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Aquatic Ecology Monitoring Report
Brandy and Water Creek and American Creek

Prepared for South32 | 25 November 2020

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Document control

Project number	Client	Project manager	LGA
6133	South32	Matthew Russell	Wollongong

Version	Author	Review	Status	Date
D1	Matthew Russell	Sian Griffiths	Draft	24/11/2020
R1	Matthew Russell		Final	25/11/2020

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Executive summary

Project outline

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by South32 to undertake an environmental assessment required under Environment Protection Licence (EPL) 3421 Condition E2, following an uncontrolled release of sediment from the Kemira Valley Coal Loading Facility (KVCLF) sediment pond.

The uncontrolled release occurred due to the failure of the dam during a significant weather event on August 10, 2020, that resulted in sediment deposition downstream of the pond in Brandy and Water Creek and American Creek. An environmental assessment (Niche 2020) recommended further monitoring to assess potential long-term impacts from the event and any construction related impacts to the waterway.

This report assesses the water quality and aquatic ecology undertaken as part of the recommended monitoring program.

Scope of this assessment

The primary objective of this report is to evaluate the monitoring program as recommended in the Environmental Assessment Report (Niche 2020):

> '*The monitoring program is recommended to include monthly visual assessment and in situ physiochemical and water sampling up and downstream of the sediment dam and up and downstream of American Creek and Brandy and Water Creek confluence for a period of four months. A spring AUSRIVAS study should be conducted on one occasion after the completion of the sediment dam*.'

This report analyses the findings of the monitoring to:

- Determine if there are any long-term impacts associated with the event.
- Assess any potential construction impacts associated with the sediment dam reinstatement works.

Methods

As part of the aquatic monitoring, a field survey was conducted by Niche Aquatic Ecologist and accompanied by a South32 Specialist - Environment on 14 November 2020. The survey included the following:

- Visual aquatic habitat assessment.
- Water quality monitoring.
- Macroinvertebrate stream health monitoring using Australian Rivers Assessment System (AUSRIVAS) rapid assessment sampling protocols and stream health indicators - Stream Invertebrate Grade Number Average Level (SIGNAL), Number of Taxa and Ephemeroptera, Plecoptera and Trichoptera (EPT) Index.

Field surveys were undertaken at sites up and downstream of the sediment pond and up and downstream of Brandy and Water Creek and American Creek confluence as recommended by the Environmental Assessment Report (Niche 2020).

The aquatic monitoring report also assesses results from the field survey, and water quality monitoring undertaken by South32.

Conclusions and recommendations

The result of the aquatic monitoring indicates that there are no long-term impacts associated with the event. Previous sampling in August immediately downstream of the sediment pond showed some impact to stream ecology (Niche 2020), however sampling by Niche a week later showed that there had been an improvement in stream health. Monitoring conducted in November showed that this improvement was maintained, and downstream sites was similar in stream health to the upstream sites. This finding was reflected up and downstream of American Creek and Brandy and Water Creek confluence which also showed similarities in invertebrates, water quality and stream health indicators. Overall, all sites were considered to be consistent with the ecology expected in a moderately disturbed system. The lack of coal fines evident in the recent round of monitoring support the recovery in aquatic habitat and that there are no long-term impacts associated with the event that occurred in August. As such, further monitoring dedicated to assessing this event is not considered to be required.

Glossary and list of abbreviations

Term or abbreviation	Definition
ANZECC	Australian and New Zealand Environment and Conservation Council
AUSRIVAS	Australian Rivers Assessment System
DPIE	Department of Planning, Industry and Environment
DTV	Default Trigger Level
EPA	Environmental Protection Authority
EPL	Environment Protection Licence
EPT	Ephemeroptera, Plecoptera and Trichoptera
SIGNAL	Stream Invertebrate Grade Number Average Level

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1. Introduction

1.1 Context

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by South32 to provide an environmental assessment report under EPL 3241 Condition E2, following an uncontrolled release of sediment from Kemira Valley Coal Loading Facility (KVCLF) sediment pond (the event).

The uncontrolled release occurred due to the failure of the dam during a significant weather event on August 10, 2020, that resulted in sediment deposition downstream of the pond in Brandy and Water Creek and American Creek. An environmental assessment (Niche 2020) recommended further monitoring to assess potential long-term impacts from the event and any construction related impacts to the waterways.

This report assesses the water quality and aquatic ecology as part of the recommended monitoring program.

1.2 Scope of this assessment

The primary objective of this report is to conduct monitoring as recommended in the Environmental Assessment Report (Niche 2020):

> '*The monitoring program is recommended to include monthly visual assessment and in situ physiochemical and water sampling up and downstream of the sediment dam and up and downstream of American Creek and Brandy and Water Creek confluence for a period of four months. A spring AUSRIVAS study should be conducted on one occasion after the completion of the sediment dam*.'

This report analyses the finding of the monitoring to:

- Determine if there are any long-term impacts associated with the event.
- Assess any potential construction impacts associated with the sediment pond reinstatement works.

1.2.1 Limitations

There is no pre-event ecological data to compare post-event results. As such, it is not possible to infer with certainty any before /after temporal differences in macroinvertebrate populations in the downstream environment. This assessment is based on comparisons of the upstream and downstream presence/absence of pollution sensitive aquatic invertebrates and comparison to model reference streams using AUSRIVAS in two post event surveys.

1.3 Background

Dendrobium Coal Pty Ltd (DCPL) operates under Environment Protection Licence (EPL) 3241 issued by the Environment Protection Authority (EPA), Development Consent DA 60-03-2001 issued by the Department of Planning, Industry and Environment (DPIE) and Consolidated Coal Lease (CCL) 768, issued by the Resources Regulator.

The Kemira Valley Coal Loading Facility (KVCLF) (Figure 1) receives coal from Dendrobium Mine via the Kemira Valley Tunnel. Coal is transported from underground to KVCLF via the coal clearance system which is comprised of an extensive conveyor network. The coal is then fed into a rill tower and deposited onto a 150,000 tonne stockpile from which it is loaded into trains via an enclosed rail-loading chute.

A sediment pond at Kemira Valley collects dirty water from the KVCLF, which includes receiving waters from internal road runoff and the coal stockpile area.

A buffer dam (which operates separately to the sediment pond) is located on the northern side of the coal stockpile that also collects water runoff from the stockpile area and acts as a buffer for storage in the sediment pond.

Water collected in the sediment pond is pumped out of the pond pursuant to EPL 3241 via Licence Discharge Point (LDP) 25, which is discharged at LDP 5, located at Marley Place, Unanderra. The water from the sediment pond is mixed with water pumped out from the Dendrobium underground water storage. The water level in the sediment pond is maintained via this pump out at a low level to provide wet weather storage capacity. EPL 3241 also lists LDP 23, which provides for wet weather discharge by spillway overflow from the sediment pond.

Brandy and Water Creek flows around the KVCLF site. Clean water on and around the site is directed into Brandy and Water Creek. A clean water culvert transfers water from the western side of the site to Brandy and Water Creek. This culvert passes underneath the Kemira Valley sediment pond.

On 10 August 2020 it was identified that a release of water, containing mostly fine coal particles, had occurred from the base of the sediment pond. Rainfall over the period leading up to the event was in excess of 150 mm. The pond was still operational and overtopping at 6:40 am on 10 August 2020, and at 7.00 am, an operator observed water being discharged from the sediment pond though the base of the sediment pond. Water monitoring was conducted on the day of the event and in the following days, and pollution incident response measures were instigated to limit further sediments entering the waterways.

The site of the incident was inspected and assessed by Niche aquatic ecologist, on 12 and 19 August 2020, and an Environmental Assessment report was prepared for the EPA (Niche 2020).

The report recommended additional monitoring to:

- Determine if there are any long-term impacts associated with the event.
- Monitor for any potential construction impacts associated with the sediment dam reinstatement works.

Since the event the following has been completed in restoring the sediment dam and stream function:

- The clean water diversion has been reinstated and is functioning as designed.
- Installed erosion and sediment controls have been maintained.
- The geosynthetic clay liner installation has been completed.

While the sediment pond reinstatement works are near completion, all works associated with restoring the tributary flow paths and permanent water management feature have been completed.

1.4 Previous monitoring survey

The result of the environmental assessment indicated that there was limited measurable impact to stream ecology. Immediately downstream of the sediment dam showed some impact to stream ecology however this location has a high potential for recovery due to the presence of several macroinvertebrate families including sensitive EPT and other pollution sensitive taxa, as well as connection to unimpacted upstream

habitat from which this location could quickly recolonise. The report however suggested that there should be further monitoring to assess for potential long term and or lagged impacts.

Figure 1: Plan of Kemira Valley Coal Loading Facility

2. Results

2.1 Field survey

Aquatic ecology monitoring was conducted by a Niche Aquatic Ecologist and accompanied by a South32 Environment Specialist on 12 November 2020. The site inspection included the following:

- Visual aquatic habitat assessment.
- Water quality monitoring.
- Macroinvertebrate stream health monitoring using Australian Rivers Assessment System (AUSRIVAS) rapid assessment sampling protocols and stream health indicators - Stream Invertebrate Grade Number Average Level (SIGNAL), Number of Taxa and Ephemeroptera, Plecoptera and Trichoptera (EPT) Index.

2.1.1 Aquatic habitat assessment

Visual assessment of aquatic habitat was conducted using the AUSRIVAS protocol. The survey is a rapid assessment intended to describe aquatic 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.

2.1.2 Water quality

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

- Temperature (°C)
- Conductivity (µS/cm)
- pH
- Alkalinity measured with a standard titration kit (mg $CaCO_3$/L)
- Dissolved Oxygen (DO) (% saturation and mg/L)
- Turbidity (NTU).

Water quality was compared to ANZECC guidelines for upland streams.

2.1.3 Macroinvertebrate survey

AUSRIVAS

Sampling was primarily focussed on Brandy and Water Creek above the confluence of American Creek as any impact is likely to be more detectable given it is above other potentially confounding catchment influences (i.e. American Creek). This was conducted up and downstream of the sediment pond.

Riffle

Riffles (defined as section of stream with shallow with fast, turbulent water running over rocks) were selected to be sampled as there were limited areas to sample pools up and downstream of the sediment pond. Additionally, riffle habitats typically contain several filter feeders and sensitive aquatic fauna that are susceptible impacts from sedimentation.

Sampling was conducted according to AUSRIVAS protocols flowing water (riffle) habitat which entailed disturbing 10 metres of habitat by digging with the feet in the substratum and capturing dislodged macroinvertebrates downstream with a 250 micrometre (µ/m) dip net.

Sorting

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

Physical variables

The chemical and physical variables required for running the AUSRIVAS predictive model were also recorded: i.e. latitude and longitude, distance from stream source, altitude, land-slope and rainfall.

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). Small crustaceans Ostrocoda, Copapoda and Cladocera were not included as part of the analysis. Identification keys used included:

- Dean, J., Rosalind, M., St Clair, M., and Cartwright, D. (2004). Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera) Cooperative Research Centre for Freshwater Ecology
- Gooderham, J. and Tsyrlin, E. (2002). The Waterbug Book: A guide to the Freshwater Macroinvertebrates of Temperate Australia, CSIRO Publishing
- Hawking and Theischinger (1999). A guide to the identification of larvae of Australian families and to the identification of ecology of larvae from NSW
- Madden, C. (2010). Key to genera of Australian Chironomidae. Museum Victoria Science Reports 12,1-31
- Madden, C. (2011). Draft identification key to families of Diptera larvae of Australian inland waters La Trobe University
- Smith, B. (1996). Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters Murray Darling Freshwater Research Centre
- Website - http://www.mdfrc.org.au/bugguide/.

2.1.4 Data analysis

AUSRIVAS

Samples collected using AUSRIVAS protocol were analysed using the predictive models for NSW riffle and pool habitats (Turak *et al*. 2004). The AUSRIVAS model predicts the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stress, such as pollution or habitat degradation. The AUSRIVAS NSW spring model were used for the data collected. Observed to Expected ratio (OE50), SIGNAL (Stream Invertebrate Grade Number Average Level), and number of taxa were the indices used to interpret stream health.

Note the AUSRIVAS model used for this assessment was outside of the sampling season protocols for use of the models and as such the results need to be interpreted prudently as it is unfit for seasonal comparison

or to other AUSRIVAS assessed sites. However, it can give an indicative stream health, particularly if supported through additional macroinvertebrate indicators.

Other additional indicators used in the assessment are:

- SIGNAL (Stream Invertebrate Grade Number Average Level) scores
- Number of taxa
- The EPT (Ephemeroptera, Plecoptera and Tricoptera) Index.

Observed to Expected ratio OE50

The Observed to Expected ratio (OE50) is the ratio of the number of invertebrate families observed at a site (NTC50) to the number of families expected (NTE50) at that site. Only macroinvertebrate families with a greater than 50% predicted probability of occurrence are used by the model. OE50 provides a measure of biological impairment at the test site. Bands derived from the OE50 indicate the level of impairment of the assemblage. The OE50 ratios are divided into bands representing different levels of impairment (Table 1).

Table 1: AUSRIVAS band interpretation

Band	OE50 Riffle	Interpretation
Band X	Infinity >1.18	Represents a more biologically diverse community than reference
Band A	0.8-1.18	Is considered similar to reference condition
Band B	0.43 -0.8	Represents sites significantly impaired
Band C	0.06-0.43	Represents sites in a severely impaired condition
Band D	>0.06	Represents sites that are extremely impaired

SIGNAL (Stream Invertebrate Grade Number Average Level) scores

The revised SIGNAL2 biotic index developed by Chessman (2003) was also used to determine the "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate 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. 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

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

Taxa Richness

The richness of macroinvertebrate families (or class/orders if not identified to family level) was calculated as an indicator of stream health. The higher the number, the healthier the aquatic ecosystem.

EPT Index

The EPT (Ephemeroptera, Plecoptera and Tricoptera) index is based on the insect orders that contain a majority of pollution sensitive taxa (Lenat 1988). All genera of Ephemeroptera, Plecoptera and Tricoptera were identified and the number of distinct taxa were counted as an indicator of ecosystem health. The higher the number, the healthier the aquatic ecosystem.

2.2 Aquatic monitoring sites

The sampling sites for the field inspection are shown in Table 4 and Figure 2. The stream was surveyed at Site 1-3, and Site 5-7. This was consistent with sites recommended to be monitored in the Environmental Assessment Report (Niche 2020). Site 4 and Site 8 was not resurveyed. Additional monitoring included AUSRIVAS macroinvertebrate monitoring at Site 6 – American Creek upstream of Brandy and Water Creek confluence and Site 7 -American Creek downstream of Brandy and Water Creek confluence, where only water quality sampling and visual inspection had been conducted in August.

Table 4: Location and types of assessment conducted at survey sites

Site Number	Location	Habitat	Sampled	Sample	Easting	Northing
Site 1	Upstream of Sediment dam	Riffle	12 August 2020	Visual assessment, water quality and macroinvertebrates	300375	6189262
Site 2	50m downstream of sediment dam	Riffle	12 and 19 August 20200	Visual assessment, water quality and macroinvertebrates	300358	6188948
Site 3	1.6 km downstream of sediment dam	Riffle	19 August 2020	Visual assessment and macroinvertebrates	301405	6187937
Site 4	Upstream of American Creek confluence	Pool	Not sampled	-	302051	6187236
Site 5	Near confluence of American Creek	Riffle	12 August 2020	Visual assessment, water quality and macroinvertebrates	302085	6186945

Site 6	American Creek upstream of Brandy and Water Creek confluence	-	12 August 2020	Visual assessment, water quality and macroinvertebrates	302056	6186913
Site 7	American Creek downstream of Brandy and Water Creek confluence	-	12 August 2020	Visual assessment, water quality and macroinvertebrates	302169	6186908
Site 8	American Creek near Prices highway	-	12 August 2020	-	302967	6187255

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3. Results

3.1 Rainfall

There were two low rainfall events in the two weeks preceding the field survey (undertaken on 12 November 2020). At the time of the survey the water levels within the waterways were low. However, there was significant rainfall the week prior to water quality sampling conducted by South32 on the 29 October 2020 when 75mm antecedent rainfall was recorded (24 October 2020- 29 October 2020) (Figure 3). This resulted in visually turbid water flow from the upstream catchment (Plate 1). A large rainfall event also occurred on 31 October 2020 after water quality monitoring with 24 hour total of 81mm recorded at Kemira Valley (Figure 3).

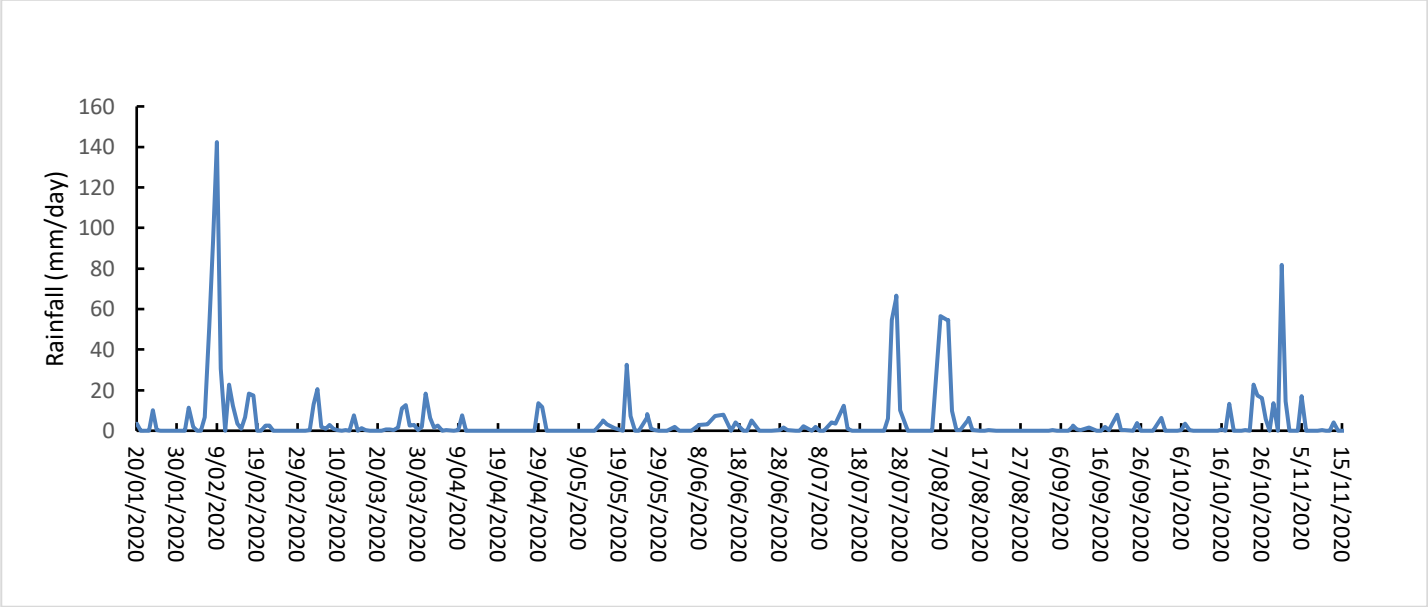

Figure 3: Rainfall at Kemira Valley (2020)

Plate 1: Kemira Valley upstream (Site 1) 29 October 2020 during South32 water quality sampling

3.2 Visual inspection

3.2.1 Sediment pond outlet

The clean water diversion culvert underneath the sediment pond has been reinstated and the outlet stabilised (Plate 2 A-B). No suspended sediment was observed coming from the tributary which flows underneath the sediment pond.

3.2.2 Aquatic habitat

In general, the overall habitat of Brandy and Water Creek and American Creek are disturbed and affected by urbanisation. While there are sections of native vegetation (near Site 3), there are areas that have limited riparian vegetation and/or are dominated by weeds e.g. Mysore Thorn (*Biancaea decapetala*). The banks in some sections are at high risk of erosion with unconsolidated sandy banks, limited vegetation and showing signs of past and active bank erosion. The streams consisted of both lentic (pools) and lotic (flowing) habitat types with substrate ranging from sands/fine sediment, boulder, cobbles and gravel.

Visual assessment of benthic habitat found some clay conglomerates and gravels located near the sediment pond near the culvert which collapsed. However, the coal fines which were observed after the event in August 2020 (Plate 2C) were not observed in November 2020 (Plate 2 D-F). This was the case in both pool and riffle habitat. It appears that recent rainfall events have washed the remaining coal fines through the system, which were previously observed in August in some places on the stream bed. Photographs of each sites are shown in Annex 1 (Plate 3).

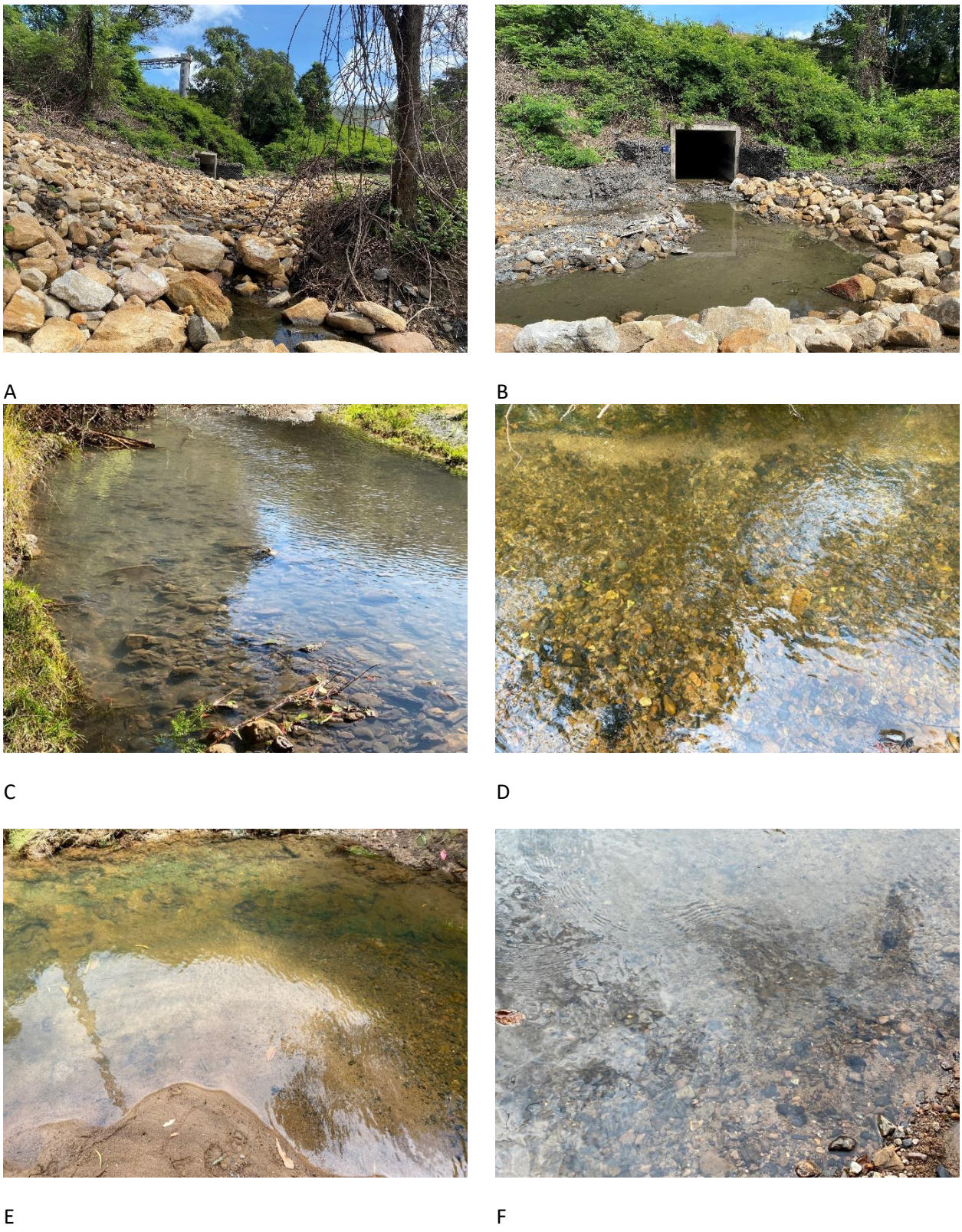

Plate 2: A -B– Outlet of tributary at Brady and Water Creek , C -Fine layer of pool fines in pool habitat taken August 2020, C, D, E, F -Typical stream bed substrate -no evidence of coal fines in November 2020.

3.2.3 Fauna observations

Fish were captured as part of the November spring macroinvertebrate sampling , including:

- Coxs Gudgeon (*Gobiomorphus coxii*) at Site 1
- Australian Smelt (*Retropinna semoni*) at Brandy and Water Creek upstream of American Creek (Site 5)

- Flathead Gudgeon (*Philypnodon grandiceps*) at American Creek downstream of Brandy and Water Creek (Site 7).

3.3 Water quality

Water quality results for August are presented in Table 5: Water quality results-12 August 2020 and for November are presented in Table 6. The water quality results for 12 November 2020 showed that:

- Temperature ranged between 16.34 – 21.59°C
- Conductivity was low and below ANZECC DTVs, ranging between 262-297µ/cm.
- All sites were below the DTV for turbidity, with the exception of Brandy and Water Creek above the sediment pond (Site 1) which was slightly above.
- Dissolved oxygen was mostly within ANZECC DTVs and ranged between 92.4 – 114% saturation, with the exception of Site 2 which was above ANZECC guidelines.
- The pH of all sites exceeded ANZECC trigger values with the highest recorded upstream of the sediment pond (8.17) (Site 1). Alkalinity was moderate 80-120 mg$CaCO_3$/L.

Table 5: Water quality results-12 August 2020

Season	Brandy and Water Creek			American Creek		
Site	**1**	**2**	**5**	**6**	**7**	**8**
Temperature °C	12.32	12.39	13.61	13.87	13.8	13.35
Electrical conductivity (µS/cm)	236	247	266	301	286	306
Turbidity (NTU)	**49**	**50**	**45.8**	11.2	**105**	**30.1**
Dissolved oxygen (% sat)	105	98	98	95.2	98.8	100
pH	**8.17**	8	7.68	7.52	7.59	7.57
Alkalinity (mg $CaCO_3$/L)	80	80	60	60	60	80

NOTES: ANZECC guidelines for upland streams: Electrical conductivity (30-350µS/cm), Turbidity (2-25 NTU), pH (6.5-8.0), Dissolved Oxygen (90-110%). Text in bold indicates those variables that exceed the default trigger values.

Table 6: Water quality results -18 November 2020

Season	Brandy and Water Creek				American Creek	
Site	**1**	**2**	**3**	**5**	**6**	**7**
Temperature °C	16.34	17.24	21.59	19.89	20.23	20.38
Electrical conductivity (µS/cm)	262	267	278	285	297	292
Turbidity (NTU)	**48**	13.3	12.4	5.7	6.5	6.4
Dissolved oxygen (% sat)	106	**114**	108	95.4	101.5.	92.4
pH	**8.84**	**8.51**	**8.28**	**8.12**	**8.27**	**8.05**
Alkalinity (mg $CaCO_3$/L)	120	100	120	100	100	80

NOTES: ANZECC guidelines for upland streams: Electrical conductivity (30-350µS/cm), Turbidity (2-25 NTU), pH (6.5-8.0), Dissolved Oxygen (90-110%). Text in bold indicates those variables that exceed the default trigger values.

3.3.1 Water quality – South32 results

Water quality samples have been undertaken by South32 monthly since the event. All results, including immediately after the event are provided in Annex 2 (Table 9 and Table 10). The monthly results in September and October are discussed below.

The major physiochemical observations in monthly monitoring results were differences in Total Suspended Solids (TSS) between sites upstream and downstream of the sediment pond, which in September were small, but elevated at all sites in October following recent high rainfall. The highest result was recorded upstream of the sediment dam (389mg/L) exceeding ANZECC guidelines (25mg/L). DTVs were also exceeded downstream of the sediment pond and above the confluence of American Creek. However, in American Creek up and downstream of the confluence results were below ANZECC DTVs. Electrical conductivity also showed some small exceedances of DTVs at most site samples in both months. The pH showed exceedance in Site 1 and Site 2 in September; however most sites were within ANZECC DTVs in October.

The results also showed that Oil and Grease were below detection limits during the initial stages of the event and remained below detection limits on both sampling occasions (September and October).

Water samples were tested for total metals in October and showed exceedance for Copper and Zinc, particularly at Site 1 (upstream) and Site 2 (downstream) of the sediment pond for 95 % (DTVs -Cu 1.4 ug/L, Zn 8 ug/L) level of protection, which is recommended for application to slightly to moderately disturbed ecosystems. However, it should be noted that these exceedances also occurred upstream of the sediment dam and sampling was conducted after a high rainfall event.

3.4 Macroinvertebrates - AUSRIVAS and SIGNAL

Macroinvertebrate samples were taken at Site 1, 2, 3, 5 6 and 7 in Brandy and Water Creek and American Creek on 12 November 2020. Raw data is provided in Annex 3 (Table 11 and Table 12).

The previous survey results (August) are presented in Table 7 and new data raw data (November) provided in Table 8. Overall, in November, 38 different taxa were collected from all sites. This was a reduction from August (43 different taxa). This reduction was the result of pollution tolerant invertebrates only; additionally, it should be noted that the total numbers are not directly comparable as different sites were sampled. The number of taxa in November ranged from 19 to 22 among sites. Site 2 and Site 3 in Brandy and Water Creek recorded the highest and Site 6 and 7 in American Creek the lowest. Site 1 showed a marked reduction in the number of invertebrates (Table 7 and Table 8). This was the result was a combination of mostly pollution tolerant macroinvertebrates and three pollution sensitive families.

Of the sites that were resurveyed, AUSRIVAS show there has been a slight decrease in OE50 scores in November in Site 1, 2 and 3 and an increase in Site 5 since August. However downstream sites in Brandy and Water Creek (Site 2) and American Creek (Site 7) were comparable to or higher than upstream sites. These OE50 score are categorised as Band B (Table 1) which indicate that sites have fewer families than was expected and are categorised as significantly impaired (Table 8).

The SIGNAL scores for all sites, including the upstream site, were between 4.00-5.15, which may indicate severe-mild pollution in Brandy and Water Creek and American Creek (Table 7and Table 8). As a whole it is considered that the waterways are experiencing 'moderate pollution' (Table 3) consistent with what would be expected of a disturbed stream. Note that SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic pollution. Environmental stress (e.g. high flow events or prolonged low flows) may result in poor water quality occurring naturally in waterways. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are in natural condition or within background levels.

In comparison to the previous survey in August, with the exception of Site 3, all sites that were resurveyed had a higher SIGNAL score in November. Additionally, downstream sites in Brandy and Water Creek (Site 2) and American Creek (Site 7) were comparable to or higher than upstream sites. Overall, the SIGNAL2 scores reflect the presence of both pollution tolerant and pollution sensitive taxa which are utilising the riffle habitat.

The EPT index score were relatively high for all sites ranging from 6-9 taxa among sites. Downstream sites in Brandy and Water Creek (Site 2) and American Creek (Site 7) were comparable to or higher than upstream sites. Site 3 had the lowest EPT score (6). Compared to August surveys, there was a slight decrease in Site 1 and Site 3, however other sites were slightly higher in EPT scores. EPT families observed include mayflies – Caenidae (SIGNAL 4), Baetidae (SIGNAL 5), Leptophlebiidae (SIGNAL 8); Caddisfly – Conoesucidae (SIGNAL 7), Philopotamidae (SIGNAL 8), Hydroptilidae (SIGNAL 4), Glossossomatidae (SIGNAL 9), Ecnomidae (SIGNAL 5), Hydropsychidae (SIGNAL 6), Hydrobiosidae (SIGNAL 8), Helicopsychidae (SIGNAL 8), Leptoceridae (SIGNAL 6), and stonefly Gripopterygidae (SIGNAL 8). Other non- EPT sensitive taxa include: Dobsonfly Corydalidae (SIGNAL 7) observed at Site 1, Site 2 and Site 5; Riffle Beetle Elmidae (SIGNAL 7) observed at Site 1, Site 3, Site 5, Site 6 and Site 7; Psephenidae (SIGNAL 6) observed Site 2, Site 5, and Site 7; Scirtidae (SIGNAL 6) observed at Site 4 and Site 5; and Acarina (SIGNAL 6) at Site 1, Site 3 and Site 6.

Overall, the indicators show that the waterway is under natural or anthropogenic stress, however seem consistent with that of a slightly disturbed stream in an urbanised catchment and provides habitat for a variety of sensitive invertebrates.

Table 7: AUSRIVAS results -August 2020

Date	Site	No of taxa	OE 50	SIGNAL	Band	EPT
12 August 2020	1	31	0.77	4.80	B	10
12 August 2020	2	19	0.41	4.88	C	7
19 August 2020	2	24	0.71	4.79	B	9
12 August 2020	3	23	0.74	5.17	B	9
19 August 2020	4	21	0.74	3.5	B	5
19 August 2020	5	20	0.44	4.31	B	8

Table 8: AUSRIVAS results -November 2020

Date	Site	No of taxa	OE 50	SIGNAL	Band	EPT
12 November 2020	1	20	0.65	5.10	B	8
12 August November 2020	2	22	0.69	5.14	B	9
12 August November 2020	3	22	0.57	4.00	B	6
12 August November 2020	5	20	0.62	5.45	B	9
12 August November 2020	6	19	0.51	4.74	B	7
12 August November 2020	7	19	0.57	4.84	B	8

4. Discussion

4.1 Aquatic habitat

Since the event in August there have been several moderate to high rainfall events (Plate 1, Figure 3). This has resulted in high flow that reworked the benthos and transported remaining coal fines through the system. The pool and riffle habitat and banks were observed to be free from any coal fine material. While there are some gravels and clay located in close proximity to the culvert exit, there are no coal fines or suspended sediment entering Brandy and Water Creek from this tributary. The outlet work and erosion and control measures appear to have stabilised this area, managed sediment and effectively restored this confluence.

4.2 Water quality

The water quality showed some exceedances of physicochemical measures and metals (copper and zinc); however, this appears to be related to the high flow event in October (Plate 1) which also showed higher suspended sediment loads at the time. Additionally, these exceedances occurred upstream of the sediment pond, indicating that elevated levels were originating from the catchment rather than from the site itself and are not thought to be related to any resuspension and transportation of material from the event. This is further supported by previous water quality sampling results which showed no exceedance of these metals in the water and sediment soon after the event (Niche 2020).

4.3 Aquatic ecology

Overall, while there is some expected variability in stream health indicators, the results were similar to previous surveys with all sites scoring in Band B and containing similar sensitive pollution tolerant and EPT taxa to what was observed previously. Additionally, there was similarity in indicators between up and downstream sites. While there was a slight reduction in OE 50 scores at Site 2 and Site 3 compared to August, this occurred at the upstream site (Site 1) where there was also a marked reduction in the number of taxa. This indicates catchment influences (e.g. high flow events) are likely contributing to difference in macroinvertebrate communities and in consideration of all results not the consequence of any long-term impacts from the event. Niche (2020) concluded that the coal fine sediment was nontoxic and fine sedimentation impact was localised and temporary and it was considered likely that any ecological impact would be subsequently followed by recovery and with no long-term ecological impacts. This conclusion is supported by this report, which has found that there was no significant presence of coal fines in the waterways. While there is no before data to compare results with, the fact that previous studies found no mechanism for ecotoxicity and the physical impact of coal fine sedimentation was temporary, it is unlikely there is any long-term impacts associated with event. Furthermore, the system is shown to support several sensitive invertebrate families as well as at least three native fish, indicating suitable habitat for primary and secondary consumers.

5. Conclusion and recommendations

The result of the aquatic monitoring indicates that there are no long-term impacts associated with the event. Previous sampling in August immediately downstream of the sediment pond showed some impact to stream ecology (Niche 2020), however sampling by Niche a week later showed that there had been improvement in stream health. Monitoring conducted in November showed that this improvement was maintained, and the downstream site was similar in stream health to the upstream site. This finding was reflected up and downstream of the American Creek and Brandy and Water Creek confluence which also showed similarities in invertebrates, water quality and stream health indicators. Overall, all sites were considered to be consistent with the ecology expected in a moderately disturbed system. The lack of coal fines evident in the recent round of monitoring indicate a recovery in aquatic habitat and show that there are no long-term impacts associated with the event that occurred in August. As such, further monitoring dedicated to assessing this event is not considered to be required.

6. References

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000). National water quality management strategy and assessment guidelines: Australian and New Zealand guidelines for fresh and marine water quality ANZECC/ARMCANZ. Environment Australia.

Chessman, B.C, Growns, J.E and Kotlash, A.R. (1997). Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: Application to the Hunter River system, New South Wales in Mari*ne and Freshwater Research*, 48, pp. 159-172.

Chessman, B.C. (2003). Signal 2. A scoring system for macroinvertebrates ('water bugs') in Australian rivers user manual. Department of Environment and Heritage.

Dean, J., Rosalind, M., St Clair, M., and Cartwright, D. (2004). Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera) Cooperative Research Centre for Freshwater Ecology.

Gooderham, J. and Tsyrlin, E. (2002). The Waterbug Book: A guide to the Freshwater Macroinvertebrates of Temperate Australia, CSIRO Publishing.

Hawking, J. and Theischinger, G. (1999). A guide to the identification of larvae of Australian families and to the identification of ecology of larvae from NSW.

Lenat, D.R. (1988). Water quality assessment using a qualitative collection method for benthic macroinvertebrates. J.N. Am. *Benthological Soc*. 7: 222-233.

Lancaster J. and Downes, B.J. (2013). *Aquatic Entomology*. Oxford University Press.

Madden, C. (2010). Key to genera of Australian Chironomidae. Museum Victoria Science Reports 12, 1-31.

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

Murray Darling Freshwater Research (2019). Retrieved from: https://www.mdfrc.org.au/bugguide/ (accessed August 2020).

Niche (2020). Environmental Assessment report. Prepared for South32.

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.

South32 (2000). Incident Report Kemira Valley Sediment Pond. South32.

Turak, E., Waddel, l N., and Johnstone, G. (2004). New South Wales Australian River Assessment System (AUSRIVAS): Sampling and Processing Manual, 2004. Natural Heritage Trust, Department of Environment and Conservation NSW.

Woods, P.J. & Armitage, P.D. (1997). Biological effects of fine sediment in the lotic environment. Environmental Management, 21: 203-21

Annex 1: Aquatic habitat photographs

Site 1 upstream

Site 1 downstream

Site 2 upstream

Site 2 downstream

Site 3 upstream

Site 3 downstream

Site 5 upstream

Site 5 downstream

Site 6 upstream

Site 6 downstream

Site 7 upstream

Site 7 downstream

Plate 3: Upstream and downstream photographs of each site (November).

Annex 2: Water quality and sediment results– South32

Table 9: Physiochemical water quality results

			HORIBA					LAB Results (ALS)					
COC Name	**Site**	**Date**	**NTU**	**Temp**	**pH**	**EC**	**DO %**	**pH**	**EC mS/cm**	**TSS mg/L**	**O&G mg/L**	**DO mg/L**	**Location**
DEN-INV^KV1-US	DEN-KV1-US	10/08/2020	---	---	---	---	---	7.79	0.221	27	<5	10.2	Point 7 Sample Point
DEN-INV^KV2-DS	DEN-KV2-DS	10/08/2020	---	---	---	---	---	7.83	0.248	113	<5	10.2	Point 10 Sample Point
DEN-INV^KV3-DDS	DEN-KV3-DDS	11/08/2020	---	---	---	---	---	8.15	0.659	24	<5	10.3	Allans Creek - Bluescope
DEN-INV^KV1-US	DEN-KV1-US	12/08/2020	---	---	---	---	---	7.78	0.253	16	<5	8.6	Point 7 Sample Point
DEN-INV^KV2-DS	DEN-KV2-DS	12/08/2020	---	---	---	---	---	7.84	0.263	26	<5	8.9	Point 10 Sample Point
DEN-INV^KV4-CF	DEN-KV4-CF	12/08/2020	---	---	---	---	---	7.84	0.28	16	<5	8.9	Brandy and Water Creek @ confluence
DEN-INV^KV5-CF-DS	DEN-KV5-CF-DS	12/08/2020	---	---	---	---	---	7.88	0.303	13	<5	9	Downstream from American CK and B&W CK confluence
DEN-INV^KV6-CF-US	DEN-KV6-CF-US	12/08/2020	---	---	---	---	---	7.88	0.314	<5	<5	9.1	American Creek @ confluence
DEN-INV^KV1-US	DEN-KV1-US	13/08/2020	18.7	11.74	7.91	0.257	105.2	---	---	---	---	---	Point 7 Sample Point
DEN-INV^KV2-DS	DEN-KV2-DS	13/08/2020	25.5	11.86	7.81	0.265	97.1	---	---	---	---	---	Point 10 Sample Point
DEN-INV^KV4-CF	DEN-KV4-CF	13/08/2020	487*	13.56	6.59	0.281	108.1	---	---	---	---	---	Brandy and Water Creek @ confluence
DEN-INV^KV5-CF-DS	DEN-KV5-CF-DS	13/08/2020	11.6	13.72	7.63	0.306	126.7	---	---	---	---	---	Downstream from American CK and B&W CK confluence
DEN-INV^KV6-CF-US	DEN-KV6-CF-US	13/08/2020	2.2	13.45	7.54	0.315	98.7	---	---	---	---	---	American Creek @ confluence

			HORIBA					LAB Results (ALS)					
COC Name	**Site**	**Date**	**NTU**	**Temp**	**pH**	**EC**	**DO %**	**pH**	**EC mS/cm**	**TSS mg/L**	**O&G mg/L**	**DO mg/L**	**Location**
DEN-INV^KVSED-A	DEN-KVSED-A	14/08/2020	---	---	---	---	---	TBC	TBC	TBC	TBC	TBC	Slurry - Sed Pond A/B KV
DEN-INV^KV1-US	DEN-KV1-US	14/08/2020	22	13.49	7.86	0.292	96.9	---	---	---	---	---	Point 7 Sample Point
DEN-INV^KV2-DS	DEN-KV2-DS	14/08/2020	31.2	13.43	7.99	0.295	111.8	---	---	---	---	---	Point 10 Sample Point
DEN-INV^KV4-CF	DEN-KV4-CF	14/08/2020	19	13.29	7.8	0.318	113.7	---	---	---	---	---	Brandy and Water Creek @ confluence
DEN-INV^KV5-CF-DS	DEN-KV5-CF-DS	14/08/2020	14.3	13.43	7.59	0.346	95.1	---	---	---	---	---	Downstream from American CK and B&W CK confluence
DEN-INV^KV6-CF-US	DEN-KV6-CF-US	14/08/2020	6.8	13.73	7.75	0.345	97.4	---	---	---	---	---	American Creek @ confluence
LDP5	LDP5	13/08/2020	334	18.9	7.86	1.37	81.7	---	---	---	---	---	Marley Place
LDP5	LDP5	14/08/2020	7.3	21.89	8.02	1.99	67.3	---	---	---	---	---	Marley Place
DEN-KV1-US	DEN-KV1-US	17/08/2020	18.6	13.11	8.41	0.317	98.2	7.81	0.322	7	<5	10.5	Point 7 Sample Point
DEN-KV2-DS	DEN-KV2-DS	17/08/2020	15.6	13.6	8.3	0.324	103.2	7.95	0.327	7	<5	10.4	Point 10 Sample Point
DEN-KV4-CF	DEN-KV4-CF	17/08/2020	13.4	14.97	7.86	0.345	91.7	7.95	0.347	14	<5	10.5	Brandy and Water Creek @ confluence
DEN-KV5-CF-DS	DEN-KV5-CF-DS	17/08/2020	9.3	15.6	8.15	360	82.1	7.98	0.361	5	<5	10.3	Downstream from American CK and B&W CK confluence
DEN-KV6-CF-US	DEN-KV6-CF-US	17/08/2020	3.2	15.21	7.54	0.359	86.7	7.94	0.362	<5	<5	10	American Creek @ confluence
DEN-KV2-DS	DEN-KV2-DS	19/08/2020	---	---	---	---	---	---	---	---	---	---	Point 10 Sample Point
DEN-KV4-CF	DEN-KV4-CF	19/08/2020	---	---	---	---	---	---	---	---	---	---	Brandy and Water Creek @ confluence

			HORIBA					LAB Results (ALS)					
COC Name	**Site**	**Date**	**NTU**	**Temp**	**pH**	**EC**	**DO %**	**pH**	**EC mS/cm**	**TSS mg/L**	**O&G mg/L**	**DO mg/L**	**Location**
DEN-KV5-CF-DS	DEN-KV5-CF-DS	19/08/2020	---	---	---	---	---	---	---	---	---	---	Downstream from American CK and B&W CK confluence
DEN-KV6-CF-US	DEN-KV6-CF-US	19/08/2020	---	---	---	---	---	---	---	---	---	---	American Creek @ confluence
DEN-KV7-DS	DEN-KV7-DS	19/08/2020	---	---	---	---	---	---	---	---	---	---	Brandy and Water Creek DS from site, along Endevour Easement
DEN-INV^KV8-SED		25/08/2020											American Creek @ O'Brien's Rd - Sediment sample
DEN-DEND7	DEN-DEND7	16/09/2020						8.32	0.453	6	<5	10.1	Upstream of Kamira valley
DEN-DEND10	DEN-DEND10	16/09/2020						8.4	0.460	<5	<5	9.7	Downstream of Kamira Valley
DEN-INV^KV1-US	DEN-INV^KV1-US	29/10/2020						7.73	0.377	389	<5	8.7	Upstream of KV
DEN-INV^KV2-DS	DEN-INV^KV2-DS	29/10/2020						7.87	0.398	227	<5	8.6	Downstream of KV
DEN-INV^KV4-CF	DEN-INV^KV4-CF	29/10/2020						8.02	0.461	35	<5	8.7	Brandy and Water Creek @ confluence
DEN-INV^KV5-CF-DS	DEN-INV^KV5-CF-DS	29/10/2020						7.98	0.377	14	<5	8.7	Downstream from American CK and B&W CK confluence
DEN-INV^KV6-CF-DS	DEN-INV^KV6-CF-DS	29/10/2020						7.99	0.342	10	<5	8.8	American Creek @ confluence

Table 10: Water sample results

			Water sample (Metals) (mg/L)				
COC Name	**Site**	**Date**	**Arsenic**	**Copper**	**Nickel**	**Zinc**	**Location**
DEN-INV^KV1-US	DEN-INV^KV1-US	29/10/2020	<0.001	0.011	0.004	0.022	Upstream of KV
DEN-INV^KV2-DS	DEN-INV^KV2-DS	29/10/2020	0.002	0.015	0.007	0.032	Downstream of KV
DEN-INV^KV4-CF	DEN-INV^KV4-CF	29/10/2020	<0.001	0.003	<0.001	0.006	Brandy and Water Creek @ confluence
DEN-INV^KV5-CF-DS	DEN-INV^KV5-CF-DS	29/10/2020	<0.001	0.002	<0.001	<0.005	Downstream from American CK and B&W CK confluence

DEN-INV^KV6-CF-DS	DEN-INV^KV6-CF-DS	29/10/2020	<0.001	0.002	<0.001	<0.005	American Creek @ confluence

Annex 3: Macroinvertebrate results– South32

Table 11: Macroinvertebrate data (August)

Taxa-	Site 1	Site 2	Site 5	Site 2	Site 4	Site 5
	12 August 2020			19 August 2020		
Nematode	1	0	0	0	0	0
Turbellaria	1	0	0	0	0	0
Corydalidae	2	0	0	0	5	1
Lymnaeidae	0	0	0	0	0	1
Ancylidae	1	0	0	0	0	0
Corallanidae	1	1	0	0	0	0
Hydrobiidae	33	1	5	4	3	2
Physidae	8	0	1	0	1	11
Oligochaeta	3	0	0	4	5	3
Gripopterygidae	0	0	0	1	1	0
Acarina	1	0	0	0	1	0
Atyidae	1	7	5	0	1	26
Dytiscidae	19	12	18	2	3	14
Gyrinidae	0	0	2	0	0	2
Elmidae	1	2	0	1	2	0
Hydrophilidae	3	1	0	1	0	4
Scirtidae	5	0	0	0	4	1
Psephenidae	0	0	0	1	1	0
Tipulidae	2	1	0	1	1	0
Simuliidae	0	0	0	1	0	0
Stratiomiyidae	15	1	0	2	2	2
Tanypodinae	3	0	2	2	0	0
Orthocladiinae	0	0	1	3	0	0
Chironominae	0	0	3	1	0	1

Taxa-	Site 1	Site 2	Site 5	Site 2	Site 4	Site 5
Baetidae	6	2	80	6	46	1
Leptophlebiidae	8	9	4	0	2	2
Caenidae	15	0	77	10	32	125
Veliidae	1	8	0	0	1	0
Gerridae	2	0	2	1	0	0
Corixidae	4	1	77	1	0	5
Notonectidae	0	1	1	0	0	3
Isostictidae	0	0	0	0	0	1
Gomphidae	1	1	0	1	1	0
Hemicorduliidae	0	0	1	0	0	0
Libellulidae	0	0	0	0	0	3
Conoesucidae	1	1	0	22	2	0
Philopotamidae	1	0	0	1	3	0
Hydroptilidae	0	0	1	0	0	0
Glossossomatidae	1	1	1	0	0	0
Ecnomidae	3	1	1	1	0	1
Hydropsychidae	6	2	13	12	77	0
Helicopsychidae	1	0	0	1	1	0
Leptoceridae	24	10	102	1	16	82

Table 12: Macroinvertebrate data (November)

Taxa	Site 1	Site 2	Site 3	Site 5	Site 6	Site 7
Turbellaria	0	0	5	0	0	0
Corydalidae	1	2	0	1	0	0
Ancylidae	0	1	0	0	0	0
Hydrobiidae	17	5	9	0	0	0
Physidae	0	0	2	4	1	6
Oligochaeta	7	2	5	3	6	13

Taxa	Site 1	Site 2	Site 3	Site 5	Site 6	Site 7
Gripopterygidae	1	1	0	1	0	0
Acarina	2	0	2	0	0	10
Atyidae	4	0	9	0	1	8
Dytiscidae	7	2	5	0	1	4
Gyrinidae	0	0	0	1	0	1
Elmidae	1	0	7	5	6	2
Hydrophilidae	4	3	2	1	1	5
Hydraenidae	0	0	1	0	0	0
Scirtidae	0	0	4	5	0	0
Psephenidae	0	2	0	1	1	0
Tipulidae	1	0	0	0	0	0
Simuliidae	0	5	0	7	6	10
Stratiomiyidae	1	1	2	0	0	0
Ceratopogonidae	5	6	1	0	0	0
Tanypodinae	0	0	0	0	1	0
Orthocladiinae	4	13	8	0	2	15
Chironominae	0	1	1	0	4	0
Baetidae	8	44	27	37	20	24
Leptophlebiidae	3	6	2	1	2	1
Caenidae	6	9	5	1	5	2
mesoveliidae	0	1	1	0	0	0
Gomphidae	0	0	0	1	5	2
Hemicorduliidae	0	0	0	0	0	0
Libellulidae	0	0	0	1	0	0
Conoesucidae	1	1	0	0	0	0
Hydrobiosidae	0	1	0	2	0	1
Philopotamidae	1	1	11	17	11	1
Hydroptilidae	0	0	0	0	0	1
Glossossomatidae	1	2	0	0	0	0

Taxa	Site 1	Site 2	Site 3	Site 5	Site 6	Site 7
Ecnomidae	0	0	0	0	2	0
Hydropsychidae	3	34	13	139	21	19
Heliopsychidae	0	0	0	1	1	0
Leptoceridae	0	0	15	2	0	6

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