Appendix 4

Aquatic Monitoring Report:

Autumn 2019 and Spring 2019

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Tasman Coal Aquatic Monitoring Report

Autumn 2019

Prepared for Donaldson Coal Pty Ltd

July 2019

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Cover photograph: Blue Gum Creek

Executive summary

The Tasman Coal mine ceased production in July 2013 and the site has subsequently been undergoing 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 aquatic monitoring 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 Riparian and Channel and Environment (RCE) inventory assessment.
- 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).

The report found that 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 overall health it does provide suitable 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 filamentous algae. Ongoing issues with siltation and erosion appear to be continuing to impact at the downstream site. As discussed in previous reports, these disturbances appear unrelated to the mine's previous operations, but rather the combination of past and ongoing land use management issues in the broader catchment and low flows.

Table of Contents

List of Figures

List of Plates

List of Tables

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

The Tasman Coal mine ceased production in July 2013 and the site has subsequently been undergoing rehabilitation since September 2014. Monitoring of stream health of Blue Gum Creek is conducted biannually as part of the environmental monitoring requirements for the Tasman Coal mine . The aquatic monitoring 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.

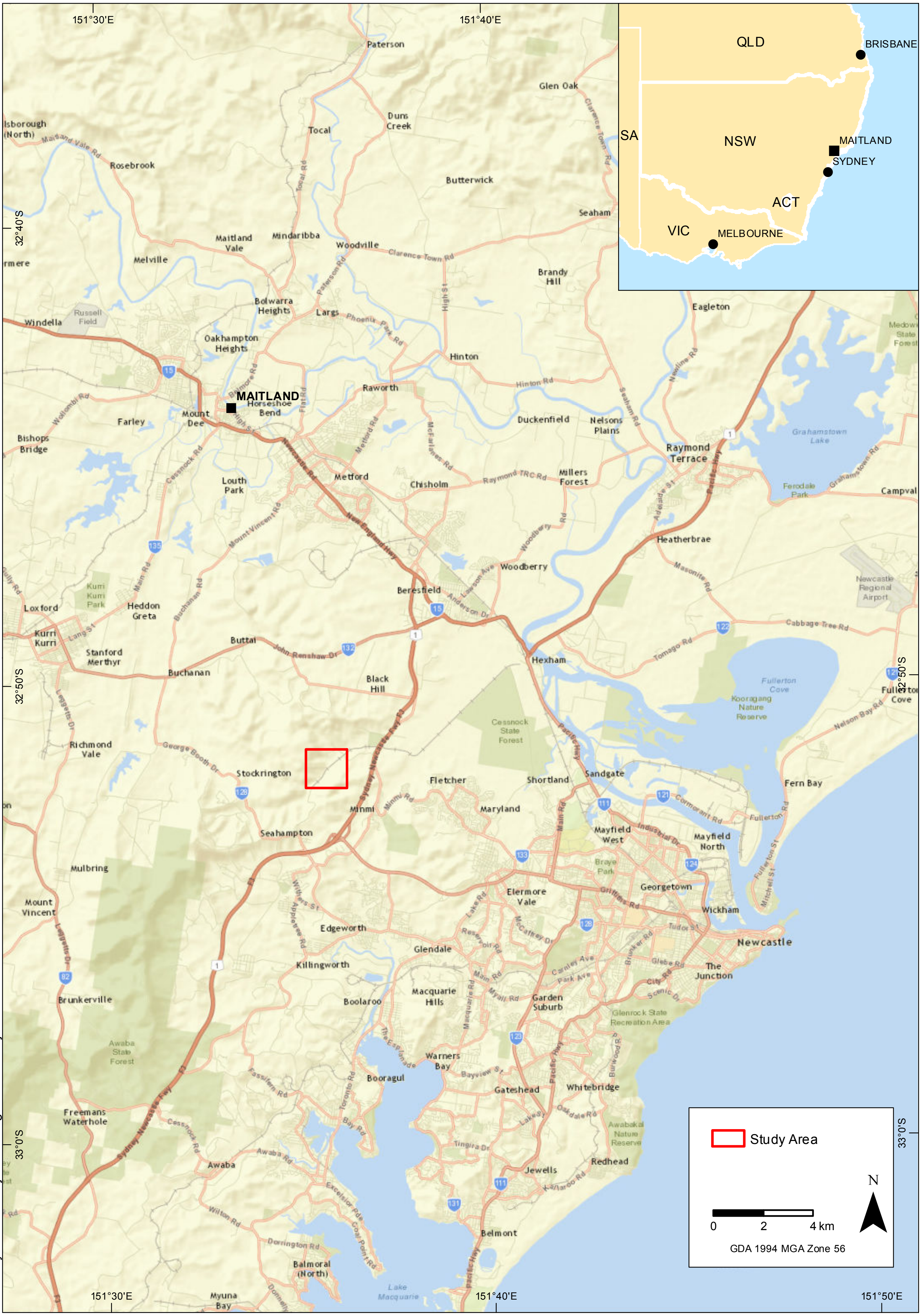
1.2 Catchment characteristics

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 monitoring 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 (RCE) inventory assessment.
- 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 sampling sites are required to be sampled on Blue Gum Creek (Figure 2, Table 1). These are located downstream of the Tasman Coal rehabilitation area.

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 for this monitoring event were undertaken on 28 May 2019. 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.

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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 $CaCO_3$/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.
- 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/.

2.2.1 Data analysis

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.

2.2.2 Opportunistic observations

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

3. Results

3.1 Weather conditions

Surveys were conducted on 28 May 2019. The weather was mild (approximately 18°C) with light winds. The highest daily rainfall in the previous five months occurred in March, with daily total of 66.3 mm (Figure 3). There was little rain fall in the two weeks prior to sampling. There were low flows at the time of sampling.

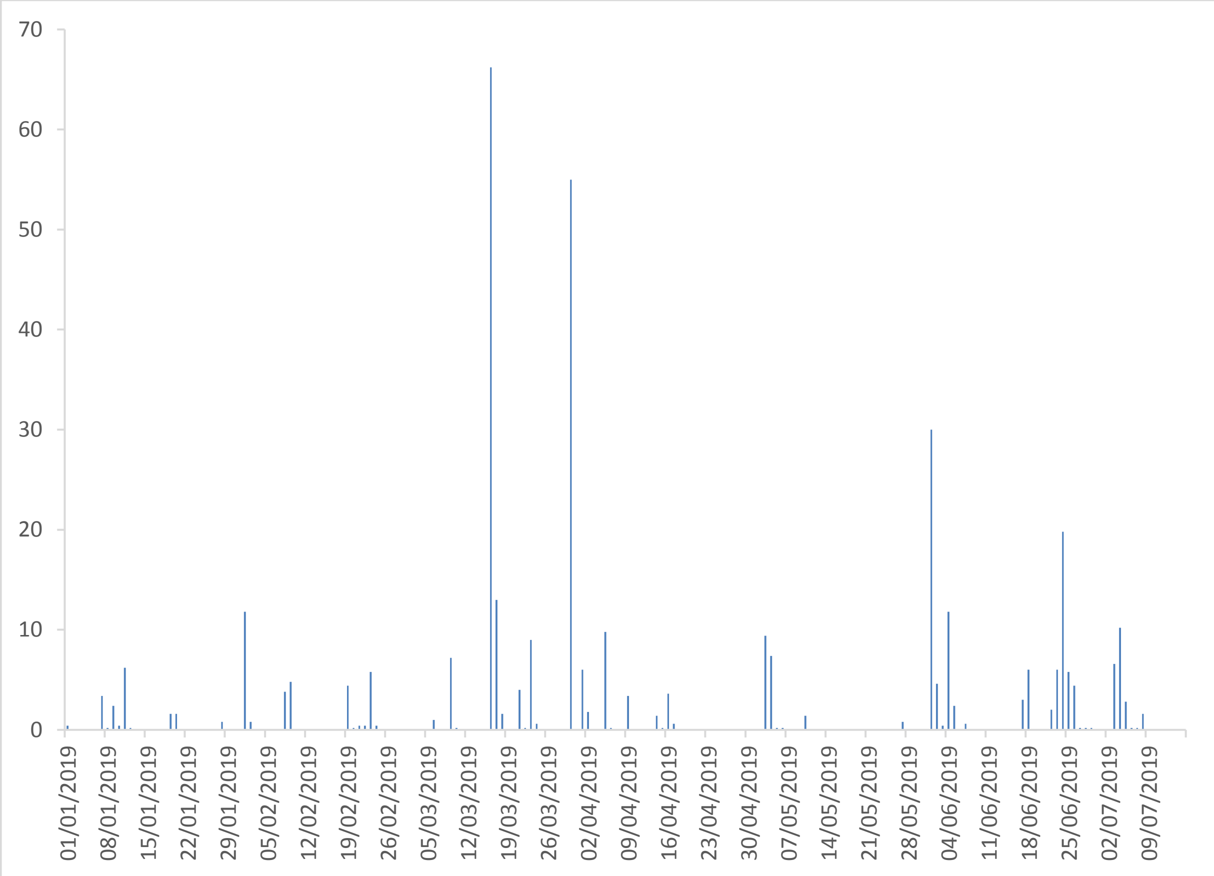

Figure 3: Total daily rainfall at Abel rain gauge (January –July 2019). Source: Donaldson Coal

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 sampling sites generally had moderate riparian and channel health (RCE 20-40) which is consistent with previous monitoring events. The upstream site (BGC@SR) had a mixture of native and exotic vegetation, however the channel was stable and no erosion or sedimentation present. The Blue Gum Creek downstream site (BGC@DHB) had fine sand/silt substrate and showed some evidence of erosion and sedimentation. Duck Weed (*Spirodela spp.*) was present at the downstream site. Both sampling sites had significant algae growth. Table 4 shows the RCE inventory scores of each sampling site.

Table 4. RCE inventory scores

Site number	Autumn 2015	Spring 2015	Autumn 2016	Spring 2016	Autumn 2016	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019
BGC@SR	33	36	39	40	38	-	39	38	38
BGC@DHB	36	36	39	32	38	35	36	36	35

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 Autumn 2019 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 Gum (*Eucalyptus saligna*), Cheese Tree (*Glochidion ferdinandi*), Coachwood (*Ceratopetalum apetalum*) and Sandpaper fig (*Ficus coronata*). The mid-storey was dominated by Lantana (*Lantana camara*), Tobacco Bush (*Solanum mauritianum*), Cheese Tree (*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.* /Lots of algae
	Water quality observations	Poor, Lots of filamentous algae
Comments		Similar to previous sampling conditions, although water quality appears to have deteriorated and appears soupy.

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 Autumn 2019 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	35
	Vegetation	Canopy vegetation included Blue Gum (*E. saligna*) and Lilly Pilly (*Syzygium smithii*). The mid-storey was dominated by Lantana *(L. camara*), Cheese Tree (*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 20%/ Gravel 10%/ Silt 55%/ Sand 10%
	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. No flow. Bank clear of some vegetation.

3.3 Water quality

Water quality results (Table 7), showed that the temperature was consistent between both upstream (BG@SR) and downstream (BG@DHB) sites (10.69°C and 10.68 °C respectively). Conductivity was relatively high at both sites (976µ/cm and 973 µ/cm); exceeding the default ANZECC guideline of 350 µ/cm but below the EPL limit of 2000 µ/cm. Turbidity measurements were low at the upstream site, 4.4 NTU (BGC@SR) and high at the downstream site, 130.4 NTU (BGC@DHB), exceeding ANZECC guidelines. Dissolved Oxygen (DO) was low; 27.8% saturation upstream and 14% saturation downstream which is below the ANZECC guideline of 80-110%. The pH readings of 7.31 and 6.83 were both within ANZECC guidelines. Alkalinity was 120 mg $CaCO_3$/L upstream and 140 $CaCO_3$/L downstream.

Table 7. Water quality results

Site number	Temp (C°)	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH	Alkalinity (mg $CaCO_3$/L)
BGC@SR	10.69	976	4.4	27.8	7.31	120
BGC@DHB	10.68	973	130.4	14	6.83	140

ANZECC guidelines for upland streams: Electrical conductivity (30-350 µS/cm)/ EPL Limit 2000 µ/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 sampling 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
BGC@SR	19	4.05	4.28
BGC@DHB	13	4	4.44

The sampling sites had a low- moderate diversity of macroinvertebrate families (13-19) (Table 8). SIGNAL2 and weighted SIGNAL 2 scores indicated that the sites had moderate pollution (~4 SIGNAL), with a dominance of pollution tolerant macroinvertebrate families. However, pollution sensitive mayflies Leptophlebiidae (SIGNAL 8) and caddis flies Leptoceridae (SIGNAL 6) were recorded at both sampling sites. Other sensitive species include beetle larvae Elmidae (SIGNAL 8) at Blue Gum Creek upstream site and Scirtidae (SIGNAL 6) at Blue Gum Creek downstream site. There has been an increase in SIGNAL 2 score since sampling in Spring 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.

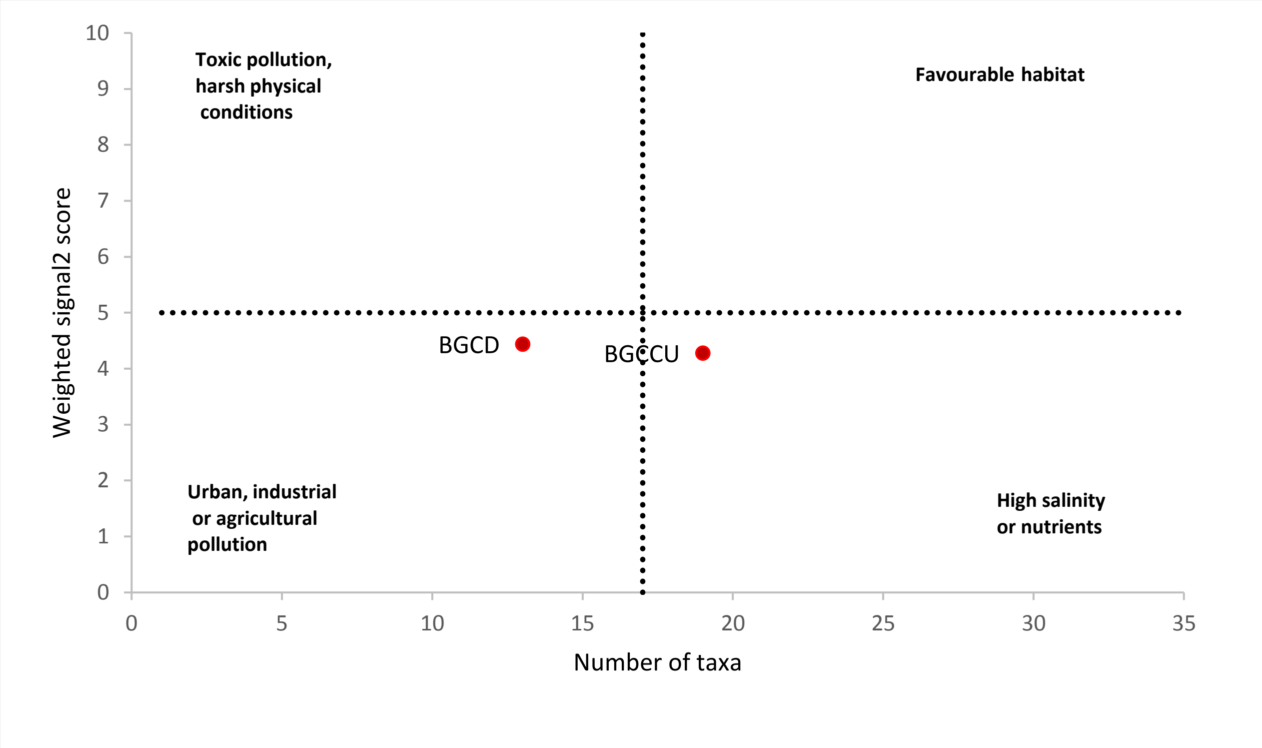

Figure 4. SIGNAL 2 Bi-plot

Table 9. 2015, 2016, 2017, 2018, 2019 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	Autumn 2019 Weighted SIGNAL 2
BGC@SR	4.45	3.29	3.75	3.98	3.41	-	3.96	3.18	4.28
BGC@DHB	4.1	3.17	3.76	2.73	2.94	3.43	3.81	3.54	4.44

3.5 Other fauna

Introduced fish *Gambusia holbrooki* were observed at the Blue Gum Creek upstream site (BGC@SR).

4. Discussion

4.1 RCE Inventory Scores

RCE Inventory scores were similar to previous results with scores between 20-40 indicating moderate condition. These scores are similar to those calculated in Spring 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 low SIGNAL scores recorded (~4) are consistent with previous monitoring and potentially the result of the creek being highly disturbed. Disturbances include presence of weeds, and visible erosion and siltation at the downstream site. There was also filamentous algae present at both sites, potentially indicating high nutrients. The low flows are also likely contributing to a reduction in the quality and quantity of pool habitat for aquatic species.

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 some sensitive taxa. The results are consistent with conclusions from previous monitoring reports that found both sites 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 2018a, b).

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 are consistent with recent surveys (Niche 2017a, b; Niche 2018a, b) and results 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 EC and dissolved oxygen, these results are likely within the pre – mine variability of Blue Gum Creek.

5. Conclusion

Blue Gum Creek continues to exhibit aquatic monitoring results that indicate degradation and poor stream health. This is indicated by the dominance of pollution tolerant macroinvertebrate communities present, presence of weeds and filamentous algae. 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 Tasman Coal mine's previous operations, but rather past and ongoing land use management issues exacerbated by low flows.

6. References

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Madden, C. (2011) Draft identification key to families of Diptera larvae of Australian inland waters La Trobe University.

Robyn Tuft and Associates (2014). Tasman Coal Mine Macroinvertebrate Sampling Program Pre-mining Survey – November 2014

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.

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/

Annex 1. Macroinvertebrate survey results

	Blue Gum Creek at Stockrington Road upstream site	Blue Gum Creek at Dog Hole Bridge downstream site
Hydrobiidae	5	
Oligochaeta	1	
Atyidae	3	
Dytiscidae	9	17
Elmidae	1	
Hydrophilidae	6	
Scirtidae		17
Dixidae	1	
Ceratopogonidae	1	
Tanypodinae	6	
Chironominae	7	70
Baetidae	7	
Leptophlebiidae	31	24
Corixidae	1	1
Coenagrionidae	1	2
Megapodagrionidae		1
Gomphidae	1	1
Hemicorduliidae	2	2
Libellulidae	1	
Leptoceridae	3	2
Micronectidae	2	1
Sphaeriidae		3
Glossiphoniidae		1

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Tasman Coal Aquatic Monitoring Report

Spring 2019

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Document control

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4920	Donaldson Coal	Matthew Russell	Newcastle/Maitland

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Blue Gum Creek continues to exhibit degradation and poor stream health. This is indicated by pollution tolerant macroinvertebrate communities present, presence of weeds, and filamentous algae. However algae coverage had reduced in the upstream site since Autumn 2019 survey and showed visual improvement in aquatic habitat. Ongoing issues with siltation and erosion appear to be continuing to impact at the downstream site. As discussed in previous reports, these disturbances appear unrelated to the mine’s previous operations, but rather the combination of past and ongoing land use management issues in the broader catchment and low flows.

Table of Contents

List of Figures

List of Plates

List of Tables

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CMA	Catchment Management Area
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Ecology	The study of the relationship between living things and the environment.
Ephemeral	Existing for a short amount of time.
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally).
LMP	Landscape Management Plan
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 though they are a natural condition
Stress	Response to a stressor such as an environmental condition or a stimulus.

1. Introduction

1.1 Background

The Tasman Coal mine ceased production in July 2013 and the site has subsequently been undergoing rehabilitation since September 2014. Monitoring of stream health of Blue Gum Creek is conducted biannually as part of the environmental monitoring requirements for the Tasman Coal mine. The aquatic monitoring 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.

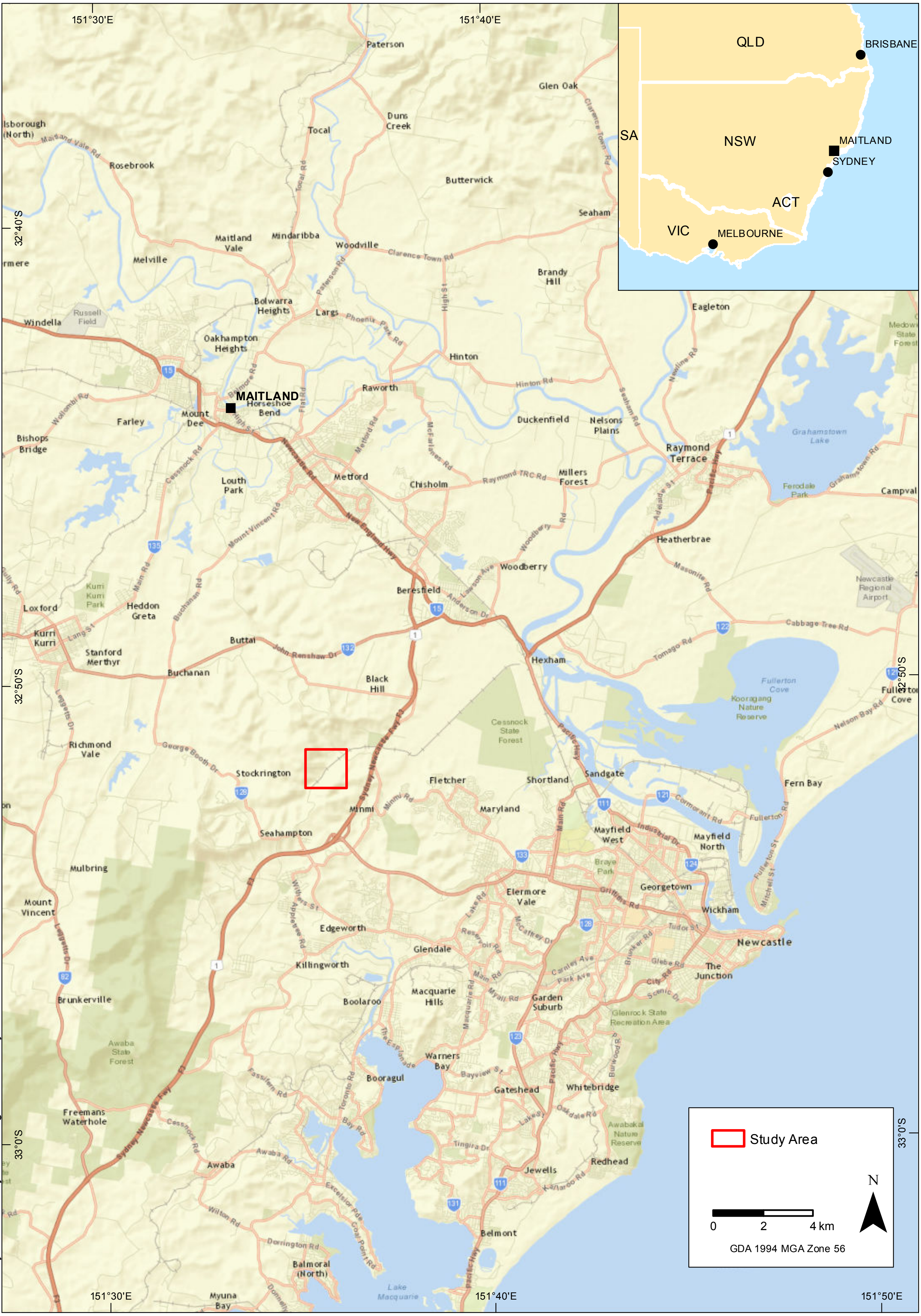
1.2 Catchment characteristics

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 monitoring 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 (RCE) inventory assessment.
- 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 monitoring sites

Two sampling sites are required to be sampled on Blue Gum Creek (Figure 2; Table 1). These are located downstream of the Tasman Coal rehabilitation area.

Table 1: Location of sampling sites

Site acronym	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 for this monitoring event were undertaken on 16 September 2019. 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 one and four 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. This assessment provides an assessment of 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

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

- Temperature (°C)
- Conductivity (µS/cm)
- pH
- Dissolved oxygen (DO)(% saturation and mg/L)
- Turbidity (NTU).

Alkalinity (mg $CaCO_3$/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 of macroinvertebrates 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 to identify taxa included:

- Centre for Freshwater Ecosystems (n.d.) – Identification Key and Ecology of Australian Freshwater Invertebrates. http://www.mdfrc.org.au/bugguide/.
- 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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- Madden, C. (2011) Draft identification key to families of Diptera larvae of Australian inland waters La Trobe University.
- Smith, B. (1996) Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters Murray Darling Freshwater Research Centre.

2.3 Data analysis

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

The revised SIGNAL2 biotic index developed by Chessman (2003a and 2003b) 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 SIGNAL2 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 SIGNAL2 scores

SIGNAL2 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 and Tsyrlin 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 the surveys at each site.

3. Results

3.1 Weather conditions

Surveys were conducted on 16 September 2019. The weather was mild (approximately 24°C) with light to moderate winds. There was low-moderate rain fall in the month prior to sampling (maximum daily rainfall was 44 mm on 30 August 2019; Figure 3). There were low flows within the study area at the time of sampling.

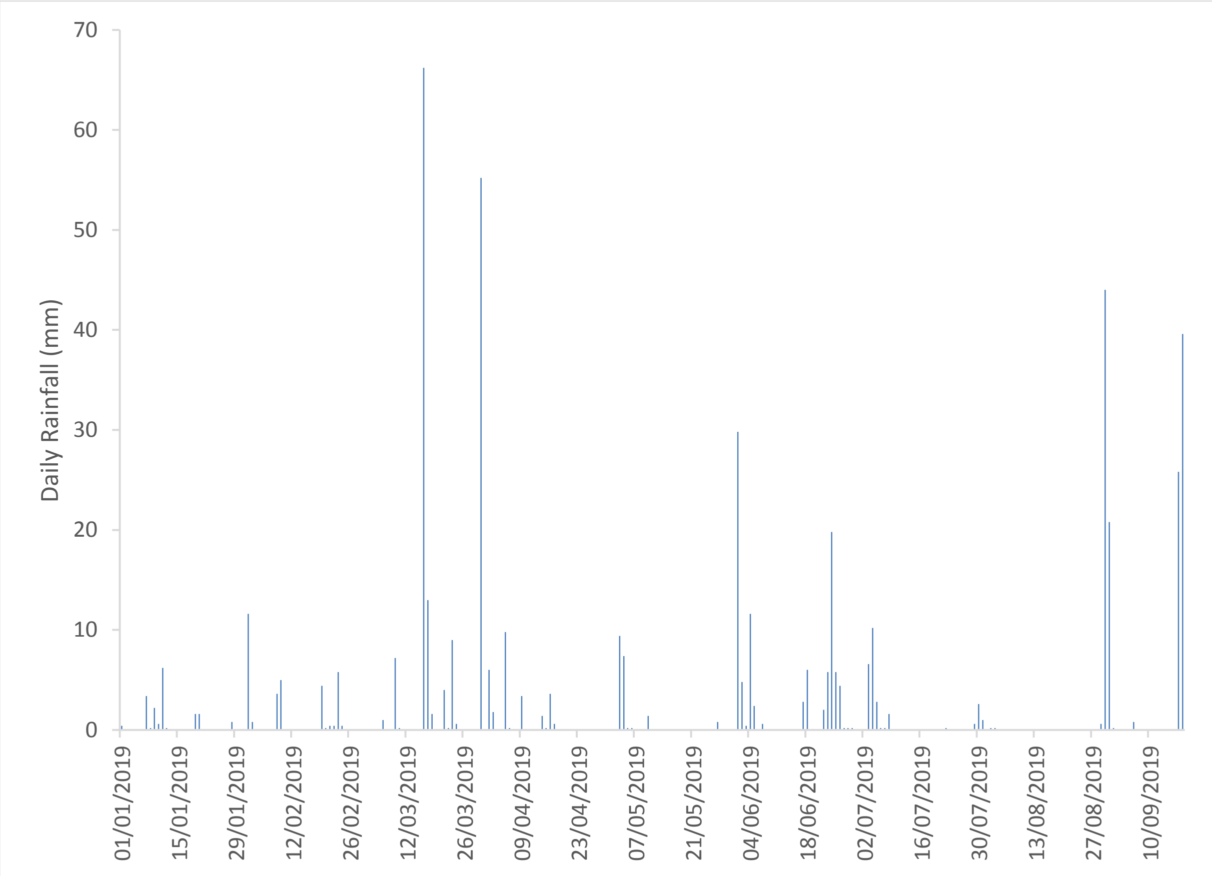

Figure 3: Total daily rainfall at Abel rain gauge (January –September 2019). Source: Donaldson Coal

3.2 Aquatic habitat/condition

The aquatic habitat of the study area comprises pools with no riffles present. Water level was low during the survey. The sampling sites generally had moderate riparian and channel health (RCE 20-40) which is consistent with previous monitoring events. The upstream site (BGC SR) had a mixture of native and exotic vegetation, however the channel was stable and no erosion was present. There was a fine layer of sedimentation present on the creek banks (covering the rocks and vegetation) most likely fluvial deposition from recent rainfall events. The Blue Gum Creek downstream site (BGC DHB) had fine sand/silt substrate and showed some evidence of erosion and sedimentation. Duck Weed (*Spirodela* spp.) was present at the downstream site. Both sampling sites had slight algae growth with a notable reduction at the upstream site. Table 4 shows the RCE inventory scores of each sampling site.

Table 4: RCE inventory scores (2015-2019)

Site	Autumn 2015	Spring 2015	Autumn 2016	Spring 2016	Autumn 2017	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Spring 2019
BGC SR	33	36	39	40	38	-	39	38	38	40
BGC DHB	36	36	39	32	38	35	36	36	35	36

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

3.2.1 Blue Gum Creek at Stockrington Road

The aquatic habitat at Blue Gum Creek at Stockrington Road (Plate 2) at the time of the spring 2019 monitoring surveys is detailed in Table 5.

Blue Gum Creek at Stockrington (Downstream) Blue Gum Creek at Stockrington (Upstream)

Plate 2: Blue Gum Creek at Stockrington

Table 5: Blue Gum Creek at Stockrington habitat results

	Attribute	Blue Gum Creek at Stockrington
	Photograph	Plate 2
Riparian	RCE score	40
	Vegetation	Canopy vegetation included Blue Gum (*Eucalyptus saligna*), Cheese Tree (*Glochidion ferdinandi*), Coachwood (*Ceratopetalum apetalum*) and Sandpaper fig (*Ficus coronata*). The mid-storey was dominated by Lantana (*Lantana camara*), Tobacco Bush (*Solanum mauritianum*), Cheese Tree (*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.* / algae
	Water quality observations	Clearer than previous sampling in Autumn 2019. Some algal growth
Comments		Similar to previous sampling conditions; although water quality seems to have improved slightly with clearer water and less algae. Evidence of sedimentation on dry banks and vegetation. Less algal growth than Autumn 2019 survey.

3.2.2 Blue Gum Creek at Dog Hole Bridge

The aquatic habitat at Blue Gum Creek at Dog Hole Bridge (Plate 3) at the time of the spring 2019 monitoring surveys is detailed in Table 6.

Blue Gum Creek at Dog Hole Bridge (Downstream)

Blue Gum Creek at Dog Hole Bridge (Upstream)

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*) and Lilly Pilly (*Syzygium smithii*). The mid-storey was dominated by Lantana *(L. camara*), Cheese Tree (*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 camara, Privet (Ligustrum sinense)*
Stream characteristics	Modal width (m)	2.5m
	Substrate	Boulder 5%/ Cobble 20%/ Gravel 10%/ Silt 55%/ Sand 10%
	Flow/depth	No flow/<1m
	Macrophytes/algae	Slender Knot weed (*P. decipiens*), Duck Weed (*Spirodela* spp.) Some algae.
	Water quality observations	Low flow, some algae.
Comments		Similar to previous sampling / sedimentation from uprooted tree(s).

3.3 Water quality

Water quality results (Table 7), showed that the temperature was similar between both upstream (BGC SR) and downstream (BGC DHB) sites (14.43°C and 13.15 °C respectively). Conductivity was similar at both sites (619µS/cm and 518 µ/cm); exceeding the default ANZECC guideline of 350 µS/cm but below the EPL limit of 2000 µS/cm. Turbidity measurements were low at the upstream site, 7 NTU (BGC SR) and higher at the downstream site, 43.4 NTU (BGC DHB), however neither exceeding ANZECC guidelines. Dissolved Oxygen (DO) was low; 34.8% saturation upstream and 18.3% saturation downstream which is below the ANZECC guideline of 80-110%. The pH readings of 7.5 and 7.0 were both within ANZECC guidelines. Alkalinity was 120 mg $CaCO_3$/L upstream and 100 $CaCO_3$/L downstream indicating that the stream has a good buffering capacity to changes in pH.

Table 7: Water quality results

Site acronym	Temp (C°)	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH*	Alkalinity (mg $CaCO_3$/L)
BGC SR	14.43	**619**	7.0	**34.8**	7.5	120
BGC DHB	13.15	**518**	43.4	**18.3**	7.0	100

ANZECC trigger values 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.

3.4 Macroinvertebrates

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

Table 8. Macroinvertebrate SIGNAL2 results

Site acronym	Number of Taxa	SIGNAL2 Score	SIGNAL2 weighted Score
BGC SR	12	3.41	4.05
BGC DHB	21	3.76	4.11

The sampling sites had a low - moderate diversity of macroinvertebrate families (12-21) (Table 8). SIGNAL2 and weighted SIGNAL 2 scores indicated that the sites had moderate pollution (~4 SIGNAL), with a dominance of pollution tolerant macroinvertebrate families. However, pollution sensitive mayflies Leptophlebiidae (SIGNAL 8) were recorded at both sites and caddis flies Leptoceridae (SIGNAL 6) were recorded only at the Dog Hole Bridge site (Downstream). Other sensitive species include mites (Acarina) (SIGNAL 6) at both sites and Scirtidae (SIGNAL 6) at Blue Gum Creek downstream site. There has been a slight decrease in SIGNAL 2 score since sampling in Autumn 2019 (Table 9). The SIGNAL bi-plot (Figure 4) indicates that the upstream sites are potentially suffering from urban, industrial or agricultural pollution and downstream high nutrients or salinity.

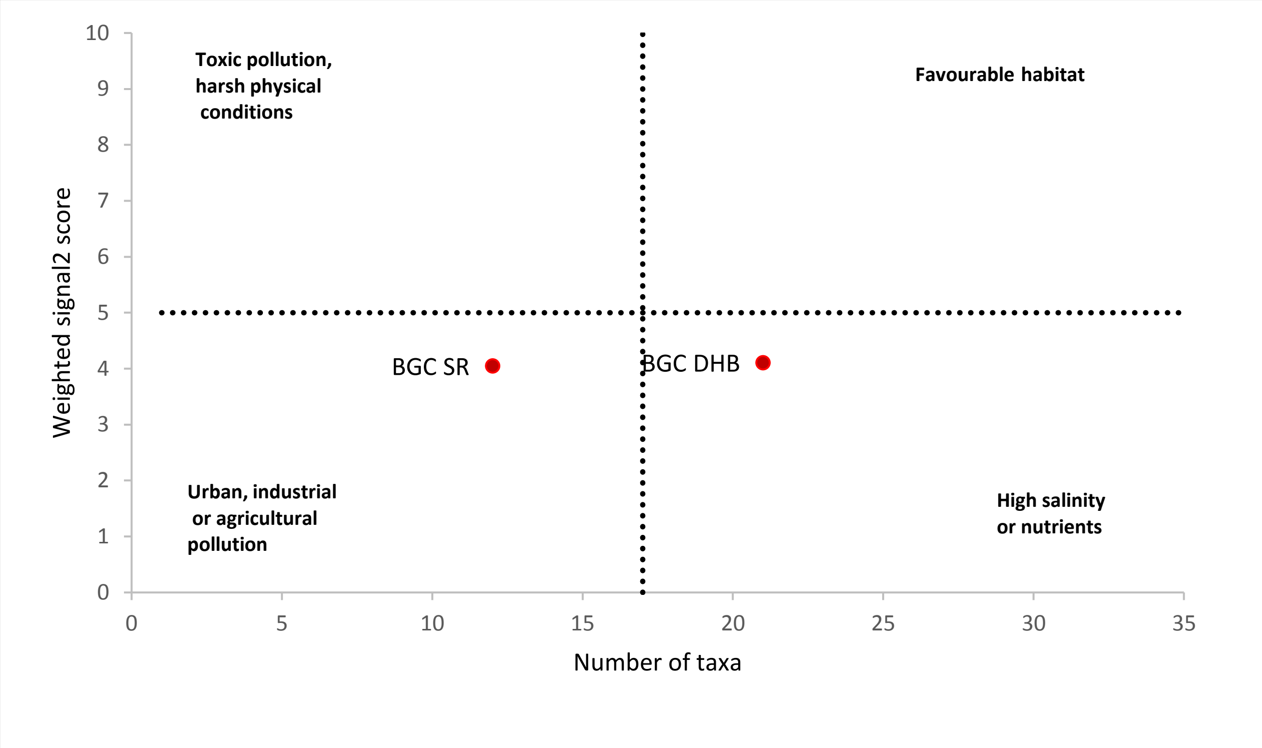

Figure 4. SIGNAL2 Bi-plot

Table 9. Weighted SIGNAL2 scores (2015, 2016, 2017, 2018 and 2019)

Site	SIGNAL2 weighted Autumn 2015	SIGNAL2 weighted Spring 2015	SIGNAL2 Weighted Autumn 2016	SIOGNAL2 Weighted Spring 2016	SIOGNAL2 Weighted Autumn 2017	SIGNAL2 weighted Spring 2017	SIGNAL2 weighted Autumn 2018	SIGNAL2 weighted Spring 2018	SIGNAL2 weighted Autumn 2019	SIGNAL2 weighted Spring 2019
BGCSR	4.45	3.29	3.75	3.98	3.41	-	3.96	3.18	4.28	4.05
BGCDHB	4.1	3.17	3.76	2.73	2.94	3.43	3.81	3.54	4.44	4.11

3.5 Other fauna

No other aquatic fauna were observed at the time of the Spring 2019 sampling.

4. Discussion

4.1 RCE scores

RCE Inventory scores were similar to previous monitoring results with scores ranging 20-40, indicating moderate condition. These scores are similar to those calculated in Autumn 2019 (Table 4) and are within the range of scores (33-40) recorded since commencement of the monitoring program (Tuft 2013).

4.2 SIGNALs scores and macroinvertebrate communities

The low SIGNAL scores recorded (~4) are consistent with previous monitoring and potentially the result of the creek being highly disturbed. Disturbances include presence of weeds, and visible erosion and siltation at the downstream site. There was filamentous algae present at both sites, potentially indicating high nutrients, however this algal growth was lower than previous survey in Autumn 2019. The low flows are also likely contributing to a reduction in the quality and quantity of pool habitat for aquatic species, as a result of the extended dry periods and lack of consistent rain fall. However recent flow appear to have improved aquatic habitat slightly at the upstream 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) (Annex 1), indicating that Blue Gum Creek can support some sensitive taxa. The results are consistent with conclusions from previous monitoring reports that found both sites 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 2018a, b, Niche 2019a).

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 are consistent with recent surveys (Niche 2017a, b; Niche 2018a, b; Niche 2019a) and results 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 EC and low dissolved oxygen, these results are likely within the pre–mine variability of Blue Gum Creek.

5. Conclusion and recommendations

5.1 Conclusions

Blue Gum Creek continues to exhibit aquatic monitoring results that indicate degradation and poor stream health. This is indicated by the dominance of pollution tolerant macroinvertebrate communities present, presence of weeds and filamentous algae. The upstream site aquatic habitat however appeared to have improved since survey in Autumn 2019, a likely response to recent rainfall and river flow. Ongoing issues with siltation and erosion appear to be continuing to impact on this waterway downstream. As discussed in previous reports, these disturbances appear unrelated to the Tasman Coal mine's previous operations, but rather past and ongoing land use management issues exacerbated by low flows.

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

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

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

Annex 1. Macroinvertebrate survey results

	Blue Gum Creek	
Site	**Stockrington Road**	**Dog Hole bridge**
Turbellaria	2	
Tateidae formerly - Hydrobiidae		42
Planorbidae	2	1
Physidae	1	3
Oligochaeta	6	1
Acarina	3	2
Dytiscidae		3
Gyrinidae		1
Hydrophilidae		17
Scirtidae		2
Hydrochidae		1
Tipulidae		1
Tanypodinae		2
Chironominae		1
Baetidae	1	4
Leptophlebiidae	13	116
Corixidae	5	2
Pleidae	1	
Megapodagrionidae		1
Hemicorduliidae	2	
Libellulidae	1	
Leptoceridae		5

	Blue Gum Creek	
Site	**Stockrington Road**	**Dog Hole bridge**
Micronectidae – formerly Corixidae	2	1
Sphaeriidae		3
Glossiphoniidae		1

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Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)