

Upper Barwon River Macroinvertebrate Sampling Report Spring 2022

- Final
- January 2022

Upper Barwon River Macroinvertebrate Sampling Report Spring 2022

Austral Research and Consulting
ABN 73 007 840 779
15 Buntings Rd
Kirkstall Vic 3283 Australia
Web: www.austral.net.au

Austral Research and Consulting has prepared this document for Barwon Water for their express use only. The information contained within this document is based on sources that are believed to be reliable but Austral Research and Consulting does not guarantee that this document is definitive or free from error. Austral Research and Consulting does not accept liability for any loss caused, or arising from, reliance upon the information provided.

Document history and status

Revision	Date issued	Reviewed by	Approved by
Draft	22nd January 2023	Will McCance & Jared Scott	
Final	31 st January 2023	Kylie Iervasi	

Printed:	7 February 2023
Last saved:	7 February 2023 12:06 PM
File name:	
Author:	Kylie Iervasi
Project manager:	Kylie Iervasi
Name of organisation:	Barwon Water
Name of project:	Barwon River/ Boundary Creek Survey
Name of document:	Upper Barwon River Macroinvertebrate Sampling Report 2019-2022
Document version:	Final
Project number:	

Contents

1. Introduction	5
1.1. Background	5
1.2. Objectives	5
1.3. Summary	5
2. Methods	6
2.1. Site Selection	6
2.2. Sampling methodology	7
2.2.1. In-situ water quality	7
2.2.2. Metals in water	7
2.2.3. Macroinvertebrates	7
2.2.4. Site descriptions	7
3. Results	9
3.1. Water Quality	9
3.2. Macroinvertebrates	16
4. Conclusions	19
5. References	20
Appendix 1:	21
5.1. Site 1- East Barwon River @ Kents Road	21
5.2. Site 2- East Barwon River @ Dewings Bridge Road	24
5.3. Site 3- West Barwon River @ Seven Bridges Road	27
5.4. Site 4- Barwon River 100m upstream of Boundary Creek confluence	30
5.5. Site 5- Boundary Creek @ Colac- Forrest Road	32
5.6. Site 6- Barwon River 100m downstream of Boundary Creek confluence	35
5.7. Site 7- Barwon River @ north boundary of plantation	38
5.8. Site 8- Barwon River @ Colac- Lorne Road	41
5.9. Site 9- Barwon River @ Birregurra	44
5.10. Site 10- Barwon River @ Conns Lane	47
5.11. Site 11- Barwon River @ Winchelsea- Deans Marsh Road	50
5.12. Site 12- Barwon River @ Princes Hwy bridge, Winchelsea	53
5.13. Site 5.1- Boundary Creek downstream of McDonalds Dam	56
5.14. Site 5.2- Boundary Creek upstream of Big Swamp	57
5.15. Site BS1- Big Swamp eastern end	58
5.16. Site BS2- Big Swamp western end	58
Appendix 2:	59

1. Introduction

Austral Research and Consulting (Austral) were contracted by Barwon Water in Spring 2019 to undertake an investigation into the ecological condition of the upper Barwon River with regard to the extent of impact of low pH inflows from Boundary Creek.

The initial surveys determined a baseline for ongoing monitoring of the Barwon River as part of a remediation plan required by a section 78 Ministerial Notice and twice yearly monitoring is now carried out on sites in along both the Upper Barwon River and Boundary Creek including Big Swamp.

1.1. Background

Studies have confirmed that historic groundwater extraction from the Barwon Downs borefield to boost Geelong's water supply in conjunction with a dry climate led to reductions in flows in lower Boundary Creek (Jacobs, 2017), an increased occurrence of wet-dry cycling and a decrease in groundwater levels. These factors led to the oxidation of naturally occurring acid sulfate soils in Big Swamp, thus releasing acid into the system and lowering the pH. This process has led to the discharge of acidity into the lower reaches of Boundary Creek, which flows into the Barwon River approximately 3.7 km downstream of Big Swamp.

A community and stakeholder working group was established in 2018 to develop a remediation plan for Big Swamp and Boundary Creek and the Boundary Creek, Big Swamp and Surrounding Environment - Remediation and Environmental Protection Plan (REPP) (Barwon Water, 2020) was released in December 2019 and updated in February 2020.

1.2. Objectives

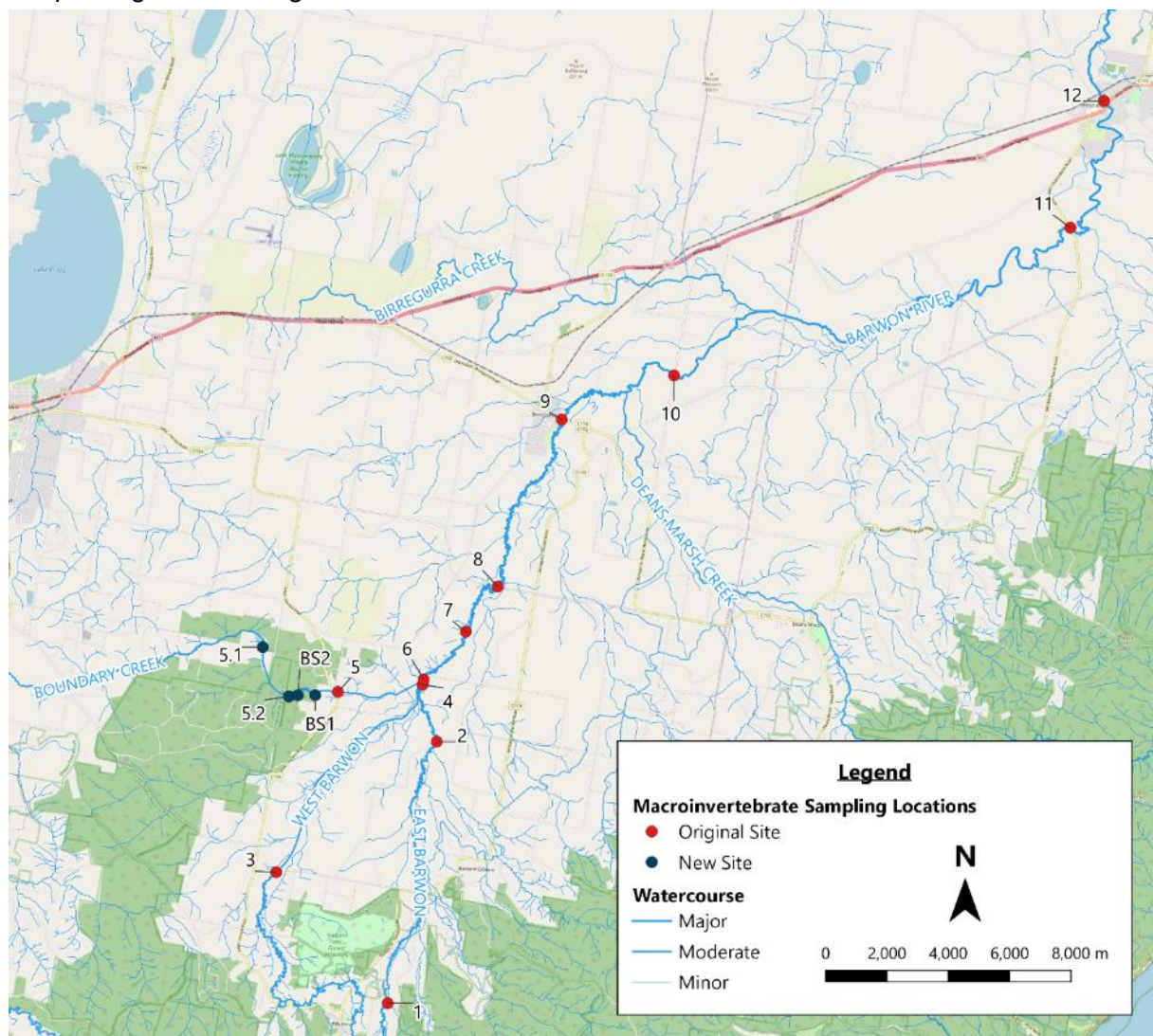
The objective of this report is to provide interim or snapshot data (Spring 2022) on the ecological condition of Boundary Creek (including where it flows through Big Swamp) and the upper Barwon River. Some comparisons have been with previous Spring data but full analysis and comparisons with previous data and targets will be completed following Autumn sampling each year.

1.3. Summary

As part of the REPP, Barwon Water has committed to continuing water quality and macroinvertebrate sampling along the Barwon River and within Boundary Creek to identify any changes in the conditions and assess the effectiveness of the remedial actions. Sampling biannually gives an indication of any impacts during higher flow (Spring) and lower flow (Autumn) conditions and will give an indication as to whether metals and altered pH are being mobilised and affecting the river system. The latest results indicate that whilst Boundary Creek is still being impacted by water quality from Big Swamp, the Barwon River is in very good condition at a number of sites downstream of the Boundary Creek confluence.

2. Methods

A total of twelve sites were surveyed along East Barwon, West Barwon, and Barwon Rivers in addition to Boundary Creek (Figure 1) in Spring 2019, Autumn 2020, Spring 2020, Autumn 2021, Spring 2021 and Autumn 2022. A further 4 sites were surveyed on Boundary Creek and in Big Swamp along with the original twelve in Autumn 2022.



- **Figure 1: Barwon River and Boundary Creek (base map from Open Street Map).** Red markers are original sites, blue are new sites added in Autumn 2022. Big Swamp east (BS1) was sampled in Autumn 2022 and Spring 2022 and Big Swamp west (BS2) in Spring 2022 as it was dry in Autumn 2022.

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, three sites are on Boundary Creek, two sites in Big Swamp (west site is intermittently dry) 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).

- **Table 1: Site locations, descriptions and approximate distance from Boundary Creek/ Barwon River confluence.**

Site no.	Site description	Distance from Boundary Creek conf.	Latitude	Longitude
1	East Barwon River @ Kents Road	Upstream	-38.512196	143.732530
2	East Barwon River @ Dewings Bridge Road	Upstream	-38.434878	143.747933
3	West Barwon River @ 7 Bridges Road	Upstream	-38.474669	143.689396
4	Barwon River 100m u/s of Boundary Ck conf.	Upstream	-38.418236	143.742025
5	Boundary Creek @ Colac-Forrest Road	Boundary Creek	-38.421122	143.710475
6	Barwon River 100m d/s of Boundary conf.	100m	-38.416717	143.742383
7	Barwon River @ north boundary of plantation	3.7km	-38.402291	143.757554
8	Barwon River @ Colac-Lorne Road	7.5km	-38.388771	143.768956
9	Barwon River @ Birregurra	17.6km	-38.339105	143.790971
10	Barwon River @ Conns Lane	21.7km	-38.325134	143.832385
11	Barwon River @ Winchelsea- Deans Marsh Road	42.4km	-38.278018	143.978382
12	Barwon River @ Princes Hwy bridge, Winchelsea	50.6km	-38.240445	143.989326
5.1	Boundary Creek @ d/s McDonalds Dam	Boundary Creek	-38.408599	143.681938
5.2	Boundary Creek @ u/s Big Swamp	Boundary Creek	-38.422875	143.692198
BS1	Big Swamp @ eastern end	Big Swamp	-38.422270	143.702076
BS2	Big Swamp @ western end	Big Swamp	-38.423042	143.695382

2.2. Sampling methodology

Macroinvertebrates and *in situ* water quality, vegetation, site descriptions and photos were collected with specific sampling methods detailed below.

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, field filtered using 0.45µm membrane filter, using bottles containing Nitric Acid (HNO₃) preservative and kept refrigerated prior to delivery to the NATA accredited ALS Laboratory.

2.2.3. Macroinvertebrates

Macroinvertebrates were collected at each site and photos and site assessment sheets were completed as per Victorian EPA guidelines (EPA Victoria, 2021). In the absence of riffle habitats, two edge samples (labelled A and B) were collected (EPA Victoria, 2021) using a 250µm mesh dip net to sample ten metres of representative habitat at two locations at each site on the 9th and 10th November, 2021. The contents of the net were 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 Victoria, 2021). 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 Victoria, 2021).

2.2.4. Site descriptions

EPA Victoria field sampling and habitat assessment sheets were filled out at each site and site photos taken (EPA Victoria, 2021). This information has been summarised in Appendix 1. The reported habitat parameter score is not expected to change over the short term unless works have

been undertaken at the site such as riparian revegetation or fencing or large woody debris introduction or the site is experiencing changes in flow such as drought conditions.

3. Results

3.1. Water Quality

The *in situ* water quality information in Table 4 below give an indication of the conditions at the time of sampling.

■ **Table 2: In-situ water quality data- Spring 2019, Autumn 2020, Spring 2020, Autumn 2021, Spring 2021, Autumn 2022 and Spring 2022.**

Site Waterway	Season	Temp. (°C)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm@25°C)	Dissolved oxygen (DO) (mg/L)	DO %	Alkalinity (mg/L)	Turbidity (NTU)
Site 1 East Barwon River@ Kents Road	Spring 19	13.2	6.2	186.7	240	13.07	123	5	9.09
	Autumn 20	14	8.67	161.8	210.2	4.42	47.5	5	2.6
	Spring 20	16.0	7.2	123.7	149.5	7.79	80.1	35	2.88
	Autumn 21	10.6	6.5	93.5	129.0	7.59	68.7	25	8.5
	Spring 21	12.2	6.59	120.5	159.7	9.92	94.2	30	5.86
	Autumn 22	12.0	6.96	209.7	279.3	8.40	77.7	30	26.2
	Spring 22	14.5	7.62	178.5	223.4	3.64	35.7	25	6.97
Site 2 East Barwon River @ Dewings Bridge Road	Spring 19	15.5	6.3	544	664	6.8	66.8	10	9.97
	Autumn 20	16	7.71	180.7	218.2	5.85	59.9	10	9.49
	Spring 20	16.2	7.6	272.0	327.3	10.86	110.4	55	9.35
	Autumn 21	11.2	6.58	228.9	311.8	8.21	74.2	35	8.2
	Spring 21	16.6	6.65	220.1	245.4	9.02	94.5	40	7.88
	Autumn 22	14.5	6.53	387.7	484.1	12.54	120.9	45	12.9
	Spring 22	13.4	7.63	250.4	321.7	3.30	31.8	35	18.3
Site 3 West Barwon River@ Seven Bridges Road	Spring 19	14.7	5.26	473.4	590.6	7.3	73.5	10	16.3
	Autumn 20	14.4	8.23	179.6	224.0	4.45	42.9	10	3.28
	Spring 20	12.7	7.1	195.2	255.0	6.12	56.3	50	5.58
	Autumn 21	9.7	7.3	165.1	233.4	7.21	63.9	30	3.65
	Spring 21	14.7	6.73	179.1	221.1	6.63	66.4	35	3.54
	Autumn 22	10.6	7.02	240.7	331.5	7.49	67.5	30	3.43
	Spring 22	12.5	7.51	256.6	336.7	3.01	28.3	40	12.7
Site 4 Barwon River 100m upstream of Boundary Creek confluence	Spring 19	17.9	7.4	575	664	9.15	96.4	10	8.01
	Autumn 20	17	6.60	211.2	248.4	6.08	64.3	10	41.5
	Spring 20	14.1	7.4	248.1	326.1	8.25	80.5	55	17.7
	Autumn 21	10.8	7.03	224.3	308.7	7.96	71.2	35	14.2

Site Waterway	Season	Temp. (°C)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm @25°C)	Dissolved oxygen (DO) (mg/L)	DO %	Alkalinity (mg/L)	Turbidity (NTU)
	Spring 21	17.3	6.88	242.3	277.4	8.06	83.5	45	12.6
	Autumn 22	13.6	7.31	423.4	541.6	9.73	93.5	45	30.5
	Spring 22	Site not accessible due to high water							
Site 5.1 Boundary Creek downstream of McDonalds Dam	Autumn 22	13.2	6.81	461	694	6.23	59.5	35	3.29
	Spring 22	14.6	7.35	290.9	361.8	3.27	32.2	40	14.2
Site 5.2 Boundary Creek upstream of Big Swamp	Autumn 22	8.9	6.72	410	592	10.18	87.2	30	5.07
	Spring 22	14.0	6.63	280.8	355.8	3.68	35.8	40	13.8
Site BS2 Big Swamp western end	Spring 22	14.7	5.87	272.2	338.4	2.06	20.6	20	9.64
Site BS1 Big Swamp eastern end	Autumn 22	9.6	5.48	656	929	19.4	2.20	10	20.1
	Spring 22	13.7	6.30	306.4	390.3	2.90	28.0	30	26.9
Site 5 Boundary Creek@ Colac-Forrest Road	Spring 19	12.1	3.94	777	1030	7.43	67.6	0	2.92
	Autumn 20	10.4	4.05	680	944	2.05	18.5	0	260
	Spring 20	12.9	3.1	614	798	5.31	50.6	0	6.82
	Autumn 21	10.0	4.0	286.6	401.2	8.76	76.8	20	35.7
	Spring 21	14.6	6.05	364.5	453.7	8.10	87.7	20	75.3
	Autumn 22	10.4	4.75	830	1152	7.37	66.2	0	22.3
	Spring 22	13.9	6.02	328.4	416.5	3.69	35.2	20	36.9
Site 6 Barwon River 100m downstream of Boundary Creek confluence	Spring 19	14.4	7.34	608	756	7.3	71.3	10	9.43
	Autumn 20	15.8	6.88	207.7	250.6	6.58	66.1	10	31.7
	Spring 20	13.9	7.0	298.5	378.8	6.88	67.1	50	12.2
	Autumn 21	10.9	7.19	254.2	347.7	7.03	62.9	25	20.6
	Spring 21	16.7	7.48	262.2	310.8	6.20	66.3	30	18.5
	Autumn 22	12.4	7.25	477	628	9.38	88.1	35	12.5
	Spring 22	15.2	6.20	304.8	374.6	3.67	35.9	30	18.1
Site 7 Barwon River @ north boundary of plantation	Spring 19	13.4	7.9	599	770	7.2	71.7	5	10
	Autumn 20	15.4	6.46	207.9	256.2	7.46	75.6	5	21.8
	Spring 20	14.2	7.1	276.6	348.2	7.15	69.7	45	13.6
	Autumn 21	10.7	7.14	258.1	354.6	6.78	61.9	20	17.9

Site Waterway	Season	Temp. (°C)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm @25°C)	Dissolved oxygen (DO) (mg/L)	DO %	Alkalinity (mg/L)	Turbidity (NTU)
Site 8 Barwon River @ Colac-Lorne Road	Spring 21	15.7	7.62	254.2	309.0	6.72	68.5	45	12.87
	Autumn 22	14.5	7.04	510	637	9.09	91.7	35	12.9
	Spring 22	13.3	7.95	304.7	392.6	3.67	35.3	35	21.7
	Spring 19	16.2	7.8	660	795	8.8	87.9	10	13.5
	Autumn 20	15.9	6.79	234.8	284.8	3.22	32	10	5.13
	Spring 20	16.3	7.3	286.3	344.2	6.55	67.7	50	5.61
	Autumn 21	11.0	6.74	255.8	350.3	7.10	64.2	25	12.4
	Spring 21	16.9	7.35	244.3	255.7	6.75	70.4	35	13.0
Site 9 Barwon River @ Birregurra	Autumn 22	13.7	7.21	552	701	6.14	59.1	35	4.04
	Spring 22	14.0	7.69	322.1	4	7.4	32.6	40	20.9
	Spring 19	15.4	7.8	1049	1288	9.7	98	15	16.6
	Autumn 20	16.2	6.79	494.4	600.6	6.65	69.8	15	11.1
	Spring 20	16.7	7.5	477.8	568.1	8.28	86.6	25	16.2
	Autumn 21	10.0	7.62	372.9	523.3	7.69	67.0	40	23.7
	Spring 21	16.8	7.15	366.0	437.5	7.61	77.5	45	32.4
	Autumn 22	14.1	7.56	1115	1412	9.88	92.7	55	9.25
Site 10 Barwon River @Conns Lane	Spring 22	16.0	6.63	574	694	4.24	43.0	45	65.9
	Spring 19	14.6	7.9	1252	1561	8.1	86.1	15	18
	Autumn 20	16.2	5.56	511	613	3.96	40.2	15	19.2
	Spring 20	15.6	7.5	756	920	7.45	76.2	75	22.2
	Autumn 21	11.1	7.14	372.5	506.5	9.03	81.5	40	33.7
	Spring 21	16.8	7.29	276.3	461.3	8.05	84.7	45	19.9
	Autumn 22	14.5	7.44	1399	1119	7.09	67.5	60	19.5
	Spring 22	15.6	6.78	643	783	3.80	37.7	50	58.5
Site 11 Barwon River @Winchelsea- Deans Marsh Road	Spring 19	13	7.9	1707	2227	9.23	87	15	26.1
	Autumn 20	15.6	6.26	762	929	3.62	35.2	15	13.3
	Spring 20	15.5	7.6	863	1054	6.28	64.7	75	13.7
	Autumn 21	11.0	6.82	401.9	548.8	8.35	74.1	40	31.5
	Spring 21	16.5	7.39	444.1	589.3	7.34	75.6	45	21.1
	Autumn 22	12.4	7.46	1369	1805	7.02	65.3	70	16.2

Site Waterway	Season	Temp. (°C)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm @25°C)	Dissolved oxygen (DO) (mg/L)	DO %	Alkalinity (mg/L)	Turbidity (NTU)
Site 12 Barwon River@ Princes Hwy bridge, Winchelsea	Spring 22	14.6	8.25	1563	1950	5.02	49.7	85	81.0
	Spring 19	12.4	8	1788	2364	8.4	82.1	15	19.9
	Autumn 20	15.9	6.69	924	1117	5.25	54.5	15	20.7
	Spring 20	15.0	7.6	1048	847	6.25	62.8	85	17.1
	Autumn 21	10.8	6.93	466.1	639.8	8.18	72.7	40	31.2
	Spring 21	17.1	7.61	733	622	7.06	79.3	50	19.6
	Autumn 22	13.8	7.48	1737	2209	6.54	63.2	80	9.71
	Spring 22	15.5	8.06	1528	1868	3.66	36.9	85	85.5

As in Autumn 2022 when the extra sites on Boundary Creek were sampled, in Spring 2022 pH decreases along the length of Boundary Creek but recovers by site 7 at the end of the pine plantation. Site 4 could not be sampled due to unsafe and insufficient alternative access. The Barwon River pH values lie predominantly within the ecologically optimum range of 6.5 to 8.5 although the specific tolerance of the Barwon River system to changes in pH outside of this range have not been investigated to date. Conductivity was typical of Spring sampling in 2022. Particularly in the lower reaches of the Barwon River, dissolved oxygen levels were some of the lowest recorded in this study and turbidity levels were the highest.

- **Table 3: Metal results (0.45µm filtered) for freshwater samples (mg/L) and Australian & New Zealand Guidelines for Fresh & Marine Water Quality (2019). In all but two instances the 95% level of species protection is applied as is recommended for slightly to moderately disturbed ecosystems. Shaded cells indicate exceedance of guideline values.**

Site	Waterway	Sampling event	Filtered Metal Concentration (mg/L)												
			Aluminium	Antimony	Arsenic (total)	Cadmium	Chromium (total)	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
Toxicant default guideline values		0.055 (>6.5pH) 0.8# (<6.5pH)	0.009#	AsIII 0.024 AsV 0.013	0.0002	CrIII 0.0003 CrVI 0.001	0.0014	-	0.0034	1.9	0.00006^	0.005^	0.00005	0.008	
Site 1	East Barwon River@ Kents Road	Spring 19	< 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
		Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.21	< 0.001	0.007	< 0.0001	< 0.001	< 0.005	< 0.005
		Summer21	0.06	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.68	< 0.001	< 0.005	< 0.0001	< 0.001	< 0.005	< 0.005
		Autumn21	0.04	<0.001	<0.001	<0.0002	<0.001	<0.001	0.35	<0.001	0.046	<0.0001	<0.001	<0.001	0.002
		Spring 21	0.03	<0.001	<0.001	<0.0002	<0.001	<0.001	0.21	<0.001	0.015	<0.0001	<0.001	<0.001	<0.001
		Autumn 22	0.02	0.008	<0.001	<0.0002	<0.001	<0.001	0.42	<0.001	0.31	<0.0001	<0.001	<0.001	0.009
Site 2	Spring 22	0.03	<0.001	<0.001	<0.0002	<0.001	<0.001	0.34	<0.001	0.031	<0.0001	<0.001	<0.001	0.005	
	Spring 19	< 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	Sampling event	Filtered Metal Concentration (mg/L)												
		Aluminium	Antimony	Arsenic (total)	Cadmium	Chromium (total)	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
East Barwon River@ Dewings Bridge Road	Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.08	< 0.001	0.037	< 0.0001	0.001	< 0.005	< 0.005
	Summer21	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.22	< 0.001	0.006	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.01	<0.001	<0.001	<0.0002	<0.001	<0.001	0.19	<0.001	0.057	<0.0001	<0.001	<0.001	0.005
	Spring 21	0.02	<0.001	<0.001	<0.0002	<0.001	<0.001	0.30	<0.001	0.010	<0.0001	<0.001	<0.001	0.004
	Autumn 22	<0.01	0.006	<0.001	<0.0002	<0.001	<0.001	0.10	<0.001	0.028	<0.0001	<0.001	<0.001	0.006
	Spring 22	0.02	<0.001	<0.001	<0.002	<0.0001	<0.001	0.51	<0.001	0.063	<0.0001	<0.001	<0.001	0.004
Site 3 West Barwon River@ Seven Bridges Road	Spring 19	< 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
	Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	0.004	0.015	< 0.0001	< 0.001	< 0.005	< 0.005
	Summer21	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.09	< 0.001	0.12	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.01	<0.001	<0.001	<0.0002	<0.001	<0.001	0.21	<0.001	0.035	<0.0001	<0.001	<0.001	0.006
	Spring 21	0.03	<0.001	<0.001	<0.0002	<0.001	<0.001	0.65	<0.001	0.005	<0.0001	<0.001	<0.001	0.007
	Autumn 22	<0.01	0.004	<0.001	<0.0002	<0.001	<0.001	0.13	<0.001	0.081	<0.0001	<0.001	<0.001	0.014
Site 4 Barwon River 100m upstream of Boundary Creek confluence	Spring 22	0.06	<0.001	<0.001	<0.0002	<0.001	0.003	1.1	<0.001	0.34	<0.0001	<0.001	<0.001	0.015
	Spring 19	< 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
	Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.14	< 0.001	0.35	< 0.0001	< 0.001	< 0.005	< 0.005
	Summer21	<0.05	< 0.005	< 0.001	<0.0002	< 0.001	< 0.001	0.33	< 0.001	0.019	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.01	<0.001	<0.001	<0.0002	<0.001	<0.001	0.19	<0.001	0.06	<0.0001	<0.001	<0.001	0.002
	Spring 21	0.03	<0.001	<0.001	<0.0002	<0.001	<0.001	0.71	<0.001	0.008	<0.0001	<0.001	<0.001	0.011
Site 5.1 Boundary Creek downstream of McDonalds Dam	Autumn 22	<0.01	0.003	<0.001	<0.0002	<0.00	0.001	0.05	<0.001	0.095	<0.0001	<0.001	<0.001	0.014
	Spring 22	Site not accessible due to high water												
	Autumn 22	<0.01	0.002	<0.001	<0.0002	<0.001	<0.001	0.39	<0.001	0.015	<0.0001	<0.001	<0.001	0.007
	Spring 22	0.19	<0.001	0.001	<0.0002	<0.001	<0.001	2.8	0.001	0.25	<0.0001	<0.001	<0.001	0.004
	Autumn 22	0.01	0.002	0.001	<0.0002	<0.001	<0.001	0.59	<0.001	0.019	<0.0001	<0.001	<0.001	0.007
	Spring 22	0.20	<0.001	0.001	<0.0002	<0.001	<0.001	2.4	<0.001	0.046	<0.0001	<0.001	<0.001	0.004
Site BS1 Big Swamp eastern end	Autumn 22	0.26*	<0.001	0.003	<0.0002	0.001	0.002	48	<0.001	0.024	<0.0001	<0.001	<0.001	0.023
Site 5	Spring 19	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	Waterway	Sampling event	Filtered Metal Concentration (mg/L)											
			Aluminium	Antimony	Arsenic (total)	Cadmium	Chromium (total)	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver
Boundary Creek@ Colac-Forrest Road	Autumn20	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	17	< 0.001	0.18	< 0.0001	< 0.001	< 0.005	0.015
	Summer21	7.2*	< 0.005	0.001	<0.0002	0.001	< 0.001	40	< 0.001	0.061	< 0.0001	0.001	< 0.005	0.23
	Autumn21	1.6*	<0.001	0.004	<0.0002	<0.001	0.005	50	<0.001	0.024	<0.0001	0.003	<0.001	0.08
	Spring 21	1.2*	<0.001	<0.0002	<0.0002	<0.001	<0.001	1.3	<0.001	0.034	<0.0001	<0.001	<0.001	0.11
	Autumn 22	1.2*	0.003	0.006	<0.0002	<0.001	<0.001	51	0.003	0.042	<0.0001	0.001	<0.001	0.10
	Spring 22	1.2	<0.001	0.004	<0.0002	0.002	<0.001	20	<0.001	0.030	<0.0001	0.001	<0.001	0.052
Site 6 Barwon River 100m downstream of Boundary Creek confluence	Spring 19	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
	Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.17	< 0.001	0.16	< 0.0001	< 0.001	< 0.005	< 0.005
	Summer21	<0.05	< 0.005	< 0.001	<0.0002	< 0.001	< 0.001	0.69	< 0.001	0.29	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.07	<0.001	<0.001	<0.0002	<0.001	<0.001	2	<0.001	0.069	<0.0001	<0.001	<0.001	0.012
	Spring 21	0.06	<0.001	<0.001	<0.0002	<0.001	0.001	1.3	<0.001	0.010	<0.0001	<0.0001	<0.001	0.016
	Autumn 22	0.02	0.002	<0.001	<0.0002	<0.001	<0.001	0.19	<0.001	0.11	<0.0001	<0.001	<0.001	0.014
Site 7 Barwon River @ north boundary of plantation	Spring 22	0.11	<0.001	<0.001	<0.0002	<0.001	<0.001	1.8	<0.001	0.13	<0.0001	<0.001	<0.001	0.006
	Spring 19	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
	Autumn20	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	0.001	0.09	< 0.001	0.01	< 0.0001	< 0.001	< 0.005	0.006
	Summer21	0.06	< 0.005	< 0.001	<0.0002	< 0.001	< 0.001	0.37	< 0.001	0.023	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.07	<0.001	<0.001	<0.0002	<0.001	<0.001	0.61	<0.001	0.072	<0.0001	<0.001	<0.001	0.009
	Spring 21	0.05	<0.001	<0.001	<0.0002	<0.001	0.002	1.2	<0.001	0.005	<0.0001	<0.001	<0.001	0.040
Site 8 Barwon River @ Colac- Lorne Road	Autumn 22	0.01	0.002	<0.001	<0.0002	<0.001	<0.001	0.05	<0.001	0.14	<0.0001	<0.001	<0.001	0.008
	Spring 22	0.10	<0.001	0.001	<0.0002	<0.001	<0.001	1.9	<0.001	0.086	<0.0001	<0.001	<0.001	0.006
	Spring 19	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
	Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	< 0.005	< 0.0001	< 0.001	< 0.005	< 0.005
	Summer21	<0.05	< 0.005	< 0.001	<0.0002	< 0.001	<0.001	0.24	< 0.001	<0.005	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.04	<0.001	<0.001	<0.0002	<0.001	<0.001	0.33	<0.001	0.031	<0.0001	<0.001	<0.001	0.005
Site 9	Spring 21	0.05	<0.001	<0.001	<0.0002	<0.001	<0.001	1.2	<0.001	0.021	<0.0001	<0.001	<0.001	0.012
	Autumn 22	<0.01	0.001	<0.001	<0.0002	<0.001	<0.001	0.04	<0.001	0.052	<0.0001	<0.001	<0.001	0.012
	Spring 22	0.09	<0.001	<0.001	<0.0002	<0.001	<0.001	1.8	<0.001	0.13	<0.0001	<0.001	<0.001	0.006
	Spring 19	< 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
	Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.016	< 0.0001	< 0.001	< 0.005	< 0.005

Site	Sampling event	Filtered Metal Concentration (mg/L)												
		Aluminium	Antimony	Arsenic (total)	Cadmium	Chromium (total)	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
Barwon River @ Birregurra	Summer21	<0.05	< 0.005	< 0.001	<0.0002	< 0.001	< 0.001	0.37	< 0.001	0.037	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.02	<0.001	<0.001	<0.0002	<0.001	<0.001	0.24	<0.001	0.038	<0.0001	<0.001	<0.001	0.004
	Spring 21	0.04	<0.001	<0.001	<0.0002	<0.001	<0.001	0.99	<0.001	0.011	<0.0001	<0.001	<0.001	0.006
	Autumn 22	<0.01	<0.001	<0.001	<0.0002	<0.001	<0.001	0.02	<0.001	0.10	<0.0001	<0.001	<0.001	0.013
	Spring 22	0.05	<0.001	0.001	<0.0002	<0.001	0.001	1.4	<0.001	0.13	<0.0001	<0.001	<0.001	0.004
Site 10 Barwon River @ Conns Lane	Spring 19	< 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
	Autumn20	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.027	< 0.0001	< 0.001	< 0.005	0.008
	Summer21	0.09	< 0.005	< 0.001	<0.0002	< 0.001	<0.001	0.6	< 0.001	0.045	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.02	<0.001	<0.001	<0.0002	<0.001	<0.001	0.25	<0.001	0.025	<0.0001	<0.001	<0.001	0.005
	Spring 21	0.04	<0.001	<0.001	<0.0002	<0.001	<0.001	1.2	<0.001	0.012	<0.0001	<0.001	<0.001	0.004
	Autumn 22	<0.01	0.003	<0.001	<0.0002	<0.001	<0.001	0.03	<0.001	0.12	<0.0001	<0.001	0.003	0.012
Site 11 Barwon River @ Winchelsea- Deans Marsh Road	Spring 22	0.06	<0.001	0.001	<0.0002	<0.001	0.001	1.3	<0.001	0.096	<0.0001	<0.001	<0.001	0.004
	Spring 19	< 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
	Autumn20	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.082	< 0.0001	< 0.001	< 0.005	< 0.005
	Summer21	0.16	< 0.005	<0.001	<0.0002	< 0.001	<0.001	1.4	< 0.001	0.028	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.03	<0.001	<0.001	<0.0002	<0.001	<0.001	0.18	<0.001	0.032	<0.0001	<0.001	<0.001	0.003
	Spring 21	0.04	<0.001	0.001	<0.0002	<0.001	0.001	1.1	<0.001	0.025	<0.0001	<0.001	<0.001	0.003
	Autumn 22	<0.01	0.001	<0.001	<0.0002	<0.001	<0.001	0.03	<0.001	0.12	<0.0001	<0.001	<0.001	0.010
Site 12 Barwon River @ Princes Hwy bridge, Winchelsea	Spring 22	0.03	<0.001	0.002	<0.0002	<0.001	0.002	1.0	<0.001	0.11	<0.0001	<0.001	<0.001	0.003
	Spring 19	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
	Autumn20	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.044	< 0.0001	< 0.001	< 0.005	0.015
	Summer21	0.27	< 0.005	0.001	<0.0002	< 0.001	0.001	1.7	< 0.001	0.049	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn21	0.02	<0.001	<0.001	<0.0002	<0.001	<0.001	0.19	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001
	Spring 21	0.04	<0.001	0.001	<0.0002	<0.001	0.001	1.0	<0.001	0.021	<0.0001	<0.001	<0.001	0.003
	Autumn 22	<0.01	<0.001	<0.001	<0.0002	<0.001	0.007	0.04	<0.001	0.11	<0.0001	<0.001	<0.001	0.013
	Spring 22	0.03	<0.001	0.002	<0.0002	<0.001	0.001	1.0	<0.001	0.10	<0.0001	<0.001	<0.001	0.003

level of species protection unknown

* Aluminium results where pH is <6.5

^ 99% species protection level to account for the bioaccumulating nature of this toxicant

Shaded exceeds guideline values

Aluminium concentrations in Spring 2022 are elevated and exceeding ANZECC guideline levels at Site 3 on the West Barwon River at Seven Bridges Road which is above the confluence with Boundary Creek. They exceed guidelines at all sites along Boundary Creek (Sites 5.1, 5.2 and 5 and whilst concentrations increase along Boundary Creek, they are stable at the long term monitoring site, Site 5. Aluminium concentrations continue to be elevated along the Barwon River, often exceeding ANZECC guideline levels until past Site 10 at Conns Lane. Iron concentrations remain high in Boundary Creek and are reduced in the mainstem of the Barwon River below the Boundary Creek confluence, similar to other Spring results. Zinc concentrations exceed ANZECC guidelines in Spring 2022 at Site 3 (West Barwon at Seven Bridges Road) in addition to Site 5 on Boundary Creek.

3.2. Macroinvertebrates

Biotic indices such as AusRivAS, SIGNAL2, EPT (Ephemoptera, Plecoptera, Trichoptera) and taxa richness (number of families) scores were calculated in accordance with EPA Victoria biological indicators (EPA Victoria, 2004). EPA Victoria released their updated guidelines for the rapid bioassessment of rivers in 2021 which ties in with the Environmental Reference Standards (ERS) ((Victorian Government Gazette (VGG), 2021), formally SEPP-Waters). The main change in the objectives contained within the ERS (VGG, 2021) is that they are split into Seasons so that concurrent seasons do not need to be sampled in order for objectives to be applied. Other changes include removing SIGNAL scores and instead using SIGNAL2 scores. Also, individual edge sample scores are calculated and the average reported rather than combining families and reporting as a single sample when a riffle is not present.

A list of macroinvertebrate families found at each site in Spring 2022 is in Appendix 2.

AusRivAS scores and bands (Table 3) 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 for each season was applied to these samples.

■ **Table 4: AusRivAS Bands, Observed/Expected scores and descriptions for edge models (AusRivAS Macroinvertebrate Predictive Modelling Version 3.2.2)**

Band	OE 50 score Spring	Description
X	1.20+	More biologically diverse than reference sites
A	0.81-1.19	Reference condition
B	0.43-0.80	Significantly impaired
C	0.05-0.42	Severely impaired
D	0-0.04	Extremely impaired

SIGNAL2 is a biotic index 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 but its accuracy in identifying toxicants is less certain (EPA Victoria, 2021).

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 4 to help interpret results.

The study area crosses two biological regions. Site 1 (East Barwon River at Yaugher) is in Uplands B; characterised by upland reaches in the Otway Ranges where there is some clearing for forestry, grazing and some intensive agriculture. Sites 2 to 12 are in Central Foothills and Coastal Plains; incorporating the lower reaches of the Barwon River where the region has been substantially cleared for intensive agriculture (EPA Victoria, 2004). The ecological values of Site 1 following the recent willow removal, streambank modification, and riparian clearing works upstream of, and at, the site are more consistent with the other sites within this study and therefore consideration should be given to applying the Central Foothills and Coastal Plains objectives. Sites BS1 and BS2 are wetland sites with input from Boundary Creek and as such objectives may not be relevant.

■ **Table 5: Environmental Quality Objectives for Biological Indicators, edge habitat (VGG, 2021)**

Objective	Season	Number of Families	SIGNAL2 Index score	EPT Index score	AusRivAS Band
Uplands B	Spring	17	4.2	6	A
Central Foothills & Coastal Plains	Spring	20	3.4	N/A	A

■ **Table 6: Biotic indices in Spring 2022.**

Site	Number of Families	SIGNAL2 Index score	EPT Index score	O/E score	AusRivAS Band
1	10	4.12	2	0.62	B
2	24	3.97	N/A	0.81	A
3	23	3.49	N/A	1.20	X
4	N/A	N/A	N/A	N/A	N/A
5.1	17	3.94	N/A	1.15	A
5.2	21	4.69	N/A	0.91	A
BS2	8	2.63	N/A	0.45	B
BS1	8	3.25	N/A	0.25	C
5	9	3.45	N/A	0.6	B
6	16	3.36	N/A	0.88	A
7	20	3.74	N/A	0.92	A
8	19	4.05	N/A	1.15	A
9	20	3.91	N/A	1.06	A
10	19	4.35	N/A	0.92	A
11	14	4.43	N/A	0.88	A
12	18	4.33	N/A	1.14	A

Shaded values indicate compliance with Environmental Quality Objectives.

Table 6 shows that Site 2 on the East Barwon at Dewings Bridge Road, Site 3 on the West Barwon at Seven Bridges Road, Site 5.2 on Boundary Creek immediately above Big Swamp, and Site 7 on the Barwon River at the north boundary of the pine plantation meet all of the Environmental Quality Objectives in Spring 2022. Full analysis and reporting on macroinvertebrate community

compositions will occur following the Autumn survey which will incorporate temporal trends and allow comparisons with environmental objectives.

4. Conclusions

Barwon Water has committed to continuing water quality and macroinvertebrate sampling along the Barwon River and within Boundary Creek until remediation is successful. Sampling biannually will give an indication of any impacts during higher flow (Spring) and lower flow (Autumn) conditions and will give an indication as to whether metals and altered pH are being mobilised and affecting the river system. Sampling sites on Boundary Creek upstream of Big Swamp show that whilst the Creek may be affected by the presence of McDonalds on-stream dam, the biological health of the Creek has improved to a similar quality to the upper sites on the Barwon River (such as Site 2 at Dewings Bridge Road and Site 3 at Seven Bridges Road). The current Spring 2022 results indicate that whilst Boundary Creek is still being impacted by water quality from Big Swamp, the Barwon River is in very good condition with AusRivAS ranking all sites below the confluence with Boundary Creek as Reference Condition. Further comment and comparisons with previous results will be made following the Autumn 2023 sampling event.

5. References

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2019) *Toxicant default guideline values*. Viewed 7th February 2021. <<https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants>>.

Barwon Water (2020) *Boundary Creek, Big Swamp and Surrounding Environment – Remediation and Environmental Protection Plan*.

Barwon Water (2022) *East Barwon Willow Removal and Restoration Project*. Viewed 2nd June 2022. <https://www.yoursay.barwonwater.vic.gov.au/east-barwon-transfer>

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

EnviroDNA (2019) *Determining the distribution of platypuses in the upper Barwon region using environmental DNA* Prepared for Upper Barwon Landcare Network.

EPA Victoria (2004) *Biological Objectives for Rivers and Streams – Ecosystem Protection*. Publication No. 793.2

EPA Victoria (2021) *Guideline for environmental management (GEM)- Rapid bioassessment methodology for rivers and streams*. Publication No. 604.2

Jacobs (2017) *Yeodene Swamp Study*, Final Draft Report for Barwon Water.

Victorian Government Gazette (VGG) (2021) *Environment Reference Standard, Environment Protection Act 2017* No. S 245 Wednesday 26 May 2021.

Appendix 1:

5.1. Site 1- East Barwon River@ Kents Road



Site 1: upstream Spring 2019



Site 1: downstream Spring 2019



Site 1: upstream Autumn 2020



Site 1: downstream Autumn 2020



Site 1: upstream Spring 2020



Site 1: upstream Spring 2020



Site 1: upstream Autumn 2021



Site 1: downstream Autumn 2021



Site 1: upstream Spring 2021



Site 1: downstream Spring 2021



Site 1: upstream Autumn 2022



Site 1: downstream Autumn 2022



Site 1: upstream Spring 2022



Site 2: downstream Spring 2022

Prior to the willow removal and river realignment in early 2022, the East Barwon River at Kents Road had diverse habitat with large deep pools and some riffle/ run areas. These runs had dried to trickles in Autumn 2020 but were flowing well in Spring and Autumn 2021. The average stream width was eight meters and bank full but had contracted to five meters in Autumn 2020. Willows dominate the riparian zone and are growing within the stream channel. The substrate was a mix of clay and silt with a number of aquatic macrophytes growing in the margins and shallow pool areas. The majority of the riparian zone was exotic vegetation, dominated by blackberries (possibly poisoned in Summer 20/21), willows and pasture grass. One larval fish has been collected as bycatch during macroinvertebrate sampling. A concurrent snapshot study by EnviroDNA (2019) found evidence of platypus at this site.

Following the works in January to April 2022 (Barwon Water, 2022), the East Barwon River at Kents Road is a homogenous channel with very little riparian zone and submerged macrophytes. The banks had healed in areas in Spring 2022 from the disturbed bare earth or rip rap in Autumn 2022. Stock now appear excluded from the waterway and all woody weeds have been removed within the vicinity of the 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 in 2019 and a downgraded score of 57 out of 140 in 2022 due to the recent works. It is expected that this score will improve following the planned revegetation works and ongoing stock exclusion.

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



Site 2: upstream Spring 2019



Site 2: downstream Spring 2019



Site 2: upstream Autumn 2020



Site 2: downstream Autumn 2020



Site 2: upstream Spring 2020



Site 2: downstream Spring 2020



Site 2: upstream Autumn 2021



Site 2: downstream Autumn 2021



Site 2: upstream Spring 2021



Site 2: downstream Spring 2021



Site 2: upstream Autumn 2022



Site 2: downstream Autumn 2022



Spring 2022



Spring 2022

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 for macroinvertebrates and fish. One larval fish was found in the sample net in Autumn 2020, three pygmy perch in Spring 2020 and a pygmy perch in Spring 2021. 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 during both Spring and Autumn 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 gave this site a score of 59 out of 140 and increased to 70 out of 140, primarily due to the gradual reduction in erosional scars and the increase in submerged and emergent macrophyte beds, despite the constant stock access. Removing stock access and establishing riparian vegetation will improve the health of this site significantly.

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



Site 3: upstream Spring 2019



Site 3: downstream Spring 2019



Site 3: upstream Autumn 2020



Site 3: downstream Autumn 2020



Site 3: upstream Spring 2020



Site 3: downstream Spring 2020



Site 3: upstream Autumn 2021



Site 3: downstream Autumn 2021



Site 3: upstream Spring 2021



Site 3: downstream Spring 2021



Site 3: upstream Autumn 2022



Site 3: downstream Autumn 2022



Spring 2022



Spring 2022

The West Barwon River at Seven Bridges Road has large deep pools with a number of 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 in Spring 2019. One mountain galaxias, one common galaxias, one pygmy perch and a laval galaxias were collected in Spring 2020 and another galaxias in Spring 2021. A number of pygmy perch were collected in Autumn 2022. A concurrent snapshot study by EnviroDNA (2019) found evidence of platypus at this site in Spring 2019. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 85 out of 140 in 2019 and this has remained steady over the three years of the study.

5.4. Site 4- Barwon River 100m upstream of Boundary Creek confluence



Site 4: upstream Spring 2019



Site 4: downstream Spring 2019



Site 4: upstream Autumn 2020



Site 4: downstream Autumn 2020



Site 4: upstream Spring 2020



Site 4: downstream Spring 2020



Site 4: upstream Autumn 2021



Site 4: downstream Autumn 2021



Site 4: upstream Spring 2021



Site 4: downstream Spring 2021



Site 4: upstream Autumn 2022



Site 4: downstream Autumn 2022

The Barwon River 100 meters 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* species 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 in Spring 2019, Autumn 2021 and Autumn 2022 and a pygmy perch sampled in Spring 2021. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 79 out of 140 in 2019 and an increased score of 99 due to the establishment of more aquatic macrophytes and healed erosion. Fencing and revegetation of the left side of the river to a similar standard as the right side would see further improvements to the health of the river.

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



Site 5: upstream Spring 2019



Site 5: downstream Spring 2019



Site 5: upstream Autumn 2020



Site 5: downstream Autumn 2020



Site 5: upstream Spring 2020



Site 5: downstream Spring 2020



Site 5: upstream Autumn 2021



Site 5: downstream Autumn 2021



Site 5: upstream Spring 2021



Site 5: downstream Spring 2021



Site 5: upstream Autumn 2022



Site 5: downstream Autumn 2022



Spring 2022



Spring 2022

Boundary Creek at Colac- Forrest Road has a mix of large deep pools, a large shallow pool at the bridge and shallow runs. It has been bank full 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 during each sampling event excepting during Autumn 2020 sampling when the creek had contracted to a pool approximately 4 meters long by 2.5 meters wide. During this time the pooled water was stagnant, with low oxygen concentrations and very high turbidity. The substrate is a mix of cobble, pebble, gravel, sand, clay and silt. There are no macrophytes but there was some filamentous algae in Spring 2019, (absent since) and trailing bank vegetation present. Foam was present at the top of the reach in Spring 2020, Autumn 2021, Spring 2021 and Autumn 2022. 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 has remained steady at 81 out of 140 between 2019 and 2022 and is likely to remain so until conditions allow aquatic vegetation to establish and the riparian vegetation is improved.

5.6. Site 6- Barwon River 100m downstream of Boundary Creek confluence



Site 6: upstream Spring 2019



Site 6 : downstream Spring 2019



Site 6: upstream Autumn 2020



Site 6: downstream Autumn 2020



Site 6: upstream Spring 2020



Site 6 : downstream Spring 2020



Site 6: upstream Autumn 2021



Site 6: downstream Autumn 2021



Site 6: upstream Spring 2021



Site 6: downstream Spring 2021



Site 6: upstream Autumn 2022



Site 6: downstream Autumn 2022



Spring 2022



Spring 2022

The Barwon River 100 meters 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 was bank full in Spring 2019, Spring 2020, Autumn 2021 and Spring 2021 and had contracted to a narrow (1-2 meter) channel in Autumn 2020 and Autumn 2022. There is a narrow channel at the top of the surveyed reach, narrowing to a confined channel downstream. The river had contracted to the main channel but remained flowing, leaving the fringes to dry out in Autumn 2020 and Autumn 2022. The substrate consists of clay and silt usually with filamentous algae tangled through the macrophyte beds but in Autumn 2021 and Spring 2021 the macrophyte beds were covered in a smothering floc that was easily disturbed, forming a thick plume. This plume appeared to be absent in Autumn 2022 but this could have been due to the absence of slow flowing areas where floc would be able to settle. Macrophyte species are varied with *Triglochin*, *Polygonum*, *Phragmites*, and *Juncus* species all present in addition to trailing grasses. Four different fish species have been collected at this site as bycatch; southern pygmy perch, smelt and a galaxid in Autumn 2020, gambusia and southern pygmy perch in Spring 2020. 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 gave this site a score of 70 out of 140 in 2019 and a very similar score of 71 in 2022. As with all sites that have unrestricted stock access, the health of this site would be improved by fencing and revegetating the river on both sides.

5.7. Site 7- Barwon River @ north boundary of plantation



Site 7: upstream Spring 2019



Site 7: downstream Spring 2019



Site 7: upstream Autumn 2020



Site 7: downstream Autumn 2020



Site 7: upstream Spring 2020



Site 7: downstream Spring 2020



Site 7: upstream Autumn 2021



Site 7: downstream Autumn 2021



Site 7: upstream Spring 2021



Site 7: downstream Spring 2021



Site 7: upstream Autumn 2022



Site 7: downstream Autumn 2022



Spring 2022



Spring 2022

The Barwon River 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 gave this site a score of 90 out of 140 in 2019 and increased to 104 in 2022 primarily due to continued improvements in riparian and instream macrophyte condition.

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



Site 8: upstream Spring 2019



Site 8: downstream Spring 2019



Site 8: upstream Autumn 2020



Site 8: downstream Autumn 2020



Site 8: upstream Spring 2020



Site 8: downstream Spring 2020



Site 8: upstream Autumn 2021



Site 8: downstream Autumn 2021



Site 8: upstream Spring 2021



Site 8: downstream Spring 2021



Site 8: upstream Autumn 2022



Site 8: downstream Autumn 2022



Spring 2022



Spring 2022

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 with some substrate exposed when the river level is low. 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 in 2019 and a similar score of 73 in 2022.

5.9. Site 9- Barwon River @ Birregurra



Site 9: upstream Spring 2019



Site 9: downstream Spring 2019



Site 9: upstream Autumn 2020



Site 9: downstream Autumn 2020



Site 9: upstream Spring 2020



Site 9: downstream Spring 2020



Site 9: upstream Autumn 2021



Site 9: downstream Autumn 2021



Site 9: upstream Spring 2021



Site 9: downstream Spring 2021



Site 9: upstream Autumn 2022



Site 9: downstream Autumn 2022



Spring 2022



Spring 2022

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 and establishing well over time. There were willow removal works and replanting of the riparian zone in Spring 2019 in amongst the pasture grass and blackberry groundcover. The riparian zone is established and growing well although follow up ground cover weed management may be required. Rakali footprints are evident in the soft sediment edge during many of the sampling events. Introduced mosquitofish (*Gambusia sp.*) were bycatch in Autumn 2022. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 67 out of 140 in 2019 but has increased to 98 in 2022, primarily due to the successful reintroduction of the riparian zone following large scale willow removal.

5.10. Site 10- Barwon River @ Conns Lane



Site 10: upstream Spring 2019



Site 10: downstream Spring 2019



Site 10: upstream Autumn 2020



Site 10: downstream Autumn 2020



Site 10: upstream Spring 2020



Site 10: downstream Spring 2020



Site 10: upstream Autumn 2021



Site 10: downstream Autumn 2021



Site 10: upstream Spring 2021



Site 10: downstream Spring 2021



Site 10: upstream Autumn 2022



Site 10: downstream Autumn 2022



Spring 2022



Spring 2022

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 trailing and shallow vegetation contained filamentous algae in Autumn 2021 and 2022. Larval fish and gambusia were collected in the macroinvertebrate net in Spring 2020 and gambusia were plentiful in Autumn 2021 though not in Spring 2021. The riparian zone consists of a native revegetation project that is more successful on the right side than the left. Exotic trees are re-establishing on the left side and pasture grass dominates. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 98 out of 140 in 2019 and a similar score of 101 in 2022.

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



Site 11: upstream Spring 2019



Site 11: downstream Spring 2019



Site 11: upstream Autumn 2020



Site 11: downstream Autumn 2020



Site 11: upstream Spring 2020



Site 11: downstream Spring 2020



Site 11: upstream Autumn 2021



Site 11: downstream Autumn 2021



Site 11: upstream Spring 2021



Site 11: downstream Spring 2021



Site 11: upstream Autumn 2022



Site 11: downstream Autumn 2022



Spring 2022



Spring 2022

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 in Spring 2019. The height and force of a flood between Autumn 2021 and Spring 2021 sampling can be seen in the upstream Spring 2021 photo of the log wedged in the forked tree in the left foreground. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 90 out of 140 in 2019 and the similar but slightly higher score of 98 in 2022 with the introduction of more woody debris into the channel following the 2021 floods and the continuing growth of riparian vegetation.

5.12. Site 12- Barwon River @ Princes Hwy bridge, Winchelsea



Site 12: upstream Spring 2019



Site 12: downstream Spring 2019



Site 12: upstream Autumn 2020



Site 12: downstream Autumn 2020



Site 12: upstream Spring 2020



Site 12: downstream Spring 2020



Site 12: upstream Autumn 2021



Site 12: downstream Autumn 2021



Site 12: upstream Spring 2021



Site 12: downstream Spring 2021



Site 12: upstream Autumn 2022



Site 12: downstream Autumn 2022



Spring 2022



Spring 2022

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) in Spring found evidence of platypus at this site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 88 out of 140 in 2019 and a similar score of 91 in 2022.

5.13. Site 5.1- Boundary Creek downstream of McDonalds Dam



Site 5.1: upstream Autumn 2022



Site 5.1: downstream Autumn 2022



Spring 2022



Spring 2022

Site 5.1 on Boundary Creek was added to the current sampling regime to replicate the site sampled by Austral in 2014/2015 for Jacobs (2017) and give some context to the health of Boundary Creek upstream of Big Swamp. Boundary Creek below McDonalds Dam is between 3 and 4 meters wide with a mix of deep pools, shallower pools and artificial riffle areas from the culvert/ bridge. There were isolated patches of aquatic macrophytes in 2014 but none were present in 2022. Whilst large trees are a feature of the riparian zone, live blackberries and bare ground where they have been poisoned, dominate. Intensive agriculture exists outside of the riparian zone. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 87 out of 140 in 2014 and a similar score of 91 in 2022.

5.14. Site 5.2- Boundary Creek upstream of Big Swamp



Site 5.2: upstream Autumn 2022



Site 5.2: downstream Autumn 2022



Spring 2022



Spring 2022

Site 5.2 on Boundary Creek was added to the current sampling regime to give additional information on the biological health of Boundary Creek upstream of Big Swamp. Boundary Creek is between 1 and 2 meters wide either side of the vehicle crossing and is very different to all other sites sampled with a mix of large and small, deep and shallow pools and runs. There are extensive areas of macrophytes including *Triglochin*, *Ranunculus* and *Cyperus* beds and isolated patches of *Alisma* and *Juncus*. The riparian zone is extensive consisting of predominantly, if not totally, native species. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gave this site a score of 130 out of 140, the highest of any in this study.

5.15. Site BS1- Big Swamp eastern end



Site BS1: upstream Autumn 2022



Site BS1: downstream Autumn 2022



Spring 2022



Spring 2022

Site BS1 in Big Swamp was added to the current sampling regime to give additional information on the condition of Big Swamp. The water level was shallow and was slowly flowing around the extensive amount of large woody debris and beds of Giant Rush and scattered sedges and rushes such as *Gahnia* and *Cyperus*. There was a high amount of iron floc present on the substrate.

5.16. Site BS2- Big Swamp western end



Site BS1: upstream Spring 2022



Site BS1: downstream Spring 2022

Site BS2 in Big Swamp was dry in Autumn 2022 and whilst was holding water in Spring 2022, this was not flowing as it is at Site BS1. The vegetation and water quality were similar in the two Big Swamp sites.

Appendix 2:

	1A	1B	2A	2B	3A	3B	5.1A	5.1B	5.2A	5.2B	BS2	BS1	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B	11A	11B	12A	12B
Aeshnidae			2															1				1						
Atriplectididae									1																			
Atyidae	2	3	3		1	5	4								2		10	4	4	8	1	4	2	5	4	2		2
Baetidae	2	1	1	2	21	7				1					1	1		1	16	16	1	11	1	6	40	19	34	15
Belostomatidae																					3	1						
Caenidae				14	1		1																					
Calamoceratidae				2													1	2	2	4	2	5					2	2
Ceinae			5		1		19	17	2	3					1	1	9	16	8	12		2	1	13	1		1	3
Ceratopogonidae			3		1				1		2									2				1			1	
Chaoboridae								1																				
Chironominae	2	3	8	1	7	30	19	24	28	15	29	32	16	7	5	2	6	4	3	3	10	10	1	2	2	2	9	8
Coenagrionidae			32	35		2		4	3		1				1		8	12	7	5	26	17	16	7	2		2	
Corduliidae																		1										
Corixidae				3	2	10	1								3	3	7	8	4	9		11	4	14	5	9	9	22
Crambidae			2																		1							
Culicidae									1	1																		
Dixidae								1	1																			
Dugesidae			3			1	1	12				10	6	4			4	4		1	12	9	2	2				
Dytiscidae			1		2	5		1			2			1	3	1				2							1	
Elmidae																		1										
Gerridae		1																										
Glossiphoniidae			2																									
Gripopterygidae		2					1		2	9					1				2		2	6	3	7	1	3	7	1
Gyrinidae			1												1		1	3	2	2		1			8	4		
Hirudinea																		1										
Hydrobiidae	7	7					12	1	18	14																		
Hydrobiosidae									1											1								
Hydrophilidae									1						3	8												
Hydropsychidae										1																		
Hydroptilidae						1	1		1	1					3		1		10		2	2	3					

[illegible]