Appendix 5

Aquatic Monitoring Report:

Autumn 2018 and Spring 2018

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Tasman Coal Aquatic Monitoring Report

Autumn 2018

Prepared for Donaldson Coal Pty Ltd

July 2018

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Cover photograph: Blue Gum Creek

Executive summary

Tasman Coal ceased production in July 2013 and the site has subsequently been under rehabilitation since September 2014. As part of environmental monitoring requirements for the Tasman Coal mine, the aquatic ecological health of Blue Gum Creek is monitored. The program includes methods for measuring macroinvertebrates as well as water quality and catchment riparian conditions.

The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek. The monitoring includes:

- Assessment of stream condition using RCE.
- Assessment of habitat condition using the AUSRIVAS proforma.
- Assessment of water quality against default ANZECC trigger values.
- Assessment of the macroinvertebrate community condition using SIGNAL.

Aquatic environments downstream of Tasman Coal rehabilitation works have moderate riparian and channel morphology condition. Assessment of macroinvertebrates using weighted SIGNAL scores showed that Blue Gum Creek was in poor stream health, however some pollution sensitive taxa (Leptophlebiidae and Elmidae) were sampled.

Blue Gum Creek continues to exhibit degradation and overall in poor stream health. Ongoing issues with siltation and erosion appear to be continuing to impact on this creek. However, these disturbances appear unrelated to the mines previous operations, but rather ongoing land use management issues in the surrounding area. It is expected that a bridge upgrade will ameliorate erosion at the upstream site.

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Glossary and abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
Anthropogenic	Caused or produced by humans
Aquatic macroinvertebrates	Animals that have no backbone, are visible with the naked eye and spend all or part of their life in water
AUSRIVAS	Australian Rivers Assessment system
CMA	Catchment Management Area
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
Ecology	The study of the relationship between living things and the environment.
Ephemeral	Existing for a shot amount of time
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally).
RCE inventory	Riparian and Channel and Environment inventory assessment
Riparian	Relating to the banks of a natural waterway.
SIGNAL	Stream Invertebrate Grade Number Average Level. SIGNAL2 scores are indicative only and pollution does not refer to just anthropogenic sources. Environmental stress may result in poor water quality occurring naturally in waterways such as those conditions found in ephemeral streams. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even when they are natural condition.
Stress	Response to a stressor such as an environmental condition or a stimulus

1. Introduction

1.1 Background

Tasman Coal ceased production in July 2013 and the site has subsequently been under rehabilitation since September 2014. As part of the environmental monitoring requirements for the Tasman Coal mine, monitoring of stream health of Blue Gum Creek was conducted. The program includes monitoring macroinvertebrates, water quality and catchment-riparian condition. These measures are used to evaluate the effectiveness of water quality protection measures established during development of the area for mining, and success of catchment rehabilitation.

1.2 Catchment characteristics

Blue Gum Creek originates at Mount Sugarloaf, approximately 2 km North-West of West Wallsend. It drains a catchment area of approximately 16km^2 upstream of Pambalong Nature Reserve. The catchment upstream of the monitoring sites is predominantly bushland, with areas that include the rehabilitated mine site and the Hunter Expressway corridor. Stockrington Quarry is also located inside the catchment to the north of the Blue Gum Creek. The lower catchment includes rural land use with grazing, which occurs adjacent to the downstream site (**Error! Reference source not found.**).

1.3 Aim

The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek to determine if water quality protection measures and catchment rehabilitation are having a positive influence on the environment. The monitoring includes:

- Assessment of stream condition using RCE.
- Assessment of habitat condition using the AUSRIVAS proforma.
- Assessment of water quality against default ANZECC trigger values.
- Assessment of the macroinvertebrate community condition using SIGNAL.

Drawn by: GT Project Manager: MR Project Number: 2469 Date: 31/07/2015

Regional location of study area
Tasman Coal - Aquatic Monitoring

FIGURE 1

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2. Methods

2.1 Location of sampling sites

Two sites are required to be sampled on Blue Gum Creek (Figure 2, Table 1). These are located downstream of the Tasman Coal rehabilitation area. There is no upstream site to determine reference condition for these streams.

Table 1. Location of sampling sites

Site name	Stream	Location	Easting	Northing
BGC@SR	Blue Gum Creek	Blue Gum Creek upstream of Stockrington Road	368006	6362135
BGC@DHB	Blue Gum Creek	Blue Gum Creek downstream at Dog Hole Bridge	369275	6363473

2.2 Field methods

Field surveys were undertaken on 7-8th May 2018. The field methods were consistent with standardised techniques in field sampling as prescribed by AUSRIVAS (Turak *et al.* 2000). The AUSRIVAS methods of sampling both pools and riffles have been modified for this project, as no suitable in-stream riffle features are present.

2.2.1 Aquatic habitat and stream condition

Riparian, Channel and Environment Inventory assessment (RCE)

The RCE Inventory (Chessman *et al.* 1997) provides a comparative measure of stream condition by assessing both the stream and its riparian environment in terms of habitat diversity, habitat condition and the degree of human-induced disturbance. Thirteen categories each receive a score between 1 and 4 based on their condition, resulting in an accumulated score of between 13 and 52. The maximum score (52) indicates a stream with little or no obvious physical disruption and the lowest score (13) indicates a heavily channelled stream without any riparian vegetation. An RCE score greater than 40 indicates a stream considered to be in good condition with potential for higher biodiversity values. RCE scores of 20-40 indicate a stream is in moderate condition and below 20 indicates that the stream is in very poor condition. This assessment provided a score for the general condition of the stream and must be interpreted accordingly.

Habitat description

A description of aquatic habitat was also produced using the AUSRIVAS proforma. The survey is a rapid visual assessment used to describe the habitat based on the following parameters:

- geomorphology
- channel diversity
- bank stability
- riparian vegetation and adjacent land use
- water quality
- macrophytes
- local impacts and land use practices.

Location of study sites
Tasman Coal - Aquatic Monitoring
FIGURE 2
Imagery: (c) Nearmap (May 2015)

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2.2.2 Water quality

Water quality was measured *in situ* using a calibrated Yeokal 611 water quality probe at each site. The following variables were recorded:

- temperature (°C)
- conductivity (µS/cm)
- pH
- dissolved oxygen (DO)(% saturation and mg/L)
- turbidity (NTU).

Alkalinity (mg $CaCa_3$/L) was measured with a standard titration kit. Water quality data were compared with the ANZECC (2000) default guideline values to physical and chemical stressors for protection of slightly upland aquatic ecosystems in South-Eastern Australia.

2.2.3 Macroinvertebrates

Samples were collected from pool edges for a length of 10 metres, either as a continuous line or in disconnected segments. Sampling in segments was often undertaken to ensure the sampling of sub-habitats such as macrophyte beds, bank overhangs, submerged branches and root mats. Segmented sampling was also employed where pool length was short and it was logistically difficult to sample in a continuous line (e.g. in-stream logs). A 250 µm dip net was drawn through the water with short sweeps towards the bank to dislodge benthic fauna while scraping submerged rocks and debris, sides of the stream bank and the bed substrate (Plate 1). Further sweeps in the water column targeted the suspended fauna.

Plate 1. Sampling method

Each sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps, pipettes and or paint brushes. Each tray was picked for a minimum period of 40 minutes, after which they were picked at 10 minute intervals for either a total of one hour or until no new specimens had been found. Care was taken to collect cryptic and fast moving animals, in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% ethanol.

Laboratory methods-invertebrate identification

Macroinvertebrate samples were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Keys used include:

- Dean, J., Rosalind, M., St Clair, M., and Cartwright, D. (2004). Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera). Cooperative Research Centre for Freshwater Ecology.
- Gooderham, J. and Tsyrlin, E. (2002). The Waterbug Book: A guide to the Freshwater Macroinvertebrates of Temperate Australia, CSIRO Publishing.
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- Smith, B. (1996). Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters. Murray Darling Freshwater Research Centre.
- Website - http://www.mdfrc.org.au/bugguide/.

2.3 Data analysis

2.3.1 SIGNAL2: (Stream Invertebrate Grade Number Average Level) scores

The revised SIGNAL2 biotic index developed by Chessman (2003a, b) was used to determine the "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their response to a range of environmental conditions (Table 2). The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. A weighted SIGNAL2 score was also calculated (see Chessman 2003b). The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site.

Table 3 provides a broad guide for interpreting the health of the site according to the SIGNAL 2 score of the site.

Table 2. SIGNAL Grade and the Level of Pollution Tolerance

SIGNAL Grade	Pollution Tolerance
10-8	Indicates a greater sensitivity to pollution
7-5	Indicates a sensitivity to pollution
4-3	Indicates a tolerance to pollution
2-1	Indicates a greater tolerance to pollution

Table 3. Guide to interpreting the SIGNAL 2 scores

SIGNAL 2 Score	Habitat quality
Greater than 6	Healthy habitat
Between 5 and 6	Mild pollution
Between 4 and 5	Moderate pollution
Less than 4	Severe pollution

(Source: Gooderham J and Tsyrlin E 2002)

*Note that SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic pollution. Environmental stress may result in poor water quality occurring naturally in waterways. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even when they are natural condition.

2.3.2 Opportunistic observations

Opportunistic visual observations of aquatic fauna were recorded during sampling at each site.

3. Results

3.1 Weather conditions

Surveys were conducted during May 2018. The weather was mild (approximately 25°C) with moderate winds. The highest daily rainfall in the first five months of 2018 occurred in March with a daily total of 161mm (Figure 3) and 20.4mm in April. However, there were no significant rain events >30mm daily total in the preceding month (Figure 3). There were low flows at the time of sampling.

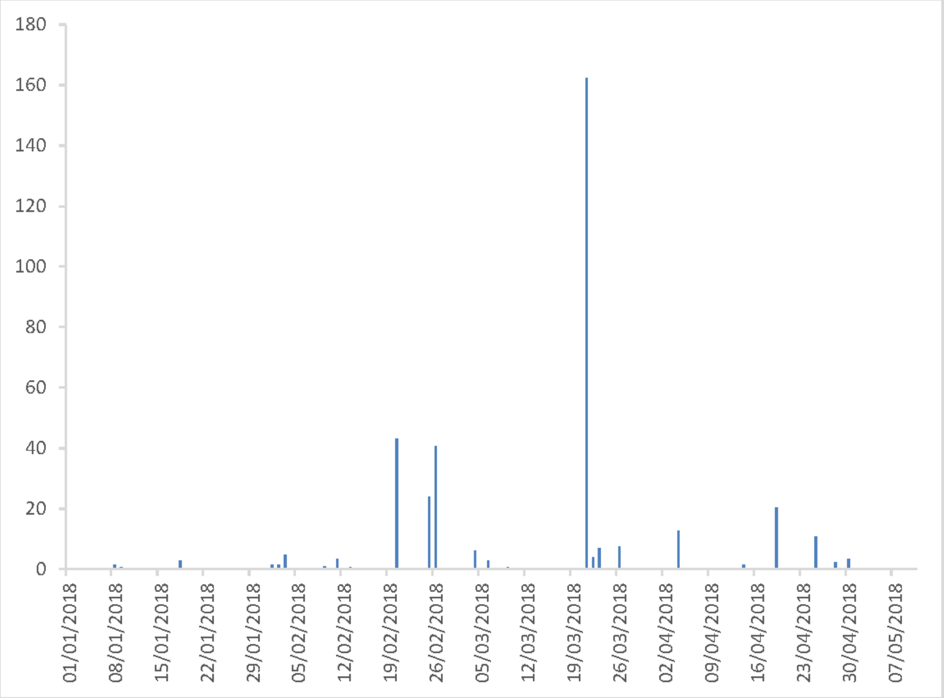

Figure 3. Total daily rainfall at Abel rain gauge (2018). Source: Donaldson Coal

3.2 Aquatic habitat

The aquatic habitat of the study area comprises of pools with no riffles present and water level was low during the survey. The sites generally had moderate riparian and channel health (RCE 20-40). The upstream site had bridge repair work approximately 50m upstream of the sample site (Plate 2). Blue Gum Creek downstream site had fine sand/silt substrate and showed some evidence of erosion. Extensive under scrubbing of native vegetation at the site has left the banks susceptible to further erosion and weed invasion. Duck Weed (*Spirodela spp.*) (Plate 3) was present at the downstream site, which also had significant algae growth. Table 4 shows the RCE inventory scores of each site.

Table 4. RCE inventory scores

Site number	Autumn 2015	Spring 2015	Autumn 2016	Spring 2016	Autumn 2016	Spring 2017	Autumn 2018
BGC@SR	33	36	39	40	38	-	39
BGC@DHB	36	36	39	32	38	35	36

3.2.1 Blue Gum Creek at Stockrington Road

The aquatic habitat of Blue Gum Creek at Stockrington Road (Plate 2) at the time of the autumn 2018 monitoring surveys is detailed in Table 5.

Plate 2. Blue Gum Creek at Stockrington Road. Left: sampling site. Right: Bridge repair work upstream.

Table 5. Blue Gum Creek at Stockrington Road habitat results

	Attribute	Blue Gum Creek at Stockrington road upstream
	Photograph	Plate 2
Riparian	RCE score	38
	Vegetation	Canopy vegetation included Blue Gums (*Eucalyptus saligna*), Cheese Trees (*Glochidion ferdinandi*), Coachwood (*Ceratopetalum apetalum*) and Sandpaper figs (*Ficus coronata*). The mid-storey was dominated by Lantana (*Lantana camara*), Tobacco Bush (*Solanum mauritianum*), Cheese Trees (*G. Ferdinandi*) and the groundcover by native and exotic grasses and herbs.
	Stream shading	Low
	Exotic vegetation	Lantana (*L. camara*), Crofton Weed (*Ageratina adenophora*), Tobacco bush (*S. mauritianum*) (
Stream characteristics	Modal width (m)	2
	Substrate	Silt 70%/Boulder 20%/Sand 10%
	Flow/depth	No flow/<1m
	Macrophytes/algae	Slender knot weed (*Persicaria decipiens*),Cat tail *Typha sp.* upstream at Rd Bridge/Lots of algae
	Water quality observations	Poor, Lots of filamentous algae
Comments		Similar to previous sampling conditions, although water quality appears to have deteriorated. Bridge work occurring upstream.

3.2.2 Blue Gum Creek at Dog Hole Bridge

The aquatic habitat of Blue Gum Creek at Dog Hole Bridge (Plate 3) at the time of the autumn 2018 monitoring surveys is detailed in Table 6.

Plate 3. Blue Gum Creek at Dog Hole Bridge

Table 6. Blue Gum Creek at Dog Hole Bridge habitat results

	Attribute	Blue Gum Creek at Dog Hole Bridge
	Photograph	Plate 3
Riparian	RCE score	36
	Vegetation	Canopy vegetation included Blue Gum (*E. saligna*), Lilly Pilly (*Syzygium smithii*) trees. The mid-storey was dominated by Lantana (*L. camara*), Cheese Trees (*G. ferdinandi*) and Privet (*Ligustrum sinense*) and the ground cover by native grasses, herbs, and Scurvy Weed (*Commelina cyanea*).
	Stream shading	Moderate
	Exotic vegetation	Lantana (*L.camara*), Privet (*L. sinense*)
Stream characteristics	Modal width (m)	2.5
	Substrate	Boulder 5%, Cobble 30%, Gravel 20%, Silt 65%, Sand 20%
	Flow/depth	No flow/<1m
	Macrophytes/algae	Slender Knot weed (*P. decipiens*), Duck Weed (*Spirodela* spp.) Lots of algae
	Water quality observations	Poor, Lots of algae and macrophytes.
Comments		Similar to previous sampling conditions. Flow was very low. Bank clear of some vegetation.

3.3 Water quality

Unfortunately physiochemical water quality could not be measured at the time because of a meter malfunction. Alkalinity was 220 mg $CaCa_3$/L upstream and 160 mg CaCa3/L downstream (Table 7). There was a surface scum observed at both sites.

Table 7. Water quality results

Site number	Temp (C°)	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH	Alkalinity (mg $CaCa_3$/L)
BGCUS						220
BGCDs						160

ANZECC guidelines for upland streams: Electrical conductivity (30-350 µS/cm), Turbidity (6-50 NTU), pH (6.5-8), Dissolved Oxygen (80-110%). Text in bold indicate those variables that exceed the default trigger values.

Note: For some waterways, default ANZECC guidelines do not reflect typical background water quality and chemistry Therefore an assessment of water quality monitoring data against default values can suggest the condition of the waterway is outside the normal range, or polluted, when in fact it is 'clean', or vice versa

3.4 Macroinvertebrates

SIGNAL2 results for the two monitoring sites are provided in Table 8. Raw data is provided in Annex 1.

Table 8. Macroinvertebrate results

Site number	Number of Taxa	SIGNAL2	SIGNAL2 weighted
BGCUS	11	4.0	3.96
BGCDS	16	3.63	3.81

The sites had a low diversity of macroinvertebrate families (9-16) (Table 8). SIGNAL2 and weighted SIGNAL 2 scores indicated that the sites had severe pollution (<4 SIGNAL), with a dominance of pollution tolerant macroinvertebrate families. However, pollution sensitive mayflies i.e. Leptophlebiidae (SIGNAL 8) were recorded at both sites as well as beetle Elmidae (SIGNAL 7) upstream. There has been a slight increase in SIGNAL 2 score since sampling in spring 2017 (Table 9). The SIGNAL bi-plot (Figure 4) indicates that the sites are suffering from urban, industrial or agricultural pollution.

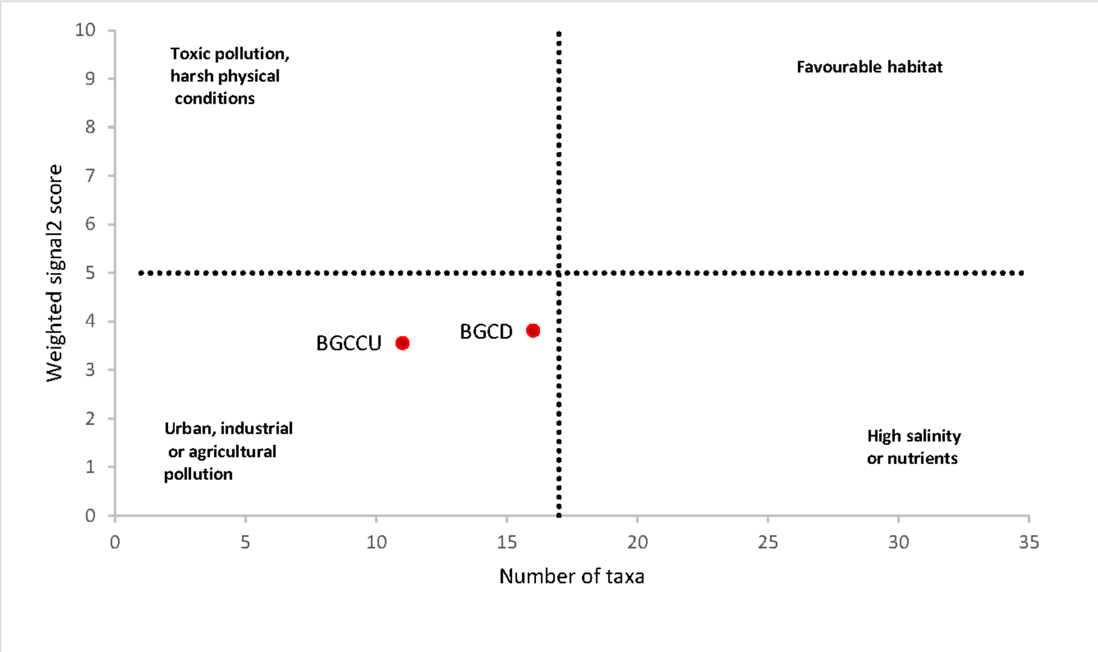

Figure 4. SIGNAL 2 Bi-plot

Table 9. 2015, 2016, 2017, 2018 weighted SIGNAL scores

Site number	Autumn 2015 Weighted SIGNAL 2	Spring 2015 Weighted SIGNAL 2	Autumn 2016 Weighted SIGNAL 2	Spring 2016 Weighted SIGNAL 2	Autumn 2017 Weighted SIGNAL 2	Spring 2017 Weighted Signal	Autumn 2018 Weighted SIGNAL 2
BGC@SR	4.45	3.29	3.75	3.98	3.41	-	3.96
BGC@DHB	4.1	3.17	3.76	2.73	2.94	3.43	3.81

3.5 Other fauna

Introduced fish *Gambusia holbrooki* were observed at both sites.

4. Discussion

4.1 RCE Scores

RCE score were similar to previous results with scores 20-40, indicating moderate condition. These scores are similar to those calculated in spring 2017 (Table 4) and are within the range of scores (33-40) recorded since commencement of the monitoring program (Tuft 2013).

4.2 SIGNAL Scores and stream health

The poor SIGNAL scores (<4) is potentially the result of the creek being highly disturbed. Disturbances appear to include erosion and siltation that have likely resulted in elevated salinity, and under scrubbing and clearing of streamline midstorey and understorey vegetation at the downstream monitoring site.

Despite some poor SIGNAL scores at both sites, there remains potential for improvements in stream health with the presence of sensitive mayfly taxa Leptophlebiidae (SIGNAL 8) and Elmidae (SIGNAL 8) (Annex 1), indicating that Blue Gum Creek can support sensitive taxa. The results are consistent with conclusions from previous monitoring reports that found both sites to show a predominance of pollution tolerant families and few sensitive taxa (Tuft 2014; Niche 2015 a,b; Niche 2016 a,b; Niche 2017 a, b).

4.3 Water quality

Water quality could not be measured on this sampling occasion however, measured high alkalinity indicates that the waterway has a high buffering capacity; providing it with a high resistance to changes in pH. Visually, water quality appeared consistent with observations from previous monitoring periods.

5. Conclusion

Blue Gum Creek continues to exhibit degradation and poor stream health. This is indicated by pollution tolerant macroinvertebrate communities present, presence of weeds and steam bank stability. Ongoing issues with siltation and erosion appear to be continuing to impact on this waterway. As discussed in previous reports, these disturbances appear unrelated to the mines previous operations, but rather ongoing land use management issues. The current work involving the upgrade of the upstream bridge is having an impact on the stream, however on completion is likely to ameliorate erosion in this section of the stream and may improve stream health immediately downstream.

6. References

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Chessman B. (2003b) SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers, Monitoring River Heath Initiative Technical Report no 31, Commonwealth of Australia, Canberra DWR, 199

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Turak E., Waddell N., and Johnstone G. (2000) NSW AUSRIVAS Sampling and Processing Manual. Department of Environment and Conservation.

Websites

http://ausrivas.ewater.com.au/

http://www.mdfrc.org.au/bugguide/

http://www.bom.gov.au/

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Annex 1. Macroinvertebrate survey results

	Blue Gum Creek at Stockrington Road upstream site	Blue Gum Creek at Dog Hole Bridge downstream site
Hydrobiidae		3
Corbiculidae		1
Acarina	1	
Cladocera	2	
Dytiscidae	8	14
Elmidae	2	
Hydrophilidae		4
Scirtidae		1
Tanypodinae	2	2
Chironominae	11	17
Baetidae	1	
Leptophlebiidae	2	15
Mesoveliidae	1	1
Veliidae	1	
Corixidae		1
Notonectidae		1
Pleidae	2	
Coenagrionidae	1	1
Isostictidae		2
Megapodagrionidae		2
Hemicorduliidae		1
Leptoceridae		1

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Tasman Coal Aquatic Monitoring Report

Spring 2018

Prepared for Donaldson Coal Pty Ltd

January 2019

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Cover photograph: Blue Gum Creek

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The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek. The monitoring includes:

- Assessment of stream condition using Riparian and Channel and Environment inventory assessment (RCE).
- Assessment of habitat condition using the AUSRIVAS proforma.
- Assessment of water quality against default ANZECC trigger values.
- Assessment of the macroinvertebrate community condition using Stream Invertebrate Grade Number Average Level (SIGNAL).

Aquatic environments downstream of Tasman Coal rehabilitation works have moderate riparian and channel morphology condition. Assessment of macroinvertebrates using weighted SIGNAL scores showed that Blue Gum Creek was in poor stream health, however some pollution sensitive taxa (Leptophlebiidae) were sampled which shows that despite the poor health does provide habitat for this sensitive family.

Blue Gum Creek continues to exhibit degradation and poor stream health. This is indicated by pollution tolerant macroinvertebrate communities present, presence of weeds and stream bank stability. Ongoing issues with siltation and erosion appear to be continuing to impact on this waterway. However, the completion of the bridge upstream of the site has improved bank stability and erosion at this location, however has not led to measurable improvements in stream ecology. As discussed in previous reports, these disturbances appear unrelated to the mine's previous operations, but rather ongoing land use management issues.

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Tasman Coal ceased production in July 2013 and the site has subsequently been under rehabilitation since September 2014. As part of the environmental monitoring requirements for the Tasman Coal mine, monitoring of stream health of Blue Gum Creek was conducted. The program includes monitoring macroinvertebrates, water quality and catchment-riparian condition. These measures are used to evaluate the effectiveness of water quality protection measures established during development of the area for mining, and success of catchment rehabilitation.

1.2 Catchment characteristics

Blue Gum Creek originates at Mount Sugarloaf, approximately two kilometres north-west of West Wallsend. It drains a catchment area of approximately 16 square kilometres upstream of Pambalong Nature Reserve. The catchment upstream of the monitoring sites is predominantly bushland, with areas that include the rehabilitated mine site and the Hunter Expressway corridor. Stockrington Quarry is also located inside the catchment to the north of Blue Gum Creek. The lower catchment includes rural land use with grazing, which occurs adjacent to the downstream site (Figure 1).

1.3 Aim

The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek to determine if water quality protection measures and catchment rehabilitation are having a positive influence on the environment. The monitoring includes:

- Assessment of stream condition using Riparian and Channel and Environment inventory assessment (RCE).
- Assessment of habitat condition using the AUSRIVAS proforma.
- Assessment of water quality against default ANZECC trigger values.
- Assessment of the macroinvertebrate community condition using Stream Invertebrate Grade Number Average Level (SIGNAL).

Drawn by: GT Project Manager: MR Project Number: 2469 Date: 31/07/2015

Regional location of study area
Tasman Coal - Aquatic Monitoring

FIGURE 1

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2. Methods

2.1 Location of sampling sites

Two sites are required to be sampled on Blue Gum Creek (Figure 2, Table 1). These are located downstream of the Tasman Coal rehabilitation area. There is no upstream site to determine reference condition for these streams.

Table 1. Location of sampling sites

Site name	Stream	Location	Easting	Northing
BGC@SR	Blue Gum Creek	Blue Gum Creek upstream of Stockrington Road	368006	6362135
BGC@DHB	Blue Gum Creek	Blue Gum Creek downstream at Dog Hole Bridge	369275	6363473

2.2 Field methods

Field surveys were undertaken on 14 November 2018. The field methods were consistent with standardised techniques in field sampling as prescribed by AUSRIVAS (Turak *et al*. 2000). The AUSRIVAS methods of sampling both pools and riffles have been modified for this project, as no suitable in-stream riffle features are present.

2.2.1 Aquatic habitat and stream condition

Riparian, Channel and Environment Inventory assessment (RCE)

The RCE Inventory (Chessman *et al*. 1997) provides a comparative measure of stream condition by assessing both the stream and its riparian environment in terms of habitat diversity, habitat condition and the degree of human-induced disturbance. Thirteen categories each receive a score between 1 and 4 based on their condition, resulting in an accumulated score of between 13 and 52. The maximum score (52) indicates a stream with little or no obvious physical disruption and the lowest score (13) indicates a heavily channelled stream without any riparian vegetation. An RCE score greater than 40 indicates a stream considered to be in good condition with potential for higher biodiversity values. RCE scores of 20-40 indicate a stream is in moderate condition and below 20 indicates that the stream is in very poor condition. This assessment provided a score for the general condition of the stream and must be interpreted accordingly.

Habitat description

A description of aquatic habitat was also produced using the AUSRIVAS proforma. The survey is a rapid visual assessment used to describe the habitat based on the following parameters:

- geomorphology
- channel diversity
- bank stability
- riparian vegetation and adjacent land use
- water quality
- macrophytes
- local impacts and land use practices.

Drawn by: GT Project Manager: MR Project Number: 2469 Date: 5/08/2015

Location of study sites
Tasman Coal - Aquatic Monitoring

FIGURE 2

Imagery: (c) Nearmap (May 2015)

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2.2.2 Water quality

Water quality was measured *in situ* using a calibrated Yeokal 611 water quality probe at each site. The following variables were recorded:

- temperature (°C)
- conductivity (µS/cm)
- pH
- dissolved oxygen (DO)(% saturation and mg/L)
- turbidity (NTU).

Alkalinity (mg $CaCa_3$/L) was measured with a standard titration kit. Water quality data were compared with the ANZECC (2000) default guideline values to physical and chemical stressors for protection of slightly upland aquatic ecosystems in South-Eastern Australia.

2.2.3 Macroinvertebrates

Samples were collected from pool edges for a length of 10 metres, either as a continuous line or in disconnected segments. Sampling in segments was often undertaken to ensure the sampling of sub-habitats such as macrophyte beds, bank overhangs, submerged branches and root mats. Segmented sampling was also employed where pool length was short and it was logistically difficult to sample in a continuous line (e.g. in-stream logs). A 250 µm dip net was drawn through the water with short sweeps towards the bank to dislodge benthic fauna while scraping submerged rocks and debris, sides of the stream bank and the bed substrate (Plate 1). Further sweeps in the water column targeted the suspended fauna.

Plate 1: Sampling method – dip netting

Each sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps, pipettes and or paint brushes. Each tray was picked for a minimum period of 40 minutes, after which they were picked at 10 minute intervals for either a total of one hour or until no new specimens had been found. Care was taken to collect cryptic and fast moving animals, in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% ethanol.

Laboratory methods-invertebrate identification

Macroinvertebrate samples were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Keys used include:

- Dean, J., Rosalind, M., St Clair, M., and Cartwright, D. (2004). Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera). Cooperative Research Centre for Freshwater Ecology.
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- Smith, B. (1996). Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters. Murray Darling Freshwater Research Centre.
- Website - http://www.mdfrc.org.au/bugguide/.

2.3 Data analysis

2.3.1 SIGNAL2: (Stream Invertebrate Grade Number Average Level) scores

The revised SIGNAL2 biotic index developed by Chessman (2003a, b) was used to determine the "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their response to a range of environmental conditions (Table 2). The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. A weighted SIGNAL2 score was also calculated (see Chessman 2003b). The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site.

Table 3 provides a broad guide for interpreting the health of the site according to the SIGNAL 2 score of the site.

Table 2. SIGNAL Grade and the Level of Pollution Tolerance

SIGNAL Grade	Pollution Tolerance
10-8	Indicates a greater sensitivity to pollution
7-5	Indicates a sensitivity to pollution
4-3	Indicates a tolerance to pollution
2-1	Indicates a greater tolerance to pollution

Table 3. Guide to interpreting the SIGNAL 2 scores

SIGNAL 2 Score	Habitat quality
Greater than 6	Healthy habitat
Between 5 and 6	Mild pollution
Between 4 and 5	Moderate pollution
Less than 4	Severe pollution

(Source: Gooderham J and Tsyrlin E 2002)

*Note that SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic pollution. Environmental stress may result in poor water quality occurring naturally in waterways. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even when they are in natural condition.

2.3.2 Opportunistic observations

Opportunistic visual observations of aquatic fauna were recorded during sampling at each site.

3. Results

3.1 Weather conditions

Surveys were conducted on 14 November 2018. The weather was mild (approximately 25°C) with light winds. The highest daily rainfall in the previous five months occurred in June and October, with daily totals of 33.8 mm and 28.2 mm respectively (Figure 3). There was little rain fall in the two weeks prior to sampling. There were low flows at the time of sampling.

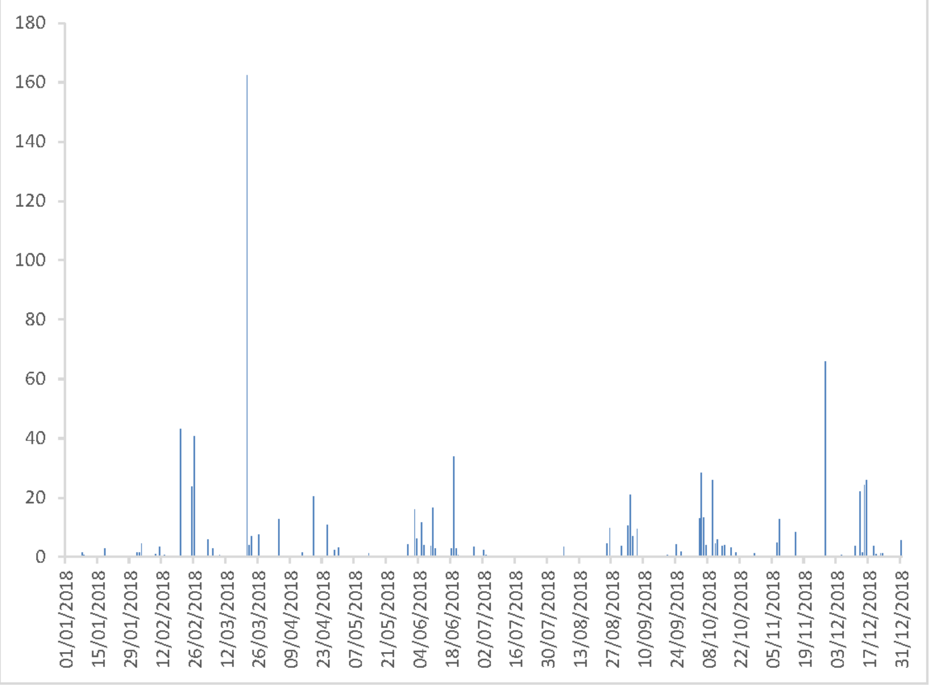

Figure 3: Total daily rainfall at Abel rain gauge (January –December 2018). Source: Donaldson Coal

3.2 Aquatic habitat

The aquatic habitat of the study area comprises pools with no riffles present. Water level was low during the survey. The sites generally had moderate riparian and channel health (RCE 20-40). The upstream site (BGC@SR) bridge repair work had been under construction in autumn was completed. The Blue Gum Creek downstream site (BGC@DHB) had fine sand/silt substrate and showed some evidence of erosion. Extensive under scrubbing of native vegetation at the site has left the banks susceptible to further erosion and weed invasion. Duck Weed (*Spirodela spp.*) (Plate 3) was present at the downstream site, which also had significant algae growth. Table 4 shows the RCE inventory scores of each site.

Table 4. RCE inventory scores

Site number	Autumn 2015	Spring 2015	Autumn 2016	Spring 2016	Autumn 2016	Spring 2017	Autumn 2018	Spring 2018
BGC@SR	33	36	39	40	38	-	39	38
BGC@DHB	36	36	39	32	38	35	36	36

3.2.1 Blue Gum Creek at Stockrington Road

The aquatic habitat of Blue Gum Creek at Stockrington Road (BGC@SR)(Plate 2) at the time of the Spring 2018 monitoring surveys is detailed in Table 5.

Plate 2. Blue Gum Creek at Stockrington Road.

Table 5. Blue Gum Creek at Stockrington Road habitat results

	Attribute	Blue Gum Creek at Stockrington road upstream
	Photograph	Plate 2
Riparian	RCE score	38
	Vegetation	Canopy vegetation included Blue Gums (*Eucalyptus saligna*), Cheese Trees (*Glochidion ferdinandi*), Coachwood (*Ceratopetalum apetalum*) and Sandpaper figs (*Ficus coronata*). The mid-storey was dominated by Lantana (*Lantana camara*), Tobacco Bush (*Solanum mauritianum*), Cheese Trees (*G. Ferdinandi*) and the groundcover by native and exotic grasses and herbs.
	Stream shading	Low
	Exotic vegetation	Lantana (*L. camara*), Crofton Weed (*Ageratina adenophora*), Tobacco bush (*S. mauritianum*)
Stream characteristics	Modal width (m)	2
	Substrate	Silt 70%/Boulder 20%/Sand 10%
	Flow/depth	No flow/<1m
	Macrophytes/algae	Slender knot weed (*Persicaria decipiens*),Cat tail *Typha sp.* upstream at Rd Bridge/Lots of algae
	Water quality observations	Poor, Lots of filamentous algae
Comments		Similar to previous sampling conditions, although water quality appears to have deteriorated. Bridge work occurring upstream.

3.2.2 Blue Gum Creek at Dog Hole Bridge

The aquatic habitat of Blue Gum Creek at Dog Hole Bridge (BGC@DHB)(Plate 3) at the time of the Spring 2018 monitoring surveys is detailed in Table 6.

Plate 3. Blue Gum Creek at Dog Hole Bridge

Table 6. Blue Gum Creek at Dog Hole Bridge habitat results

	Attribute	Blue Gum Creek at Dog Hole Bridge
	Photograph	Plate 3
Riparian	RCE score	36
	Vegetation	Canopy vegetation included Blue Gum (*E. saligna*), Lilly Pilly (*Syzygium smithii*) trees. The mid-storey was dominated by Lantana *(L. camara*), Cheese Trees (*G. ferdinandi*) and Privet (*Ligustrum sinense*) and the ground cover by native grasses, herbs, and Scurvy Weed (*Commelina cyanea*).
	Stream shading	Moderate
	Exotic vegetation	Lantana (*L.camara*), Privet (*Ligustrum sinense*)
Stream characteristics	Modal width (m)	2.5
	Substrate	Boulder 5%, Cobble 30%, Gravel 20%, Silt 65%, Sand 20%
	Flow/depth	No flow/<1m
	Macrophytes/algae	Slender Knot weed (*P. decipiens*), Duck Weed (*Spirodela* spp.) Lots of algae
	Water quality observations	Poor, Lots of algae and macrophytes.
Comments		Similar to previous sampling conditions. Flow was very low. Bank clear of some vegetation.

3.3 Water quality

Water quality results (Table 7), showed that temperature was consistent between both upstream (BG@SR)and downstream (BG@DHB) sites (18.91°C and 17.43 °C respectively). Conductivity was relatively high at both sites (740µ/cm and 1249 µ/cm); exceeding the default ANZECC guideline of 350 µ/cm but below the EPL limit of 2000 µ/cm. Turbidity measurements were low 17.8 NTU at the upstream site (BGC@SR) and 37.1 NTU at downstream site (GBC@DHB), within ANZECC guidelines. Dissolved Oxygen (DO) was low; 38.8% upstream (with ANZECC guidelines) and 34.4% saturation downstream outside the ANZECC guideline of 80-110%. The pH readings of 7.18 and 7.05 were both within ANZECC guidelines. Alkalinity was 280 mg $CaCa_3$/L upstream and 140 $CaCa_3$/L downstream.

Table 7. Water quality results

Site number	Temp (C°)	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH	Alkalinity (mg $CaCa_3$/L)
BGCUS	18.91	740	17.8	38.8%	7.18	280
BGCDs	17.43	1249	37.1	25.0%	7.05	220

ANZECC guidelines for upland streams: Electrical conductivity (30-350 µS/cm), Turbidity (6-50 NTU), pH (6.5-8), Dissolved Oxygen (80-110%). Text in bold indicate those variables that exceed the default trigger values.

Note: For some waterways, default ANZECC guidelines do not reflect typical background water quality and chemistry. Therefore, an assessment of water quality monitoring data against default values can suggest the condition of the waterway is outside the normal range, or polluted, when in fact it is 'clean', or vice versa.

3.4 Macroinvertebrates

SIGNAL2 results for the two monitoring sites are provided in Table 8. Raw data is provided in Annex 1.

Table 8. Macroinvertebrate results

Site number	Number of Taxa	SIGNAL2	SIGNAL2 weighted
BGCUS	19	3.47	3.18
BGCDS	11	3.55	3.54

The sites had a low- moderate diversity of macroinvertebrate families (11-19) (Table 8). SIGNAL2 and weighted SIGNAL 2 scores indicated that the sites had severe pollution (<4 SIGNAL), with a dominance of pollution tolerant macroinvertebrate families. However, pollution sensitive mayflies i.e. Leptophlebiidae (SIGNAL 8) were recorded at both sites. There has been a slight decrease in SIGNAL 2 score since sampling in autumn 2018 (Table 9). The SIGNAL bi-plot (Figure 4) indicates that the downstream sites are potentially suffering from urban, industrial or agricultural pollution and upstream high nutrients or salinity.

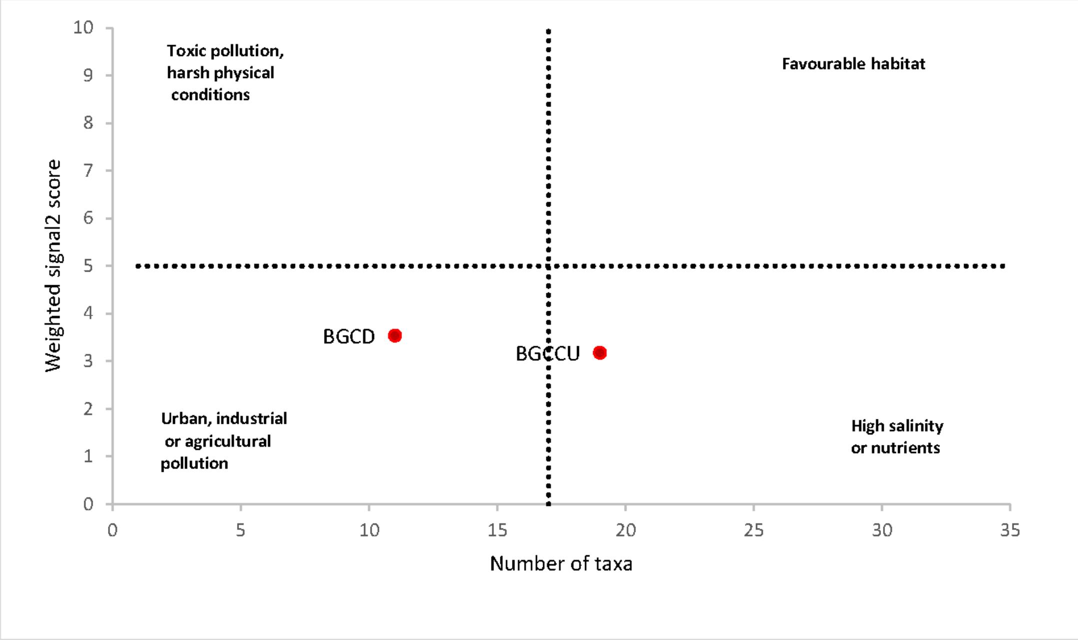

Figure 4. SIGNAL 2 Bi-plot

Table 9. 2015, 2016, 2017, 2018 weighted SIGNAL scores

Site number	Autumn 2015 Weighted SIGNAL 2	Spring 2015 Weighted SIGNAL 2	Autumn 2016 Weighted SIGNAL 2	Spring 2016 Weighted SIGNAL 2	Autumn 2017 Weighted SIGNAL 2	Spring 2017 Weighted Signal	Autumn 2018 Weighted SIGNAL 2	Spring 2018 Weighted SIGNAL 2
BGC@SR	4.45	3.29	3.75	3.98	3.41	-	3.96	3.18
BGC@DHB	4.1	3.17	3.76	2.73	2.94	3.43	3.81	3.54

3.5 Other fauna

Introduced fish *Gambusia holbrooki* were observed at the Blue Gum Creek upstream site.

4. Discussion

4.1 RCE Scores

RCE scores were similar to previous results with scores 20-40, indicating moderate condition. These scores are similar to those calculated in autumn 2018 (Table 4) and are within the range of scores (33-40) recorded since commencement of the monitoring program (Tuft 2013).

4.2 SIGNAL Scores and stream health

The poor SIGNAL scores (<4) is potentially the result of the creek being highly disturbed. Disturbances appear to include erosion and siltation that have likely resulted in elevated salinity, and under scrubbing and clearing of streamline midstorey and understorey vegetation at the downstream monitoring site. There was also filamentous algae present at both sites, potentially indicating high nutrients.

Despite some poor SIGNAL scores at both sites, there remains potential for improvements in stream health with the presence of sensitive mayfly taxa Leptophlebiidae (SIGNAL 8) (Annex 1), indicating that Blue Gum Creek can support sensitive taxa. The results are consistent with conclusions from previous monitoring reports that found both sites to show a predominance of pollution tolerant families and few sensitive taxa (Tuft 2014; Niche 2015 a, b; Niche 2016 a, b; Niche 2017 a, b, Niche 2018).

4.3 Water quality

This report identified elevated electrical conductivity (EC) within Blue Gum Creek. Although relatively high and exceeding ANZECC default guidelines, these levels were observed in recent surveys (Niche 2015a,b, Niche 2016,a,b; Niche 2017a, b) and prior to the commencement of the mine operations (Newcastle Coal 2002). High alkalinity in Blue Gum Creek indicates that the waterway has a high buffering capacity; providing it with a high resistance to changes in pH. Despite exceedances in conductivity and dissolved oxygen, these results are likely within the pre – mine variability of these streams. However, ongoing erosion and siltation issues are potentially further contributing to elevated EC in Blue Gum Creek.

5. Conclusion

Blue Gum Creek continues to exhibit degradation and poor stream health. This is indicated by pollution tolerant macroinvertebrate communities present, presence of weeds and stream bank stability. Ongoing issues with siltation and erosion appear to be continuing to impact on this waterway. The completion of the bridge upstream site has improved bank stability and erosion at this location, however, has not led to measurable improvements in stream ecology. As discussed in previous reports, these disturbances appear unrelated to the mines previous operations, but rather ongoing land use management issues.

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Websites

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http://www.mdfrc.org.au/bugguide/

http://www.bom.gov.au/

Annex 1. Macroinvertebrate survey results

	Blue Gum Creek at Stockrington Road upstream site	Blue Gum Creek at Dog Hole Bridge downstream site
Turbellaria		1
Lymnaeidae		1
Hydrobiidae	1	
Physidae	13	
Corbiculidae	1	
Oligochaeta	4	5
Acarina	2	
Atyidae	1	
Dytiscidae	27	6
Hydrophilidae	8	
Hydraenidae		1
Scirtidae	2	58
Stratiomiyidae	1	
Culicidae	1	
Tanypodinae	6	1
Chironominae	70	54
Baetidae	1	
Leptophlebiidae	4	1
Mesoveliidae	1	
Naucridae	1	8
Corixidae	10	
Leptoceridae	6	1

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