

2022-2023 Annual Report

Boundary Creek, Big Swamp and
Surrounding Environment
Remediation and Environmental
Protection Plan (REPP)

28 September 2023

Executive Summary

In June 2017, Barwon Water acknowledged that the historic management of periodic groundwater pumping activities at the Barwon Downs borefield, conducted between 1982 and 2016 to supplement drinking water supplies during dry periods, had led to a reduction in groundwater contribution from the Lower Tertiary Aquifer into Boundary Creek, a tributary of the Barwon River.

This reduction, in conjunction with the changes in land use, Millennium Drought, and the complexities associated with management and regulation of a private on-stream dam that controls flow into the lower reaches of Boundary Creek, resulted in the occurrence of 'cease to flow' and 'acid flush' events along Boundary Creek and Big Swamp – a wetland that is primary fed by inflows from Boundary Creek.

To help address these impacts, Barwon Water has already implemented the following remedial actions:

- Cessation of groundwater pumping activities at the Barwon Downs borefield: The purpose of this action is to allow groundwater levels to recover and enable groundwater-surface water interaction along Boundary Creek to return;
- Provision of supplementary flows, where required, to maintain flows of at least 0.2 ML/day at the Boundary Creek at Yeodene stream gauge (site 233228) all year round: The purpose of this action is to minimise wet-dry cycling and the occurrence of cease to flow events, maintain saturation of acid sulfate soils, minimise fire risks and provide suitable conditions for wetland species to recolonise impacted areas;
- Prevent the encroachment of dry vegetation classes: The purpose of this action is to provide suitable conditions for wetland species to recolonise impacted areas; and
- Development of risk-based contingency measures to be implemented in the unlikely event that they are required: The purpose of this action is to develop last resort controls to minimise the potential for high-risk events, should these persist following the implementation of the primary remedial actions.

In addition to these actions, Barwon Water is currently preparing to decommission the Barwon Downs borefield extraction bores in line with its commitment outlined in the 2023-2028 Price Submission.

Environmental monitoring works, undertaken to monitor the progress of these remedial actions to date indicate:

- The ongoing recovery of the Lower Tertiary Aquifer, with groundwater levels in the central portions of the aquifer nearing pre-pumping levels;

- The ongoing recovery and maintenance of soil moisture within Big Swamp's upper aquifer system, and subsequent decrease in the severity of wet-dry cycling processes and the potential for acid flush / fish kill events in the Barwon River;
- That supplementary flows continue to assist in maintaining flows in the lower reaches of Boundary Creek during the drier months (i.e., between December and April) when streamflows are at their lowest. As such, no cease to flow events were recorded during the 2022-2023 reporting period. The data also indicates that groundwater-surface water interaction along Boundary Creek has returned to some degree with the aim to phase supplementary flows out once groundwater levels have met their intended targets;
- Continued improvement in the water quality within the lower reaches of Boundary Creek and Big Swamp compared to worst case conditions, with Boundary Creek at Yeodene (Site #233228) meeting the pH targets during the 2022-2023 reporting period for the first time since the implementation of the REPP, and
- That significant recolonisation of Big Swamp with desired species has occurred since the 2010 fires, with Big Swamp exhibiting suitable conditions for aquatic flora and fauna. Noting that the vegetation and macroinvertebrate communities within Big Swamp continue to adapt to the changing conditions as these work towards a 'new normal'.

Despite these improvements, given all the remediation success targets have not yet been achieved concurrently, remediation is not yet complete and will continue in line with the REPP (Barwon Water, 2023a).

The remedial actions that have been committed to as part of the Boundary Creek and Big Swamp Remediation Plan will also continue to facilitate the recovery of the Lower Tertiary Aquifer within the surrounding environment and help to address any groundwater pumping-derived hydraulic influences that have led to streamflow reductions in select surface water features (Barwon Water, 2023b).

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1 Introduction

In June 2017, Barwon Water acknowledged that the historic management of periodic groundwater pumping activities at the Barwon Downs borefield, conducted between 1982 and 2016 to supplement drinking water supplies during dry periods, had led to a reduction in groundwater contribution from the Lower Tertiary Aquifer into Boundary Creek, a tributary of the Barwon River.

This reduction, in conjunction with the changes in land use, Millennium Drought, and the complexities associated with management and regulation of a private on-stream dam that controls flow into the lower reaches of Boundary Creek, resulted in the occurrence of 'cease to flow' and 'acid flush' events along Boundary Creek and Big Swamp – a wetland that is primary fed by inflows from Boundary Creek.

This occurred, despite meeting the provisions set out in the groundwater extraction licence(s) that were intended to offset the potential impacts from Barwon Water's groundwater pumping activities on Boundary Creek. This drying subsequently resulted in the enhanced oxidation of naturally occurring acid sulfate soils and discharge of acidity and metals impacting the condition and function of Big Swamp and the lower reaches of Boundary Creek.

In May 2018, Barwon Water established a community and stakeholder working group to help inform the development of a Remediation Plan to address the impacts caused by Barwon Water's activities. In September 2018, Barwon Water's commitment to undertake remedial works was legally strengthened through the issuing of a Ministerial Notice by Southern Rural Water (SRW) under section 78 of the *Water Act*. The Boundary Creek, Big Swamp and Surrounding Environment Remediation and Environmental Protection Plan (REPP) was subsequently submitted to Southern Rural Water (SRW) in December 2019, and subsequently amended to account for Southern Rural Water and Independent Technical Reference Panel (ITRP) feedback prior to acceptance in February 2020. Noting that this was more recently updated in July 2023. The objectives of the REPP are twofold:

1. **The Boundary Creek and Big Swamp Remediation Plan** - That outlines the controls and actions that have and will be implemented to:
 - **Ensure** no further harm from Barwon Water's historic groundwater pumping or remediation actions
 - **Protect** the water quality and ecological values of the Barwon River
 - **Improve** the water quality and streamflows within Boundary Creek, and
 - **Improve** the ecological values of Big Swamp.
2. **The Surrounding Environment Investigation** - To investigate whether other areas within the regional groundwater system have been impacted by historical management of groundwater extraction activities at the Barwon Downs borefield.

A key requirement of the section 78 notice and the REPP is the provision of quarterly updates to Southern Rural Water to report on progress with implementation of the plan, as well as an Annual Report. In line with the section 78 notice and the approved governance framework, the Annual Report is required to be submitted to Southern Rural Water for review and comment before being made publicly available by 30 September each year.

The 2022-2023 Annual Report is the fourth Annual Report issued following acceptance of the REPP in February 2020. This annual report provides an overview of the progress against the actions and timeframes outlined in the REPP, with progress presented in a similar format to that of the quarterly updates. The Annual Report also provides more detail on technical investigations, monitoring, data collected, and tracking against the remediation success targets.

2 Implementation of the REPP

In accordance with the REPP, Barwon Water have adopted an adaptive management approach, whereby the REPP can be adapted in response to the current 'state of knowledge', or in response to data collected as part of the routine environmental monitoring program. This approach allows Barwon Water and Southern Rural Water to evaluate how the confirmed areas of impact and the surrounding environment more broadly are responding to the adopted remediation actions and take further action, such as implementation of contingency measures, if required.

To help address the requirements of the section 78 notice and ensure momentum was maintained, several key milestones and actions were established, as shown in Figure 1. While the timeframes presented only extend until the end of 2024, Barwon Water acknowledges that it may take several years to meet all the Boundary Creek and Big Swamp remediation success targets, and that the number and nature of remedial actions or contingency measures may change in line with the adaptive management approach.

This acknowledges that the number and nature of remedial actions needs to be balanced with practicality, as is required under the section 78 notice, along with the environmental implications, costs, risks, and trade-offs associated with implementing remedial actions that may alter the condition or intrinsic value of the swamp.

Regular assessment of monitoring results against the success targets and triggers for the implementation of contingency measures will continue beyond the timeframes outlined in Figure 1 until successful remediation has been achieved.

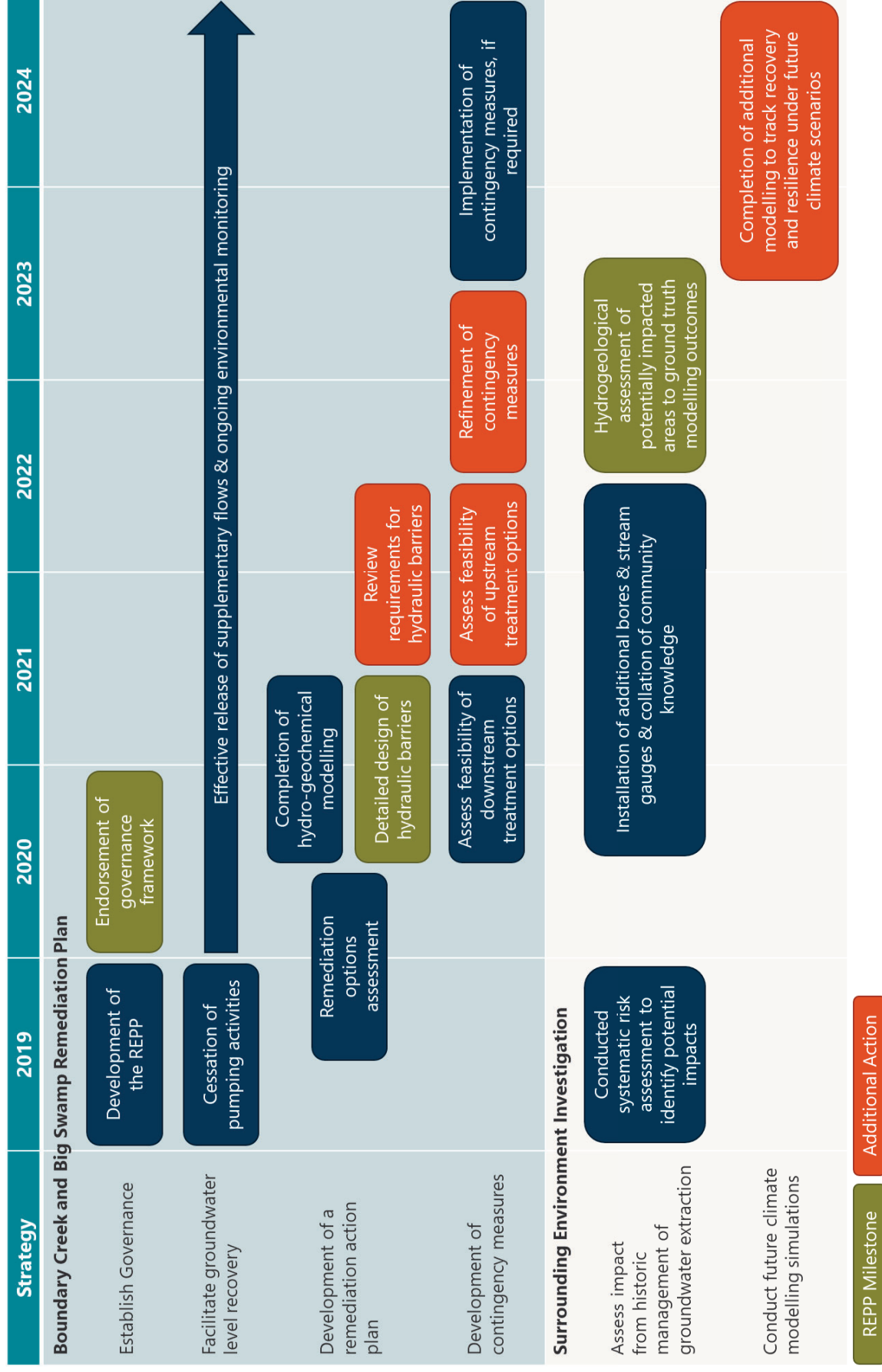


Figure 1 Timeframes for the implementation of the REPP

3 Barwon Downs Borefield

3.1 Metering

As Barwon Water no longer hold a groundwater extraction licence, no groundwater extraction activities can occur at the Barwon Downs borefield.

On 17 July 2023, Barwon Water applied for a licence to decommission the Barwon Downs borefield extraction bores in line with the commitments outlined in Barwon Water's 2023-2028 Price Submission. Barwon Water are currently planning for the decommissioning works following receipt of the Licence to Decommission on 25 September 2023, with on-ground decommissioning works anticipated to commence in 2024/2025. This is two years earlier than the timeframes outlined in the 2023-2028 Price Submission.

3.2 Supplementary Flows

Following the identification of potential streamflow losses in the lower reaches of Boundary Creek during the 2002 licence renewal process, environmental provisions, such as the release of 2 ML/day of supplementary flows, were later included in the licence(s) to offset the potential impacts to Boundary Creek during pumping periods.

While there are currently no obligations to release these supplementary flows via the now expired groundwater licence, the use of supplementary flows continues to be an action as part of the Boundary Creek and Big Swamp Remediation Plan to assist with maintaining flow in Boundary Creek and aid in re-wetting Big Swamp. Further information regarding the supplementary flows is provided in Section 4.5.3.

3.3 Land Subsidence Monitoring

Land subsidence monitoring in the Barwon Downs region has routinely been conducted by Barwon Water's spatial services team on an annual basis since 2003 in accordance with the now expired groundwater extraction licence to monitor any changes in ground levels that may occur due to the groundwater extraction activities. While land subsidence monitoring commenced before this time, the monitoring network was upgraded and expanded as part of the 2002 licence renewal process to increase the accuracy and spatial distribution of the monitoring network. As such, the 2003 data has not been compared to historic data due to the differences in survey methods. However, for comparison, based on the historic data dating back to 1987, subsidence of between 5 and 23 mm was recorded between 1987 and 2002.

The results from the June 2023 survey event, along with a comparison against the 2003 data is presented in Table 1. Positive height differences indicate an increase in ground levels, while negative height differences indicate a decrease in ground levels (i.e., subsidence).

As shown in Table 1, a maximum subsidence of between 37 and 89 mm was recorded across the monitoring network during worst-case conditions, which, with the exception of

monitoring station 38090024, occurred between 2010 and 2012. This was well below the 200 mm subsidence trigger stipulated in the groundwater licence(s). The June 2023 data also indicates that ground levels at monitoring stations have recovered by between 8 and 54 mm since worst-case conditions, with residual subsidence of between 15 and 79 mm recorded across the monitoring network during the 2022-2023 reporting period.

In addition to this, the historic data indicates some fluctuation in ground levels over time. These fluctuations are likely due to changes in the soil moisture content that can lead to the swelling or contraction of the soils rather than being representative of consolidation and/or subsidence. This is particularly relevant as the majority of these monitoring points are located on the Gellibrand Marl – the regional surficial aquifer system as opposed to the Lower Tertiary Aquifer.

Table 1 Ellipsoid height differences for each observation compared to the 2003 baseline licence monitoring data (mm)

Station ID	2003 Reference Ellipsoid Height (m)	Historic Maximum Subsidence as compared to 2003 data (mm)	Year Maximum Height Difference was Recorded	2022-2023 Adjusted Ellipsoid Height (m)	Height Difference as compared to 2003 data (mm)	Change since worst-case conditions (mm)
Primary Control Stations						
20790040	273.773	0	N/A	273.773	0	0
20880024	242.411	-25	2010	242.395	-16	9
20590052	357.221	-26	2020	357.220	-1	25
39780106	265.954	-30	2010	265.934	-20	10
Monitoring Stations						
32390045	157.246	-75	2010	157.225	-21	54
32390046	158.557	-50	2010	158.539	-18	32
26470027	142.360	-45	2010	142.330	-30	15
26470032	145.315	-63	2010	145.289	-26	37
26470033	147.003	-76	2010	146.969	-34	42
26470036	173.639	-63	2010	173.624	-15	48
39870025	177.600	-37	2011	177.571	-29	8
39870026	173.557	-38	2010	173.530	-27	11
38090024	108.285 Adjusted in 2015	-89	2018	108.206	-79	10
38090025	117.938 Adjusted in 2017	-48	2012	117.910	-28	20
38090026	145.600	-41	2012	145.573	-27	14

Note:

The adjustments shown for monitoring stations 38090024 and 38090025 were due to these marks being damaged. As such these marks were reset and a new height was recorded.

3.4 Recovery of the Lower Tertiary Aquifer

In accordance with the conditions outlined in the groundwater extraction licence(s), Barwon Water have undertaken routine groundwater level monitoring since the 1980's. These monitoring activities continued following the cessation of groundwater pumping activities in 2016, and today form part of the Boundary Creek, Big Swamp and Surrounding Environment Remediation and Environmental Protection Plan (REPP) Environmental Monitoring Program. A map outlining the location of Barwon Water's regional groundwater observation bores as well as those contained within the State Observation Bore Network (SOBN) are provided in Figure 2.

As outlined in the hydrographs presented in Appendix A, the majority of groundwater observation bores within the Lower Tertiary Aquifer continue to display a long-term increasing trend since the cessation of groundwater pumping activities in 2016. This is also evident in the groundwater level summary table provided in Table 2 that provides a snapshot of the residual drawdown and recovery observed in each groundwater observation bore since worst case conditions. These recoveries are also presented visually in Figure 2, noting that these have not been modified to account for localised flow patterns or any potential extractive uses.

As outlined in Figure 2, groundwater observation bores located within the central confined portion of the Graben generally report recoveries between 55 and 80% when compared to worst case conditions, while recoveries within the unconfined portions of the Lower Tertiary Aquifer (i.e., where these outcrop at surface) and through the pipeline restriction (refer Figure 2) are more variable. This is also supported by recent work (Barwon Water, 2023b) that indicated that these flow paths are still recovering following the cessation of groundwater pumping activities.

For consistency with previous years, the residual drawdown contours are also presented in Appendix B. Noting that, unlike previous years these have been plotted as one aquifer system rather than breaking these down into their individual geological formations. Hydrographs for each geological unit are provided in Appendix A. Consistent with the recovery contours, the residual drawdown contours provided in Appendix B are generated based on the recorded groundwater levels and have not been modified to account for localised flow patterns or any potential extractive uses.

Table 2 Summary of groundwater level recovery within the Lower Tertiary Aquifer

Bore ID	Nature of aquifer at this location	Ground Elevation (mAHD)	Approx. Surface Elevation of the Lower Tertiary Aquifer (mAHD)	Maximum Recorded Groundwater Elevation (mAHD)	Maximum Recorded Pressure Head (m)	Lowest Recorded Groundwater Elevation (mAHD)	Lowest Recorded Pressure Head (m)	Maximum Drawdown (m)	Maximum 2022/2023 Groundwater Elevation (mAHD)	Maximum 2022/2023 Pressure Head (m)	Observed Water Level Recovery (m)	Residual Drawdown (m)	Recovery
G11	Confined	156.6	-191.1	115.6	306.7	109.9	300.9	5.8	110.7	301.7	0.8	5.0	14%
G12	Confined	158.0	-192.0	115.3	307.3	111.2	303.2	4.1	-	-	-	-	-
BK69	Unconfined	248.2	248.1	227.7	N/A	222.8	N/A	4.9	223.3	N/A	0.5	4.4	10%
G13	Confined	140.2	-231.1	160.7	391.8	113.8	344.9	46.9	140.9	372.0	27.1	19.8	58%
G14	Confined	140.3	-290.7	158.8	449.5	100.7	391.3	58.1	147.5	438.2	46.8	11.3	81%
G17	Confined	171.5	25.3	158.6	133.3	125.4	100.1	33.2	146.8	121.5	21.4	11.8	65%
G20	Confined	164.2	-114.7	157.9	272.5	104.7	219.3	53.2	147.2	261.8	42.5	10.7	80%
G21	Confined	146.1	-246.0	162.6	408.7	109.7	355.7	53.0	146.4	392.4	36.8	16.2	69%
G22	Unconfined	179.0	232.8	108.5	N/A	92.6	N/A	15.9	94.3	N/A	1.7	14.1	11%
G23	Unconfined	232.3	232.0	171.0	N/A	160.8	N/A	10.2	161.9	N/A	1.1	9.1	11%
G24	Confined	171.6	22.3	158.9	136.6	125.8	103.5	33.1	147.1	124.8	21.3	11.8	64%
G25	Confined	175.9	175.7	150.0	N/A	140.6	N/A	9.4	143.2	N/A	2.7	6.8	28%
G28	Confined	204.0	10.0	175.3	165.3	166.6	156.6	8.7	167.6	157.6	1.0	7.7	11%
Y40	Confined	156.1	35.7	126.5	90.8	120.6	84.9	5.9	121.2	85.5	0.6	5.3	11%
Y41	Unconfined	141.9	139.9	129.4	N/A	126.1	N/A	3.3	127.4	N/A	1.4	1.9	41%
M24	Confined	156.0	-317.5	161.3	478.8	112.8	430.2	48.6	150.0	467.5	37.2	11.3	77%
M25	Confined	158.4	-323.8	158.6	482.4	119.7	443.5	38.9	149.2	473.0	29.5	9.4	76%
M27	Confined	141.7	-226.5	159.5	386.0	133.0	359.5	26.6	149.4	375.9	16.5	10.1	62%
M28	Confined	127.6	-8.8	153.0	161.8	127.0	135.7	26.1	146.7	155.5	19.7	6.3	76%
M29	Confined	177.7	115.7	163.1	47.4	147.6	31.9	15.5	154.1	38.4	6.5	9.0	42%
M30	Unconfined	202.7	201.9	176.7	N/A	173.0	N/A	3.7	175.3	N/A	2.3	1.4	62%
M31	Unconfined	174.0	171.0	160.2	N/A	151.1	N/A	9.2	152.9	N/A	1.8	7.4	20%
YEO19	Unconfined	176.6	176.6	162.8	N/A	120.1	N/A	42.7	152.4	N/A	32.3	10.3	76%
YEO20R	Unconfined	174.5	173.9	163.4	N/A	149.2	N/A	14.2	152.7	N/A	3.6	10.6	25%
YEO21	Confined	137.4	92.5	155.6	63.1	127.9	35.3	27.8	145.2	52.7	17.4	10.4	63%
YEO22	Confined	179.2	112.7	162.5	49.8	128.2	15.5	34.3	150.6	38.0	22.5	11.9	65%
YEO23	Confined	163.5	4.9	160.5	155.6	139.8	134.9	20.7	152.3	147.4	12.5	8.2	61%
YEO37	Unconfined	158.9	155.7	158.0	2.4	144.6	N/A	13.4	151.9	N/A	7.3	6.1	54%
YEO38	Unconfined	163.7	156.4	158.1	1.8	152.7	N/A	5.5	152.7	N/A	0.0	5.4	1%
YEO39	Unconfined	162.5	159.0	163.0	3.9	148.3	N/A	14.7	157.7	N/A	9.4	5.3	64%
YEO40R	Unconfined	167.1	167.1	160.2	N/A	146.8	N/A	13.4	151.3	N/A	4.5	8.9	34%
YEO41	Unconfined	207.0	205.9	164.8	N/A	129.1	N/A	35.8	151.1	N/A	22.1	13.7	62%
YEO42	Confined	210.1	198.9	162.6	N/A	147.5	N/A	15.2	152.9	N/A	5.5	9.7	36%
YEO44	Confined	175.2	-21.6	155.2	176.9	132.3	153.9	22.9	148.7	170.3	16.4	6.6	71%
YYG217	Unconfined	190.9	105.1	140.6	35.5	138.7	33.7	1.9	140.6	35.5	1.8	0.1	95%
YYG218	Unconfined	190.5	105.1	161.0	56.0	157.3	52.2	3.7	-	-	-	-	-
YYG221	Unconfined	132.7	51.5	147.1	95.5	133.2	81.7	13.8	142.9	91.4	9.6	4.2	70%

Bore ID	Nature of aquifer at this location	Ground Elevation (mAHD)	Approx. Surface Elevation of the Lower Tertiary Aquifer (mAHD)	Maximum Recorded Groundwater Elevation (mAHD)	Maximum Recorded Pressure Head (m)	Lowest Recorded Groundwater Elevation (mAHD)	Lowest Recorded Pressure Head (m)	Maximum Drawdown (m)	Maximum 2022/2023 Groundwater Elevation (mAHD)	Maximum 2022/2023 Pressure Head (m)	Observed Water Level Recovery (m)	Residual Drawdown (m)	Recovery
W4	Confined	120.0	-137.0	120.2	257.3	119.4	256.4	0.9	-	-	-	-	-
W7	Confined	120.8	-178.3	166.0	344.3	142.4	320.7	23.6	155.4	333.7	13.0	10.6	55%
W9	Confined	143.8	-266.4	154.1	420.5	136.1	402.5	17.9	-	-	-	-	-
BA54	Confined	157.3	-26.2	153.2	179.4	143.6	169.8	9.6	147.8	174.0	4.3	5.4	44%
BA56	Confined	167.5	49.9	147.9	98.0	140.6	90.7	7.3	144.9	94.9	4.2	3.0	58%
BA57	Confined	155.3	83.3	152.3	68.9	138.7	55.4	13.5	142.2	58.9	3.5	10.1	26%
BA58	Unconfined	157.0	-80.6	151.9	232.4	139.5	220.0	12.4	-	-	-	-	-
E68	Confined	228.2	207.5	206.6	N/A	202.4	N/A	4.2	205.2	N/A	2.8	1.4	66%
BD3	Confined	180.3	151.6	150.9	N/A	144.0	N/A	6.9	146.5	N/A	2.5	4.4	36%
BSTB1C	Confined	144.1	116.6	-	-	141.7	25.1		147.7	31.1	6.0	-	-
BSBH13	Confined	147.4	132.4	-	-	-	-		148.1	15.7	-	-	-

Note:

During the 2022/2023 reporting period additional elevation surveys were conducted to verify the elevations of unsurveyed bores. Where elevation discrepancies were identified the data has been updated to account for this information.

Bores G18, G19 and M22 that are presented in Figure 2 are installed in the Clifton Formation and hence have not been included in this assessment.



Figure 2 Recovery of the Lower Tertiary Aquifer since worst case condition

4 Boundary Creek and Big Swamp Remediation Plan

4.1 Boundary Creek and Big Swamp Status Update

Consistent with the observations provided in the Quarterly Updates, the following observations can be made from the data that has been collected as part of Barwon Water's routine environmental monitoring program:

- Groundwater levels within Big Swamp's upper aquifer system continue to be maintained above the reactive horizon (i.e. where there is a high potential acidity) (refer Figure 3 and Figure 4). This positive outcome continues to minimise any further oxidation of acid sulfate soils and reduce the severity of wet-dry cycling processes.
- Groundwater levels from bores installed in the Lower Tertiary Aquifer system within Big Swamp continue to indicate the long-term recovery and repressurisation of the Lower Tertiary Aquifer system (refer Figure 3 and Figure 4), with the western end of the swamp consistently reporting artesian conditions since March 2022 (refer Figure 4). This is a positive shift towards the restoration of groundwater-surface water interaction in Boundary Creek upstream of Big Swamp.
- Standing water continues to be visible, at least seasonally, within Big Swamp's inundation areas, with visible improvements in the western portion of the swamp compared to March 2022 (refer Table 3). This is a positive transition to providing suitable conditions for desired species and minimising the occurrence of 'acid flush' events, that occur following severe drying events.
- Between 1 July 2022 and 30 June 2023, the pH levels in Boundary Creek downstream of Big Swamp (site 233276) have ranged between 4.4 and 7.7 (average of 6.1 pH units) (refer Figure 5), while the pH levels in Boundary Creek at Yeodene (site 233228) have ranged between 3.8 and 6.5 (average of 5.6 pH units) (refer Figure 6). This is 1.9 pH units above the 2019/20 average, 1.5 pH units above the 2020/21 average and 0.5 pH units above the 2021/22 average. This year-on-year improvement indicates a marked reduction in the frequency and duration of severe acid flush events.
- Between 1 July 2022 and 30 June 2023, average daily streamflow's at stream gauge 233228 (Boundary Creek at Yeodene) have ranged between 0.9 and 154 ML/day, reporting an average daily flow of 15.4 ML/day (refer Figure 5 and Figure 6). As such, no cease to flow events have occurred during 2022-2023.

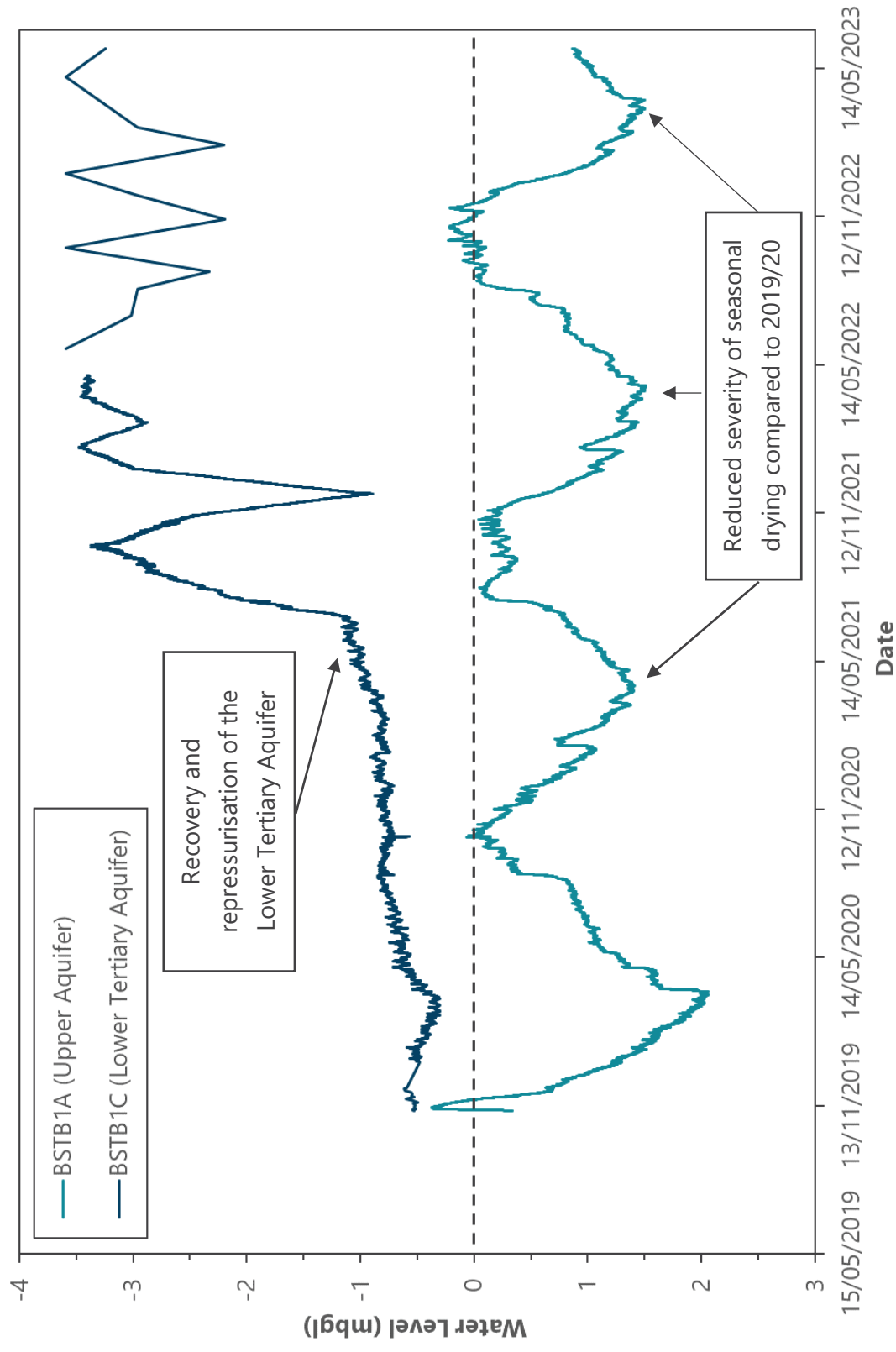


Figure 3 Groundwater levels in the eastern portion of the swamp. Note that since the logger was removed from BSTB1C in April 2022 due to leakage associated with repressurisation of the LTA, the data presented after this time relates to spot sampling data

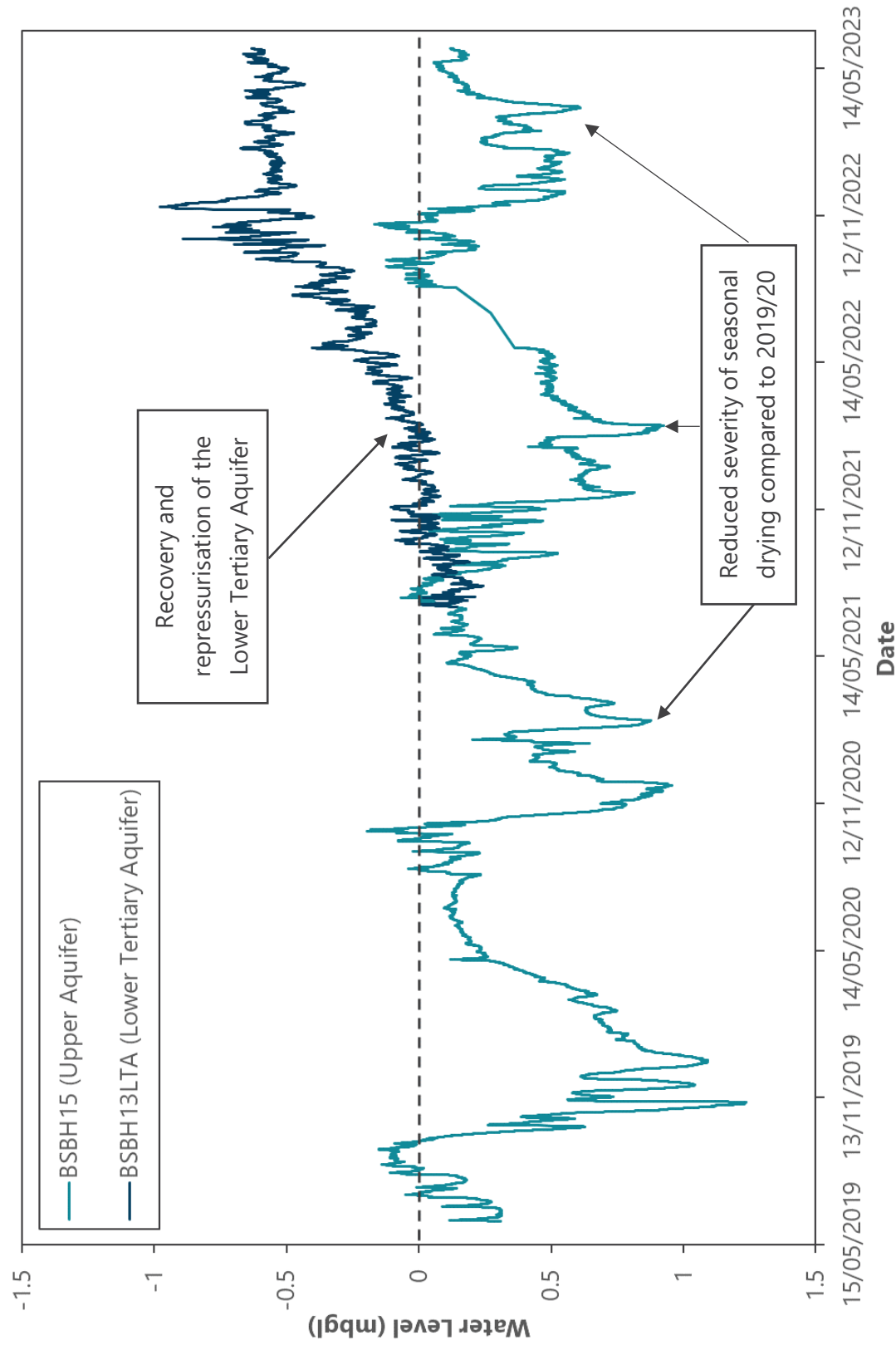


Figure 4 Groundwater levels in the western portion of the swamp. Note that the logger from BSBH15 was found to be missing on 14 July 2022 and was replaced on 15 August 2022, data between these times relates to spot sampling data

Table 3 Visual comparison of Big Swamp between March 2022 and June 2023

Date	Western end of Big Swamp	Eastern end of Big Swamp
March 2022		
October 2022		
February 2023		
April 2023		

Boundary Creek – downstream of Big Swamp (Site 233276)

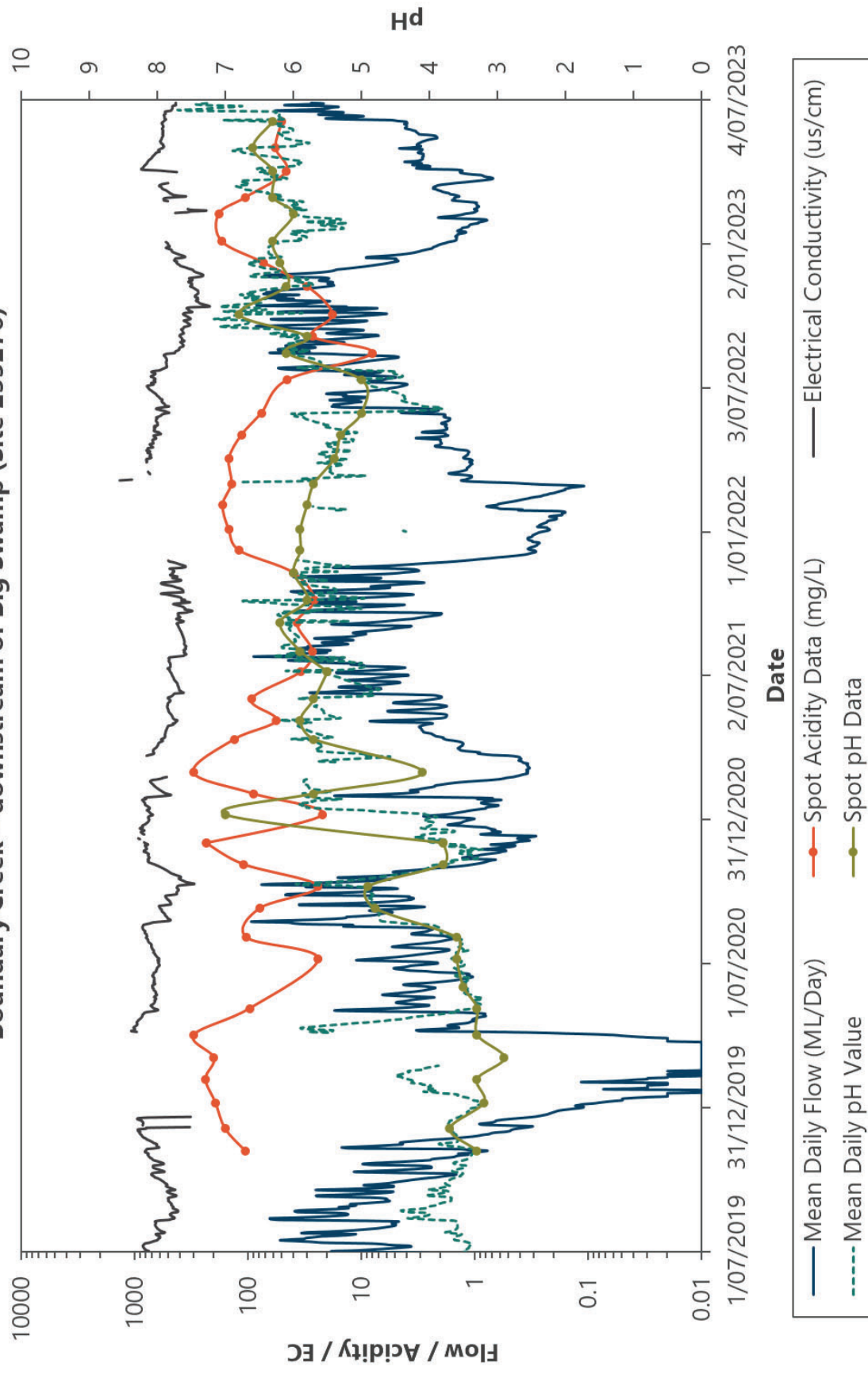


Figure 5 Streamflow, pH, EC and acidity readings in Boundary Creek – downstream of Big Swamp as recorded at stream gauge 233276 and during routine spot sampling

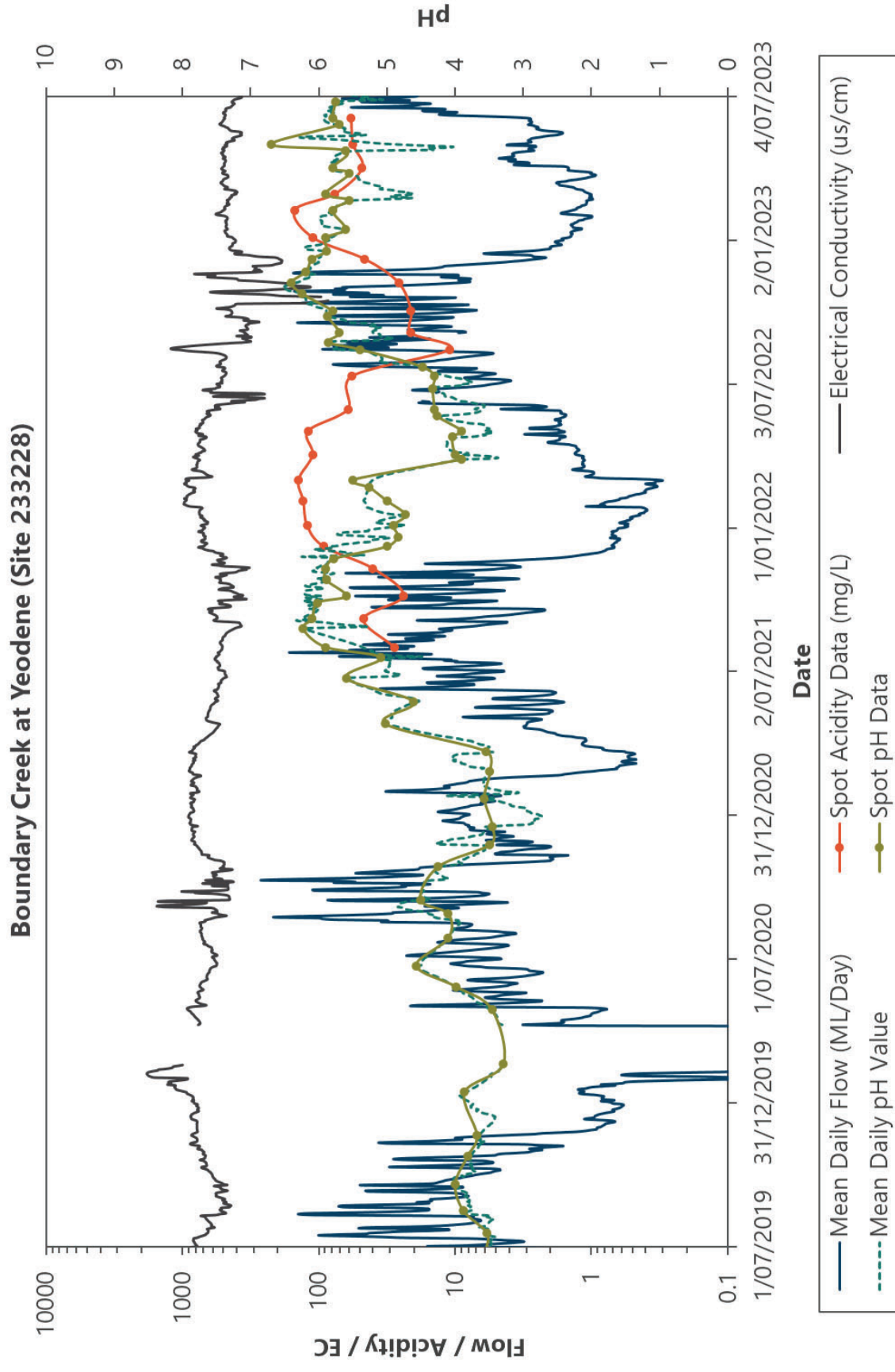


Figure 6 Streamflow, pH and acidity readings in Boundary Creek at Yeodene as recorded at stream gauge 233228 and during routine spot sampling

4.2 Actions Completed on the Boundary Creek and Big Swamp Remediation Plan During 2022-2023

Table 4 outlines the actions completed for the Boundary Creek and Big Swamp Remediation Plan between 1 July 2022 and 30 June 2023.

Table 4 Boundary Creek and Big Swamp Remediation Plan - Actions completed in 2022-2023 (1 July 2022 - 30 June 2023)

Action Items	Comment / Link
REPP Specific Items	
Completion of quarterly Remediation Reference Group meetings	Completed on: 21 September 2022 16 November 2022 08 March 2023 14 June 2023
Submission of Quarterly and Annual Reports	Complete. Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/boundary-creek
Continue to collect data from new and existing monitoring assets	Ongoing
Continue to release supplementary flows, where required, to maintain a flows of at least 0.2 ML/day at the Yeodene stream gauge #233228. Noting that this has been updated to reflect the changes outlined in the interim draft REPP that was submitted to Southern Rural Water on 22 December 2023	Ongoing. Refer to Section 4.5.3 for further information.
Undertake macro-invertebrate and water quality sampling in the Barwon River and Boundary Creek as outlined in the REPP	Complete. The findings of the autumn and spring sampling events are provided in the Upper Barwon River Macroinvertebrate Sampling Report 2019-2023 that can be accessed via the Your Say website via the following link: https://www.yoursay.barwonwater.vic.gov.au/boundary-creek
Undertake vegetation monitoring works as outlined in the REPP	Complete and uploaded to the Your Say Website. Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/boundary-creek

Action Items	Comment / Link
<p>Progress amendment of the REPP based on the current 'state of knowledge' and the adaptive management approach and close out any outstanding feedback items from the 2020 version of the REPP.</p> <p>This will include a review of the adopted remedial actions and the development of a risk-based remedial strategy that accounts for recent community and stakeholder feedback regarding the preference to facilitate natural recovery processes.</p>	<p>An interim draft of the revised REPP was submitted to Southern Rural Water on 22 December 2022 for initial feedback.</p> <p>This was subsequently revised based on this feedback along with the outcomes of the Ecological Risk Assessment (ERA) and Paleoenvironmental Study, and submitted to Southern Rural Water on 31 July 2023.</p> <p>Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/boundary-creek</p>
Development of risk-based contingency measures	<p>The risk-based contingency measures have been included in the revised REPP.</p> <p>The design of a mobile downstream treatment contingency measure was also submitted to Southern Rural Water on 31 July 2023. This replaces the previous design of a permanent downstream chemical dosing plant and aims to overcome a number of the risks and challenges associated with the permanent downstream chemical dosing plant and help address community and stakeholder feedback.</p>
Completion of a Level 3 Ecological Risk Assessment to quantify the risks of the existing metal and acidity loads on Boundary Creek, Big Swamp, and the Barwon River and to help inform the development of suitable triggers for the implementation of relevant contingency measures, if required.	<p>Complete. This was submitted to Southern Rural Water on 31 July 2023 and uploaded to the Your Say Website.</p> <p>Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/boundary-creek</p>
Completion of a paleoenvironmental study of Big Swamp	<p>Complete. This was submitted to Southern Rural Water on 31 July 2023 and uploaded to the Your Say Website.</p> <p>Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/boundary-creek</p>
Completion of broader community information sessions	Delayed until September 2023 to capture the July 2023 submissions outlined above.
Additional Items	
Attendance at Southern Rural Water's CLG meeting to discuss the outcomes of the Upstream Treatment Investigation	Completed on 24 August 2022

Action Items	Comment / Link
Attendance at Southern Rural Water's CLG meeting to provide an overview of the revisions to the REPP	Completed on 15 March 2023
Inclusion of decommissioning of the Barwon Downs production bores in the 2023-2028 price submission	The draft price submission was posted for community feedback in July 2022. Barwon Water's final Price Submission was approved by the Essential Services Commission on 23 June 2023.
Development of the Barwon Downs Borefield Decommissioning Plan	Draft report complete – pending finalisation. Once complete, this will be uploaded to the Your Say Website. Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/boundary-creek

4.3 Upcoming Actions Associated with the Boundary Creek and Big Swamp Remediation Plan During 2023-2024

Table 5 outlines the upcoming actions / milestones associated with the Boundary Creek and Big Swamp Remediation Plan between 1 July 2023 and 30 June 2024.

Table 5 Boundary Creek and Big Swamp Remediation Plan – Upcoming actions / milestones for the 2023-2024 (1 July 2023 - 30 June 2024)

Action Items	Due
Submission of the final revised REPP to Southern Rural Water	31 July 2023
Submission of the mobile downstream treatment contingency measure design to Southern Rural Water	31 July 2023
Submission of the Barwon Downs borefield bore decommissioning licence application to Southern Rural Water	31 July 2023
Submission of the Ecological Risk Assessment for Boundary Creek, Big Swamp, and the Barwon River to Southern Rural Water	31 July 2023
Submission of the Paleoenvironmental Study to Southern Rural Water	31 July 2023
Continue to collect data from new and existing monitoring assets	Ongoing

Action Items	Due
Continue to release supplementary flows, where required, to try to maintain a flow of at least 0.2 ML/day at the Yeodene stream gauge #233228	Ongoing
Completion of community information sessions to engage with the broader community	Two community information sessions are due to occur in September 2023.
Completion of quarterly Remediation Reference Group meetings	Due in September, December, March and June each year. Noting that timing can change to account for RRG member availability or technical works.
Submission of Quarterly and Annual Reports	Quarterly reporting will occur in September, December, March and June each year and will be submitted to Southern Rural Water within 14 days of completion of the quarter. In addition to this, a draft annual report will be submitted to Southern Rural Water for review and comment at least 14 days prior to the September submission date (being 30 September each year).
Completion of fish surveys in the Upper Barwon Region	While not a requirement of the REPP, Barwon Water have engaged Arthur Rylah Institute to conduct some fish surveys in the Upper Barwon Region. The first event is to occur in 2024, with a follow up event scheduled for 2025
Climate resilience modelling of waterways influenced by former groundwater pumping activities at the Barwon Downs borefield	31 December 2024

4.4 Status of Remedial Actions

The status of the remedial actions outlined in the REPP is provided in Table 6 below.

Table 6 Status of remedial actions

Remedial Action	Purpose	Relevant Objectives	Priority	Progress
Cessation of groundwater pumping activities	Allow groundwater levels in the Lower Tertiary Aquifer (LTA) and Upper Aquifer system to recover and enable groundwater-surface water interaction to return	1,2,3,4,5	Short term	Complete and ongoing
Decommissioning of the Barwon Downs extraction bores		1,2,3,4,5	Mid-longer term	Preparations underway following receipt of a Licence to Decommission

Remedial Action	Purpose	Relevant Objectives	Priority	Progress
				from Southern Rural Water on 25 September 2023
Provision of supplementary flows, where required, to maintain flows of at least 0.2 ML/day at the Boundary Creek at Yeodene stream gauge (site 233228)	<p>Minimise wet-dry cycling and the occurrence of cease to flow events, maintain saturation of acid sulfate soils, minimise fire risks and provide suitable conditions for wetland species to recolonise impacted areas.</p> <p>0.2 ML/day has been set to clearly indicate that flow has been maintained and account for the accuracy limitations (+/- 0.1 ML) of the stream gauge infrastructure at very low flows. As such flows less than 0.1 ML/day are considered to indicate a potential cease to flow event.</p>	1,2,3,4,5	Short term	Complete and ongoing
Prevent the encroachment of dry vegetation classes	Provide suitable conditions for wetland species to recolonise disturbed areas.	4,5	Mid-longer term	Ongoing
Development of risk-based contingency measures to be implemented in the unlikely event that they are required	To minimise the potential for high-risk events, should these persist following the implementation of the primary remedial actions	2,3,4,5	Mid-longer term	In progress – pending acceptance from Southern Rural Water

Note:

The water (untreated water) for supplementary flows is sourced from the Colac or Barwon water supply system in accordance with the conditions and limits stipulated in Barwon Water's existing Bulk Entitlements for the Colac and Upper Barwon systems.

4.5 Review of Success Targets

Table 7 below summarises the success targets that have been developed to determine progress against the remedial objectives. Noting that these have been updated in line with the adaptive management approach and in accordance with the revised REPP.

When all the success targets have been achieved concurrently, remediation is considered to have been completed and the requirements of the section 78 notice satisfied. However, these do not aim to protect the system from stressors beyond Barwon Water's control. As such, there is still some uncertainty as to whether these can be achieved in the presence of non-pumping related changes and ongoing stressors that may impact on the ability of the system to recover.

Further detail regarding the progress against each of these success targets is provided in the sections outlined in Table 7.

Table 7 Success targets for remediation of Boundary Creek and Big Swamp

Remedial Objective	Success Target	Measurement	Section Reference
Facilitate groundwater level recovery and enable groundwater-surface water interaction to return	Maintain groundwater levels at the levels outlined in the REPP for a period of 2 consecutive years (Note: targets have been set for both the Lower Tertiary Aquifer and Upper Aquifer systems)	Groundwater levels / elevations from routine environmental monitoring works	Refer Section 4.5.1 and 4.5.2
Reduce the fire risk in Big Swamp			
Reduce the severity of wet-dry cycling processes and the occurrence of 'acid flush' events in Boundary Creek	Supplementary flows have not been required for a period of 2 consecutive years to mitigate against prolonged cease to flow events, where a prolonged cease to flow event is defined as more than 14 days with flow less than 0.1 ML/day at the Boundary Creek at Yeodene stream gauge (site 233228)	Telemetered flow measurements (ML/day)	Refer Section 4.5.3
Control/manage oxidation of naturally occurring acid sulfate soils	Annual pH levels – as indicated by the 25 th and 75 th percentiles, recorded at the Boundary Creek at Yeodene stream gauge (site 233228) maintained between 5 and 9 pH units for a period of 2 consecutive years*	Telemetered and spot sampling data	Refer Section 4.5.4

Remedial Objective	Success Target	Measurement	Section Reference
Preserve/improve the ecological values of Big Swamp and Boundary Creek	The inundation areas within Big Swamp have or have the potential to develop aquatic flora and fauna. This success target applies until the other success targets have been met	Routine vegetation and macro-invertebrate monitoring	Refer Section 4.5.5

4.5.1 Groundwater Levels within the Lower Tertiary Aquifer System

As outlined in the revised REPP (Barwon Water, 2023a), groundwater level targets have been set for eight (8) Lower Tertiary Aquifer monitoring bores to indicate when the remedial objectives have been achieved.

A summary of the groundwater level statistics for each of the Lower Tertiary Aquifer monitoring bores against these targets is provided in Table 8 below. Refer to the hydrographs provided in Appendix A for further information.

Based on this assessment, only groundwater levels at BSTB1C have consistently met the target water levels for more than two (2) consecutive years, with BSBH13 and YEO22 consistently achieving the target water levels during the 2022-2023 reporting period. Water levels in the remaining bores indicate that recovery is still underway and on track to achieving the target water levels in the future.

Table 8 Lower Tertiary Aquifer water level target assessment

Site Code	Reporting Period	Lowest Groundwater Level (mAHD)	Highest Groundwater Level (mAHD)	Average Groundwater Level (mAHD)	Groundwater Level Target (mAHD)	Status of Groundwater Level Target
BSBH13	2019-2020	-	-	-	147.4	Achieved
	2020-2021	-	-	-		
	2021-2022	147.14	147.79	147.41		
	2022-2023	147.55	148.10	147.89		
BSTB1C	2019-2020	144.36	144.82	144.57	144.1	Achieved for more than 2 consecutive years
	2020-2021	144.62	145.23	144.90		
	2021-2022	144.95	147.65	146.71		
	2022-2023	146.25	147.65	147.08		
YEO19 (109110)	2019-2020	149.65	150.20	149.91	155.0	On Track
	2020-2021	150.37	150.99	150.71		
	2021-2022	150.50	151.47	150.95		
	2022-2023	150.89	152.42	151.63		
YEO20R (109111)	2019-2020	149.86	150.38	150.14	155.0	On Track
	2020-2021	147.50	151.58	150.04		
	2021-2022	151.54	151.99	151.76		
	2022-2023	151.82	152.74	152.14		
YEO22 (109113)	2019-2020	146.00	147.37	146.48	150.0	Achieved
	2020-2021	148.54	149.21	148.89		
	2021-2022	149.39	149.87	149.63		
	2022-2023	150.05	150.64	150.38		
YEO37 (109128)	2019-2020	148.73	150.24	149.79	155.0	On Track
	2020-2021	150.22	150.53	150.37		
	2021-2022	150.80	150.99	150.92		

Site Code	Reporting Period	Lowest Groundwater Level (mAHD)	Highest Groundwater Level (mAHD)	Average Groundwater Level (mAHD)	Groundwater Level Target (mAHD)	Status of Groundwater Level Target
	2022-2023	151.21	151.90	151.70		
YEO39 (109130)	2019-2020	154.87	155.44	155.25	160.0	On Track
	2020-2021	155.46	155.93	155.73		
	2021-2022	156.09	156.96	156.47		
	2022-2023	156.43	157.69	157.08		
YEO41 (109132)	2019-2020	147.75	149.48	148.11	155.0	On Track
	2020-2021	149.06	149.65	149.35		
	2021-2022	149.69	150.11	149.97		
	2022-2023	150.55	151.14	150.82		

Note:

Cells highlighted in green indicate where groundwater levels were above the target water level.

4.5.2 Groundwater Levels within the Upper Aquifer System

As outlined in the revised REPP (Barwon Water, 2023a), groundwater level targets have also been set for bores installed within Big Swamps Upper Aquifer System. Unlike the targets set for the Lower Tertiary Aquifer, these have been set to maintain moisture within Big Swamp and minimise any further oxidation of acid sulfate soils and fire risks.

A summary of the groundwater level statistics for each of the Upper Aquifer System monitoring bores against these targets is provided in Table 9 below. Refer to the hydrographs provided in Appendix C for further information.

Based on this assessment, seven (7) bores have consistently met the target water levels for more than two (2) consecutive years, with another four (4) consistently achieving the target water levels during the 2022-2023. While the remaining four (4) bores have met the target water levels at least some of the time, this is not yet consistently being achieved. Despite this, the data suggests that recovery is still underway and on track to consistently achieving the target water levels in the near future.

Table 9 Upper Aquifer water level target assessment

Site Code	Reporting Period	Lowest Groundwater Level (mAHD)	Highest Groundwater Level (mAHD)	Average Groundwater Level (mAHD)	Groundwater Level Target (mAHD)	Status of Groundwater Level Target
BSBH01	2019-2020	141.47	142.21	141.79	141.2	Achieved for more than 2 consecutive years
	2020-2021	141.54	142.40	141.82		
	2021-2022	141.47	142.22	141.83		
	2022-2023	141.61	142.66	141.85		
BSBH02	2019-2020	141.49	142.29	141.85	140.6	Achieved for more than 2 consecutive years
	2020-2021	141.78	142.44	141.96		
	2021-2022	141.69	142.29	141.97		
	2022-2023	141.94	142.83	142.12		
BSBH03	2019-2020	141.54	142.27	141.88	140.1	Achieved for more than 2 consecutive years
	2020-2021	141.78	142.31	141.96		
	2021-2022	141.70	142.36	142.01		
	2022-2023	141.92	142.85	142.13		
BSBH04	2019-2020	143.03	143.40	143.21	142.8	Achieved for more than 2 consecutive years
	2020-2021	143.27	143.68	143.42		
	2021-2022	143.37	143.77	143.56		
	2022-2023	143.61	144.09	143.77		
BSBH05	2019-2020	142.09	143.08	142.53	142.1	Achieved for more than 2 consecutive years
	2020-2021	142.64	143.13	142.85		
	2021-2022	142.31	143.14	142.75		
	2022-2023	142.14	143.36	142.80		
BSBH06	2019-2020	141.41	142.61	142.04	141.9	Achieved
	2020-2021	141.83	142.79	142.19		
	2021-2022	141.52	142.70	142.17		
	2022-2023	141.93	143.07	142.39		

Site Code	Reporting Period	Lowest Groundwater Level (mAHD)	Highest Groundwater Level (mAHD)	Average Groundwater Level (mAHD)	Groundwater Level Target (mAHD)	Status of Groundwater Level Target
BSBH07	2019-2020	142.22	143.06	142.72	142.1	Achieved for more than 2 consecutive years
	2020-2021	142.63	143.06	142.93		
	2021-2022	142.42	143.09	142.84		
	2022-2023	142.36	143.05	142.76		
BSBH08	2019-2020	143.51	144.11	143.81	144.2	Partially Achieved
	2020-2021	143.79	144.27	144.00		
	2021-2022	143.90	144.39	144.13		
	2022-2023	144.09	144.61	144.30		
BSBH09	2019-2020	142.89	143.77	143.17	142.9	Achieved
	2020-2021	143.16	143.63	143.37		
	2021-2022	143.21	143.66	143.40		
	2022-2023	143.23	143.98	143.38		
BSBH10	2019-2020	142.58	143.90	143.19	142.3	Achieved for more than 2 consecutive years
	2020-2021	143.36	143.99	143.75		
	2021-2022	143.14	143.90	143.65		
	2022-2023	143.37	144.23	143.51		
BSBH11	2019-2020	145.00	146.44	145.76	145.6	Achieved
	2020-2021	145.59	146.56	145.86		
	2021-2022	145.46	146.57	146.07		
	2022-2023	145.76	146.91	146.12		
BSBH12	2019-2020	145.60	146.39	145.96	146.0	Achieved
	2020-2021	145.94	146.48	146.04		
	2021-2022	145.95	146.53	146.17		
	2022-2023	146.04	146.78	146.16		

Site Code	Reporting Period	Lowest Groundwater Level (mAHD)	Highest Groundwater Level (mAHD)	Average Groundwater Level (mAHD)	Groundwater Level Target (mAHD)	Status of Groundwater Level Target
BSBH14	2019-2020	146.02	146.85	146.41	147.4	Partially Achieved
	2020-2021	146.51	147.13	146.78		
	2021-2022	146.88	147.42	147.11		
	2022-2023	147.26	147.89	147.50		
BSBH15	2019-2020	146.18	147.57	146.97	147.1	Partially Achieved
	2020-2021	146.46	147.62	147.06		
	2021-2022	146.50	147.49	147.00		
	2022-2023	146.81	147.73	147.23		
BSBH18	2019-2020	147.20	148.26	147.87	148.4	Partially Achieved
	2020-2021	147.77	148.53	148.11		
	2021-2022	147.45	148.40	148.08		
	2022-2023	147.77	148.60	148.08		

Note:

Cells highlighted in green indicate where groundwater levels were above the target water level.

4.5.3 Boundary Creek Streamflows

In line with the revised REPP (Barwon Water, 2023a), this success target aims to minimise the prolonged occurrence of cease to flow events in the absence of supplementary flows.

Approximately 215 ML of supplementary flows were released into Reach 1 of Boundary Creek during the 2022-2023 period (refer Appendix D) to:

1. Minimise wet-dry cycling and the occurrence of cease to flow events
2. Maintain saturation of acid sulfate soils
3. Minimise fire risks, and
4. Provide suitable conditions for wetland species to recolonise impacted areas.

These continue to assist in maintaining flows in the lower reaches of Boundary Creek during the drier months (i.e., between December and April) when streamflows are at their lowest (refer Figure 7). This has resulted in a minimum flow of 0.9 ML/day being maintained at the Boundary Creek at Yeodene stream gauge site (site #233228) during the 2022-2023 period (Table 10). Noting that between March and May 2023 Barwon Water installed an automated flow release valve on the outlet of the private on-stream dam to manage the passing flows as best as possible.

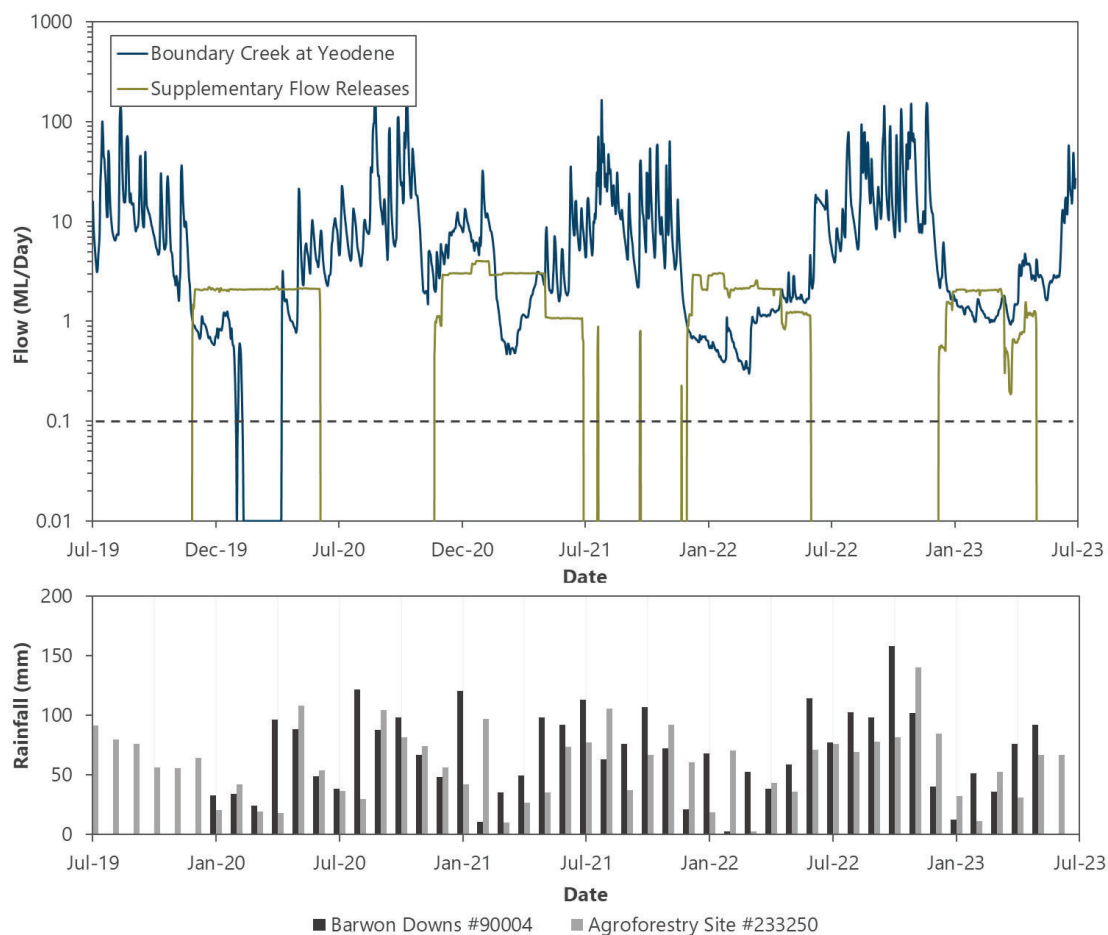


Figure 7 Surface water flows at the Yeodene stream gauge (site #233228)

Table 10 Summary flow statistics for Boundary Creek at Yeodene (site #233228). Data obtained from WMIS

Measure	2019-2020	2020-2021	2021-2022	2022-2023
Min	0.0	0.5	0.3	0.9
10th Percentile	0.0	1.1	0.5	1.2
25th Percentile	0.7	2.4	0.8	1.7
50th Percentile	3.0	6.0	1.9	4.2
75th Percentile	8.8	11.0	10.1	15.0
90th Percentile	20.3	26.2	22.5	47.5
Max	141.9	258.6	161.8	153.7
Average	8.4	13.1	8.0	15.4
Duration of potential cease to flow events	3 – 58 days	Nil	Nil	Nil

While no cease to flow events have been recorded since 2020-2021, given summer flows are currently being maintained by the supplementary flow releases, the flow success target (that aims for these not to be required) has not yet been achieved. As groundwater levels recover it is expected that groundwater discharge will help to reduce the severity of wet-dry cycling processes and occurrence of acid flush events in Boundary Creek and mean the supplementary flows can be phased out.

4.5.4 Boundary Creek pH

Based on the telemetered and spot sampling data obtained from the Department of Environment, Land, Water & Planning's Water Measurement Information System (WMIS) (<https://data.water.vic.gov.au/>) and the analytical results from Barwon Water's routine water quality monitoring program, the 25th and 75th percentiles recorded at Boundary Creek at Yeodene (site #233228) during 2022-2023 were within the target pH range of 5-9 pH units (refer Table 11) for the first year since the implementation of the REPP.

More broadly, the average annual pH recorded during the 2022-2023 period was 0.5-0.6 pH units higher than the previous reporting, with average annual pH increasing by 1.9 pH units since 2019-2020. This indicates that the oxidation of naturally occurring acid sulfate soils is currently being adequately managed.

Table 11 Summary pH statistics for Boundary Creek at Yeodene (site 233228)

Data Source	Measure	Reporting Period			
		2019-2020	2020-2021	2021-2022	2022-2023
Telemetered Data (WMIS)	Min	3.3	2.7	3.4	3.8
	25th Percentile	3.5	3.6	4.3	5.2
	75th Percentile	3.8	4.5	5.9	6.0
	Max	4.5	5.6	6.3	6.5
	Average	3.7	4.1	5.1	5.6

Data Source	Measure	Reporting Period			
		2019-2020	2020-2021	2021-2022	2022-2023
Spot Sampling Data (WMIS & Barwon Water)	Min	3.3	3.5	3.9	4.3
	25th Percentile	3.6	3.5	4.3	5.6
	75th Percentile	4.0	4.5	5.8	5.9
	Max	4.6	5.6	6.2	6.7
	Average	3.8	4.1	5.1	5.7

Note:

Bold text indicates data relevant to the assessment of the pH success target.

Cells highlighted in green indicate where pH values are within the target pH range.

4.5.5 Ecological Values

Based on the outcomes of the 2022 Vegetation Monitoring Report (Eco Logical Australia, 2023) and Ecological Risk Assessment (Nation Partners, 2023), the inundation areas within Big Swamp currently have the potential to support the growth/establishment of aquatic flora and fauna. As such, the ecological success target is currently being achieved. This is also supported by the significant recovery in the cover and structure of vegetation post drought and fires (Eco Logical Australia, 2023).

More broadly, the findings from this work also indicate that the swamp continues to adapt to a new environmental state. It is expected that this will continue as groundwater levels recover and the occurrence of low pH events are minimised.

Further information regarding the vegetation monitoring and ecological risk assessment can be found on the Your Say website (<https://www.yoursay.barwonwater.vic.gov.au/boundary-creek>). Noting that these reports pre-date the revised vegetation success target.

4.6 Contingency Measures

Table 12 outlines the status of each of the contingency measures adopted in revised REPP (Barwon Water, 2023a).

Table 12 Status of risk-based contingency measures

Contingency Approach	Remedial Objective	Status
Minimise the potential for acid-related fish kill events in the Barwon River	Mobile downstream treatment system (pending revised design)	<p>The design of the mobile downstream treatment system was submitted to Southern Rural Water on 31 July 2023.</p> <p>As supplementary flows are currently being used to maintain flows in Boundary Creek until sufficient surface water-groundwater interaction returns, flows less than 0.1 ML/day have not been recorded in 2022/2023. As such, implementation of this contingency measure is not required at this point in time.</p>

Contingency Approach	Remedial Objective	Status
Reduce the severity of wet-dry cycling processes	Tier 1: Water diversion barriers (e.g., straw bales or similar)	Groundwater levels within Big Swamps Upper Aquifer system continue to indicate ongoing recovery, with average groundwater levels from 11 of 15 bores greater than or equal to their intended target. As such, implementation of this contingency measure is not required as this point in time.
	Tier 2: Adjustment of existing drainage lines / channels	
Improve the condition and function of Big Swamp	Tier 1: Removal of dry vegetation classes and/or undesired species from the swamp plain	Significant improvement in ecological values has occurred since 2012. Recent results indicate that quadrats in, or adjacent to, inundation areas exhibit a prevalence of species that prefer moist to wet conditions – this suggests that the potential to develop aquatic flora and fauna has been maintained.
	Tier 2: Revegetation of areas with low species diversity with desired species (mesic specialist lifeforms)	

4.7 Boundary Creek and Big Swamp Water Quality

Analytical data for key analytes of interest, obtained as part of Barwon Water's routine groundwater and surface water monitoring program, are shown in Figure 8, with summary data provided in Appendix E. For the purposes of understanding the broad acidification/neutralisation processes at play this figure displays both the individual concentrations from surface water monitoring stations and the average groundwater concentrations within the western and eastern portions of the swamp.

Consistent with the 2021-2022 Annual Report (Barwon Water, 2022), groundwater in the eastern and western portions of Big Swamp continue to exhibit substantially different chemical characteristics, with the western portion of the swamp reporting an increase in electrical conductivity, acidity, sulfate and aluminium compared to the 2021-2022 reporting period. While the increase in electrical conductivity could represent an increase in groundwater-surface water interaction upstream of the swamp, the increase in acidity and aluminium is likely due to flushing as the water levels increase. However, this is expected to stabilise once the targets are met.

Data from Boundary Creek downstream of Big Swamp (site #233276), Boundary Creek and Yeodene (site #233228) and the eastern portion of the swamp continue to indicate long-term water quality improvements, with seasonal flushing evident as moisture returns following dry periods.



Figure 8 Concentrations of key analytes over time (Note that site #233228 was only added to the routine water quality monitoring program in August 2021)

5 Surrounding Environment Investigation

5.1 Surrounding Environment Investigation Status Update

Over the last 12 months Barwon Water has focused on progressing the Phase 1 Impact Assessment works that aim to:

- Test the underlying assumptions of the regional groundwater model that was used to identify the areas for further investigation based on a systematic risk assessment framework;
- 'Ground truth' the findings of the model to confirm, or otherwise, potential groundwater pumping related impacts; and
- Determine if Barwon Water's historical management of groundwater pumping activities at the Barwon Downs borefield resulted in any environmentally significant adverse impacts within the surrounding environment.

The findings of this work were submitted to Southern Rural Water on 31 July 2023 (Barwon Water, 2023b) did not identify any evidence of environmentally significant adverse impacts within the surrounding environment. Nevertheless, the remedial actions that have already been committed to as part of the Boundary Creek and Big Swamp Remediation Plan will continue to facilitate the recovery of the Lower Tertiary Aquifer within the surrounding environment and help to address any groundwater pumping-derived hydraulic influences that have led to streamflow reductions in select surface water features (Barwon Water, 2023b).

5.2 Actions Completed on the Surrounding Environment Investigation During 2022-2023

Table 13 outlines the actions completed on the Surrounding Environment Investigation between 1 July 2022 and 30 June 2023.

Table 13 Surrounding Environment Investigation - Actions completed in 2022-2023 (1 July 2022 - 30 June 2023)

Action Items	Comment / Link
Completion of quarterly Remediation Reference Group meetings	Completed on: 21 September 2022 16 November 2022 08 March 2023 14 June 2023
Submission of Quarterly and Annual Reports	Complete. Refer to the Your Say website located here:

Action Items	Comment / Link
	https://www.yoursay.barwonwater.vic.gov.au/bo-undary-creek
Continue to collect data from new and existing monitoring assets	Ongoing
Continue collation of community information regarding sites/issues of concern to inform the surrounding environment investigation	Ongoing
Subject to streamflows and site conditions, complete the remaining stream gauge installations	<p>The installation of the Barongarook Creek stream gauge was completed in May 2023.</p> <p>The East Barwon stream gauge reinstatement works have not yet been completed and remain on hold given the surrounding environment investigation has indicated that Barwon Water's historic management of groundwater pumping activities at the Barwon Downs borefield have not resulted in any environmentally significant adverse impacts at this location. On this basis, Barwon Water no longer plan to reinstate this stream gauge.</p>
Commence the assessment phase of the surrounding environment investigation	<p>Complete – the Kwarren and Barwon Downs Hydrogeological Assessments have now been completed and were submitted to Southern Rural Water and part of the Surrounding Environment Investigation Report on 31 July 2023.</p> <p>Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/bo-undary-creek</p>
Progress amendment of the REPP based on the high-level approach to the Surrounding Environment Investigation that was submitted to Southern Rural Water on 30 June 2022	<p>An interim draft of the revised REPP was submitted to Southern Rural Water on 22 December 2022 for initial feedback.</p> <p>This was subsequently revised based on this feedback along with the outcomes of the Ecological Risk Assessment (ERA) and Paleoenvironmental Study, and submitted to Southern Rural Water on 31 July 2023.</p> <p>Refer to the Your Say website located here: https://www.yoursay.barwonwater.vic.gov.au/bo-undary-creek</p>
Completion of broader community information sessions	Delayed until September 2023 to capture the July 2023 submissions outlined above.

5.3 Upcoming Actions Associated with the Surrounding Environment Investigation During 2023-2024

Table 14 outlines the upcoming actions / milestones associated with the Surrounding Environment Investigation between 1 July 2023 and 30 June 2024.

Table 14 Surrounding Environment Investigation - Upcoming actions / milestones for the 2023-2024 (1 July 2023 - 30 June 2024)

Action Items	Due
Submission of the final revised REPP to Southern Rural Water	31 July 2023
Scope any further works required as part of the surrounding environment investigation	30 September 2023
Engage a suitably qualified consultant/contractor to conduct the future climate resilience modelling work	30 September 2023
Completion of community information sessions to engage with the broader community	Two community information sessions are due to occur in September 2023.
Continue collection of data from new monitoring assets to track recovery	Ongoing
Completion of quarterly Remediation Reference Group meetings	Due in September, December, March and June each year. Noting that timing can change to account for RRG member availability or technical works.
Submission of Quarterly and Annual Reports	Quarterly reporting will occur in September, December, March and June each year and will be submitted to Southern Rural Water within 14 days of completion of the quarter. In addition to this, a draft annual report will be submitted to Southern Rural Water for review and comment at least 14 days prior to the September submission date (being 30 September each year).
Completion of fish surveys in the Upper Barwon Region	First event to occur in 2024, with a follow up event scheduled for 2025
Climate resilience modelling of waterways influenced by former groundwater pumping activities at the Barwon Downs borefield	31 December 2024

6 Issues Register

Table 15 below outlines any issues that have been identified during implementation of the REPP that may impact future implementation activities.

Table 15 Issues register

Issue	Likelihood	Consequence	Comments
Availability of appropriate consultants or contractors to undertake works required under the REPP	Medium	Low	Barwon Water has experienced delays regarding the availability of consultants, contractors, and materials to complete work for this project. With consultants continuing to be close to capacity this remains an ongoing risk and may lead to unexpected delays.
Extended remediation timeframes	Medium	Low	While water level and quality improvements are evident, changing climatic conditions could impede the recovery seen to date or lead to another decline in the future. While this is beyond Barwon Water's control, this may provide a barrier to meeting the remediation success targets.

7 Community Engagement

In accordance with the REPP, Barwon Water's community and stakeholder Remediation Reference Group (RRG) continues to meet on a quarterly basis to discuss the implementation of the REPP and any changes that are required as part of the adaptive management approach.

The Remediation Reference Group continues to be supported by their own nominated independent technical experts Associate Professor Vanessa Wong, Professor Richard Bush and Dr Darren Baldwin, who provide specialist advice and support prior to and during the Remediation Reference Group meetings. Detailed feedback received during the quarterly Remediation Reference Group meetings are provided in the Quarterly updates that can be accessed via the Your Say website located here:

<https://www.yoursay.barwonwater.vic.gov.au/boundary-creek>.

During 2022/2023, the RRG nominated experts were also invited to provide input to and feedback on various technical works.

During the 2022-2023 period, Barwon Water also:

- Attended Southern Rural Water's Community Leaders Group meetings when requested to present and field questions;

- Responded to any community concerns/issues that related to the REPP and/or Barwon Downs borefield;
- Engaged with LAWROC on the scope of the additional investigations being undertaken in the Kawarren/Love Creek area;
- Inclusion of two LAWROC representatives in the workshops conducted with Barwon Water, the consultants and the nominated independent experts. Noting that the two representatives were also invited to provide feedback on the draft report.

In addition to this, Barwon Water continue to share regular updates via the Your Say website: <https://www.yoursay.barwonwater.vic.gov.au/boundary-creek> and other media such as local newspapers, newsletters and social media.

8 REPP Amendments

As outlined in Section 4 above, an interim draft of the revised REPP was submitted to Southern Rural Water on 22 December 2022 for initial feedback. This was subsequently revised based on feedback received from Southern Rural Water along with the outcomes of the Ecological Risk Assessment (ERA) and Palaeoenvironmental Study, and submitted to Southern Rural Water on 31 July 2023.

For the purposes of this report, the revised REPP that was submitted to Southern Rural Water on 31 July 2023 is considered to be the current version of the REPP.

9 Progress Report

Table 16 outlines the actions that have been completed, are currently in progress, or are yet to commence as part of implementation of the REPP through to the end of the 2023-2024 monitoring and reporting period (30 June 2024). It is important to note that additional tasks may be added as they are identified during the implementation of the REPP.

Table 16 Task Tracker

#	Activity	Due Date	Status	Health Indicator	Comments
1.0	Meeting with SRW to be held at the Barwon Water office to develop work plan towards confirming priority actions relating to feedback provided.	30-Apr-20	Complete	Complete	Complete
2.0	Complete autumn macro-invertebrates survey	30-Jun-20	Complete	Complete	Report now complete and is now uploaded on website
3.0	Complete soil incubation testing	31-May-20	Complete	Complete	Report has been finalised and is now uploaded on website
4.0	Submit quarterly report to SRW and publish to website	30-Jun-20	Complete	Complete	Completed and uploaded to website
5.0	Scoping of SW-GW technical work packages required to inform detailed design and address feedback register	30-Nov-20	Complete	Complete	Complete
6.0	Complete installation of additional monitoring assets required to inform the Surrounding Environment Investigation	30-Jun-23	Complete	Complete	The installation of 21 additional groundwater bores and the development of 4 pre-existing groundwater bores was completed in June 2022. 4 of 5 proposed stream Gauges have now been installed. The installation of the Barongarook Creek stream gauge was completed in May 2023.

#	Activity	Due Date	Status	Health Indicator	Comments
					The East Barwon stream gauge reinstatement works have not yet been completed and remain on hold given the surrounding environment investigation has indicated that Barwon Water's historic management of groundwater pumping activities at the Barwon Downs borefield have not resulted in any environmentally significant adverse impacts at this location. On this basis, Barwon Water no longer plan to reinstate this stream gauge.
7.0	Conclusion of monitoring period enabling the capture of a full seasonal cycle of data to inform updates to the groundwater-surface water model and geochemical model.	31-Jul-20	Complete	Complete	The data collected from this work has since been included in the relevant technical reports
8.0	REPP Feedback Work plan - Submission and Acceptance	31-Jul-20	Complete	Complete	Completed
9.0	Governance Framework - Submission and Acceptance	31-Jul-20	Complete	Complete	Completed
10.0	Barwon Water Communications and Engagement Plan	Ongoing	Ongoing	Ongoing	The Communications and Engagement Plan continues to be adapted in line with the adaptive management approach.
11.0	Submission of the updated REPP to Southern Rural Water to account for the current state of knowledge and close out any outstanding feedback. SRW to accept the updated REPP.	31-Jul-23	Complete	Complete	On 22 December 2023 Barwon Water submitted an interim draft of the revised REPP to Southern Rural Water for initial comment and feedback. This was subsequently updated to account for the additional work and feedback and was submitted to Southern Rural Water on 31 July 2023.

#	Activity	Due Date	Status	Health Indicator	Comments
12.0	Submit annual report to SRW and publish to Your Say website	30-Sep-20	Complete	Complete	Completed
13.0	Remediation Reference Group Meeting	2-Dec-20	Complete	Complete	Completed
14.0	Establish vegetation monitoring for Boundary Creek and Big Swamp Remediation Plan	31-Dec-20	Complete	Complete	Completed
15.0	Update groundwater-surface water model	31-Dec-20	Complete	Complete	Completed and uploaded to website
16.0	Submit quarterly report to SRW and publish to Your Say website	31-Dec-20	Complete	Complete	Completed
17.0	Remediation Reference Group Meeting	17-Mar-21	Complete	Complete	Completed
18.0	Submit quarterly report to SRW and publish to Your Say website	31-Mar-21	Complete	Complete	Completed
19.0	Remediation Reference Group Meeting	23-Jun-21	Complete	Complete	Completed
20.0	Submit quarterly report to SRW and publish to Your Say website	30-Jun-21	Complete	Complete	Completed and uploaded to website
21.0	Submission of detailed design of the hydraulic barriers outlining proposed controls or actions and any revisions to success measures/targets.	1-Jul-21	Complete	Complete	Complete. Submitted to Southern Rural Water on 1 July 2021. Barwon Water have since reviewed the viability of this remedial action as part of the Outcomes and Implications of the Upstream Treatment Investigation (Barwon Water, 2022) and no longer consider hydraulic barriers a potential remedial action due to the unintended impacts that would result from implementing this approach. This has since been reflected in the revised REPP.
22.0	Update Hydro geochemical model	31-Jul-21	Complete	Complete	Completed and uploaded to website

#	Activity	Due Date	Status	Health Indicator	Comments
23.0	Complete detailed design of contingency measure and feasibility assessment for upstream for new upstream treatment method	31-Jul-21	Complete	Complete	<p>Barwon Water has since ruled out the use of the proposed semi-passive caustic magnesia treatment system. This decision was supported by Southern Rural Water and the Independent Technical Review Panel (ITRP) in their response received on 29 August 2022.</p> <p>Following completion of the Upstream Treatment Investigation in June 2022, Barwon Water have since developed a risk based contingency approach that focuses on minimising the potential for high-risk events, should these persist following the implementation of the primary remedial actions.</p> <p>As part of this, Barwon Water submitted the design on a mobile downstream contingency measure to Southern Rural Water on 31 July 2023.</p>
24.0	Remediation Reference Group Meeting	8-Sep-21	Complete	Complete	Completed
25.0	Submit annual report to SRW and publish to Your Say website	30-Sep-21	Complete	Complete	Completed and uploaded to website
26.0	Remediation Reference Group Meeting	9-Dec-21	Complete	Complete	Completed
27.0	Submit quarterly report to SRW and publish to Your Say website	31-Dec-21	Complete	Complete	Completed and uploaded to website
28.0	Completion of upstream treatment investigation and development of Trial Plan	14-Jan-22	Complete	Complete	<p>Complete. Submitted to SRW on 14 Jan 2022.</p> <p>Barwon Water has since ruled out the use of the proposed semi-passive caustic magnesia treatment system. This decision</p>

#	Activity	Due Date	Status	Health Indicator	Comments
					was supported by Southern Rural Water and the Independent Technical Review Panel (ITRP) in their response received on 29 August 2022.
29.0	Remediation Reference Group Meeting	21-Mar-21	Complete	Complete	Completed
30.0	Submit quarterly report to SRW and publish to Your Say website	31-Mar-22	Complete	Complete	Completed and uploaded to website
31.0	Hosted community information session in Winchelsea	10-May-22	Complete	Complete	Completed
32.0	Hosted community information session in Colac	17-May-22	Complete	Complete	Completed
33.0	Remediation Reference Group Meeting	8-Jun-22	Complete	Complete	Completed
34.0	If trial plan is approved undertake upstream treatment trial	30-Jun-22	Complete	Complete	Barwon Water has since ruled out the use of the proposed semi-passive caustic magnesia treatment system. This decision was supported by Southern Rural Water and the Independent Technical Review Panel (ITRP) in their response received on 29 August 2022.
35.0	Decision on implementation of full-scale upstream treatment, hydraulic barriers, and downstream treatment	30-Jun-22	Complete	Complete	
36.0	Submit quarterly report to SRW and publish to Your Say website	30-Jun-22	Complete	Complete	Completed and uploaded to website
37.0	Remediation Reference Group Meeting	21-Sep-22	Complete	Complete	Completed
38.0	Submit quarterly report to SRW and publish to Your Say website	30-Sep-22	Complete	Complete	Completed and uploaded to website
39.0	Submit annual report to SRW and publish to website	30-Sep-22	Complete	Complete	Completed and uploaded to website
40.0	Remediation Reference Group Meeting	16-Nov-22	Complete	Complete	Completed

#	Activity	Due Date	Status	Health Indicator	Comments
41.0	Submit quarterly report to SRW and publish to Your Say website	31-Dec-22	Complete	Complete	Completed and uploaded to website
42.0	Remediation Reference Group Meeting	8-Mar-23	Complete	Complete	Completed
43.0	Submit quarterly report to SRW and publish to Your Say website	31-Mar-23	Complete	Complete	Completed and uploaded to website
44.0	Remediation Reference Group Meeting	14-Jun-23	Complete	Complete	Completed
45.0	Submit quarterly report to SRW and publish to Your Say website	14-Jul-23	Complete	Complete	Completed and uploaded to website
46.0	Submission of the Ecological Risk Assessment to Southern Rural Water	31-Jul-23	Complete	Complete	Submitted to Southern Rural Water on 31 July 2023
47.0	Submission of the Paleoenvironmental Study of Big Swamp to Southern Rural Water	31-Jul-23	Complete	Complete	Submitted to Southern Rural Water on 31 July 2023
48.0	Development of the Barwon Downs Borefield Decommissioning Plan	31-Jul-23	Complete	Complete	Submitted to Southern Rural Water as part of a bore decommissioning licence application on 17 July 2023.
49.0	Submission of the revised downstream treatment contingency measures	31-Jul-23	Complete	Complete	Submitted to Southern Rural Water on 31 July 2023
50.0	Provide the outcomes of the Surrounding Environment Investigation to Southern Rural Water to determine if further remedial works is required	31-Jul-23	Complete	Complete	Submitted to Southern Rural Water on 31 July 2023
51.0	Remediation Reference Group Meeting	6-Sep-23	Complete	Complete	Completed
52.0	Submit annual report to SRW and publish to website	30-Sep-23	Complete	Complete	Completed and uploaded to website
53.0	Submit quarterly report to SRW and publish to website	14-Oct-23	In Progress	On track	
54.0	Remediation Reference Group Meeting	31-Dec-23	Not started		

#	Activity	Due Date	Status	Health Indicator	Comments
55.0	Submit quarterly report to SRW and publish to website	14-Jan-24	Not started		
56.0	Remediation Reference Group Meeting	31-Mar-24	Not started		
57.0	Submit quarterly report to SRW and publish to website	14-Apr-24	Not started		
58.0	Remediation Reference Group Meeting	30-Jun-24	Not started		
59.0	Submit quarterly report to SRW and publish to website	14-Jul-24	Not started		
60.0	Completion of follow up investigations on Deans Marsh, Matthews and Pennyroyal Creeks	31-Dec-24	Not started		
61.0	Completion of further modelling work to track recovery and test what may happen under future climate scenarios	31-Dec-24	Not started		
62.0	Completion of Fish Surveys in the Upper Barwon	31-Dec-25	Not started		

10 References

Barwon Water, 2022, 2021-2022 Annual Report – Boundary Creek, Big Swamp and surrounding environment Remediation and Environmental Protection Plan (REPP), September 2022

Barwon Water, 2023a, Boundary Creek, Big Swamp and Surrounding Environment – Remediation and Environmental Protection Plan (REPP), July 2023

Barwon Water, 2023b, Surrounding Environment Investigation Report – Remediation and Environmental Protection Plan (REPP), July 2023

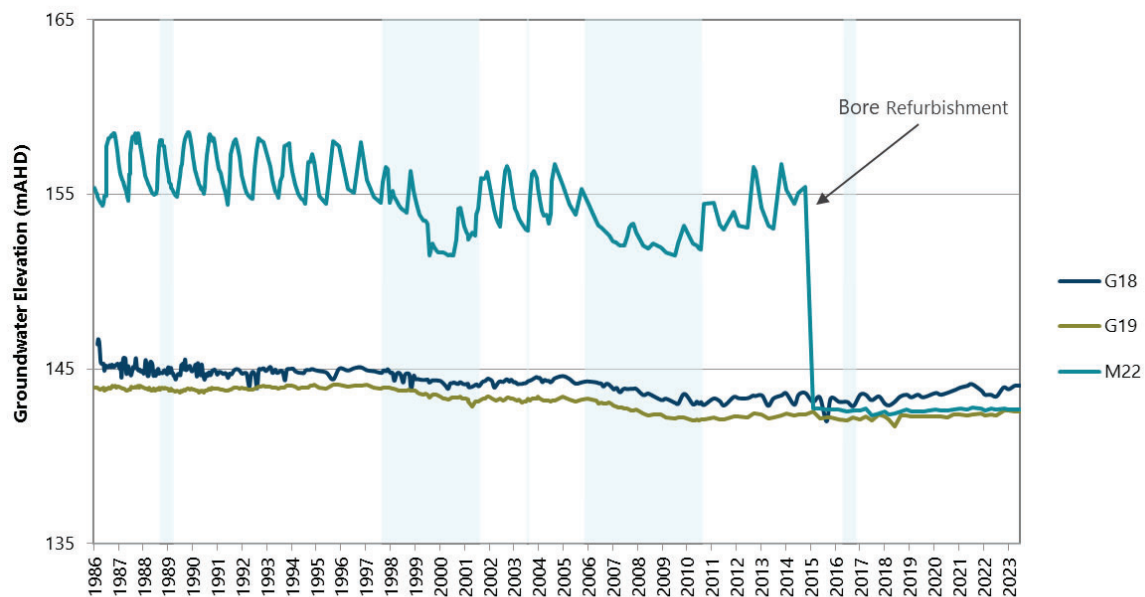
Eco Logical Australia, 2023, Big Swamp Vegetation Monitoring Report – 2022, June 2023

Nation Partners, 2023, Ecological Risk Assessment: Boundary Creek, Big Swamp and the Barwon River, July 2023

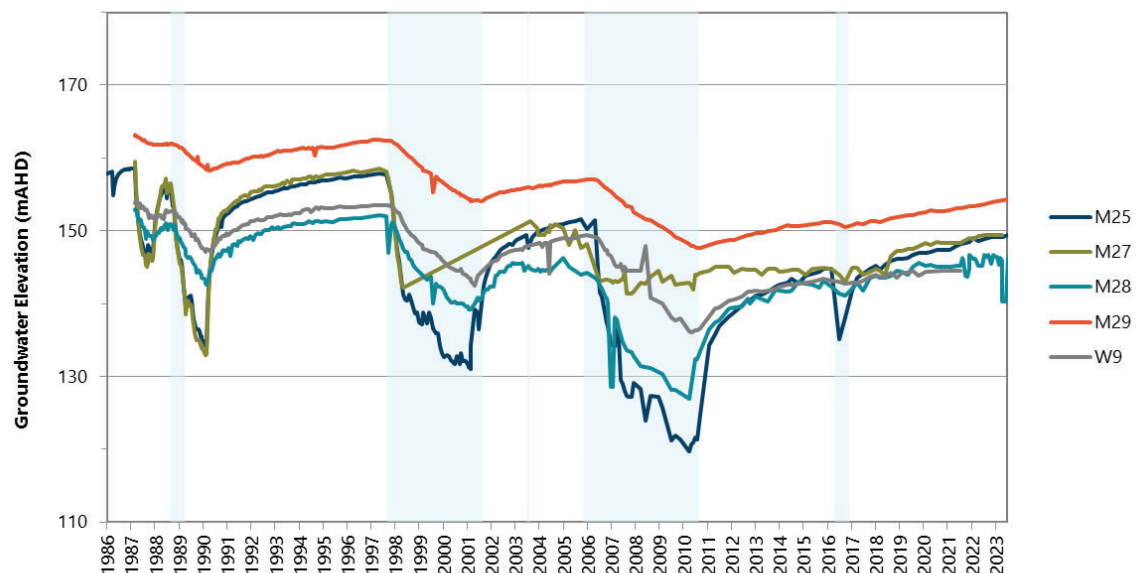
Appendix A. Hydrographs from Regional Groundwater Monitoring Bores

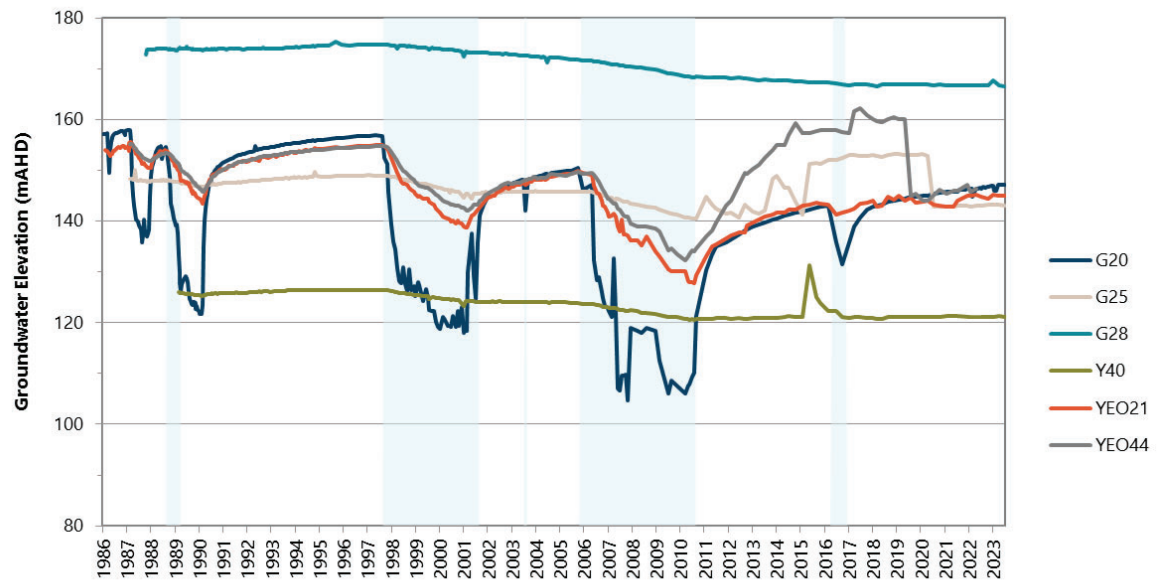
Note: Light blue shading denotes periods of groundwater extraction

Clifton Formation

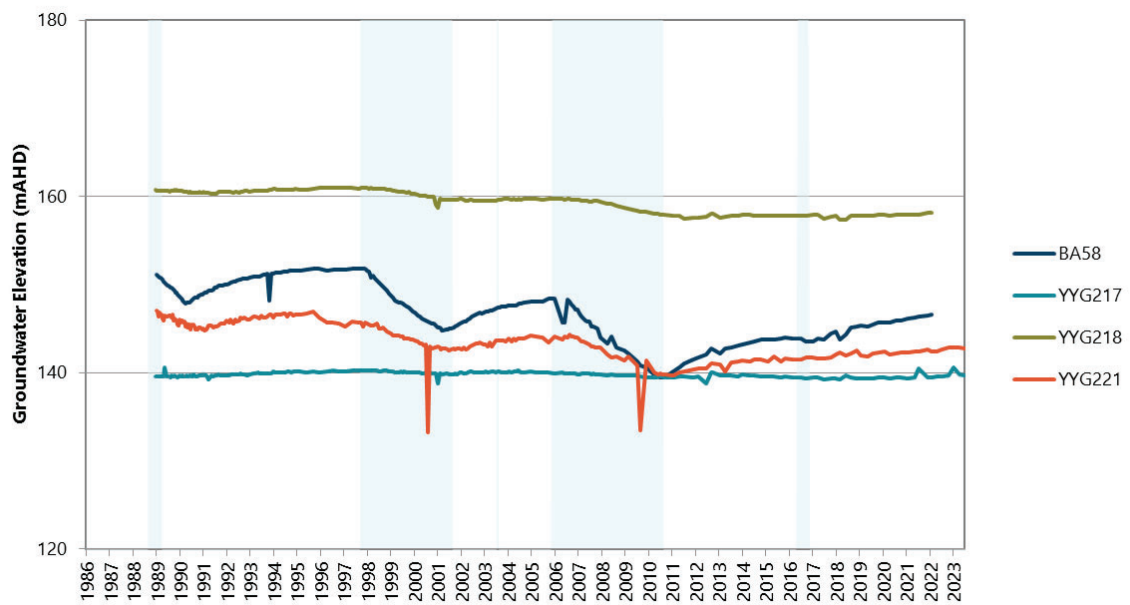


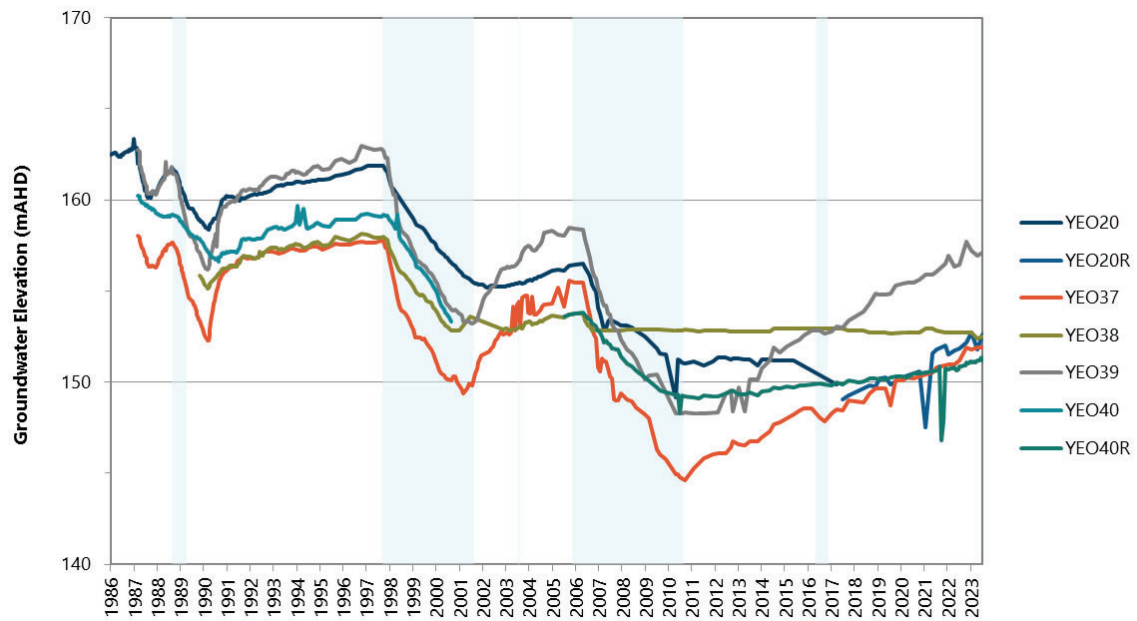
Mepunga Formation



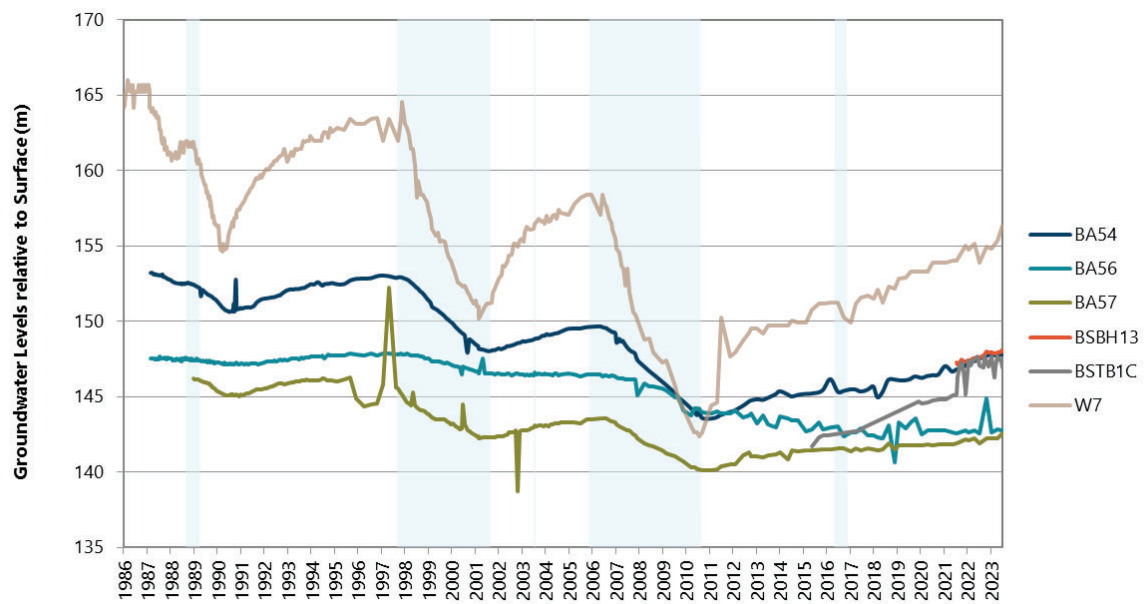


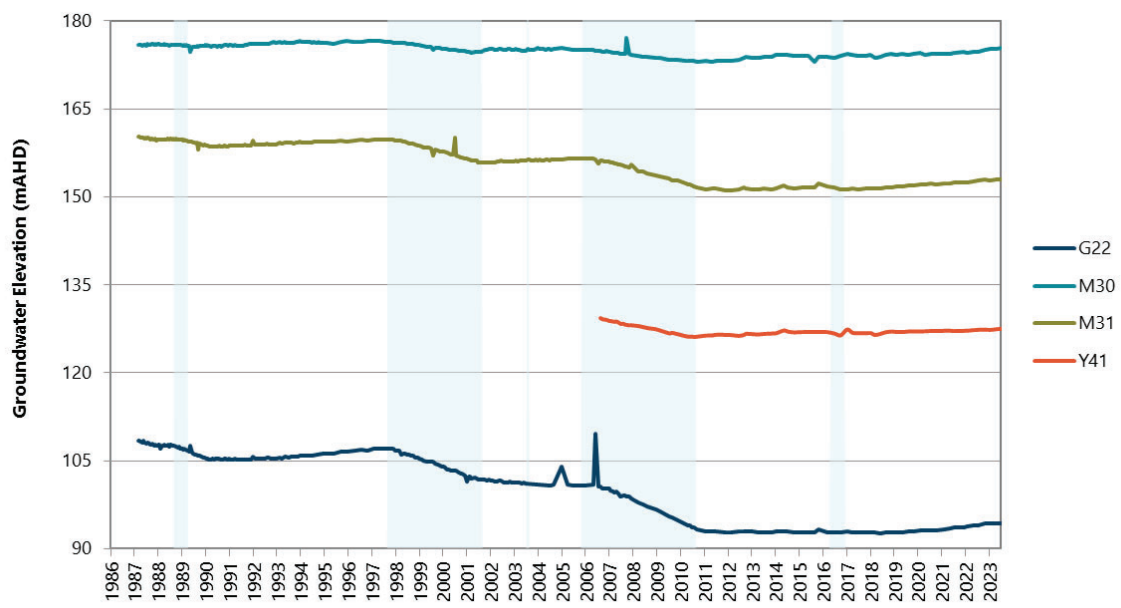
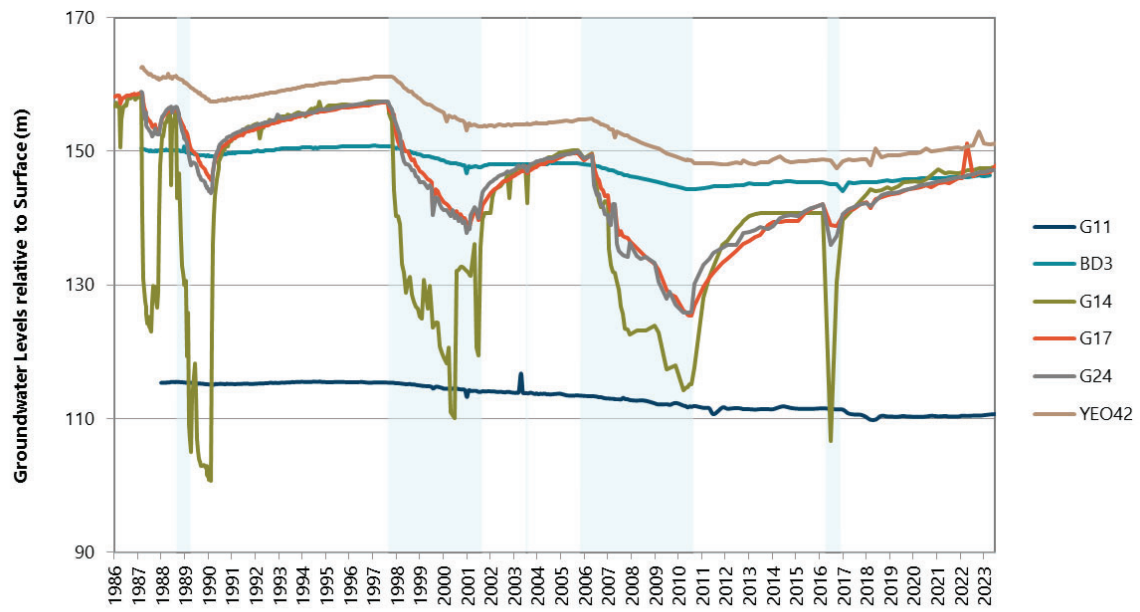
Dilwyn Formation – Unconfined Areas



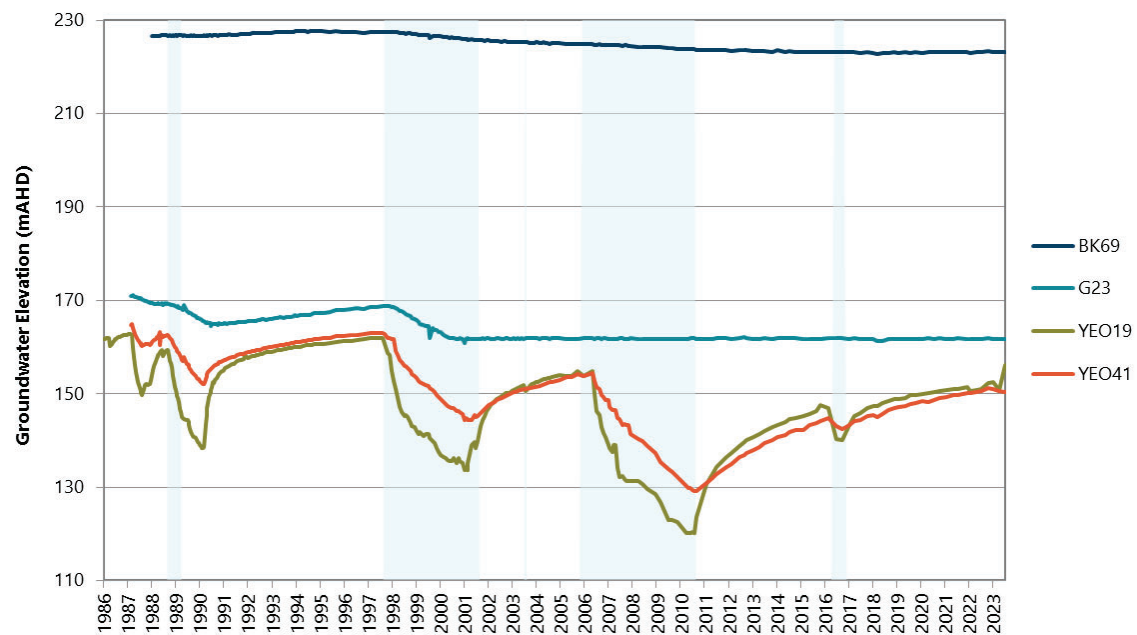


Dilwyn Formation – Confined Areas

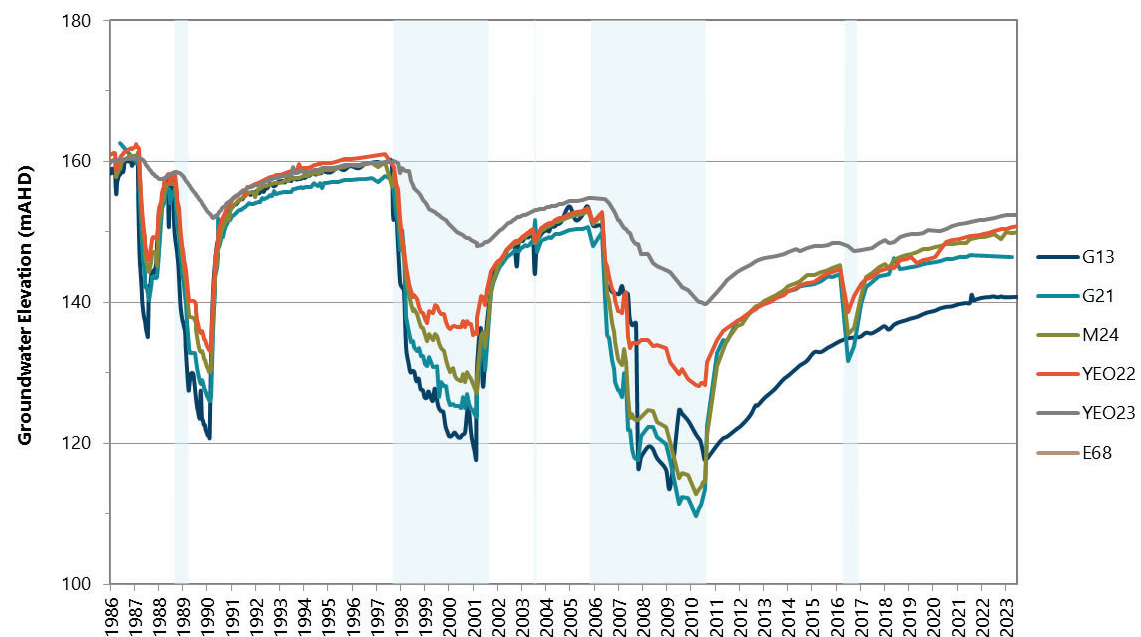




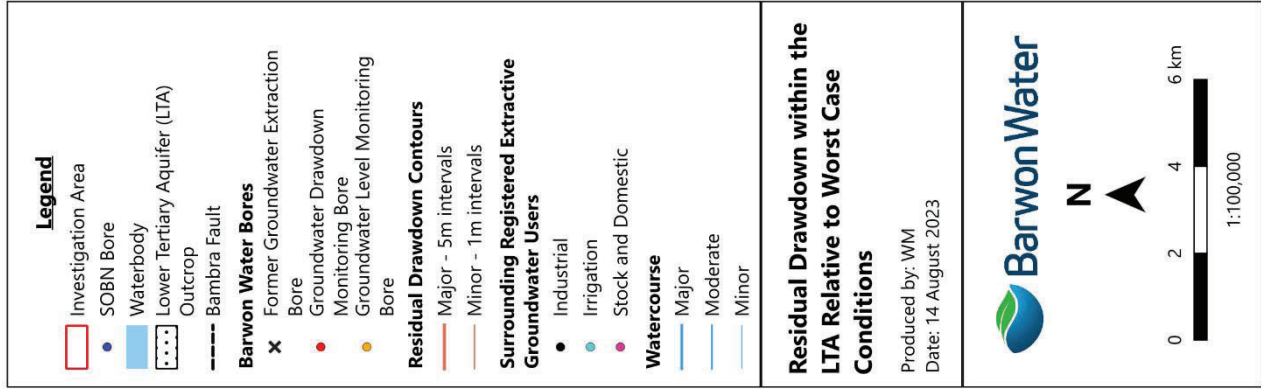
Pebble Point – Unconfined Areas



Pebble Point – Confined Areas



Appendix B. Residual Drawdown Contours



Appendix C. Hydrographs from Big Swamp Monitoring Bore

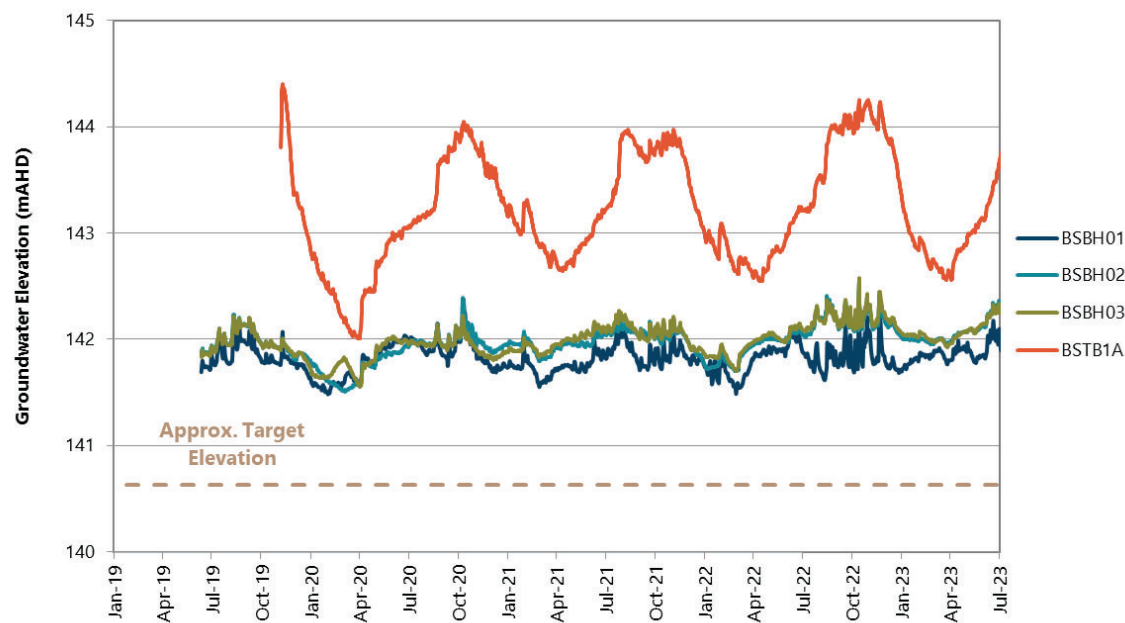


Big Swamp - Groundwater Monitoring Locations

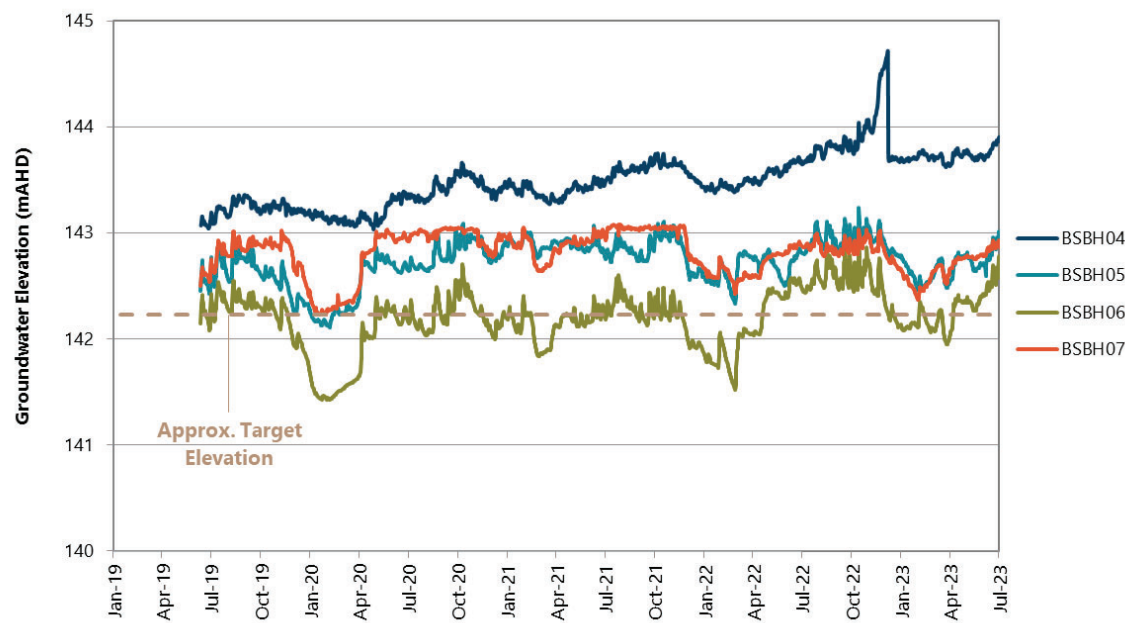
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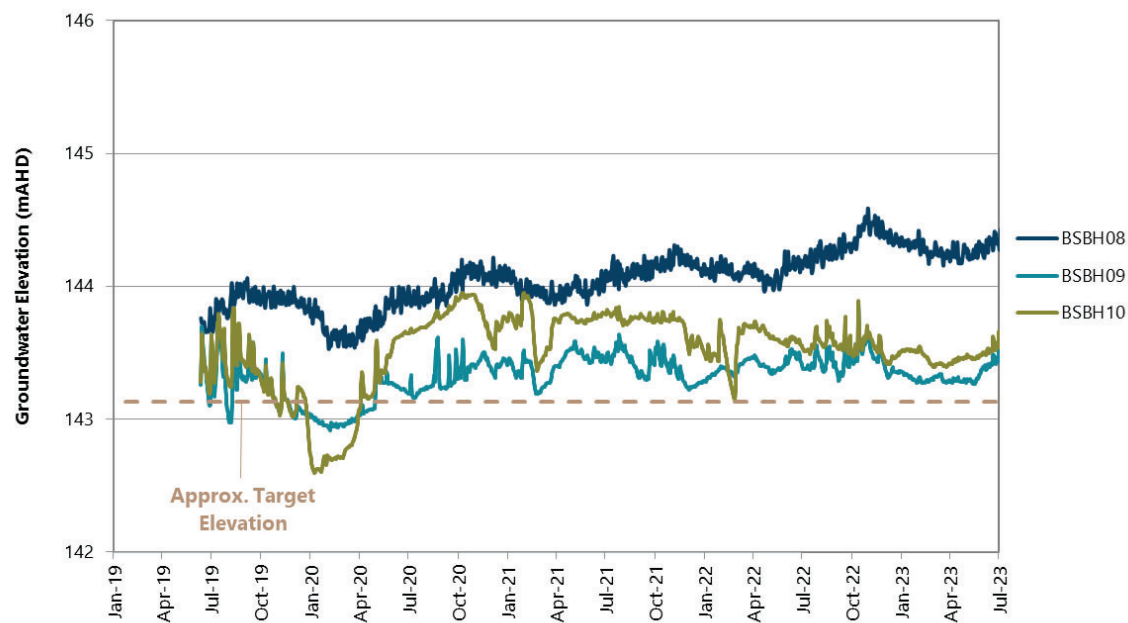
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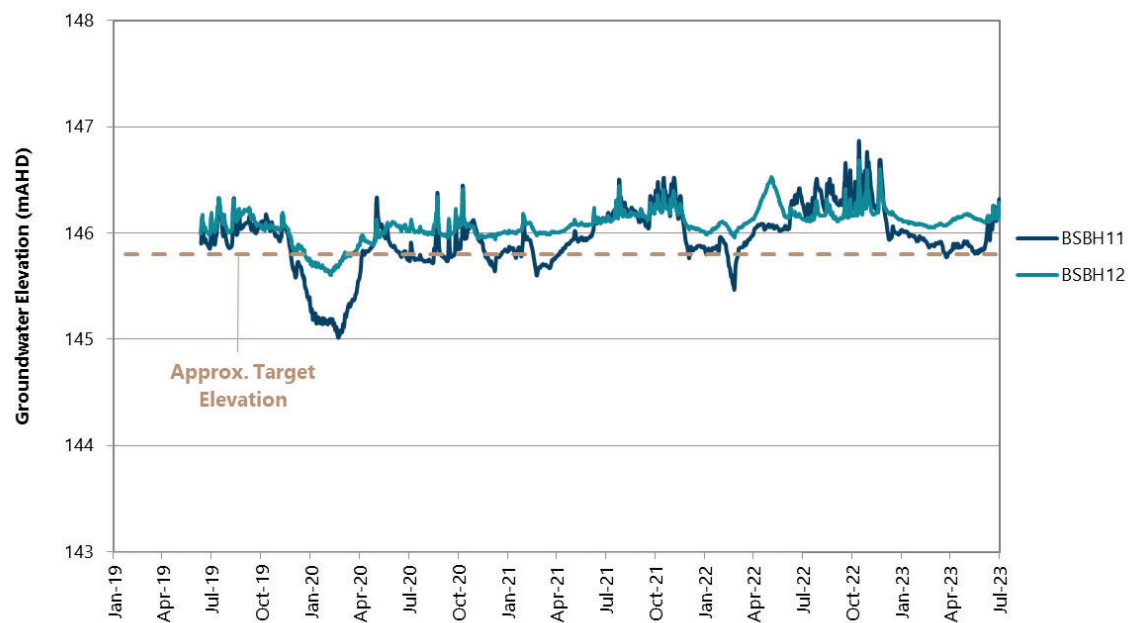
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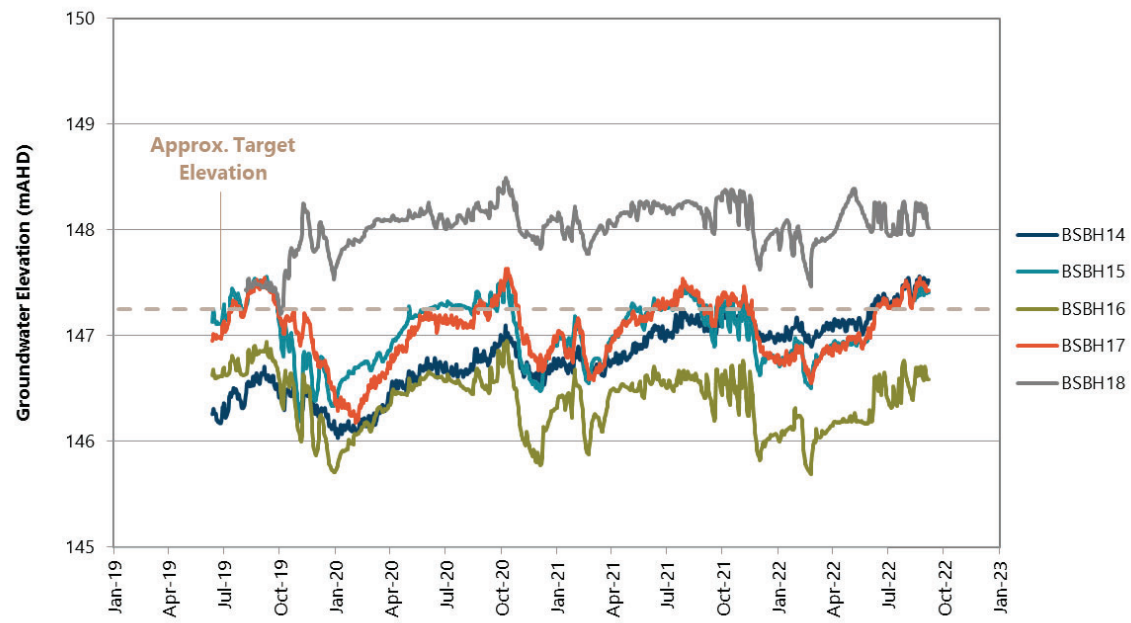
Transect 3



Transect 4



Transect 5



Appendix D. Supplementary Flow Data

Table D1 Supplementary Flow Releases 2022-2023

Date	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023	Jun 2023
1	0.00	0.00	0.00	0.00	0.00	0.00	1.99	2.03	2.06	0.62	1.26	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.01	2.07	0.61	1.21	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	1.99	2.01	2.07	0.62	0.81	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	2.05	2.05	2.08	0.61	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	2.08	2.06	2.05	0.63	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	2.07	2.06	2.06	0.67	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	2.08	2.06	1.97	0.67	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	2.08	1.83	2.03	0.73	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.33	2.08	2.03	2.10	0.76	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.56	2.08	2.03	2.11	0.77	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.53	2.09	2.05	2.11	0.74	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.57	2.08	2.05	2.00	0.78	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.58	2.08	2.04	1.78	0.78	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.57	2.08	2.03	1.78	0.78	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.55	2.09	2.03	1.77	0.78	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.54	2.07	2.05	1.27	1.11	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.54	2.08	2.04	0.31	1.55	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.52	2.05	2.04	0.54	1.36	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.51	1.97	2.05	0.50	1.09	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	1.19	2.03	2.05	0.50	1.21	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	1.56	2.02	2.06	0.48	1.17	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	1.57	2.01	2.05	0.44	1.17	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	1.56	2.01	2.05	0.34	1.22	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	1.55	2.03	2.05	0.20	1.21	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	1.51	2.04	2.06	0.19	1.15	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	1.50	2.03	2.05	0.19	1.19	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	1.52	2.02	2.06	0.20	1.14	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	1.53	2.04	2.06	0.46	1.13	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	1.31	2.06		0.65	1.21	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	1.98	2.04		0.66	1.27	0.00	0.00
31	0.00	0.00		0.00		1.98	2.04		0.66		0.00	
Total	0.00	0.00	0.00	0.00	0.00	24.56	63.46	57.04	37.63	28.73	3.28	0.00

Appendix E. Spot Water Quality Sampling Data

Table E1 Spot sampling water quality data from Boundary Creek downstream of Big Swamp (site #233276)

Sampled Date	PH (field)	Electrical Conductivity (EC)	Acidity as CaCO ₃	Sulfate as SO ₄	Total Iron	Ferric Iron	Ferrous Iron	Soluble Aluminum
	pH Units	uS/cm	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L
6/11/2019	3.3	800	106	130	18			10
4/12/2019	3.7	890	159	160	16	16	0.5	13
6/01/2020	3.2	1000	193	200	3.2		15	0.04
5/02/2020	3.3	1100	236	220	30		58	9.4
3/03/2020	2.9	1300	199	28	20	17	3.3	12
1/04/2020	3.3	1200	300	290	91		110	10
5/05/2020	3.3	670	96	96	7.5	4.6	2.9	6.3
1/06/2020	3.5	700		88	9	0.2	3.9	8.2
7/07/2020	3.6	600	24	46	5.5	8.4	2.1	3.9
3/08/2020	3.6	790	103	85	14	2.6	5.6	11
9/09/2020	4.8	600	79	61	12	5.1	9.4	5.3
7/10/2020	4.9	410	24	24	9.9	3	4.8	1.2
4/11/2020	3.8	670	109	130	38		35	10
1/12/2020	3.8	820	233	200	67		69	11
6/01/2021	7	390	22	8	2.6	2.2	0.4	0.02
2/02/2021	5.7	530	90	74	60	24	36	2.5
1/03/2021	4.1	830	303	210	94	11	83	9.1
12/04/2021	5.7	590	132	100	77	7	70	2.4
6/05/2021	5.9	410	56	46	50	12	38	1
2/06/2021	5.7	490	93	65	62	14	48	1.2
7/07/2021	5.5	480	34	23	24	6	18	0.71

2/08/2021	5.9	360	27	15	9.7	5	4.7	0.5
7/09/2021	6.2	440	37	23	32	19	13	0.76
6/10/2021	5.8	390	26	10	13	6.1	6.9	0.24
10/11/2021	6	470	40	35	47	12	35	0.86
8/12/2021	5.9	720	119	92	72	7	65	2.3
4/01/2022	5.9	690	148	100	91	27	64	1.4
4/02/2022	5.8	740	167	150	61	0.2	62	3
3/03/2022	5.7	760	140	130	67		99	2.8
4/04/2022	5.4	730	147	130	61	14	47	2.5
4/05/2022	5.3	630	114	110	43	24	19	2.1
1/06/2022	5	530	76	78	43	5	38	1.9
13/07/2022	5	680	45	38	27	9	19	1.5
16/08/2022	6.1	400	8	14	8.2	7.9	0.3	0.14
6/09/2022	5.9	380	27	29	15	7.3	7.7	0.9
4/10/2022	6.8	350	18	36	20	13	6.8	0.6
9/11/2022	6.1	330	30	27	25	22	2.6	1.2
9/12/2022	6.2	370	73	44	44	43	0.9	0.5
5/01/2023	6.3	540	170	52	40	40	0.1	0.5
9/02/2023	6	573	181	52	53	8	45	0.6
2/03/2023	6.3	520	105	45	57	13	44	0.4
4/04/2023	6.3	653	46	48	63	34	29	1.2
4/05/2023	6.6	560	57	36	34	1	34	0.9
7/06/2023	6.3	540	50	31	40	40	0.2	0.9

Table E2 Spot sampling water quality data from Boundary Creek at Yeodene (site #233228)

Sampled Date	PH (field)		Electrical Conductivity (EC)	Acidity as CaCO ₃	Sulfate as SO ₄	Total Iron	Ferric Iron	Ferrous Iron	Soluble Aluminum
	pH Units								
6/11/2019	3.68	-	-	-	-	-	-	-	-
4/12/2019	-	-	-	-	-	-	-	-	-
6/01/2020	3.86	-	-	-	-	-	-	-	-
5/02/2020	3.29	-	-	-	-	-	-	-	-
3/03/2020	-	-	-	-	-	-	-	-	-
1/04/2020	3.46	-	-	-	-	-	-	-	-
5/05/2020	3.98	-	-	-	-	-	-	-	-
1/06/2020	4.57	-	-	-	-	-	-	-	-
7/07/2020	4.1	-	-	-	-	-	-	-	-
3/08/2020	4.1	-	-	-	-	-	-	-	-
9/09/2020	4.51	-	-	-	-	-	-	-	-
7/10/2020	4.25	-	-	-	-	-	-	-	-
4/11/2020	3.49	-	-	-	-	-	-	-	-
1/12/2020	3.45	-	-	-	-	-	-	-	-
6/01/2021	3.57	-	-	-	-	-	-	-	-
2/02/2021	3.49	-	-	-	-	-	-	-	-
1/03/2021	3.55	-	-	-	-	-	-	-	-
12/04/2021	5.03	-	-	-	-	-	-	-	-
6/05/2021	4.61	-	-	-	-	-	-	-	-
2/06/2021	5.6	-	-	-	-	-	-	-	-
7/07/2021	5.09	-	-	-	-	-	-	-	-

2/08/2021	5.9	420	28	23	9.2	3.1	6.1	0.57
7/09/2021	6.1	460	47	32	26	10	16	0.95
6/10/2021	5.6	410	24	15	13	6	7	0.31
10/11/2021	5.9	550	40	44	46	19	27	1.1
8/12/2021	5	680	92	89	55	7	48	2
4/01/2022	4.9	700	122	110	67	14	53	1.4
4/02/2022	5	720	130	140	57	25	32	2
3/03/2022	5.5	860	141	130	85		97	0.15
4/04/2022	4	770	111	120	44	18	26	1.7
4/05/2022	3.9	620	120	87	35	22	13	1.8
1/06/2022	4.3	750	61	84	40	7	33	2
13/07/2022	4.3	580	57	45	26	4	21	1.5
16/08/2022	5.4	460	11	24	13	12	0.7	0.65
6/09/2022	5.7	420	21	36	13	3.4	9.6	0.8
4/10/2022	5.8	420	21	43	18	9	9	1.2
9/11/2022	6.4	350	26	33	19	17	3.4	1.1
9/12/2022	6.1	420	46	53	37	36	1.2	0.8
5/01/2023	5.9	530	110	61	34	34	0.2	0.6
9/02/2023	5.8	883	151	59	40	10	30	0.6
2/03/2023	5.9	490	76	52	51	23	29	0.4
4/04/2023	5.8	538	48	54	41	20	21	0.8
4/05/2023	6.7	570	56	41	32	1	31	0.9
7/06/2023	5.8	570	58	36	32	32	0.2	1.1

Table E3 Spot sampling water quality statistics from bores installed in the western portion of the swamp (i.e., BSBH14-BSBH18)

Sampled Date	Average no. of data points	pH (Field)			Electrical Conductivity (EC)			Acidity as CaCO3			Sulfate as SO4			Total Iron			Ferric Iron			Ferrous Iron			Soluble Aluminium		
		Min pH	Max pH	Average pH	Min EC	Max EC	Average EC	Min Acidity	Max Acidity	Average Acidity	Min Sulfate	Max Sulfate	Average Sulfate	Min Fe	Max Fe	Average Fe	Min Fe ³⁺	Max Fe ³⁺	Average Fe ³⁺	Min Fe ²⁺	Max Fe ²⁺	Average Fe ²⁺	Min Al	Max Al	Average Al
7/08/2019	5	2.9	3.8	3.3	750	4800	2110	141	2750	886	130	3400	1068										13	120	45
8/11/2019	5	2.8	3.8	3.4	680	4100	2236	113	2130	897	120	2500	1114	20	1100	518							11	98	46
4/12/2019	5	3.1	4.2	3.7	740	4200	2288	210	1968	961	140	3000	1280	25	1100	427	0.2	390	135	0.3	880	294	10	80	40
6/01/2020	5	3.2	5.1	4.2	800	7800	3140	206	2690	972	190	3300	1202	82	1200	436	3	230	93	54	1300	413	8	110	37
7/02/2020	5	2.5	3.9	3.3	290	4000	1762	145	2630	981	140	3100	1198	16	990	337	0.2	0.2	0.2	20	1200	400	10	150	49
4/03/2020	5	2.8	4.0	3.4	980	4200	2256	117	2460	809	160	3500	1202	24	1100	365	0.2	70	14	23	1100	353	5	160	44
1/04/2020	5	3.0	3.8	3.4	820	4000	2002	149	2600	806	150	3400	1122	5	970	303				7	1600	457	4	170	46
5/05/2020	5	3.0	3.8	3.4	810	4600	2064	152	3090	952	150	3900	1256	13	1100	357	2	49	26	15	1200	351	7	170	48
3/06/2020	5	3.0	3.8	3.4	680	5200	2146				140	4400	1368	17	410	151									
7/07/2020	5	3.2	4.0	3.7	770	5200	2204	149	3140	922	150	4200	1342	16	1400	388	0.2	12	7	16	1900	487	6	170	48
4/08/2020	5	3.4	4.3	3.8	740	5000	2136	185	2810	888	130	4000	1290	22	1500	413	0.2	10	5	18	1500	440	7	120	38
10/09/2020	5	3.3	4.1	3.7	520	4500	2048	143	2580	827	54	3300	854	19	1300	369	0.2	3	2	16	1300	393	7	120	37
9/10/2020	5	3.2	3.9	3.6	630	4300	1970	110	2490	796	90	3000	1044	17	1200	351	0.2	160	47	0.2	1200	316	9	120	37
6/11/2020	5	3.1	4.0	3.6	630	4100	1986	144	2710	868	130	3500	1182	29	1300	368	0.2	0.2	0.2	29	1500	434	8	97	32
1/12/2020	5	3.0	4.1	3.7	700	4200	1960	152	2870	907	150	3500	1176	50	1100	350	20	80	50	30	1100	332	8	130	39
2/03/2021	5	2.9	4.0	3.5	670	3900	1934	127	2420	864	150	3400	1216	22	1000	312	30	30	30	25	1100	333	6	160	47
2/06/2021	5	3.1	4.0	3.6	670	4100	1980	116	2410	783	140	3200	1112	32	1000	313	0.2	180	63	0.1	910	256	5	170	51
7/09/2021	5	3.4	4.1	3.8	630	4000	1980	147	2450	866	130	3300	1212	22	1000	320				26	1000	326	6	140	47
8/12/2021	5	3.2	3.9	3.7	1100	3600	2020	274	2310	923	330	3000	1164	71	760	308	0.2	50	25	81	990	364	10	140	50
3/03/2022	5	2.9	6.1	4.1	260	2300	1432	1	1390	591	49	1200	680	18	330	160	14	14	14	4	510	177	0.01	84	28
2/06/2022	5	2.8	4.0	3.4	1400	3500	2240	291	2080	998	510	2400	1174	41	460	244	370	370	370	74	750	270	9	150	61
6/09/2022	5	3.1	4.2	3.6	1400	4200	2440	273	1910	1016	600	2800	1438	81	660	350				89	820	434	8	150	68
9/12/2022	5	3.2	3.9	3.5	1900	3500	2580	282	2020	1134	630	2500	1350	120	620	352	49	170	92	71	470	260	10	120	67
2/03/2023	5	3.1	4.0	3.5	1100	3300	2300	333	1820	961	350	2600	1386	110	660	344	0.2	88	25	90	700	352	9	140	61
7/06/2023	5	2.7	4.5	3.7	1200	3400	2420	320	2090	1026	480	2700	1376	62	750	358	60	230	124	2.1	640	234	9	130	55

Table E4 Spot sampling water quality statistics from bores installed in the eastern portion of the swamp (i.e., BSBH01-BSBH07)

Sampled Date	Average no. of data points	pH (Field)			Electrical Conductivity (EC)			Acidity as CaCO3			Sulfate as SO4			Total Iron			Ferric Iron			Ferrous Iron			Soluble Aluminium		
		Min pH	Max pH	Average pH	Min EC	Max EC	Average EC	Min Acidity	Max Acidity	Average Acidity	Min Sulfate	Max Sulfate	Average Sulfate	Min Fe	Max Fe	Average Fe	Min Fe ³⁺	Max Fe ³⁺	Average Fe ³⁺	Min Fe ²⁺	Max Fe ²⁺	Average Fe ²⁺	Min Al	Max Al	Average Al
		pH Units			uS/cm			mg/L			mg/L			mg/l			mg/L			mg/L			mg/L		
7/08/2019	7	4.6	7.0	6.1	510	2800	893	83	857	204	1	1500	250									0.01	17	2	
8/11/2019	7	4.4	7.1	5.9	550	2700	940	38	700	146	1	1400	232	62	380	178						0.01	12	2	
4/12/2019	7	4.7	6.6	6.0	510	2600	861	34	686	138	1	1400	231	17	330	84	17	90	50	0.1	240	34	0.01	11	2
6/01/2020	7	5.1	6.5	5.8	360	2500	813	100	703	207	3	1300	213	35	340	103	22	110	49	7	440	77	0.01	10	1
7/02/2020	7	3.9	6.7	6.0	240	4900	1137	27	652	130	2	1300	214	5	310	66	2	17	7	17	360	72	0.01	23	4
4/03/2020	7	4.5	7.3	6.2	480	2500	839	20	475	89	1	1300	214	33	300	93	4	120	34	19	360	73	0.01	9	1
1/04/2020	7	3.5	7.2	6.1	480	2300	789	11	532	103	1	1300	203	7	260	52	7	17	12	0.1	470	83	0.01	10	1
5/05/2020	7	4.4	6.7	6.0	520	2200	800	37	591	131	1	1200	194	28	330	86	5	66	24	12	320	63	0.01	6	1
3/06/2020	5	4.6	6.6	6.0	510	2200	814				1	1200	190	29	310	104				15	20	18	0.01	0.01	0.01
7/07/2020	7	4.8	6.6	6.1	510	2200	791	34	502	112	1	1200	191	25	240	63	0.2	20	8	17	330	69	0.01	7	1
4/08/2020	7	5.5	7.3	6.5	510	2200	801	81	520	165	1	1100	178	32	300	122	8	140	68	16	410	79	0.01	8	1
10/09/2020	7	4.6	6.7	6.1	470	2000	753	60	488	133	1	1000	161	26	220	60	4	24	12	13	310	63	0.01	6	0.8
9/10/2020	7	4.7	6.7	6.0	460	1900	730	39	439	109	1	890	144	22	200	75	2	190	59	0.1	28	16	0.01	4	0.7
6/11/2020	7	4.5	6.4	5.8	470	1900	724	64	459	145	1	930	148	22	180	58	0.2	42	18	16	250	55	0.01	5	0.7
1/12/2020	7	4.5	6.7	6.1	460	1800	697	117	424	247	2	860	136	27	200	74	8	91	29	17	270	58	0.01	4	0.6
2/03/2021	7	4.4	7.0	6.1	460	1500	649	75	359	137	2	710	113	24	150	51	0.2	44	22	2	150	28	0.01	4	0.5
2/06/2021	7	4.7	6.7	6.1	460	1400	643	26	232	78	1	500	81	25	120	57	5	91	33	0.5	140	35	0.01	3	0.4
7/09/2021	7	4.7	6.7	6.1	480	1200	626	78	298	142	1	440	73	16	97	45	0.2	31	16	10	98	29	0.01	2	0.3
8/12/2021	7	3.6	6.5	5.8	440	1100	610	45	205	77	1	280	49	19	120	54	0.2	110	35	0.8	64	20	0.01	1	0.2
3/03/2022	7	3.7	6.4	5.9	460	1000	563	8	143	55	1	230	43	21	85	46	0.2	41	19	13	71	27	0.01	1	0.2
2/06/2022	7	3.7	7.0	6.0	470	930	587	70	182	112	1	210	43	9	67	38	5	54	27	0.1	47	20	0.01	0.8	0.2
6/09/2022	7	4.7	6.6	6.1	490	880	581	75	210	112	1	230	44	32	84	51	14	75	33	8.9	36	19	0.1	1	0.2
9/12/2022	7	5.2	6.6	6.2	440	1100	567	55	136	74	1	170	35	19	79	48	19	79	48	0.1	1.2	0.3	0.1	1	0.2
2/03/2023	7	4.8	7.1	6.4	450	800	537	16	323	102	2	180	40	14	94	35	2.6	51	20	0.1	44	16	0.1	0.8	0.2
7/06/2023	7	5	7.1	6.1	470	740	547	7	147	35	1	140	32	10	49	33	9.6	49	33	0.1	0.3	0.1	0.1	0.5	0.2