in soils that are generally acidic, not saline, and have highly variable cation balance and plant available nutrient levels. Soil biology in the reference sites is on average above the guideline values, except for microbial diversity and mycorrhizal fungi. The soil in the two reference site vegetation communities is similar.

Based on this analysis, treatment 3 (topsoil) is producing soil most similar to the reference site range. Treatment 5 (sand topsoil / compost) has caused a general decline in soil fertility. Treatments 1, 2, and 4 have produced growth mediums with increased pH and nutrient levels, with most values above the reference maximums. Treatment 4 has also caused a general decline in microbial numbers. The spoil and subsoil are alkaline, causing the increase in pH. The compost is likely to be variable, and could be occasionally alkaline and contributing to the rise in pH.

The duplex soils at HVO and MTW tend to have acidic topsoils overlaying alkaline subsoils (Bill Baxter pers comms). Given that the vegetation communities have roots accessing the subsoil zones, it is likely that the plants making up these communities are tolerant of alkaline conditions. The increase in pH caused by the use of spoils and subsoils in rehabilitation areas may therefore be less of a concern. It is


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recommended however that the relationship between the pH of growth mediums and the level of establishment of the desired vegetation continue to be monitored. This monitoring will be important to determine if the use of spoils and subsoils should continue or alternative growth mediums used that more closely mimic the natural site soil pH levels.

Please do not hesitate to contact our office if you have any questions.

**SESL AUSTRALIA**

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# Appendix A
# Laboratory Results



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| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bell 1 | Loam Fine Sandy | 5.6 | 4.64 | 0.05 | 0.5 | 12 | 15.2 | 21.6 | 3.3 | 2.1 | 55.8 | 8.82 | 8.3 | 156 | 365 | 315 | 10 | 57.6 | 0.1 | 0.64 | 293 |
| Bell 2 | Loam Fine Sandy | 6.3 | 5.72 | 0.07 | 0.7 | 10.3 | 73.7 | 20.8 | 3.8 | 1.5 | 0 | 18 | 6.4 | 152 | 1522 | 260 | 11 | 34.9 | 0.4 | 0.64 | 198 |
| Bell 3 | Loam Fine Sandy | 5.9 | 5.03 | 0.07 | 0.7 | 17 | 31.2 | 22.4 | 2.6 | 2.9 | 40.2 | 6.93 | 6.4 | 170 | 1064 | 463 | 11 | 116 | 0.3 | 0.64 | 257 |
| GBREF 3 | Fine Sandy Clay Loam | 5.7 | 5.06 | 0.05 | 0.4 | 15.6 | 43.1 | 16 | 3.7 | 1 | 36 | 3.51 | 10 | 226 | 1346 | 303 | 14 | 34.1 | 0.2 | 0.6 | 196 |
| GBREF 4 | Light Sandy Clay Loam | 5.4 | 4.6 | 0.04 | 0.4 | 8.7 | 20.8 | 16 | 3.8 | 1.7 | 56.7 | 1.96 | 6.8 | 130 | 363 | 169 | 11 | 33.7 | 0.1 | 0.64 | 254 |
| GBREF 6 | Sandy Clay Loam | 5.7 | 5.14 | 0.06 | 0.6 | 13.2 | 23.4 | 25 | 2.4 | 2 | 47.1 | 1.4 | 13.2 | 125 | 619 | 401 | 11 | 62.9 | 0.1 | 0.64 | 241 |
| WAMBOG B 01 | Clay Loam | 5.9 | 5.22 | 0.05 | 0.4 | 15.7 | 30.7 | 27.5 | 3.5 | 2.3 | 35.8 | 1.94 | 6.3 | 216 | 967 | 525 | 9.7 | 83.3 | 0.1 | 0.64 | 188 |
| WAMBOG B 02 | Clay Loam | 6.6 | 6.06 | 0.06 | 0.5 | 14.2 | 44.9 | 46.7 | 5.6 | 3.2 | 0 | 2.58 | 3.3 | 309 | 1277 | 806 | 8.2 | 104 | 0.2 | 0.64 | 130 |
| WAMBOS POT 1 | Sandy Loam | 5.9 | 5.08 | 0.04 | 0.6 | 10.7 | 38.4 | 11.8 | 3.3 | 0.2 | 46.5 | 10.1 | 8.3 | 138 | 823 | 154 | 9.4 | 4.5 | 0.1 | 0.64 | 173 |
| WAMBOS POT 2 | Clay Loam | 6.6 | 5.6 | 0.12 | 1 | 17.9 | 47 | 40.6 | 3.6 | 8.7 | 0 | 0.942 | 4.1 | 256 | 1688 | 884 | 12 | 359 | 0.2 | 0.64 | 162 |
| WAMBOS POT 3 | Sandy Loam | 6.3 | 5.52 | 0.03 | 0.4 | 5.2 | 64.8 | 27.3 | 7.1 | 0.6 | 0 | 2.18 | 12.6 | 143 | 674 | 173 | 7.6 | 6.5 | 0.1 | 0.64 | 129 |
| REF 05 | Sandy Loam | 5.4 | 4.72 | 0.12 | 1.7 | 7.4 | 14.9 | 15.6 | 3.2 | 6.6 | 58.8 | 0.265 | 4.2 | 94.4 | 220 | 140 | 12 | 113 | 0.1 | 0.64 | 237 |
| | **Average** | **5.9** | **5.2** | **0.06** | **0.7** | **12.3** | **37.3** | **24.3** | **3.8** | **2.7** | **31.4** | **4.9** | **7.5** | **176.3** | **910.7** | **382.8** | **10.6** | **84.1** | **0.2** | **0.6** | **204.8** |
| | **MAX** | **6.6** | **6.1** | **0.12** | **1.7** | **17.9** | **73.7** | **46.7** | **7.1** | **8.7** | **58.8** | **18.0** | **13.2** | **309.0** | **1688.0** | **884.0** | **14.0** | **359.0** | **0.4** | **0.6** | **293.0** |
| | **MIN** | **5.4** | **4.6** | **0.03** | **0.4** | **5.2** | **14.9** | **11.8** | **2.4** | **0.2** | **0.0** | **0.3** | **3.3** | **94.4** | **220.0** | **140.0** | **7.6** | **4.5** | **0.1** | **0.6** | **129.0** |
| HVORIV2 01402 | Clay Loam | 9.1 | 8.15 | 0.29 | 2.5 | 27.1 | 50.7 | 38.7 | 2.3 | 8.5 | 0 | 3.07 | 62.3 | 239 | 2752 | 1274 | 75 | 529 | 1 | 4.6 | 131 |
| HVORIV2 01404 | Clay Loam | 8.5 | 7.93 | 0.31 | 2.7 | 22.1 | 62.2 | 27.6 | 3.8 | 6.3 | 0 | 6.18 | 85.2 | 330 | 2754 | 740 | 112 | 321 | 1.2 | 5.9 | 210 |
| HVORIV2 01405 | Sandy Clay Loam | 8.4 | 7.65 | 0.11 | 1 | 13.4 | 70 | 19.7 | 6.6 | 3.7 | 0 | 4.01 | 123 | 346 | 1880 | 320 | 13 | 115 | 0.6 | 4.4 | 197 |
| MTWNPN 201403 | Clay Loam | 7.6 | 7.3 | 0.17 | 1.5 | 16.6 | 70.9 | 23.2 | 4.7 | 1.3 | 0 | 3.72 | 148 | 304 | 2359 | 468 | 51 | 47.5 | 0.7 | 4.8 | 251 |
| | **Average** | **8.4** | **7.8** | **0.2** | **1.9** | **19.8** | **63.5** | **27.3** | **4.4** | **5.0** | **0.0** | **4.2** | **104.6** | **304.8** | **2436.3** | **700.5** | **62.8** | **253.1** | **0.9** | **4.9** | **197.3** |
| | **Maximum** | **9.1** | **8.2** | **0.3** | **2.7** | **27.1** | **70.9** | **38.7** | **6.6** | **8.5** | **0.0** | **6.2** | **148.0** | **346.0** | **2754.0** | **1274.0** | **112.0** | **529.0** | **1.2** | **5.9** | **251.0** |
| | **Minimum** | **7.6** | **7.3** | **0.1** | **1.0** | **13.4** | **50.7** | **19.7** | **2.3** | **1.3** | **0.0** | **3.1** | **62.3** | **239.0** | **1880.0** | **320.0** | **13.0** | **47.5** | **0.6** | **4.4** | **131.0** |
| HVORIV2 01406 | Clay Loam | 8.1 | 7.48 | 0.13 | 1.1 | 23.2 | 63.8 | 28.8 | 3.6 | 3.6 | 0 | 6.67 | 93.6 | 326 | 2966 | 812 | 22 | 194 | 0.8 | 4.5 | 262 |
| HVORIV2 01301 | Clay Loam | 8.6 | 7.79 | 0.24 | 2.1 | 22.4 | 48.5 | 37.9 | 3.4 | 10 | 0 | 11.6 | 18.3 | 300 | 2177 | 1031 | 30 | 518 | 0.9 | 3 | 162 |
| MTWNPN 201301 | Sandy Clay Loam | 7 | 6.96 | 0.16 | 1.5 | 8.9 | 73.9 | 19.8 | 4.6 | 1.3 | 0 | 1.07 | 28.7 | 159 | 1319 | 214 | 66 | 27.3 | 0.3 | 1.7 | 291 |
| MTWNPN 201101 | Clay Loam | 7.9 | 7.39 | 0.07 | 0.6 | 12.9 | 63.5 | 32.2 | 3.6 | 0.4 | 0 | 2.01 | 1.2 | 184 | 1641 | 505 | 11 | 11.7 | 0.4 | 1.8 | 129 |
| MTWSPN 201401 | Clay Loam | 8.1 | 7.27 | 0.11 | 0.9 | 13.8 | 67.8 | 26.5 | 3.8 | 2 | 0 | 2.09 | 29.7 | 208 | 1877 | 444 | 21 | 62.3 | 0.5 | 3.7 | 226 |
| MTWWDL 201402 | Clay Loam | 8 | 7.43 | 0.27 | 2.3 | 17.9 | 59.1 | 31.9 | 4.1 | 5 | 0 | 8.65 | 67.2 | 284 | 2118 | 693 | 127 | 205 | 0.6 | 4.7 | 310 |
| MTWNPN 201401 | Fine Sandy Clay Loam | 6.9 | 6.55 | 0.18 | 1.5 | 11.4 | 59 | 33.3 | 4.1 | 3.9 | 0 | 0.9 | 31.2 | 184 | 1348 | 462 | 54 | 102 | 0.3 | 3.3 | 263 |
| HVOCHE 201201 | Clay Loam | 7.9 | 7.13 | 0.13 | 1.1 | 15.2 | 67.2 | 23.7 | 4.5 | 4.5 | 0 | 10.9 | 69.4 | 267 | 2047 | 438 | 15 | 157 | 0.5 | 4 | 234 |
| HVOCAR2 01401 | Clay Loam | 7.5 | 6.76 | 0.17 | 1.5 | 20.1 | 59.5 | 32.1 | 4.6 | 3.8 | 0 | 1.3 | 42.2 | 361 | 2398 | 783 | 50 | 177 | 1.4 | 3.3 | 192 |
| HVOWES 2013-02 | Clay Loam | 8 | 7.45 | 0.15 | 1.3 | 13.6 | 61.8 | 32.1 | 4.2 | 2.2 | 0 | 2.07 | 23 | 222 | 1684 | 531 | 26 | 69.7 | 0.8 | 4 | 188 |
| HVOCHE S2012-03 | Sandy Loam | 8.2 | 7.63 | 0.12 | 1.7 | 15.5 | 73.5 | 19.4 | 3.4 | 3.7 | 0 | 3.99 | 117.1 | 203 | 2283 | 366 | 21 | 132 | 1.2 | 5.6 | 199 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Maximum** | **8.6** | **7.8** | **0.3** | **2.8** | **23.2** | **75.3** | **37.9** | **4.6** | **10.0** | **0.0** | **11.6** | **128.7** | **361.0** | **3002.0** | **1031.0** | **210.0** | **518.0** | **1.4** | **5.9** | **310.0** |
| | **Minimum** | **6.9** | **6.6** | **0.1** | **0.6** | **8.9** | **48.5** | **18.7** | **3.4** | **0.4** | **0.0** | **0.9** | **1.2** | **159.0** | **1319.0** | **214.0** | **11.0** | **11.7** | **0.3** | **1.7** | **129.0** |
| HVOWES 2008-01 | Clay Loam | 7.2 | 6.72 | 0.08 | 0.7 | 12.3 | 55.4 | 38.1 | 5 | 1.1 | 0 | 4.46 | 2.9 | 237 | 1367 | 569 | 11 | 32.1 | 0.4 | 1.7 | 127 |
| HVOCAR2 00901 | Light Clay | 7.7 | 6.98 | 0.07 | 0.6 | 15.9 | 35.7 | 53.6 | 5 | 5.8 | 0 | 1.79 | 2.8 | 314 | 1137 | 1035 | 8.8 | 213 | 0.5 | 1.7 | 143 |
| HVOCAR2 00902 | Light Medium Clay | 7.9 | 7.53 | 0.14 | 1.1 | 1.9 | 61.1 | 33 | 4.2 | 3.2 | 0 | 2.18 | 3.4 | 32.1 | 232 | 76 | 3.2 | 14.2 | 0.1 | 0.64 | 18.5 |
| MTWCDD 201101 | Clay Loam | 7.3 | 6.59 | 0.09 | 0.8 | 12.1 | 50.6 | 38.4 | 5.5 | 5.7 | 0 | 9.68 | 1 | 262 | 1225 | 564 | 15 | 159 | 0.3 | 1.3 | 265 |
| MTWWDL 201401 | Clay Loam | 7.1 | 7.08 | 0.37 | 3.2 | 14.3 | 59.4 | 29.4 | 5.3 | 5.9 | 0 | 3.74 | 90.5 | 298 | 1702 | 510 | 167 | 196 | 0.3 | 2.2 | 307 |
| MTWNPN 200901 | Clay Loam | 6.8 | 6.36 | 0.08 | 0.7 | 12.6 | 59 | 35.5 | 4.4 | 1 | 0 | 2.7 | 0.9 | 220 | 1490 | 543 | 17 | 26.7 | 0.3 | 1.7 | 221 |
| MTWMTO 200503 | Sandy Clay Loam | 7.8 | 7.38 | 0.26 | 2.5 | 12.3 | 44.5 | 44.8 | 2.2 | 8.6 | 0 | 2.24 | 6 | 104 | 1095 | 670 | 96 | 244 | 0.1 | 0.64 | 131 |
| MTWNPN 200501 | Clay Loam | 7.4 | 7.05 | 0.08 | 0.7 | 10.9 | 47.7 | 44.6 | 6.8 | 1.3 | 0 | 13.7 | 2.7 | 289 | 1042 | 591 | 9.9 | 33.3 | 0.3 | 0.9 | 166 |
| MTWNPN 200502 | Sandy Clay Loam | 6.6 | 6.19 | 0.08 | 0.8 | 10.7 | 46.4 | 47.4 | 5.2 | 1.2 | 0 | 13.1 | 1.8 | 220 | 994 | 616 | 15 | 30.1 | 0.3 | 0.9 | 227 |
| MTWTO2 00001 | Sandy Clay | 7.6 | 7.02 | 0.13 | 1.1 | 12 | 39.9 | 47.7 | 2.7 | 9.6 | 0 | 4.67 | 15.7 | 126 | 959 | 696 | 20 | 263 | 0.1 | 1.1 | 186 |
| | **Average** | **7.34** | **6.89** | **0.138** | **1.22** | **11.5** | **49.97** | **41.25** | **4.63** | **4.34** | **0** | **5.826** | **12.77** | **210.21** | **1124.3** | **587** | **36.29** | **121.14** | **0.27** | **1.278** | **179.15** |
| | **Maximum** | **7.9** | **7.53** | **0.37** | **3.2** | **15.9** | **61.1** | **53.6** | **6.8** | **9.6** | **0** | **13.7** | **90.5** | **314** | **1702** | **1035** | **167** | **263** | **0.5** | **2.2** | **307** |
| | **Minimum** | **6.6** | **6.19** | **0.07** | **0.6** | **1.9** | **35.7** | **29.4** | **2.2** | **1** | **0** | **1.79** | **0.9** | **32.1** | **232** | **76** | **3.2** | **14.2** | **0.1** | **0.64** | **18.5** |
| HVORIV2 01401 | Clay Loam | 9 | 8.23 | 0.37 | 3.2 | 28.1 | 43.7 | 41.3 | 3.2 | 11.7 | 0 | 6.71 | 71.4 | 354 | 2463 | 1409 | 65 | 755 | 1.1 | 4.1 | 119 |
| HVORIV2 01403 | Clay Loam | 8.7 | 7.89 | 0.15 | 1.3 | 22.2 | 49.7 | 42 | 3 | 5.3 | 0 | 2.27 | 90.9 | 258 | 2212 | 1134 | 29 | 272 | 0.9 | 6.8 | 250 |
| HVOWES 2011-01 | Light Clay | 8.4 | 7.74 | 0.19 | 1.6 | 22.6 | 46.7 | 49.1 | 2.1 | 2.2 | 0 | 2.04 | 25.8 | 186 | 2115 | 1349 | 58 | 114 | 0.2 | 4 | 88.8 |
| HVOCHE2 013-01 | Clay Loam | 8.6 | 7.92 | 0.15 | 1.3 | 19 | 62.8 | 32 | 2.8 | 2.1 | 0 | 3.44 | 62.3 | 210 | 2391 | 739 | 22 | 92.9 | 0.5 | 4.8 | 116 |
| MTWCDD 201501 | Clay Loam | 8 | 7.55 | 0.21 | 1.8 | 14.8 | 70.3 | 24.5 | 3.2 | 2.1 | 0 | 13.4 | 153 | 186 | 2087 | 441 | 83 | 72 | 0.5 | 5.7 | 237 |
| MTWTDI2 01501 | Clay Loam | 9.6 | 8.66 | 0.49 | 4.2 | 16.5 | 24.1 | 28 | 4.2 | 43.6 | 0 | 0.05 | 7.5 | 268 | 795 | 560 | 124 | 1654 | 0.4 | 9.3 | 262 |
| | **Average** | **8.7** | **8.0** | **0.3** | **2.2** | **20.5** | **49.6** | **36.2** | **3.1** | **11.2** | **0.0** | **4.7** | **68.5** | **243.7** | **2010.5** | **938.7** | **63.5** | **493.3** | **0.6** | **5.8** | **178.8** |
| | **Maximum** | **9.6** | **8.7** | **0.5** | **4.2** | **28.1** | **70.3** | **49.1** | **4.2** | **43.6** | **0.0** | **13.4** | **153.0** | **354.0** | **2463.0** | **1409.0** | **124.0** | **1654.0** | **1.1** | **9.3** | **262.0** |
| | **Minimum** | **8.0** | **7.6** | **0.2** | **1.3** | **14.8** | **24.1** | **24.5** | **2.1** | **2.1** | **0.0** | **0.1** | **7.5** | **186.0** | **795.0** | **441.0** | **22.0** | **72.0** | **0.2** | **4.0** | **88.8** |
| MTWNPN 201402 | Sand | 6.7 | 6.11 | 0.03 | 0.7 | 3.9 | 79.7 | 14.9 | 3.8 | 0.5 | 0 | 0.284 | 20.2 | 57.7 | 623 | 70 | 7.5 | 3.6 | 0.1 | 0.8 | 108 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8 | Loam Fine Sandy | 5.6 | 4.64 | 0.05 | 0.5 | 12 | 15.2 | 21.6 | 3.3 | 2.1 | 55.8 | 8.82 | 8.3 | 156 | 365 | 315 | 10 | 57.6 | 0.1 | 0.64 | 293 |
| | 9 | Loam Fine Sandy | 6.3 | 5.72 | 0.07 | 0.7 | 10.3 | 73.7 | 20.8 | 3.8 | 1.5 | 0 | 18 | 6.4 | 152 | 1522 | 260 | 11 | 34.9 | 0.4 | 0.64 | 198 |
| | 20 | Loam Fine Sandy | 5.9 | 5.03 | 0.07 | 0.7 | 17 | 31.2 | 22.4 | 2.6 | 2.9 | 40.2 | 6.93 | 6.4 | 170 | 1064 | 463 | 11 | 116 | 0.3 | 0.64 | 257 |
| DT | 26 | Sandy Loam | 5.9 | 5.08 | 0.04 | 0.6 | 10.7 | 38.4 | 11.8 | 3.3 | 0.2 | 46.5 | 10.1 | 8.3 | 138 | 823 | 154 | 9.4 | 4.5 | 0.1 | 0.64 | 173 |
| DT | 27 | Clay Loam | 6.6 | 5.6 | 0.12 | 1 | 17.9 | 47 | 40.6 | 3.6 | 8.7 | 0 | 0.942 | 4.1 | 256 | 1688 | 884 | 12 | 359 | 0.2 | 0.64 | 162 |
| DT | 28 | Sandy Loam | 6.3 | 5.52 | 0.03 | 0.4 | 5.2 | 64.8 | 27.3 | 7.1 | 0.6 | 0 | 2.18 | 12.6 | 143 | 674 | 173 | 7.6 | 6.5 | 0.1 | 0.64 | 129 |
| | | **AVERAGE** | **6.10** | **5.27** | **0.06** | **0.7** | **12.2** | **45.1** | **24.1** | **3.9** | **2.7** | **23.8** | **7.83** | **7.68** | **169** | **10223** | **374.83** | **10.17** | **96.42** | **0.20** | **0.64** | **202** |
| | | **MAX** | **6.60** | **5.72** | **0.12** | **1.0** | **17.9** | **73.7** | **40.6** | **7.1** | **8.7** | **55.8** | **18.00** | **12.60** | **256** | **1688** | **884.00** | **12.00** | **359.00** | **0.40** | **0.64** | **293** |
| | | **MIN** | **5.60** | **4.64** | **0.03** | **0.4** | **5.2** | **15.2** | **11.8** | **2.6** | **0.2** | **0.0** | **0.94** | **4.10** | **138** | **365** | **154.00** | **7.60** | **4.50** | **0.10** | **0.64** | **129** |
| | 21 | Fine Sandy Clay Loam | 5.7 | 5.06 | 0.05 | 0.4 | 15.6 | 43.1 | 16 | 3.7 | 1 | 36 | 3.51 | 10 | 226 | 1346 | 303 | 14 | 34.1 | 0.2 | 0.6 | 196 |
| | 22 | Light Sandy Clay Loam | 5.4 | 4.6 | 0.04 | 0.4 | 8.7 | 20.8 | 16 | 3.8 | 1.7 | 56.7 | 1.96 | 6.8 | 130 | 363 | 169 | 11 | 33.7 | 0.1 | 0.64 | 254 |
| | 23 | Sandy Clay Loam | 5.7 | 5.14 | 0.06 | 0.6 | 13.2 | 23.4 | 25 | 2.4 | 2 | 47.1 | 1.4 | 13.2 | 125 | 619 | 401 | 11 | 62.9 | 0.1 | 0.64 | 241 |
| | 24 | Clay Loam | 5.9 | 5.22 | 0.05 | 0.4 | 15.7 | 30.7 | 27.5 | 3.5 | 2.3 | 35.8 | 1.94 | 6.3 | 216 | 967 | 525 | 9.7 | 83.3 | 0.1 | 0.64 | 188 |
| | 25 | Clay Loam | 6.6 | 6.06 | 0.06 | 0.5 | 14.2 | 44.9 | 46.7 | 5.6 | 3.2 | 0 | 2.58 | 3.3 | 309 | 1277 | 806 | 8.2 | 104 | 0.2 | 0.64 | 130 |
| | 29 | Sandy Loam | 5.4 | 4.72 | 0.12 | 1.7 | 7.4 | 14.9 | 15.6 | 3.2 | 6.6 | 58.8 | 0.265 | 4.2 | 94.4 | 220 | 140 | 12 | 113 | 0.1 | 0.64 | 237 |
| | | **AVERAGE** | **5.78** | **5.13** | **0.06** | **0.7** | **12.5** | **29.6** | **24.5** | **3.7** | **2.80** | **39.1** | **1.94** | **7.30** | **183** | **799** | **391** | **10.9** | **71.8** | **0.13** | **0.63** | **208** |
| | | **MAX** | **6.60** | **6.06** | **0.12** | **1.7** | **15.7** | **44.9** | **46.7** | **5.6** | **6.60** | **58.8** | **3.51** | **13.20** | **309** | **1346** | **806** | **14.0** | **113.0** | **0.20** | **0.64** | **254** |
| | | **MIN** | **5.40** | **4.60** | **0.04** | **0.4** | **7.4** | **14.9** | **15.6** | **2.4** | **1.00** | **0.0** | **0.27** | **3.30** | **94** | **220** | **140** | **8.2** | **33.7** | **0.10** | **0.60** | **130** |

| | | organisms mg/kg | Total bacteria mg/kg | Total fungi mg/kg | monas mg/kg | mycetes mg/kg | positive mg/kg | negative mg/kg | oxidisers mg/kg | reducers mg/kg | anaerobes mg/kg | Protozoa mg/kg | fungi mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bacteria | | | | | | | Eukaryotes | |
| | ***Guideline*** | ***50*** | ***15*** | ***33.8*** | ***1*** | ***1*** | ***4*** | ***11*** | ***0.5*** | ***<0.005*** | ***<0.005*** | ***1.25*** | |
| 8 | Bell 1 | 70.7 | 24.7 | 44.8 | 1.4 | 6.4 | 9.6 | 15.1 | 0.0 | 0.0 | 0.2 | 1.2 | |
| 9 | Bell 2 | 66.0 | 22.6 | 42.1 | 2.0 | 5.0 | 8.4 | 14.3 | 0.0 | 0.0 | 0.2 | 1.3 | |
| 0 | Bell 3 | 94.7 | 33.3 | 59.6 | 2.1 | 8.3 | 11.9 | 21.4 | 0.0 | 0.0 | 0.3 | 1.7 | |
| 1 | GBREF 3 | 102.6 | 24.5 | 74.6 | 1.6 | 6.0 | 9.9 | 14.6 | 0.0 | 0.0 | 0.3 | 3.6 | |
| 2 | GBREF 4 | 52.6 | 17.0 | 33.8 | 1.0 | 3.5 | 7.3 | 9.7 | 0.0 | 0.0 | 0.0 | 1.8 | |
| 3 | GBREF 6 | 87.2 | 23.7 | 61.8 | 1.4 | 5.7 | 9.7 | 13.9 | 0.0 | 0.0 | 0.2 | 1.8 | |
| 4 | WAMBOGB 01 | 86.3 | 24.0 | 60.6 | 1.6 | 5.4 | 10.1 | 13.9 | 0.0 | 0.0 | 0.2 | 1.7 | |
| 5 | WAMBOGB 02 | 108.4 | 31.4 | 74.7 | 3.5 | 5.4 | 11.1 | 20.3 | 0.3 | 0.0 | 0.2 | 2.2 | 2 |
| 6 | WAMBOSPOT 1 | 54.7 | 17.4 | 36.1 | 1.1 | 4.3 | 6.2 | 11.2 | 0.0 | 0.0 | 0.0 | 1.1 | |
| 7 | WAMBOSPOT 2 | 75.3 | 21.8 | 51.5 | 1.5 | 5.4 | 8.4 | 13.4 | 0.0 | 0.0 | 0.2 | 2.1 | |
| 8 | WAMBOSPOT 3 | 47.7 | 15.6 | 31.2 | 1.1 | 3.8 | 6.1 | 9.6 | 0.0 | 0.0 | 0.2 | 0.9 | |
| 9 | REF 05 | 32.7 | 9.3 | 22.9 | 0.5 | 2.1 | 4.0 | 5.3 | 0.0 | 0.0 | 0.0 | 0.5 | |
| | **AVERAGE** | **73.2** | **22.1** | **49.5** | **1.6** | **5.1** | **8.6** | **13.6** | **0.0** | **0.0** | **0.2** | **1.7** | |
| | **MAX** | **108.4** | **33.3** | **74.7** | **3.5** | **8.3** | **11.9** | **21.4** | **0.3** | **0.0** | **0.3** | **3.6** | **2** |
| | **MIN** | **32.7** | **9.3** | **22.9** | **0.5** | **2.1** | **4.0** | **5.3** | **0.0** | **0.0** | **0.0** | **0.5** | |
| 2 | HVORIV201402 | 52.2 | 6.0 | 44.6 | 1.0 | 0.7 | 2.4 | 3.6 | 0.0 | 0.0 | 0.1 | 1.6 | |
| 4 | HVORIV201404 | 105.7 | 11.9 | 92.0 | 1.8 | 1.7 | 4.7 | 7.2 | 0.0 | 0.0 | 0.1 | 1.8 | |
| 5 | HVORIV201405 | 95.1 | 10.9 | 79.8 | 2.0 | 1.5 | 4.1 | 6.8 | 0.0 | 0.0 | 0.0 | 4.4 | 1 |
| 6 | MTWNPN201403 | 172.2 | 24.6 | 141.2 | 3.4 | 4.1 | 9.6 | 15.0 | 0.0 | 0.0 | 0.4 | 6.4 | 2 |
| | **AVERAGE** | **106.3** | **13.4** | **89.4** | **2.1** | **2.0** | **5.2** | **8.2** | **0.0** | **0.0** | **0.1** | **3.5** | **1** |
| | **MAX** | **172.2** | **24.6** | **141.2** | **3.4** | **4.1** | **9.6** | **15.0** | **0.0** | **0.0** | **0.4** | **6.4** | **2** |
| | **MIN** | **52.2** | **6.0** | **44.6** | **1.0** | **0.7** | **2.4** | **3.6** | **0.0** | **0.0** | **0.0** | **1.6** | |
| 6 | HVORIV201406 | 196.1 | 24.6 | 168.5 | 4.0 | 3.4 | 9.3 | 15.3 | 0.0 | 0.0 | 0.3 | 3.0 | 1 |
| 7 | HVORIV201301 | 76.7 | 14.9 | 59.0 | 1.8 | 2.6 | 6.1 | 8.8 | 0.0 | 0.0 | 0.1 | 2.7 | 1 |
| 7 | MTWNPN201301 | 50.9 | 10.2 | 38.1 | 0.9 | 2.3 | 3.8 | 6.4 | 0.0 | 0.0 | 0.0 | 2.5 | 1 |
| 8 | MTWNPN201101 | 109.5 | 12.1 | 93.9 | 1.9 | 2.4 | 4.3 | 7.7 | 0.0 | 0.0 | 0.0 | 3.5 | 1 |
| 1 | MTWSPN201401 | 119.9 | 16.2 | 101.8 | 2.4 | 2.2 | 6.5 | 9.6 | 0.0 | 0.0 | 0.2 | 1.8 | 1 |
| 1 | HVOCHE 201201 | 70.4 | 14.9 | 53.4 | 1.8 | 2.9 | 5.9 | 9.0 | 0.0 | 0.0 | 0.1 | 2.0 | |
| 0 | HVOCAR201401 | 60.8 | 14.1 | 44.9 | 1.4 | 2.4 | 5.9 | 8.1 | 0.0 | 0.0 | 0.1 | 1.8 | 1 |
| 0 | HVOCHE201301 | 76.9 | 12.8 | 62.2 | 2.1 | 2.0 | 5.0 | 7.8 | 0.0 | 0.0 | 0.0 | 1.9 | 1 |
| | **AVERAGE** | **95.1** | **15.0** | **77.7** | **2.0** | **2.5** | **5.9** | **9.1** | **0.0** | **0.0** | **0.1** | **2.4** | **1** |
| | **MAX** | **196.1** | **24.6** | **168.5** | **4.0** | **3.4** | **9.3** | **15.3** | **0.0** | **0.0** | **0.3** | **3.5** | **1** |
| | **MIN** | **50.9** | **10.2** | **38.1** | **0.9** | **2.0** | **3.8** | **6.4** | **0.0** | **0.0** | **0.0** | **1.8** | |
| 2 | MTWCDD201101 | 100.3 | 18.3 | 77.9 | 1.7 | 4.3 | 7.5 | 10.8 | 0.0 | 0.0 | 0.1 | 4.2 | 1 |
| 5 | MTWWDL201401 | 152.8 | 24.8 | 125.3 | 2.8 | 4.3 | 9.8 | 15.0 | 0.0 | 0.0 | 0.5 | 2.7 | 1 |
| 9 | MTWNPN200501 | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **MIN** | **62.8** | **14.3** | **47.1** | **1.6** | **3.4** | **5.9** | **8.4** | **0.0** | **0.0** | **0.0** | **1.5** |
| 1 | HVORIV201401 | 29.1 | 4.8 | 24.3 | 0.7 | 0.7 | 1.9 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | HVORIV201403 | 55.8 | 6.3 | 48.7 | 1.0 | 0.7 | 2.6 | 3.7 | 0.0 | 0.0 | 0.0 | 0.8 |
| 3 | MTWCDD201501 | 89.1 | 12.3 | 73.9 | 1.8 | 1.4 | 5.4 | 7.0 | 0.0 | 0.0 | 0.2 | 2.9 |
| 4 | MTWTDI201501 | 47.3 | 11.0 | 35.7 | 1.1 | 1.4 | 4.9 | 6.1 | 0.0 | 0.0 | 0.5 | 0.7 |
| | **AVERAGE** | **55.3** | **8.6** | **45.7** | **1.1** | **1.0** | **3.7** | **4.9** | **0.0** | **0.0** | **0.2** | **1.1** |
| | **MAX** | **89.1** | **12.3** | **73.9** | **1.8** | **1.4** | **5.4** | **7.0** | **0.0** | **0.0** | **0.5** | **2.9** |
| | **MIX** | **29.1** | **4.8** | **24.3** | **0.7** | **0.7** | **1.9** | **2.9** | **0.0** | **0.0** | **0.0** | **0.0** |

Environment and Heritage

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