

Investigation of Sediments and Macroinvertebrates in the Upper Barwon River

- Final Report
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Investigation of Sediments and Macroinvertebrates in the Upper Barwon River

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Executive Summary

Austral Research and Consulting investigated the extent of impacts from Big Swamp on surface water, sediments and the macroinvertebrate community structure in Boundary Creek and the upper Barwon River in Spring 2019. Sediment and water samples were collected and delivered to the laboratory for analysis with a specific focus on metals and the impacts of pH on these analytes from the East and West Barwon Rivers, Boundary Creek downstream of Big Swamp, and the Barwon River down to Winchelsea. Surface water and sediment results suggest that the drying and wetting of Big Swamp has mobilised Aluminium, Cadmium, Iron, Lead and Zinc in the Barwon River but this impact is not recorded downstream of Birregurra. Whilst waterway health in Boundary Creek remains impacted by Big Swamp and the macroinvertebrate community composition in the Barwon River is altered immediately downstream of the confluence, impacts detected in the sediment and water samples in the Barwon River were not reflected in overall waterway health indices. Continued monitoring of Boundary Creek and the upper Barwon River during the remediation process is recommended to provide feedback as to the success of remediation works.

1. Introduction

Austral Research and Consulting (Austral) have been contracted by Barwon Water to undertake an investigation into the sediment and water quality and macroinvertebrate condition of the upper Barwon River with regard to the extent of impact of low pH inflows from Boundary Creek.

This survey will determine a baseline for ongoing monitoring of the Barwon River as part of a remediation plan required by a section 78 Ministerial Notice by:

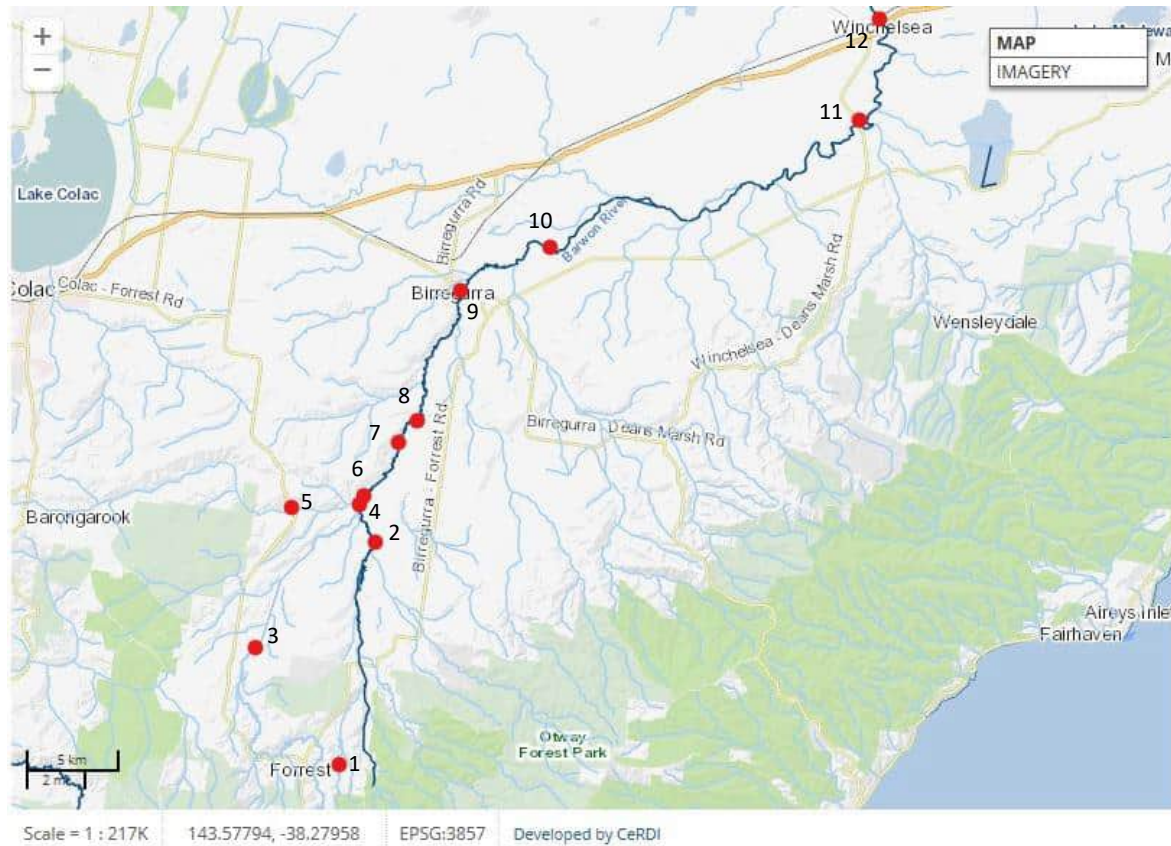
- Assessing the spatial extent of surface water effects resulting for acidic discharge from Boundary Creek in the Barwon River,
- Determining if acidic discharge from Boundary Creek has affected sediment in the Barwon River and if so, the spatial extent and depth of accumulation, and;
- Assess the potential impact of acidic discharge from Big Swamp at Yeodene on the macroinvertebrate community structure in Boundary Creek and the Barwon River.

1.1. Background

Studies have confirmed that past water extractions from the Barwon Downs borefield by Barwon Water to boost Geelong's water supply in conjunction with a dry climate lead to reductions in flows in lower Boundary Creek (Jacobs, 2017). This in turn caused Big Swamp to dry out activating naturally occurring acid sulfate soils that when rewetted have released acidic water into the lower reaches of Boundary Creek. Boundary Creek joins the Barwon River 3.7km downstream of Big Swamp.

2. Methods

A total of twelve sites were surveyed along East Barwon, West Barwon, and Barwon Rivers in addition to Boundary Creek (Figure 1).



■ **Figure 1: Barwon River and Boundary Creek (base map from Waterwatch Victoria)**

2.1. Site Selection

Sites were selected in consultation with Barwon Water to best give an indication of the impact of water coming from Big Swamp on Boundary Creek and particularly the Barwon River. Two sites are on the East Barwon River, one site is on the West Barwon River, one site is on Boundary Creek and eight sites are on the mainstem Barwon River. They incorporate existing Waterwatch sites, upstream sites that are unimpacted by Boundary Creek (sites 1-4) and sites focused on any impacts from Boundary Creek (Table 1).

Site no.	Existing number	Site description	Lat	Long
1	CO_BAR004 (inact.)	East Barwon River @ Kents Road, Yaughar	-38.512196	143.732530
2	New	East Barwon River @ Dewings Bridge Road	-38.434878	143.747933
3	CO_WES010	West Barwon River @ 7 bridges Road	-38.474669	143.689396
4	New	Barwon River immediately u/s of Boundary Ck conf.	-38.418236	143.742025
5	CO_BOU009	Boundary Creek, Colac-Forrest Road	-38.421122	143.710475
6	New	Barwon River immediately d/s of Boundary conf.	-38.416717	143.742383
7	New	Barwon River u/s CO_BAR016	-38.402291	143.757554
8	CO_BAR016	Barwon River @ Colac-Lorne Road	-38.388771	143.768956
9	CO_BAR020	Barwon River @ Birregurra	-38.339105	143.790971
10	CO_BAR030	Barwon River @ Conns Lane	-38.325134	143.832385
11	CO_BAR040	Barwon River @ Winchelsea Deans Marsh Road	-38.278018	143.978382
12	CO_BAR060	Barwon River @ Princes Hwy bridge, Winchelsea	-38.240445	143.989326

■ **Table 1: Site locations and descriptions**

2.2. Sampling methodology

Macroinvertebrates and sediments were sampled and *in situ* water quality, vegetation, site descriptions and photos were collected, specific methods are detailed below. Water quality samples should be collected monthly and macroinvertebrate samples in Spring and Autumn to ensure temporal trends and environmental variations are being detected (EPA, 2003a).

2.2.1. In-situ water quality

In-situ water quality parameters were measured at each site including dissolved oxygen (mg/l), temperature (°C), specific conductivity (µS/cm) and pH using a YSI ProPlus water quality meter. Turbidity (NTU) and alkalinity (mg/L) were measured using HACH meters and test kits respectively.

2.2.2. Metals in water

Water samples were collected for metals analysis, filtered in the field and kept refrigerated prior to delivery to the NATA accredited Eurofins Laboratory.

2.2.3. Metals in sediments

Sediment samples were collected using a PVC corer from a variety of depositional areas at each site (EPA, 2009). Three cores were taken and separated into surface to 20cm deep and 20cm to 40cm deep components. These depths were chosen as the deeper, below 20cm, samples are more likely to be indicative of pre-pumping metal concentrations than the shallower samples (D. Baldwin 2019, pers. comm., 20 Nov.) The three cores were then mixed into a composite sample for each depth, placed into jars and kept refrigerated prior to delivery to the NATA accredited Eurofins Laboratory to be analysed for metals and pH.

2.2.4. Macroinvertebrates

The benefit of monitoring the biological community is that it is affected by numerous types of toxicants and disturbances and the impacts can be evident over months or years (if two seasons are sampled) unlike chemical testing which may not capture an event.

Macroinvertebrates were collected at each site and photos and site assessment sheets were completed as per Victorian EPA guidelines (EPA, 2003b). In the absence of riffle habitats, two edge samples were collected (L. Metzling 2019 pers. comm. August 12) using a 250µm mesh dip net to sample ten meters of representative habitat at two locations at each site between 2nd and 4th October, 2019. The contents of the net was placed into a white tray to be picked through for 30 minutes with the aim of picking over 100 animals into 70% ethanol for later identification to family level following the Rapid Bioassessment Methodology for Rivers and Streams (EPA, 2003b). Macroinvertebrates were identified in the laboratory in accordance with the guidelines; to class for Oligochaeta and Mites, chironomids to sub-family and all other taxa to family except those that are not included in EPA Victoria biotic calculations (EPA, 2003b).

2.2.5. Site descriptions

EPA Victoria field sampling and habitat assessment sheets were filled out at each site and site photos taken (EPA, 2003b). These have been summarised in Appendix 1.

3. Results

3.1. Water quality

Water samples were collected and *in situ* readings taken at all 12 sites that sediments and macroinvertebrates were collected at and an *in situ* reading was taken on Boundary Creek (site 5.5) immediately upstream of the confluence with the Barwon River. Whilst a single water sample provides a snap shot of what is occurring in the waterway at one point in time, it gives an indication of the current conditions.

■ Table 2: In-situ water quality data.

Site	Waterway	Sample date	Temp. (°C)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm@25°C)	Dissolved oxygen (mg/L)	DO %	Alkalinity	Turbidity
Site 1	East Barwon Rv	04/10/19	13.2	6.2	186.7	240	13.07	123	5	9.09
Site 2	East Barwon Rv	04/10/19	15.5	6.3	544	664	6.8	66.8	10	9.97
Site 3	West Barwon Rv	03/10/19	14.7	5.26	473.4	590.6	7.3	73.5	10	16.3
Site 4	Barwon Rv	03/10/19	17.9	7.4	575	664	9.15	96.4	10	8.01
Site 5	Boundary Ck	03/10/19	12.1	3.94	777	1030	7.43	67.6	0	2.92
Site 5.5	Boundary Ck	03/10/19	14.2	5.55	1165	1285	7.05	68.2	-	-
Site 6	Barwon Rv	03/10/19	14.4	7.34	608	756	7.3	71.3	10	9.43
Site 7	Barwon Rv	03/10/19	13.4	7.9	599	770	7.2	71.7	5	10
Site 8	Barwon Rv	02/10/19	16.2	7.8	660	795	8.8	87.9	10	13.5
Site 9	Barwon Rv	02/10/19	15.4	7.8	1049	1288	9.7	98	15	16.6
Site 10	Barwon Rv	02/10/19	14.6	7.9	1252	1561	8.1	86.1	15	18
Site 11	Barwon Rv	02/10/19	13	7.9	1707	2227	9.23	87	15	26.1
Site 12	Barwon Rv	02/10/19	12.4	8	1788	2364	8.4	82.1	15	19.9

At the time of sampling, pH levels were low in the East and West branches of the Barwon River but had normalised at Site 4 above the Boundary Creek confluence. Whilst Boundary Creek has very low pH at Site 5 (Colac-Forest Road) and remains low immediately upstream of joining the Barwon River, the drop from upstream to downstream of the confluence is only 0.6 pH units and by Site 7, 3km downstream, pH

remains constant downstream. Samples taken monthly can be compared to the State Environment Protection Policy (SEPP) Waters of Victoria (2004) objectives that indicate the pH is should be between 6.5 and 8.3 (25th and 75th percentile respectively) for sites 2-12 (Cleared Hills and Costal Plains) and 6.4 to 7.7 (25th-75th percentile) for site 1 (Forests B segment).

■ **Table 3: Metal results for water samples (mg/L) and ANZECC water quality guidelines (2000, Table 3.4.1) for trigger values applying to typical *slightly–moderately disturbed systems*.**

mg/L	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
Site 1	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.33	< 0.001	0.04	< 0.0001	< 0.001	< 0.005	0.032
Site 2	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.4	< 0.001	0.15	< 0.0001	< 0.001	< 0.005	0.008
Site 3	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.31	< 0.001	0.31	< 0.0001	< 0.001	< 0.005	0.051
Site 4	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.33	< 0.001	0.15	< 0.0001	< 0.001	< 0.005	0.017
Site 5	10*	< 0.005	< 0.001	0.0002	< 0.001	< 0.001	5.4	< 0.001	0.06	< 0.0001	< 0.001	< 0.005	0.34
Site 6	0.09	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.13	< 0.001	0.17	< 0.0001	< 0.001	< 0.005	0.057
Site 7	0.07	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.15	< 0.001	0.08	< 0.0001	< 0.001	< 0.005	0.013
Site 8	0.1	< 0.005	< 0.001	< 0.0002	< 0.001	0.001	0.23	< 0.001	0.066	< 0.0001	< 0.001	< 0.005	0.015
Site 9	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.22	< 0.001	0.098	< 0.0001	< 0.001	< 0.005	0.01
Site 10	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.22	< 0.001	0.09	< 0.0001	< 0.001	< 0.005	< 0.005
Site 11	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.42	< 0.001	0.1	< 0.0001	< 0.001	< 0.005	< 0.005
Site 12	0.07	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.56	< 0.001	0.1	< 0.0001	< 0.001	< 0.005	< 0.005
ANZECC	0.05 (>6.5pH) *ID (<6.5pH ₁)	ID	0.013	0.0002	0.001	0.0014	ID	0.0034	1.2	0.00006	0.005	0.00005	0.008

ID= insufficient data

Shaded exceeds trigger values

*aluminium results where pH is <6.5

Aluminium and Zinc were the only metals that were found in concentrations higher than the ANZECC (2000) guideline levels of 0.05mg/L and 0.008mg/L respectively. Aluminium is the only metal that is higher downstream of the Boundary Creek confluence than it is upstream of the confluence although this impact appears not to extend past Site 8 at the Colac-Lorne Road. It is not clear from this study what is causing the

high reading at Site 12 at Winchelsea. Zinc levels are high above and below the Boundary Creek confluence as are Iron and Manganese levels.

3.2. Sediment surveys

Sediment data provides a historical overview of metals within the waterway.

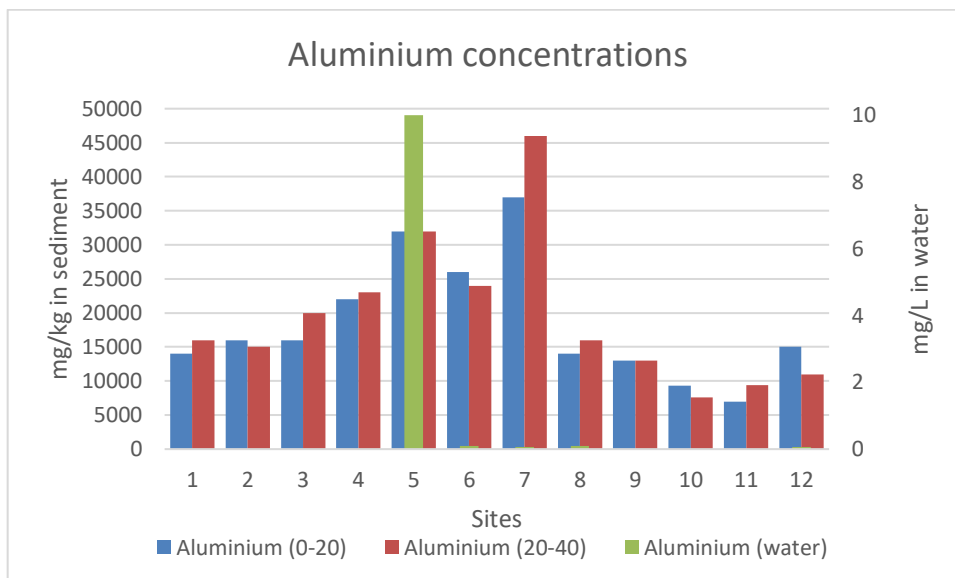
- Table 4: Metal and pH results for sediment samples at 0-20 and 20-40 cm below surface (mg/kg) and ANZECC (2000) sediment quality guidelines.

mg/kg	pH	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
SITE 1(0-20)	7.1	14000	< 10	3.6	< 0.4	14	9.6	29000	9.1	1300	< 0.1	< 2	< 0.2	56
SITE 1(20-40)	5.9	16000	< 10	3.6	< 0.4	18	11	30000	11	720	< 0.1	< 2	< 0.2	65
SITE 2(0-20)	6.8	16000	< 10	3.2	< 0.4	16	12	23000	13	540	0.1	< 2	< 0.2	59
SITE 2(20-40)	6.6	15000	< 10	3.4	< 0.4	16	13	23000	13	470	0.1	< 2	< 0.2	58
SITE 3(0-20)	6.3	16000	< 10	4.9	< 0.4	15	15	30000	16	850	0.1	< 2	< 0.2	68
SITE 3(20-40)	6.6	20000	< 10	4.2	< 0.4	17	16	32000	16	680	0.1	< 2	< 0.2	71
SITE 4(0-20)	6.1	22000	< 10	3.6	< 0.4	20	14	29000	13	740	0.1	< 2	< 0.2	74
SITE 4(20-40)	6.5	23000	< 10	3.9	< 0.4	21	15	28000	14	480	0.1	< 2	< 0.2	71
SITE 5(0-20)	4.7	32000	< 10	27	< 0.4	44	12	73000	43	50	0.1	< 2	< 0.2	120
SITE 5(20-40)	5.5	32000	< 10	23	< 0.4	43	10	40000	12	58	0.3	< 2	< 0.2	81
SITE 6(0-20)	6.5	26000	< 10	6	< 0.4	27	12	28000	14	440	0.1	< 2	< 0.2	100
SITE 6(20-40)	6.4	24000	< 10	7.4	< 0.4	25	14	33000	15	470	0.1	< 2	< 0.2	78
SITE 7(0-20)	6.8	37000	< 10	7.9	< 0.4	34	26	38000	19	860	0.1	< 2	< 0.2	75
SITE 7(20-40)	6.9	46000	< 10	17	< 0.4	40	27	60000	23	1100	0.1	< 2	< 0.2	90
SITE 8(0-20)	6.3	14000	< 10	21	< 0.4	32	7.3	56000	15	580	< 0.1	< 2	< 0.2	67
SITE 8(20-40)	6.6	16000	< 10	4.7	< 0.4	17	9.7	28000	12	1000	0.1	< 2	< 0.2	66
SITE 9(0-20)	6.6	13000	< 10	4.3	< 0.4	15	7.5	15000	9.9	320	0.1	< 2	< 0.2	38
SITE 9(20-40)	6	13000	< 10	4.2	< 0.4	17	6.7	13000	11	180	< 0.1	< 2	< 0.2	27

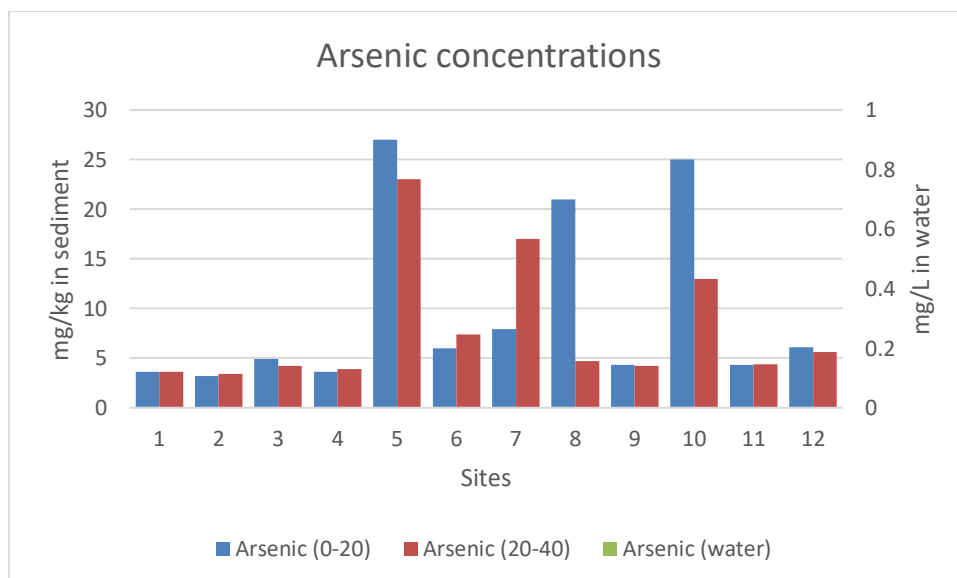
mg/kg	pH	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
SITE 10(0-20)	7	9300	< 10	25	< 0.4	18	6.7	55000	21	540	< 0.1	< 2	< 0.2	43
SITE 10(20-40)	6.3	7600	< 10	13	< 0.4	14	6.3	30000	12	560	< 0.1	< 2	< 0.2	48
SITE 11(0-20)	6.5	7000	< 10	4.3	< 0.4	11	< 5	14000	7.1	280	< 0.1	< 2	< 0.2	24
SITE 11(20-40)	6.5	9400	< 10	4.4	< 0.4	14	5.8	15000	12	330	< 0.1	< 2	< 0.2	26
SITE 12(0-20)	7.4	15000	< 10	6.1	< 0.4	21	8.8	23000	12	280	< 0.1	< 2	< 0.2	38
SITE 12(20-40)	7.3	11000	< 10	5.6	< 0.4	15	7.8	19000	10	330	< 0.1	< 2	< 0.2	35
ANZECC	-	-	2	20	1.5	80	65	-	50	-	0.15	-	1	200

Shaded exceeds trigger values.

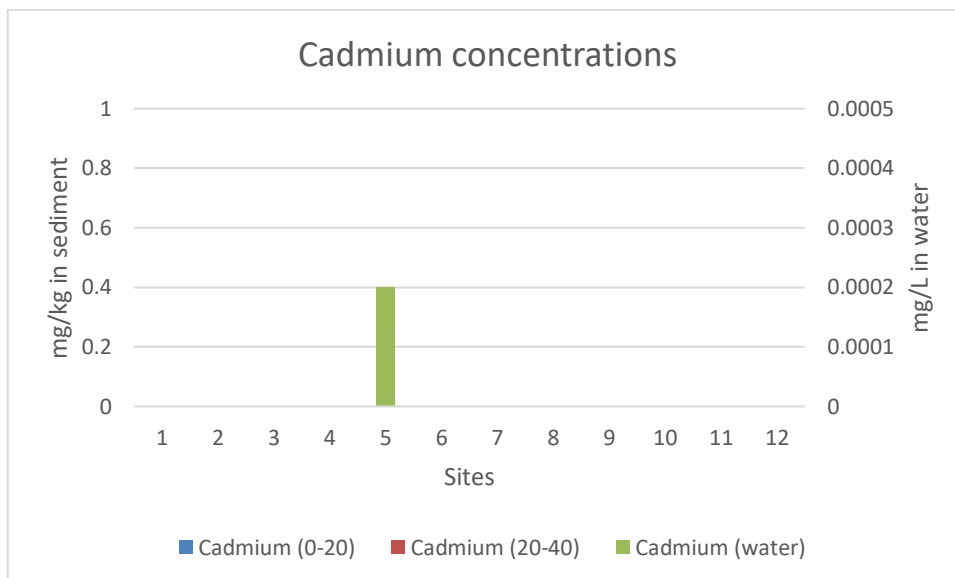
Arsenic and Mercury are the only metals in sediments that exceed the ANZECC trigger values of 20mg/kg and 0.15mg/kg respectively. Mercury exceeds the trigger value in the deep (20-40cm sediments) in Boundary Creek (Site 5) and Arsenic exceeds the trigger value in the shallow and deep sediments in Boundary Creek (Site 5) and the shallow sediments at Site 8 (Colac-Lorne Road) and Site 10 (Conns Lane).



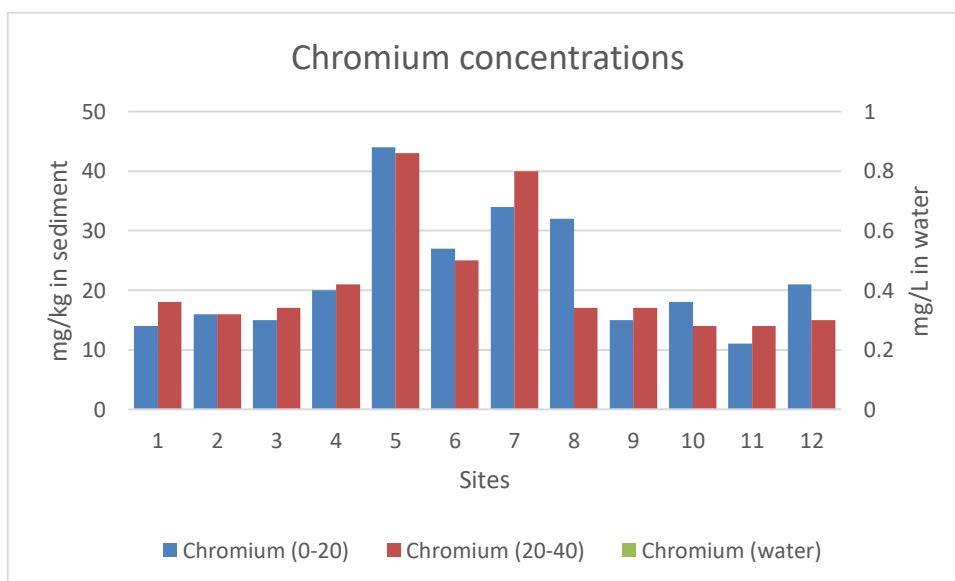
Aluminium was detected in water at sites 5, 6, 7, 8 and 12, exceeding the ANZECC trigger level (0.05mg/L). There was a spike in aluminium concentrations in sediments at sites 5 and 7 though levels are higher in the upper reaches above Boundary Creek than in the lower reaches around Birregurra and Winchelsea suggesting impacts other than from Boundary Creek. The deep and shallow sediments in Boundary Creek, site 5, have similar concentrations of aluminium.



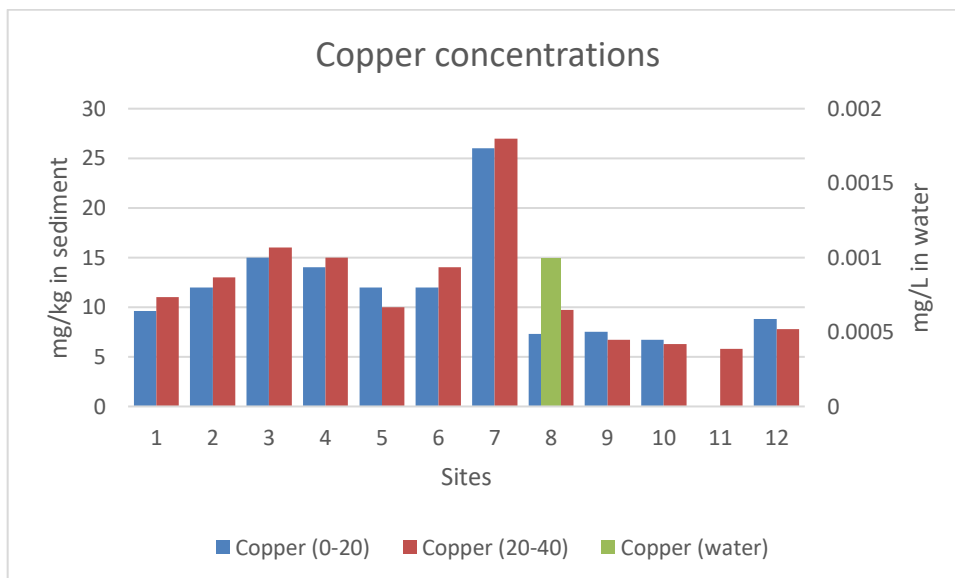
Arsenic was below detectable levels in the water and was over ANZECC guideline levels of 20 mg/kg in the shallow and deep sediments at site 5 and the shallow sediments at site 8 and 10.



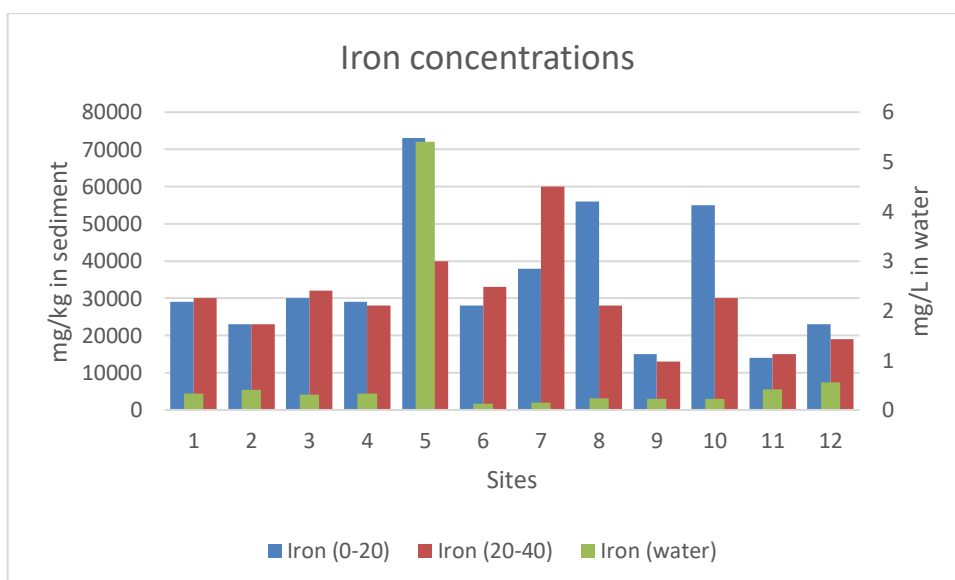
Cadmium was only detected in water at site 5 and was equal to the ANZECC guideline value (0.0002mg/L). Cadmium was not detected in sediments at any of the sites sampled.



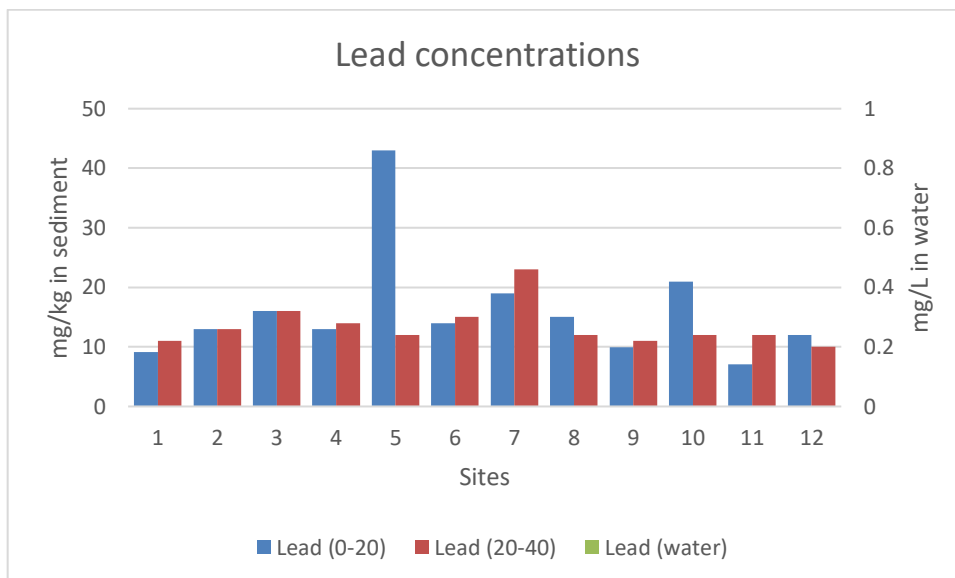
Chromium was not detected in water and despite levels in sediments peaking at sites 5 and 7 they were under ANZECC guideline levels (80mg/kg). Chromium was at similar levels in Boundary Creek (site 5) in the shallow and deeper samples.



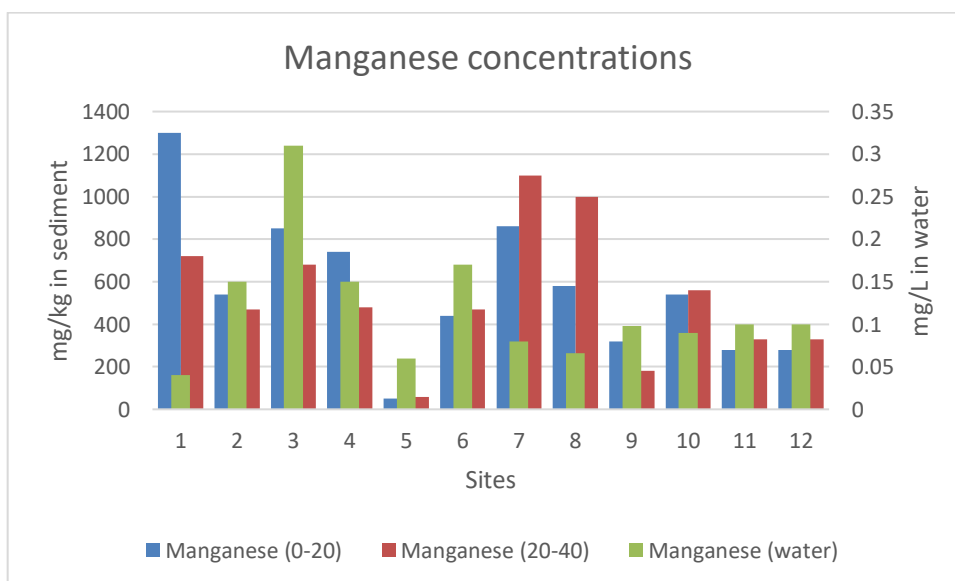
Copper was only detected in water at site 8 at the Colac-Lorne Road, below the ANZECC concentration of 0.0014mg/L. The highest concentrations of copper in sediment were recorded at site 7 and were similar in the shallow and deep samples but all results were well below ANZECC guideline levels (65mg/kg).



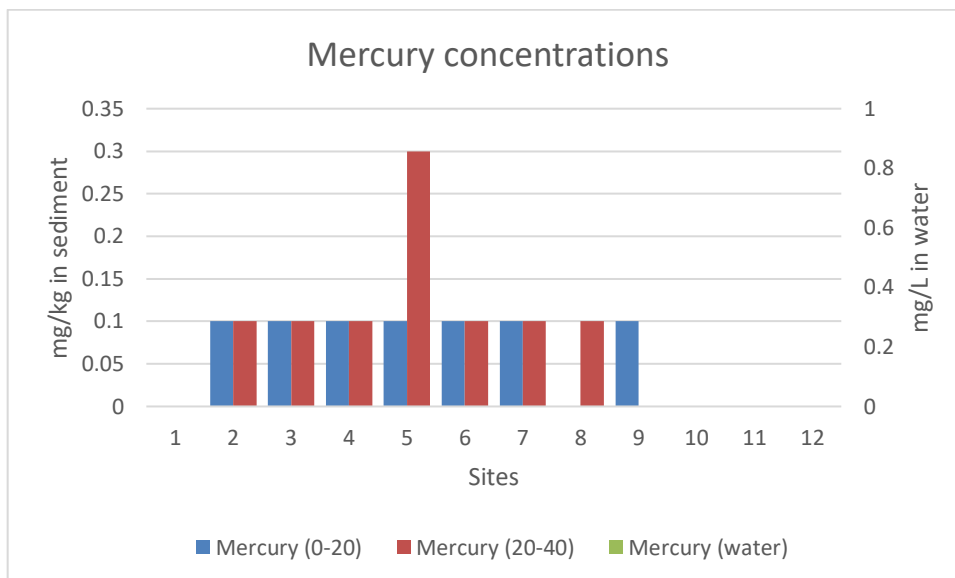
Iron was recorded in the water and sediments at all sites with highest levels in water and shallow sediments at site 5 (Boundary Creek). Iron was higher in the deeper sediments than in the shallow sediments at site 7 and higher in the shallow sediments compared to the deeper sediments at sites 5, 8 and 10.



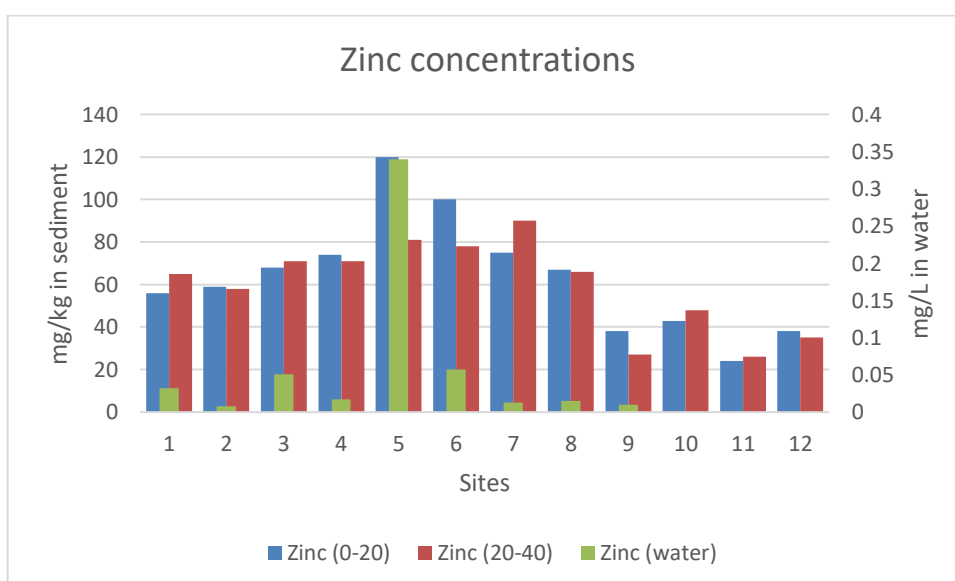
Lead was undetectable in water and was highest in shallow sediments (triple the concentration in the deeper sediments) at site 5 though below ANZECC guideline levels (50mg/kg).



Manganese is a naturally occurring trace element and concentrations in the water are well below the ANZECC guidelines for water (1.2mg/L). There are no ANZECC guidelines for sediments.



Mercury was undetectable in water and in sediment downstream of Birregurra (site 9). It is at detectable limits in sediment (0.1 mg/kg) at site 2-9 but below ANZECC guideline levels of 0.15mg/kg except in the deep sediments at site 5 where it exceeds ANZECC levels.



Zinc concentrations in sediments were below ANZECC level of 200mg/kg at all sites. Levels in water reduce along East Barwon and Barwon until site 6, after Boundary Creek and are undetectable by Conns Lane Birregurra (site 10). Concentrations are higher in shallow sediments at sites 5 and 6 and in deeper sediments at site 7.

3.3. Macroinvertebrate results

Biotic indices such as AusRivAS, SIGNAL, SIGNAL2, EPT (Ephemeroptera, Plecoptera, Trichoptera) and taxa richness (number of families and key families) scores were calculated in accordance with EPA Victoria biological objectives (EPA Victoria, 2004). Objectives have been reported but not applied as only the Spring data was collected in this study. A multi dimensional scaling (MDS) plot

was also produced to give an indication of how similar the macroinvertebrate community compositions are to each other. A full list of macroinvertebrate families found at each site is in Appendix 2.

AusRivAS scores and bands are considered to give the most accurate assessment of the health of a site as the program compares the test site to a number of reference sites that have similar physical and chemical characteristics but are relatively free of environmental impacts. The score indicates how many macroinvertebrate families were found compared to those found at reference sites. The statewide model for edge habitat in Spring was applied to these samples.

■ **Table 5: AusRivAS Bands, Observed/Expected scores and descriptions (AusRivAS Macroinvertebrate Predictive Modelling Version 3.2.2)**

Band	OE 50 score	Description
X	1.20+	More biologically diverse than reference sites
A	0.81-1.19	Reference condition
B	0.42-0.80	Significantly impaired
C	0.05-0.41	Severely impaired
D	0-0.04	Extremely impaired

SIGNAL and SIGNAL2 are biotic indices based on the tolerance or intolerance of biota (macroinvertebrates) to water pollution. Sites with high scores are likely to have low nutrient, salinity and turbidity levels and high oxygen levels. EPA biological objectives use the SIGNAL score but SIGNAL2 is also calculated as it uses updated, refined scores (Chessman, 2003).

■ **Table 6: Key to SIGNAL scores**

SIGNAL score	Water Quality
>7	Excellent
6-7	Clean Water
5-6	Mild pollution
4-5	Moderate pollution
<4	Severe pollution

The EPT score indicates the number of families that are sensitive to pollution that are present at the site with a low score usually indicating that there has been some type of disturbance. Together, these scores give a good picture of the health of the waterway at a site and potentially what is causing any disturbance.

Taxa richness, measured by the number of macroinvertebrate families collected, can give a good overview of the health of a waterway. High numbers are associated with diverse habitats present at the site but can also be influenced by mild nutrient enrichment which can increase the food supply. The score can be combined with SIGNAL2 scores as in Figure 2 to help interpret results. The number of Key Families found focuses on which taxa are expected to be in a region and is a similar concept to AusRivAS.

The study area crosses two biological regions. Forests B is characterised by upland reaches in the Otway Ranges where there is some clearing for forestry, grazing and some intensive agriculture. Site 1 falls within Forests B. Cleared Hills and Coastal Plains incorporates lower reaches of the

Barwon River where the region has been substantially cleared for intensive agriculture (EPA, 2004). Sites 2 to 12 are in this region.

■ **Table 7: Biological Objectives (EPA, 2004)**

Objective	Number of Families	SIGNAL Index score	EPT Index score	Key Families*	AusRivAS O/E score	AusRivAS Band
Forests B (Region 3)	24	5.8	9	26	0.87-1.13	A
Cleared Hills & Coastal Plains (Region 4)	26	5.5	-	22	0.85-1.15	A

* Only applicable when riffle and edge habitats sampled

The pollution sensitive Ephemeroptera, Plecoptera and Tricoptera (EPT) macroinvertebrate families are seldom found in waterways within the Cleared Hills and Coastal Plains region, therefore no objectives have been set but numbers have been reported in Table 5. Key Families is similar to the AusRivAS concept although it requires two habitats to be sampled whereas there are models based on single habitats or combined habitats. Key Families should be used if AusRivAS does not give a result for the site due to it being 'outside the experience of the model'.

■ **Table 8: Biotic index results.**

Site	Number of Families	SIGNAL	SIGNAL2#	EPT Index score#	Key Families*	AusRivAS O/E score	AusRivAS Band
1	17	4.94	3.53	3	16	Outside the experience of the model	
2	32	5.43	3.25	4	21	0.88	A
3	25	5.63	4.04	6	21	0.95	A
4	22	5.20	3.27	3	17	0.91	A
5	10	4.90	2.90	0	8	Outside the experience of the model	
6	24	5.86	4.08	7	22*	1.07	A
7	32	5.42	3.38	5	24*	0.91	A
8	26	5.38	3.77	6	25*	1.07	A
9	30	5.70	3.73	7	23*	1.12	A
10	21	5.15	3.48	3	19	1.01	A
11	21	5.32	3.90	4	18	0.83	A
12	27	5.54	3.93	6	24*	1.15	A

No objective.

□ Objective met but not applicable as only one season sampled.

* Objective met but not applicable as only edge habitats sampled.

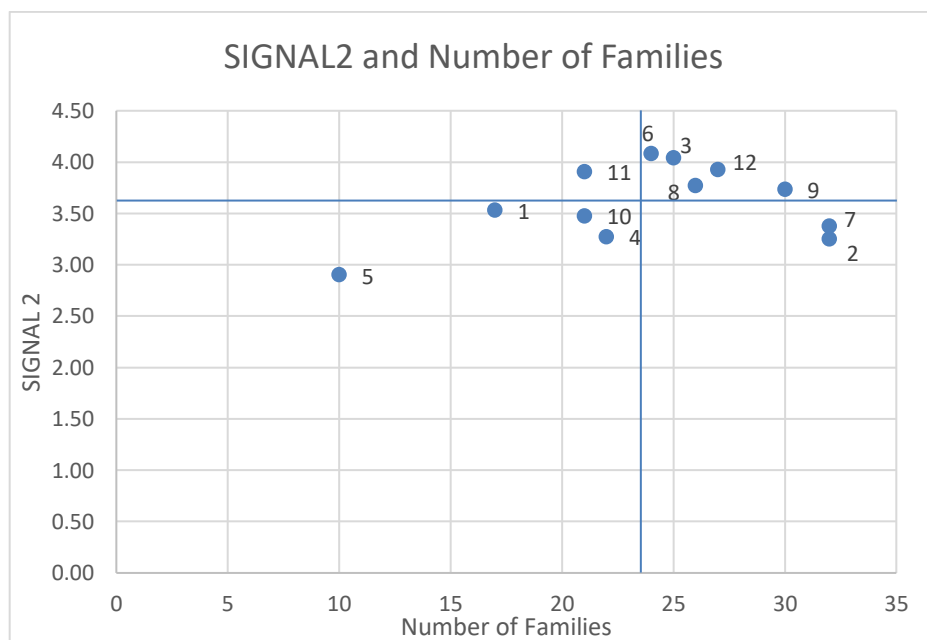
Sites 9 and 12 meet the most objectives for ecosystem protection (EPA, 2004) and have the highest AusRivAS score, suggesting that they are the healthiest sites within the upper Barwon River.

Sites 1 and 5 are 'Outside the experience of the AusRivAS model' and site 10 was 'Nearly outside the experience of the model'. This means that based on the environmental data entered, no

reference sites can be found to compare to the test site and limited reference sites were found for site 10 therefore the data should be treated with caution. This is more often the case with single season samples than combined over Autumn and Spring and unusual readings such as alkalinity at site 5 may make it difficult to match with reference sites. Sites 1 and 5 are also outliers in that they have SIGNAL scores that indicate they are subject to moderate pollution whereas all other sites are in the mild pollution category (Tables 6 and 8).

Whilst SIGNAL2 scores give an indication of water quality in the river from which the sample was collected, combining the score with the richness score (how many different macroinvertebrate families are present), can provide an indication of the types of pollution and other physical and chemical factors that are affecting the macroinvertebrate community.

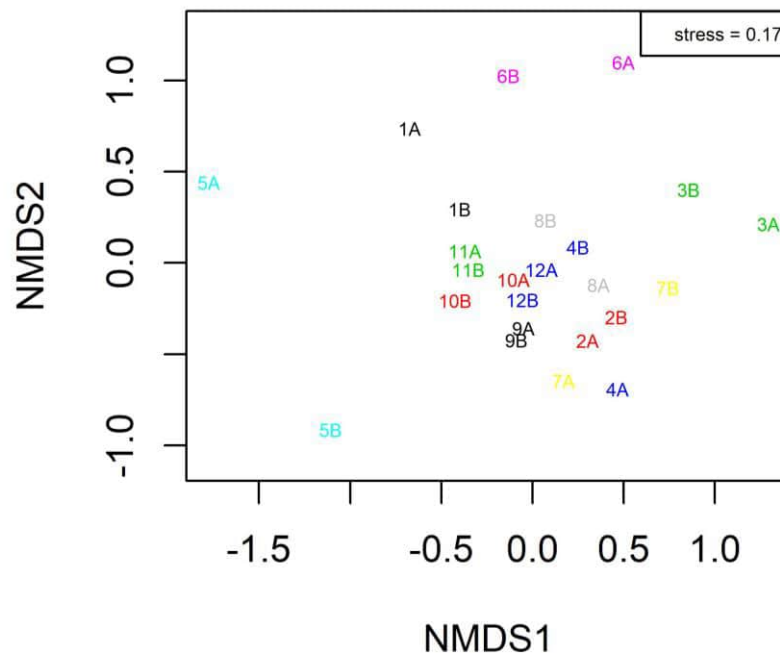
The plot is split into quadrants, the borders chosen to include the healthiest sites in the top right (Quadrant 1) and the quadrants are defined by those boundaries as detailed in Chessman (2003). As there were not any sites without human disturbance, those sites that met or were close to meeting EPA biological objectives for number of families and SIGNAL scores were included in Quadrant 1 and a cross check of which sites had the most EPT families (Table 5) confirmed the quadrant borders.



■ **Figure 2 SIGNAL2 index plotted against number of families recorded for each site.**

Sites 3, 6, 8, 9 and 12 have high SIGNAL2 and number of macroinvertebrate families suggesting the habitat and water quality are favorable and stress factors are low. Sites 2 and 7 in the bottom right quadrant have lower SIGNAL2 scores, possibly due to water quality influences but the high number of families present suggest that any toxicants are not present in large amounts. Site 11 in the top left quadrant has high SIGNAL2 scores but fewer number of families. This site is possibly affected by pollution other than what SIGNAL scores are based on (organic, nutrient enrichment or salinity). Sites 1, 4, 5, and 10 have lower SIGNAL2 scores and low numbers of families suggesting that they are subject to a number of impacts.

The MDS (Multidimensional Scaling) plot (Figure 3) shows how similar, or dissimilar, the macroinvertebrate community compositions at each site are to one another based on presence absence data.



■ **Figure 3: MDS plot of families from two edge habitats (A and B) at twelve sites.**

The above MDS plot (Figure 3) shows that sites above and below the Boundary Creek confluence have similar macroinvertebrate families present, with site 3 (East Barwon), site 5 (Boundary Creek), and site 6 (Barwon River immediately downstream of Boundary Creek) having different macroinvertebrate community compositions present.

Site 3 is different to the other sites by being the only one with the damselfly, Synlestidae, present and was also the only site that had the trichopteran (caddisfly), Conoesucidae, present. Site 3 lacked backswimmers (Notonectidae), a family of mayflies (Baetidae) and one family of amphipods (Ceinidae) that were commonly present at other sites though there were other families of each order present. Site 5 is missing many of the families that are present at other sites and is the only site that had the mosquito larvae, Culicidae, present. Site 6 is different to other sites for a number of reasons. It is lacking any snail families, one amphipod family (Janiridae), one beetle family (Scirtidae) and one bug family (Notonectidae) though there are other amphipod, beetle and bug families present at the site. This site is the only one in the study to record yabbies (Parastacidae), and the uncased caddisfly, Hydrobiosidae.

4. Discussion & Conclusion

4.1. Metals

Within the surface water, Aluminium and Cadmium were detected only in Boundary Creek whereas Iron and Zinc were detected in Boundary Creek and the Barwon River both upstream of downstream of the confluence with Boundary Creek. These metals were also found in the sediments. Metals in sediments appear to be impacted by Boundary Creek but there does not appear to be an impact by site 9, Birregurra township, approximately 20km downstream of the Boundary Creek confluence. Within Boundary Creek (site 5), there are historically high (in both the shallow and deeper sediments) concentrations of Aluminium, Arsenic and Chromium suggesting that recent events in Big Swamp have not significantly impacted concentrations of these metals. Concentrations of Iron, Lead and Zinc are higher in shallow sediments than deeper sediments, suggesting that the drying and subsequent rewetting of Big Swamp have increased the concentrations of these sediments. The spike in metals such as Arsenic at Conns Lane, Birregurra (site 10) suggest other catchment activities may be impacting the Barwon River.

4.2. Macroinvertebrates

Big Swamp continues to impact the macroinvertebrate community composition in Boundary Creek as measured at Site 5, Colac-Lorne Road. In a 2014/15 study of Boundary Creek (Austral Research and Consulting, 2015), the site at Colac-Lorne Road recorded the same number of families and EPT families but lower SIGNAL and SIGNAL2 scores (4.5 and 2.7) in Spring compared to scores in 2019 (4.9 and 2.9). This was due to the collection of an individual from a family (Dugesidae- Flatworm) that is slightly more intolerant of organic pollution than a family that wasn't collected (Oligochaeta-Worm). This indicates that conditions in Boundary Creek in 2019 are similar to that in 2014.

Within the Barwon River, macroinvertebrate community composition is impacted by Boundary Creek immediately downstream of the confluence (shown by the MDS plot) but the overall health at this site (using the biotic indices) and continuing downstream are not adversely impacted. The absence of snails at Site 6 directly downstream is one of the contributors to the difference in macroinvertebrate community composition. Their absence is possibly due to the low pH affecting shell development but has not impacted on other species such as yabbies which were only found at this site and other grazing animals such as amphipods, mayflies and caddisflies are all present.

Four of the five 'healthiest' sites as determined by SIGNAL2 and Number of Families were downstream of the confluence with Boundary Creek and five of the seven sites below the confluence had higher AusRivAS scores than those sites above the confluence. These results suggest that the Barwon River may have recovered from the 2016 fish kill event (Ryan, 2016) and once downstream of Site 6 immediately below the confluence, is not currently being adversely impacted by inflows from Boundary Creek.

4.3. Recommendations

Sampling of metals in the water along the Barwon River during the Boundary Creek remediation works should give an indication of whether they are still being mobilised by the low pH water coming into the system and may be more cost effective than continually sampling sediments. Sediments

should be sampled for metals periodically to track whether they are moving downstream or are remaining bound at the site.

Whilst macroinvertebrate communities are at reference condition at all sites excepting Site 1 which was outside the experience of the AusRivAS model for an unknown reason, and Site 5 on Boundary Creek which is severely impacted by the low pH, a second season of sampling in Autumn would give a complete picture and enable comparisons with biological objectives. Continued macroinvertebrate sampling of Boundary Creek will give an excellent indication as to its recovery during remediation works and introducing macroinvertebrate sampling at sites currently monitored by Waterwatch will add to the information already collected from the Barwon River.

5. References

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Appendix 1:

5.1. Site 1- East Barwon River@ Kents Road



Site 1: upstream



Site 1: downstream

The East Barwon at Kents Road has diverse habitat with large deep pools and some riffle/run areas. Willows dominate the riparian zone and are growing within the stream channel. The substrate is a mix of clay and silt with a number of aquatic macrophytes growing in the margins and shallow pool areas. The average stream width at this site was eight meters and was bank full at the time of sampling. The majority of the riparian zone is exotic vegetation, dominated by blackberries, willows and pasture grass. One larval fish was collected as bycatch during macroinvertebrate sampling. A concurrent snapshot study by EnviroDNA (2019) found evidence of platypus at this site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 74 out of 140.



Site1: Sediment cores

5.2. Site 2- East Barwon River@ Dewings Bridge Road



Site 2: upstream



Site 2: downstream

The East Barwon at Dewings Bridge Road consists of a slow flowing channel with extensive backwaters. There is very little riparian zone present but a number of submerged and emergent macrophytes provide good habitat. The substrate is a mix of clay and silt with some sand. The average stream width at this site was seven meters and was bank full at the time of sampling. The majority of the riparian zone is pasture grass with stock access on both sides. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 59 out of 140.



Site 2: Sediment cores

5.3. Site 3- West Barwon River@ Seven Bridges Road



Site 3: upstream



Site 3: downstream

The West Barwon River at Seven Bridges Road has large deep pools with a number of large deep backwaters. The average stream width at this site is seven meters, narrow at the top of the surveyed reach and widening into a large pool near the bridge. The substrate is clay and silt mixed with 20% sand. There are some macrophytes present along with trailing bank vegetation, roots and instream large woody debris (primarily willow branches). Willows dominate the riparian zone a mix of shrubs and native and pasture grasses in the understory. Four larval fish were collected as bycatch during macroinvertebrate sampling. A concurrent snapshot study by EnviroDNA (2019) found evidence of platypus at this site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 85 out of 140.



Site 3: Sediment cores

5.4. Site 4- Barwon River upstream of Boundary Creek confluence



Site 4: upstream



Site 4: downstream

The Barwon River immediately upstream of the Boundary Creek confluence is a large slow flowing channel with shallow side sections that support a number of macrophyte beds. The average stream width at this site is nine meters. The substrate is clay and black silt with some large woody debris and filamentous algae present in addition to the macrophytes. *Juncus*, *Typha*, *Triglochin* and *Polygonum* are all present instream though riparian vegetation is limited to some isolated trees, a narrow native plantation and pasture grass with stock access. The introduced *Gambusia* (mosquito fish) were collected as bycatch during macroinvertebrate sampling. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 79 out of 140.



Site 4: Sediment cores

5.5. Site 5- Boundary Creek @ Colac- Forrest Road



Site 5: upstream



Site 5: downstream

Boundary Creek at Colac- Forrest Road has a mix of large deep pools, a large shallow pool at the bridge and shallow runs. It was bankfull at the time of sampling with an average stream width of four meters, narrow at the top of the surveyed reach and widening into a large pool upstream of the bridge. The substrate is a mix of cobble, pebble, gravel, sand, clay and silt. There are no macrophytes but there is some filamentous algae and trailing bank vegetation present. The riparian zone is wide and a mix of native and exotic vegetation except the ground cover which is dominated by *Convolvulus* sp. and pasture grasses. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 81 out of 140.



Site 5: Sediment cores

5.6. Site 6- Barwon River downstream of Boundary Creek confluence



Site 6: upstream



Site : downstream

The Barwon River immediately downstream of the Boundary Creek confluence is a narrow deep channel with wide shallow edges dominated by grasses and aquatic macrophytes. The average stream width at this site is five meters and is bank full. It is wide but still with a narrow channel at the top of the surveyed reach and narrowing to a confined channel downstream. The substrate consists of clay and silt with filamentous algae tangled through the macrophyte beds. Macrophyte species are varied with Triglochin, Polygonum, Phragmites, and Juncus all present in addition to trailing grasses. The riparian zone is limited to grasses and scattered native trees and shrubs with stock access to the site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 70 out of 140.



Site 6: Sediment cores

5.7. Site 7- Barwon River upstream of CO_BAR16



Site 7: upstream



Site 7: downstream

The Barwon River upstream of CO_BAR16 adjacent to the northern boundary of the pine plantation has a large deep channel with any shallow areas dominated by beds of *Phragmites*. The average stream width at this site is seven meters. The substrate is clay and silt. In addition to the *Phragmites* beds there are beds of *Triglochin*, and scattered *Polygonum*, *Juncus* and other grasses. The riparian zone has a good mix of trees, shrubs and understory with a majority of native trees and shrubs. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 90 out of 140.



Site 7: Sediment cores

5.8. Site 8- Barwon River @ Colac- Lorne Road



Site 8: upstream



Site 8: downstream

The Barwon River at Colac- Lorne Road has large deep pools with a shallow areas at the sides and willow trees growing in the channel and some substrate exposed. The average stream width at this site is eight meters with a predominantly clay and silt substrate mixed with some sand. There are beds of Triglochin and Phragmites in addition to trailing grasses and large willows. The riparian zone consists of willow trees, pasture grasses and blackberries and allows stock access. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 69 out of 140.



Site 8: Sediment cores

5.9. Site 9- Barwon River @ Birregurra



Site 9: upstream



Site 9: downstream

The Barwon River at Birregurra consists of a large deep slow flowing pool. The average stream width at this site is five meters with steep clay banks. The substrate is clay and silt with willow roots, some snags and Triglochin beds scattered along the edges of the channel. There have been recent willow removal works and replanting of the riparian zone in amongst the pasture grass and blackberry groundcover. Rakali footprints were evident in the soft sediment edge. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 67 out of 140.



Site 9: Sediment cores

5.10. Site 10- Barwon River @ Conns Lane



Site 10: upstream



Site 10: downstream

The Barwon River at Conns Lane has large deep pools with some small deep backwaters and a narrow deep run at the top of the reach. The average stream width at this site is six meters. The substrate is clay and silt mixed with some sand and gravel. Phragmites beds line the channel and there are isolated patches of Triglochin in addition to Polygonum and trailing grasses along the waters edge. The riparian zone consists of relatively new and older native revegetation with pasture grass understory. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 98 out of 140.



Site 10: Sediment cores

5.11. Site 11- Barwon River@ Winchelsea- Deans Marsh Road



Site 11: upstream



Site 11: downstream

The Barwon River at Winchelsea- Deans Marsh Road has large deep pools with a shallow run at the top of the reach. The average stream width at this site is five meters and the substrate is clay and silt mixed with some sand and gravel. Triglochin is growing in the shallow areas of the channel and there are roots, large woody debris and trailing grasses. The riparian zone is predominately native trees and understory with a mix of grasses as groundcover. Rakali footprints were spotted at the waters edge. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 90 out of 140.



Site 11: Sediment cores

5.12. Site 12- Barwon River @ Winchelsea



Site 12: upstream



Site 12: downstream

The Barwon River at Winchelsea has large deep pools with a large shallow pool at the top of the reach. The average stream width at this site is twelve meters. The substrate is clay and silt mixed with sand and some gravel. In addition to the *Phragmites* beds at the top of the reach and along some edges there are also patches of *Triglochin*. Large woody debris, trailing grasses and emergent vegetation such as *Polygonum* are also present. Riparian vegetation is predominantly native with many established eucalypts and groundcover is pasture grass. A concurrent snapshot study by EnviroDNA (2019) found evidence of platypus at this site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 88 out of 140.



Site 12: Sediment cores

Appendix 2

Macroinvertebrate list Spring

Site Code	Site Location	Taxa Code	Taxa Name	Number
1	East Barwon @ Kent Road	IB019999	Hydridae	1
1	East Barwon @ Kent Road	IF619999	Dugesidae	10
1	East Barwon @ Kent Road	KG079999	Planorbidae	1
1	East Barwon @ Kent Road	KG089999	Physidae	30
1	East Barwon @ Kent Road	LO999999	Oligochaeta	1
1	East Barwon @ Kent Road	MM999999	Mites	1
1	East Barwon @ Kent Road	OP029999	Ceinidae	13
1	East Barwon @ Kent Road	OT019999	Atyidae	3
1	East Barwon @ Kent Road	QC099999	Dytiscidae	1
1	East Barwon @ Kent Road	QD109999	Simuliidae	2
1	East Barwon @ Kent Road	QDAF9999	Orthoclaadiinae	65
1	East Barwon @ Kent Road	QDAJ9999	Chironominae	5
1	East Barwon @ Kent Road	QE069999	Leptophlebiidae	1
1	East Barwon @ Kent Road	QH659999	Corixidae	12
1	East Barwon @ Kent Road	QH679999	Notonectidae	1
1	East Barwon @ Kent Road	QP039999	Gripopterygidae	31
1	East Barwon @ Kent Road	QT259999	Leptoceridae	2
2	East Barwon @ Dewings Bridge Road	IF619999	Dugesidae	1
2	East Barwon @ Dewings Bridge Road	IH999999	Nematoda	1
2	East Barwon @ Dewings Bridge Road	KG059999	Lymnaeidae	1
2	East Barwon @ Dewings Bridge Road	KG079999	Planorbidae	1
2	East Barwon @ Dewings Bridge Road	KG089999	Physidae	28
2	East Barwon @ Dewings Bridge Road	KP039999	Sphaeriidae	2
2	East Barwon @ Dewings Bridge Road	LH019999	Glossiphoniidae	1
2	East Barwon @ Dewings Bridge Road	LO999999	Oligochaeta	11
2	East Barwon @ Dewings Bridge Road	MM999999	Mites	4
2	East Barwon @ Dewings Bridge Road	OP029999	Ceinidae	22
2	East Barwon @ Dewings Bridge Road	OP069999	Paramelitidae	3
2	East Barwon @ Dewings Bridge Road	QC099999	Dytiscidae	19
2	East Barwon @ Dewings Bridge Road	QC09999I	Dytiscidae (Larva)	2
2	East Barwon @ Dewings Bridge Road	QC10999I	Gyrinidae (Larva)	1
2	East Barwon @ Dewings Bridge Road	QC119999	Hydrophilidae	1
2	East Barwon @ Dewings Bridge Road	QCAO9999	Hydrochidae	4
2	East Barwon @ Dewings Bridge Road	QD099999	Ceratopogonidae	52
2	East Barwon @ Dewings Bridge Road	QDAE9999	Tanypodinae	10
2	East Barwon @ Dewings Bridge Road	QDAF9999	Orthoclaadiinae	21
2	East Barwon @ Dewings Bridge Road	QDAJ9999	Chironominae	12
2	East Barwon @ Dewings Bridge Road	QE029999	Baetidae	14
2	East Barwon @ Dewings Bridge Road	QE039999	Oniscigastridae	1
2	East Barwon @ Dewings Bridge Road	QE069999	Leptophlebiidae	45

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Site Code	Site Location	Taxa Code	Taxa Name	Number
2	East Barwon @ Dewings Bridge Road	QH569999	Veliidae	9
2	East Barwon @ Dewings Bridge Road	QH659999	Corixidae	16
2	East Barwon @ Dewings Bridge Road	QH669999	Naucoridae	2
2	East Barwon @ Dewings Bridge Road	QH679999	Notonectidae	6
2	East Barwon @ Dewings Bridge Road	QH689999	Pleidae	1
2	East Barwon @ Dewings Bridge Road	QL019999	Crambidae	1
2	East Barwon @ Dewings Bridge Road	QO029999	Coenagrionidae	36
2	East Barwon @ Dewings Bridge Road	QO059999	Lestidae	2
2	East Barwon @ Dewings Bridge Road	QO179999	Libellulidae	1
2	East Barwon @ Dewings Bridge Road	QT259999	Leptoceridae	18
3	West Barwon @ Seven Bridges Road	IF619999	Dugesidae	2
3	West Barwon @ Seven Bridges Road	KG079999	Planorbidae	17
3	West Barwon @ Seven Bridges Road	KG089999	Physidae	5
3	West Barwon @ Seven Bridges Road	LO999999	Oligochaeta	1
3	West Barwon @ Seven Bridges Road	MM999999	Mites	17
3	West Barwon @ Seven Bridges Road	OP069999	Paramelitidae	3
3	West Barwon @ Seven Bridges Road	OP089999	Perthiidae	1
3	West Barwon @ Seven Bridges Road	OR189999	Janiridae	1
3	West Barwon @ Seven Bridges Road	QC099999	Dytiscidae (Larva)	1
3	West Barwon @ Seven Bridges Road	QC119999	Hydrophilidae	2
3	West Barwon @ Seven Bridges Road	QC209999	Scirtidae sp.	9
3	West Barwon @ Seven Bridges Road	QD099999	Ceratopogonidae	5
3	West Barwon @ Seven Bridges Road	QDAE9999	Tanypodinae	5
3	West Barwon @ Seven Bridges Road	QDAF9999	Orthoclaadiinae	6
3	West Barwon @ Seven Bridges Road	QDAJ9999	Chironominae	8
3	West Barwon @ Seven Bridges Road	QDAZ9999	Chironomidae (Pupa)	7
3	West Barwon @ Seven Bridges Road	QE069999	Leptophlebiidae	6
3	West Barwon @ Seven Bridges Road	QE089999	Caenidae	1
3	West Barwon @ Seven Bridges Road	QH569999	Veliidae	31
3	West Barwon @ Seven Bridges Road	QH659999	Corixidae	2
3	West Barwon @ Seven Bridges Road	QO029999	Coenagrionidae	2
3	West Barwon @ Seven Bridges Road	QO089999	Synlestidae	1
3	West Barwon @ Seven Bridges Road	QP039999	Gripopterygidae	4
3	West Barwon @ Seven Bridges Road	QT039999	Hydroptilidae	3
3	West Barwon @ Seven Bridges Road	QT159999	Conoesucidae	1
3	West Barwon @ Seven Bridges Road	QT259999	Leptoceridae	21
4	Barwon River @ u/s Boundary confluence	KG029999	Hydrobiidae	1
4	Barwon River @ u/s Boundary confluence	KG059999	Lymnaeidae	4
4	Barwon River @ u/s Boundary confluence	KG079999	Planorbidae	4
4	Barwon River @ u/s Boundary confluence	KG089999	Physidae	17
4	Barwon River @ u/s Boundary confluence	LO999999	Oligochaeta	5
4	Barwon River @ u/s Boundary confluence	MM999999	Mites	1

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Site Code	Site Location	Taxa Code	Taxa Name	Number
4	Barwon River @ u/s Boundary confluence	OP029999	Ceinidae	5
4	Barwon River @ u/s Boundary confluence	OP069999	Paramelitidae	1
4	Barwon River @ u/s Boundary confluence	QC069999	Halipilidae	4
4	Barwon River @ u/s Boundary confluence	QC099999	Dytiscidae	6
4	Barwon River @ u/s Boundary confluence	QC09999I	Dytiscidae (Larva)	2
4	Barwon River @ u/s Boundary confluence	QCAN9999	Curculionidae	1
4	Barwon River @ u/s Boundary confluence	QD099999	Ceratopogonidae	14
4	Barwon River @ u/s Boundary confluence	QDAE9999	Tanypodinae	23
4	Barwon River @ u/s Boundary confluence	QDAF9999	Orthoclaadiinae	29
4	Barwon River @ u/s Boundary confluence	QDAJ9999	Chironominae	9
4	Barwon River @ u/s Boundary confluence	QDAZ999I	Chironomidae (Pupa)	1
4	Barwon River @ u/s Boundary confluence	QE029999	Baetidae	24
4	Barwon River @ u/s Boundary confluence	QE069999	Leptophlebiidae	7
4	Barwon River @ u/s Boundary confluence	QH659999	Corixidae	33
4	Barwon River @ u/s Boundary confluence	QH669999	Naucoridae	4
4	Barwon River @ u/s Boundary confluence	QL019999	Crambidae	1
4	Barwon River @ u/s Boundary confluence	QO029999	Coenagrionidae	22
4	Barwon River @ u/s Boundary confluence	QT259999	Leptoceridae	15
5	Boundary Ck @ Colac- Forrest Road	IF619999	Dugesidae	1
5	Boundary Ck @ Colac- Forrest Road	OR189999	Janiridae	11
5	Boundary Ck @ Colac- Forrest Road	QC099999	Dytiscidae	2
5	Boundary Ck @ Colac- Forrest Road	QC09999I	Dytiscidae (Larva)	1
5	Boundary Ck @ Colac- Forrest Road	QC209999	Scirtidae sp.	20
5	Boundary Ck @ Colac- Forrest Road	QD079999	Culicidae	2
5	Boundary Ck @ Colac- Forrest Road	QD07999I	Culicidae (Pupa)	1
5	Boundary Ck @ Colac- Forrest Road	QDAE9999	Tanypodinae	1
5	Boundary Ck @ Colac- Forrest Road	QDAF9999	Orthoclaadiinae	1
5	Boundary Ck @ Colac- Forrest Road	QDAJ9999	Chironominae	30
5	Boundary Ck @ Colac- Forrest Road	QH659999	Corixidae	1
5	Boundary Ck @ Colac- Forrest Road	QH679999	Notonectidae	1
6	Barwon River @ d/s Boundary Ck confluence	LH019999	Glossiphoniidae	3
6	Barwon River @ d/s Boundary Ck confluence	LO999999	Oligochaeta	1
6	Barwon River @ d/s Boundary Ck confluence	MM999999	Mites	2
6	Barwon River @ d/s Boundary Ck confluence	OP029999	Ceinidae	3
6	Barwon River @ d/s Boundary Ck confluence	OP069999	Paramelitidae	56
6	Barwon River @ d/s Boundary Ck confluence	OV019999	Parastacidae	1
6	Barwon River @ d/s Boundary Ck confluence	QC099999	Dytiscidae	4
6	Barwon River @ d/s Boundary Ck confluence	QC119999	Hydrophilidae	1
6	Barwon River @ d/s Boundary Ck confluence	QCAO9999	Hydrochidae	1
6	Barwon River @ d/s Boundary Ck confluence	QD099999	Ceratopogonidae	6
6	Barwon River @ d/s Boundary Ck confluence	QD109999	Simuliidae	2
6	Barwon River @ d/s Boundary Ck confluence	QDAE9999	Tanypodinae	2

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Site Code	Site Location	Taxa Code	Taxa Name	Number
6	Barwon River @ d/s Boundary Ck confluence	QDAF9999	Orthocladiinae	33
6	Barwon River @ d/s Boundary Ck confluence	QDAJ9999	Chironominae	1
6	Barwon River @ d/s Boundary Ck confluence	QDAZ999I	Chironomidae (Pupa)	1
6	Barwon River @ d/s Boundary Ck confluence	QE029999	Baetidae	7
6	Barwon River @ d/s Boundary Ck confluence	QE069999	Leptophlebiidae	1
6	Barwon River @ d/s Boundary Ck confluence	QE089999	Caenidae	1
6	Barwon River @ d/s Boundary Ck confluence	QH569999	Veliidae	2
6	Barwon River @ d/s Boundary Ck confluence	QH659999	Corixidae	1
6	Barwon River @ d/s Boundary Ck confluence	QO029999	Coenagrionidae	1
6	Barwon River @ d/s Boundary Ck confluence	QP039999	Gripopterygidae	44
6	Barwon River @ d/s Boundary Ck confluence	QT019999	Hydrobiosidae	1
6	Barwon River @ d/s Boundary Ck confluence	QT039999	Hydroptilidae	26
6	Barwon River @ d/s Boundary Ck confluence	QT259999	Leptoceridae	3
7	Barwon River @ u/s BAR016	IF619999	Dugesidae	10
7	Barwon River @ u/s BAR016	KG079999	Planorbidae	1
7	Barwon River @ u/s BAR016	KG089999	Physidae	6
7	Barwon River @ u/s BAR016	LO999999	Oligochaeta	4
7	Barwon River @ u/s BAR016	MM999999	Mites	3
7	Barwon River @ u/s BAR016	OP029999	Ceinidae	6
7	Barwon River @ u/s BAR016	OP069999	Paramelitidae	16
7	Barwon River @ u/s BAR016	OP089999	Perthiidae	1
7	Barwon River @ u/s BAR016	OR189999	Janiridae	1
7	Barwon River @ u/s BAR016	OT019999	Atyidae	3
7	Barwon River @ u/s BAR016	QC099999	Dytiscidae	6
7	Barwon River @ u/s BAR016	QC10999I	Gyrinidae (Larva)	1
7	Barwon River @ u/s BAR016	QC119999	Hydrophilidae	2
7	Barwon River @ u/s BAR016	QC139999	Hydraenidae	1
7	Barwon River @ u/s BAR016	QC209999	Scirtidae sp.	1
7	Barwon River @ u/s BAR016	QD099999	Ceratopogonidae	6
7	Barwon River @ u/s BAR016	QDAE9999	Tanypodinae	8
7	Barwon River @ u/s BAR016	QDAF9999	Orthocladiinae	1
7	Barwon River @ u/s BAR016	QDAJ9999	Chironominae	4
7	Barwon River @ u/s BAR016	QDAZ999I	Chironomidae (Pupa)	2
7	Barwon River @ u/s BAR016	QE029999	Baetidae	3
7	Barwon River @ u/s BAR016	QH569999	Veliidae	8
7	Barwon River @ u/s BAR016	QH659999	Corixidae	9
7	Barwon River @ u/s BAR016	QH669999	Naucoridae	1
7	Barwon River @ u/s BAR016	QH679999	Notonectidae	16
7	Barwon River @ u/s BAR016	QO029999	Coenagrionidae	25
7	Barwon River @ u/s BAR016	QO059999	Lestidae	1
7	Barwon River @ u/s BAR016	QO129999	Aeshnidae	2
7	Barwon River @ u/s BAR016	QO169999	Corduliidae	4

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Site Code	Site Location	Taxa Code	Taxa Name	Number
7	Barwon River @ u/s BAR016	QP039999	Grippingidae	1
7	Barwon River @ u/s BAR016	QT039999	Hydroptilidae	1
7	Barwon River @ u/s BAR016	QT209999	Kokiriidae	1
7	Barwon River @ u/s BAR016	QT259999	Leptoceridae	7
8	Barwon River @ Colac- Lorne Road	IF619999	Dugesidae	2
8	Barwon River @ Colac- Lorne Road	KG089999	Physidae	14
8	Barwon River @ Colac- Lorne Road	LO999999	Oligochaeta	4
8	Barwon River @ Colac- Lorne Road	MM999999	Mites	1
8	Barwon River @ Colac- Lorne Road	OP029999	Ceinidae	2
8	Barwon River @ Colac- Lorne Road	OP069999	Paramelitidae	8
8	Barwon River @ Colac- Lorne Road	QC099999	Dytiscidae	4
8	Barwon River @ Colac- Lorne Road	QC109999	Gyrinidae (Larva)	1
8	Barwon River @ Colac- Lorne Road	QD099999	Ceratopogonidae	4
8	Barwon River @ Colac- Lorne Road	QD109999	Simuliidae	1
8	Barwon River @ Colac- Lorne Road	QDAE9999	Tanypodinae	4
8	Barwon River @ Colac- Lorne Road	QDAF9999	Orthocladinae	16
8	Barwon River @ Colac- Lorne Road	QDAJ9999	Chironominae	19
8	Barwon River @ Colac- Lorne Road	QE029999	Baetidae	13
8	Barwon River @ Colac- Lorne Road	QE069999	Leptophlebiidae	13
8	Barwon River @ Colac- Lorne Road	QE089999	Caenidae	3
8	Barwon River @ Colac- Lorne Road	QH569999	Veliidae	9
8	Barwon River @ Colac- Lorne Road	QH619999	Nepidae	1
8	Barwon River @ Colac- Lorne Road	QH659999	Corixidae	15
8	Barwon River @ Colac- Lorne Road	QH679999	Notonectidae	2
8	Barwon River @ Colac- Lorne Road	QL019999	Crambidae	1
8	Barwon River @ Colac- Lorne Road	QO029999	Coenagrionidae	52
8	Barwon River @ Colac- Lorne Road	QO169999	Corduliidae	2
8	Barwon River @ Colac- Lorne Road	QP039999	Grippingidae	21
8	Barwon River @ Colac- Lorne Road	QT039999	Hydroptilidae	1
8	Barwon River @ Colac- Lorne Road	QT259999	Leptoceridae	47
9	Barwon River @ Birregurra	IF619999	Dugesidae	5
9	Barwon River @ Birregurra	KG029999	Hydrobiidae	18
9	Barwon River @ Birregurra	KG059999	Lymnaeidae	1
9	Barwon River @ Birregurra	KG089999	Physidae	17
9	Barwon River @ Birregurra	LH019999	Glossiphoniidae	1
9	Barwon River @ Birregurra	LO999999	Oligochaeta	10
9	Barwon River @ Birregurra	MM999999	Mites	7
9	Barwon River @ Birregurra	OP029999	Ceinidae	29
9	Barwon River @ Birregurra	OP069999	Paramelitidae	35
9	Barwon River @ Birregurra	OR189999	Janiridae	17
9	Barwon River @ Birregurra	OT019999	Atyidae	1
9	Barwon River @ Birregurra	QC099999	Dytiscidae	1

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Site Code	Site Location	Taxa Code	Taxa Name	Number
9	Barwon River @ Birregurra	QC09999I	Dytiscidae (Larva)	3
9	Barwon River @ Birregurra	QCAO9999	Hydrochidae	2
9	Barwon River @ Birregurra	QCAO9999	Hydrochidae	3
9	Barwon River @ Birregurra	QD019999	Tipulidae	1
9	Barwon River @ Birregurra	QD099999	Ceratopogonidae	3
9	Barwon River @ Birregurra	QDAE9999	Tanypodinae	4
9	Barwon River @ Birregurra	QDAF9999	Orthocladiinae	2
9	Barwon River @ Birregurra	QDAJ9999	Chironominae	53
9	Barwon River @ Birregurra	QDAZ999I	Chironomidae (Pupa)	2
9	Barwon River @ Birregurra	QE039999	Oniscigastridae	2
9	Barwon River @ Birregurra	QE069999	Leptophlebiidae	10
9	Barwon River @ Birregurra	QH569999	Veliidae	9
9	Barwon River @ Birregurra	QH659999	Corixidae	49
9	Barwon River @ Birregurra	QH669999	Naucoridae	1
9	Barwon River @ Birregurra	QL019999	Crambidae	2
9	Barwon River @ Birregurra	QO029999	Coenagrionidae	35
9	Barwon River @ Birregurra	QP039999	Gripopterygidae	28
9	Barwon River @ Birregurra	QT039999	Hydroptilidae	1
9	Barwon River @ Birregurra	QT209999	Kokiriidae	1
9	Barwon River @ Birregurra	QT249999	Calamoceratidae	2
9	Barwon River @ Birregurra	QT259999	Leptoceridae	4
10	Barwon River @ Conns Lane	IF619999	Dugesidae	9
10	Barwon River @ Conns Lane	KG059999	Lymnaeidae	3
10	Barwon River @ Conns Lane	KG089999	Physidae	43
10	Barwon River @ Conns Lane	LO999999	Oligochaeta	3
10	Barwon River @ Conns Lane	MM999999	Mites	6
10	Barwon River @ Conns Lane	OP029999	Ceinidae	37
10	Barwon River @ Conns Lane	OP069999	Paramelitidae	3
10	Barwon River @ Conns Lane	OR189999	Janiridae	1
10	Barwon River @ Conns Lane	OT019999	Atyidae	19
10	Barwon River @ Conns Lane	QC109999	Gyrinidae	1
10	Barwon River @ Conns Lane	QC10999I	Gyrinidae (Larva)	4
10	Barwon River @ Conns Lane	QC209999	Scirtidae sp.	1
10	Barwon River @ Conns Lane	QD099999	Ceratopogonidae	6
10	Barwon River @ Conns Lane	QDAF9999	Orthocladiinae	12
10	Barwon River @ Conns Lane	QDAJ9999	Chironominae	53
10	Barwon River @ Conns Lane	QE029999	Baetidae	2
10	Barwon River @ Conns Lane	QE069999	Leptophlebiidae	6
10	Barwon River @ Conns Lane	QH569999	Veliidae	4
10	Barwon River @ Conns Lane	QH659999	Corixidae	1
10	Barwon River @ Conns Lane	QH679999	Notonectidae	2
10	Barwon River @ Conns Lane	QO029999	Coenagrionidae	36

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Site Code	Site Location	Taxa Code	Taxa Name	Number
10	Barwon River @ Conns Lane	QT259999	Leptoceridae	2
11	Barwon River @ Deans Marsh- Winchelsea Road	IF619999	Dugesidae	18
11	Barwon River @ Deans Marsh- Winchelsea Road	KG089999	Physidae	31
11	Barwon River @ Deans Marsh- Winchelsea Road	MM999999	Mites	2
11	Barwon River @ Deans Marsh- Winchelsea Road	OP029999	Ceinidae	22
11	Barwon River @ Deans Marsh- Winchelsea Road	OP069999	Paramelitidae	2
11	Barwon River @ Deans Marsh- Winchelsea Road	OR189999	Janiridae	31
11	Barwon River @ Deans Marsh- Winchelsea Road	OT019999	Atyidae	22
11	Barwon River @ Deans Marsh- Winchelsea Road	QC109999	Gyrinidae	8
11	Barwon River @ Deans Marsh- Winchelsea Road	QCA09999	Hydrochidae	1
11	Barwon River @ Deans Marsh- Winchelsea Road	QD109999	Simuliidae	11
11	Barwon River @ Deans Marsh- Winchelsea Road	QD359999	Empididae	1
11	Barwon River @ Deans Marsh- Winchelsea Road	QDAF9999	Orthoclaadiinae	15
11	Barwon River @ Deans Marsh- Winchelsea Road	QDAJ9999	Chironominae	39
11	Barwon River @ Deans Marsh- Winchelsea Road	QDAZ999I	Chironomidae (Pupa)	1
11	Barwon River @ Deans Marsh- Winchelsea Road	QE029999	Baetidae	15
11	Barwon River @ Deans Marsh- Winchelsea Road	QE069999	Leptophlebiidae	2
11	Barwon River @ Deans Marsh- Winchelsea Road	QH569999	Veliidae	4
11	Barwon River @ Deans Marsh- Winchelsea Road	QH659999	Corixidae	18
11	Barwon River @ Deans Marsh- Winchelsea Road	QH679999	Notonectidae	1
11	Barwon River @ Deans Marsh- Winchelsea Road	QO029999	Coenagrionidae	17
11	Barwon River @ Deans Marsh- Winchelsea Road	QP039999	Gripopterygidae	34
11	Barwon River @ Deans Marsh- Winchelsea Road	QT259999	Leptoceridae	4
12	Barwon River @ Winchelsea	IF619999	Dugesidae	8
12	Barwon River @ Winchelsea	KG089999	Physidae	29
12	Barwon River @ Winchelsea	LO999999	Oligochaeta	2
12	Barwon River @ Winchelsea	MM999999	Mites	12
12	Barwon River @ Winchelsea	OP029999	Ceinidae	37
12	Barwon River @ Winchelsea	OR189999	Janiridae	2
12	Barwon River @ Winchelsea	OT019999	Atyidae	13
12	Barwon River @ Winchelsea	QC099999	Dytiscidae	1
12	Barwon River @ Winchelsea	QC10999I	Gyrinidae (Larva)	6
12	Barwon River @ Winchelsea	QC209999	Scirtidae sp.	11
12	Barwon River @ Winchelsea	QC349999	Elmidae	1
12	Barwon River @ Winchelsea	QC34999I	Elmidae (Larva)	1
12	Barwon River @ Winchelsea	QD249999	Stratiomyidae	2
12	Barwon River @ Winchelsea	QDAE9999	Tanypodinae	11
12	Barwon River @ Winchelsea	QDAF9999	Orthoclaadiinae	10
12	Barwon River @ Winchelsea	QDAJ9999	Chironominae	36
12	Barwon River @ Winchelsea	QE029999	Baetidae	4
12	Barwon River @ Winchelsea	QE069999	Leptophlebiidae	6
12	Barwon River @ Winchelsea	QH569999	Veliidae	8

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Site Code	Site Location	Taxa Code	Taxa Name	Number
12	Barwon River @ Winchelsea	QH659999	Corixidae	12
12	Barwon River @ Winchelsea	QH679999	Notonectidae	2
12	Barwon River @ Winchelsea	QO029999	Coenagrionidae	49
12	Barwon River @ Winchelsea	QO039999	Isostictidae	4
12	Barwon River @ Winchelsea	QO169999	Corduliidae	1
12	Barwon River @ Winchelsea	QP039999	Gripopterygidae	26
12	Barwon River @ Winchelsea	QT039999	Hydroptilidae	1
12	Barwon River @ Winchelsea	QT249999	Calamoceratidae	1
12	Barwon River @ Winchelsea	QT259999	Leptoceridae	15