**Department of Planning and Environment**

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# Upper Hawkesbury River Water Quality Monitoring Program 2022-2023

## Summary Report

June 2023

# Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Upper Hawkesbury River Water Quality Monitoring Program 2022 - 2023

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# Contents

# 1 Introduction

## 1.1 Background

### 1.1.1 Location

Hawkesbury City Council contracted the Estuaries and Catchments Team (ECT) of the NSW Department of Planning and Environment (DPE) to assist Council staff to assess the water quality in the upper Hawkesbury River, in the 2022-2023 financial year. The upper Hawkesbury River is located in the northwest of Sydney and falls within the Hawkesbury City Council Local Government Area (LGA).

### 1.1.2 Program Outline and Scope

This document continues the reporting of an annual monitoring program that commenced in 2018. Long term monitoring programs are essential for tracking estuary ecological health and to identify potential areas requiring management.

The NSW Natural Resources Monitoring, Evaluation and Reporting (MER) Program outlines standard sampling, data analysis and reporting protocols to assess estuary ecological health (OEH, 2016). The Upper Hawkesbury River monitoring program was designed by DPE to adhere to these protocols and to also address locally relevant issues.

### 1.1.3 Aims and Objectives of the Program/OKRs

The aims of the monitoring program are to assess the ecological health of Upper Hawkesbury River using methods that are scientifically valid and standardised, and to report the information generated in an accessible way to a variety of potential end-users in a report card style format. This summary report presents the report card grades for the 2022–2023 monitoring period.

With the Hawkesbury River being such a large system that runs through several council LGAs, this program also falls within a larger overall aim to establish a standardised report card and grades that other councils can adopt.

# 2 Methodology

## 2.1 Indicators/Parameters

Turbidity and chlorophyll-a are considered to be appropriate measures of estuary ecological health as they are indicators of ecosystem performance in response to catchment pressure. The concentration of chlorophyll-a in the water column is a biological indicator reflecting phytoplankton biomass, and typically reflects the nutrient load into the system. Turbidity is a proxy measure of water clarity, where high turbidity can result in a reduction of light available for photosynthesis, limiting algal and seagrass growth. These indicators are consistent with the NSW MER protocols.

Turbidity and chlorophyll-a data collected from NSW estuaries by DPE as part of the state-wide estuarine MER program have been used to develop trigger values specific to NSW estuaries (OEH, 2016). Trigger values are derived from the 80th percentile values for variables measured in estuaries at seaward end of low disturbance catchments, for each estuary type (e.g., lake, lagoon, back dune lagoon etc). Compliance against a guideline or trigger value is commonly used to assess the status of a condition indicator. Exceeding the trigger value frequently, or by a large extent, should 'trigger' further investigation or management action. Table 1 shows updated trigger values established for coastal rivers (<10 psu) that were generated from the state-wide estuarine water quality dataset (OEH 2018) and were used for grade calculations in this report.

It should be noted that a trigger value for chlorophyll-a of 7 µg/L has been adopted instead of the standard trigger value of 4.8 µg/L (OEH 2018) which is normally applied to upper reaches of rivers with a salinity of less than 10 psu. The sites sampled in the Hawkesbury River as part of this monitoring program are within the tidal freshwater pool. Currently there is limited available data on tidal freshwater pools and therefore a trigger value for chlorophyll-a of 7 µg/l was deemed more appropriate. This is based on recommendations made in the 'Interim nutrient load cap assessment for the Hawkesbury Nepean River' report (Ferguson 2018), which identified that a knowledge gap exists and that a chlorophyll-a value of 4.8 µg/L was not appropriate for the tidal freshwater pool within the Hawkesbury River. It was also noted that guideline values for the system should be reviewed and revised as more knowledge is gained about the system in the future (Ferguson 2018). DPE is working on developing revised trigger values for freshwater tidal pools as part of the Tidal Rivers Program.

Table 1: Trigger Values for water quality indicators in NSW rivers (OEH 2018)

| Indicators | Rivers Upper (Salinity < 10 psu) |
|---|---|
| Turbidity NTU | 6 |
| Chlorophyll-a µg/L | 7*4.8 |
| Ammonia µg/L | 52 |
| NOx µg/L | 34 |
| TDN µg/L | 550 |
| TN µg/L | 670 |
| Phosphate µg/L | 5 |
| TDP µg/L | 6 |
| TP µg/L | 16 |

*A trigger value for Chlorophyll-a of 7 µg/L has been adopted instead of the standard OEH trigger value of 4.8 (see explanation above)

## 2.2 Field Methodology

Water quality sampling was carried out at 4 zones along main river stem and 1 zone in the lower Macdonald River which also falls within the Hawkesbury City Council LGA (Figure 1).

Water quality data were scheduled to be collected at 3–4-week intervals, 12 times throughout the year, between July 2022 and June 2023. Sampling at this frequency allows both monthly and seasonal variability in water quality to be assessed.

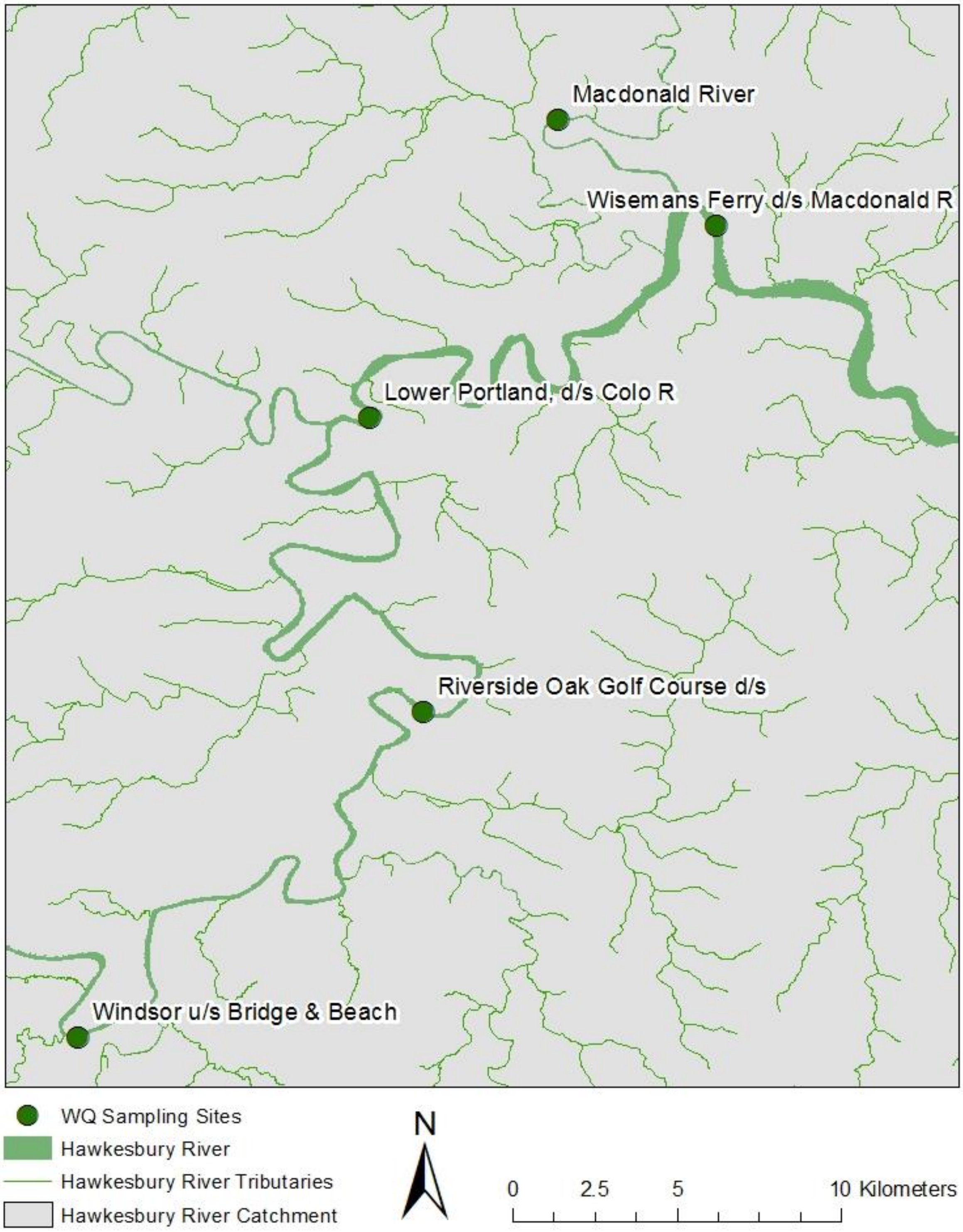



Figure 1: Locations of sampling zones in the Upper Hawkesbury River for the 2022 – 2023 monitoring program

### 2.2.1 Sampling strategy

Turbidity and other physico-chemical water quality parameters were measured using a Xylem EXO-2 multiparameter water quality sonde. The sonde logged data at approximately 0.5m depth at one second intervals for a total of 3 minutes at each site, while the vessel used for sampling freely drifted, following the method outlined in the MER protocols.

A bucket was filled using an integrated sampler which collects water from the top 1m of the water column. The bucket was subsampled for chlorophyll-a, total suspended solids (TSS) and a suite of nutrients (total nitrogen, total dissolved nitrogen, ammonium, nitrate/nitrite, total phosphorous, total dissolved phosphorous and free reactive phosphorous). A second bucket of water was then collected and subsampled for chlorophyll-a and total suspended solids to provide a replicate sample for each.

Total nutrient samples were directly transferred to 30ml vials and all other nutrient samples were filtered immediately with 0.45 µm syringe-filters into 30ml vials. Nutrient samples were kept cool, frozen as soon as possible and were analysed at Yanco laboratories. Chlorophyll and TSS analyses were done in-house using American Public Health Association (APHA) methods. Chlorophyll-a samples were kept cool and away from light in an esky until returning to the laboratory where they were filtered through 0.45 µm glass fibre filter paper under vacuum and the filter paper frozen until analysis. Concentrations were determined by fluorometry following extraction with 95% acetone solution following method APHA 10200H (APHA, 2012). TSS samples were kept cool and stored at 4°C until analysis using APHA methods 2130B and 2540D (APHA 2012).

## 2.3 Data analysis

Water quality data collected in the monitoring program were used to calculate a report card grade for the five zones in the Hawkesbury River and lower Macdonald River. Grades for water quality are calculated by calculating how often and to what extent the values for turbidity and chlorophyll-a exceed the state-wide 80$^{th}$ percentile trigger value. Only data collected from October to March are used to calculate the grades in line with MER analysis protocols (OEH 2016). Separate grades are calculated for turbidity and chlorophyll-a, and the scores for turbidity and chlorophyll are averaged to get the Overall Water Quality grade. As noted earlier, a trigger value of 7µg/L chlorophyll-a has been adopted for sites in this program instead of the standard trigger value of 4.8 µg/L for upper coastal rivers (OEH 2018).

A comprehensive description of how the grades are calculated is available in *Assessing Estuary Ecosystem Health: Sampling, data analysis and reporting protocols*, NSW Natural Resources Monitoring, Evaluation and Reporting Program (OEH 2016).

# 3 Results

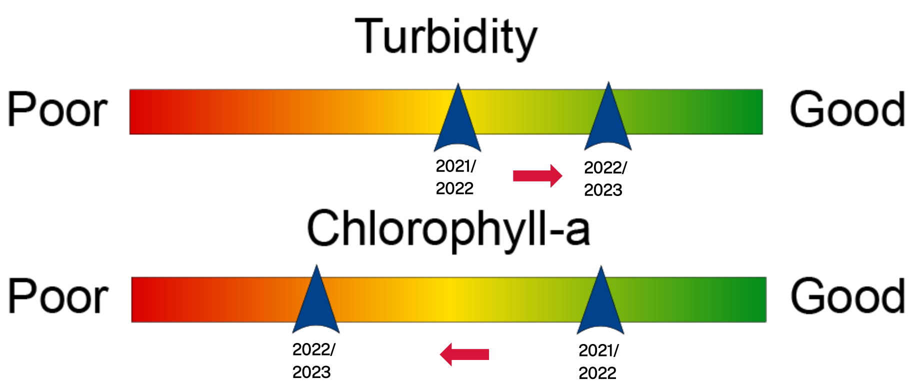
## 3.1 Report Card Grades

### 3.1.1 Wisemans Ferry (downstream of Macdonald River)

Overall water quality at Wisemans Ferry deteriorated to fair during the most recent round of sampling. The trigger value for chlorophyll-a was exceeded on three of the six sampling trips and decreased to fair. The turbidity grade however improved to good as the trigger value was exceeded on only two occasions. The mean salinity recorded at Wisemans Ferry was 1.02 psu. A maximum recorded salinity of 5.43 psu was recorded at Wisemans Ferry in March 2023. This site normally exhibits brackish estuarine conditions, however, the water remained relatively fresh (<0.15 psu) from July 2022 through to December 2022 (Figure 6, Figure 7).

**Table 2: Calculated grades at Wisemans Ferry for the 2022-2023 monitoring period and previous years for comparison. A sliding scale diagram of the turbidity and chlorophyll-a grades for 2022-23 (relative to 2021-22 grades) is shown below**

| Sampling Period | Turbidity | Chlorophyll-a | Overall Water Quality |
|---|---|---|---|
| 2018 - 2019 | C | F | D |
| 2019 - 2020 | C | B | B |
| 2020 - 2021 | B | B | B |
| 2021 - 2022 | C | B | B |
| **2022 - 2023** | **B** | **C** | **C** |



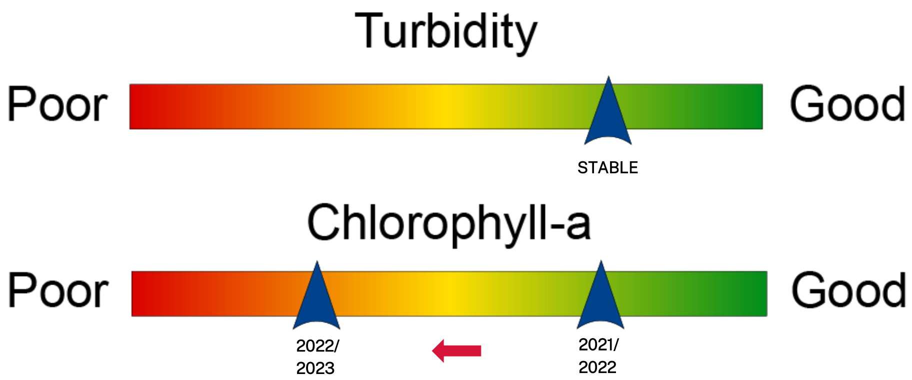
### 3.1.2 Lower Portland (downstream of Colo River)

Overall water quality observed at the Lower Portland zone deteriorated to fair during 2022-2023. Four exceedances of the trigger value were recorded for chlorophyll-a, including one sample that was more than 3 times the trigger value. This resulted in a decrease in grade from good in 2021-2022 to poor in2022-2023. The trigger value for turbidity was exceeded on two of the six sampling occasions over summer/autumn, it retained a good grade with only minor exceedances.

Salinity recorded at Lower Portland was always below 0.2 psu, with a mean salinity of 0.12 psu (Figure 6, Figure 7).

**Table 3: Calculated grades at Lower Portland for the 2022-2023 monitoring period and previous years for comparison. A sliding scale diagram of the turbidity and chlorophyll-a grades for 2022-23 (relative to 2021-22 grades) is shown below**

| Sampling Period | Turbidity | Chlorophyll-a | Overall Water Quality |
|---|---|---|---|
| 2018 – 2019 | C | F | D |
| 2019 – 2020 | B | F | C |
| 2020-2021 | B | C | B |
| 2021 - 2022 | B | B | B |
| **2022 - 2023** | **B** | **D** | **C** |



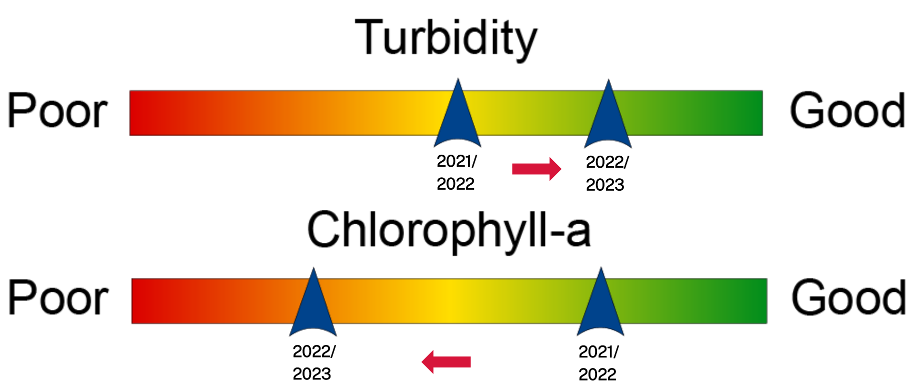
### 3.1.3 Riverside Oaks (downstream of golf course)

Overall water quality at Riverside Oaks deteriorated from good in 2021-2022 to fair in the 2022-2023 sampling period. This decline was driven by a two-grade decline in the chlorophyll-a grade, from good in 2021-2022 to poor in 2022-2023. Four trigger value exceedances were recorded for chlorophyll-a over summer/autumn, including two that were more than 4 times the trigger value. The turbidity grade improved to good in 2022-2023. Although the trigger was exceeded on all six sampling occasions, these were all minor.

Salinity recorded at Riverside Oaks was generally below 0.2 psu, with a mean salinity of 0.14 psu (Figure 6, Figure 7).

**Table 4: Calculated grades at Riverside Oaks during the 2022-2023 monitoring period and previous years for comparison. A sliding scale diagram of turbidity and chlorophyll-a grades for 2022-23 (relative to 2021-22 grades) is shown below**

| Sampling Period | Turbidity | Chlorophyll-a | Overall Water Quality |
|---|---|---|---|
| 2018 - 2019 | C | D | C |
| 2019 - 2020 | B | F | D |
| 2020 - 2021 | B | D | C |
| 2021 - 2022 | C | B | B |
| **2022 - 2023** | **B** | **D** | **C** |



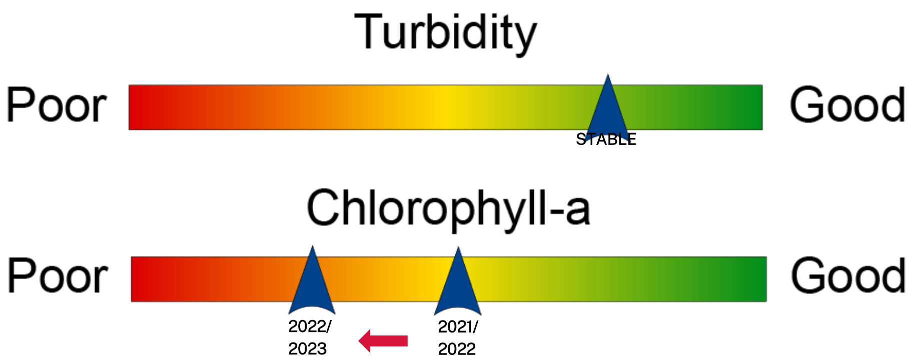
### 3.1.4 Windsor (upstream of Windsor Bridge)

Overall water quality at Windsor remained fair in the 2022-2023 sampling period, despite a decrease in chlorophyll-a grade from fair in the previous year to poor in 2022-2023. The trigger value was exceeded for chlorophyll a on four occasions including one exceedance by 460%. The trigger value for turbidity was exceeded on five sampling occasions over summer/autumn, however most of these exceedances were minor to moderate, resulting in the grade for turbidity remaining stable at good.

Salinity recorded at Windsor was generally below 0.2 psu, with a mean salinity of 0.13 psu (Figure 6, Figure 7).

**Table 5: Calculated grades at Windsor during the 2022-2023 monitoring period and previous years for comparison. A sliding scale diagram of turbidity and chlorophyll-a grades for 2022-23 (relative to 2021-22 grades) is shown below the table**

| Sampling Period | Turbidity | Chlorophyll-a | Overall Water Quality |
|---|---|---|---|
| 2018 - 2019 | C | D | D |
| 2019 - 2020 | C | D | D |
| 2020 - 2021 | B | D | C |
| 2021 - 2022 | B | C | C |
| **2022 - 2023** | **B** | **D** | **C** |



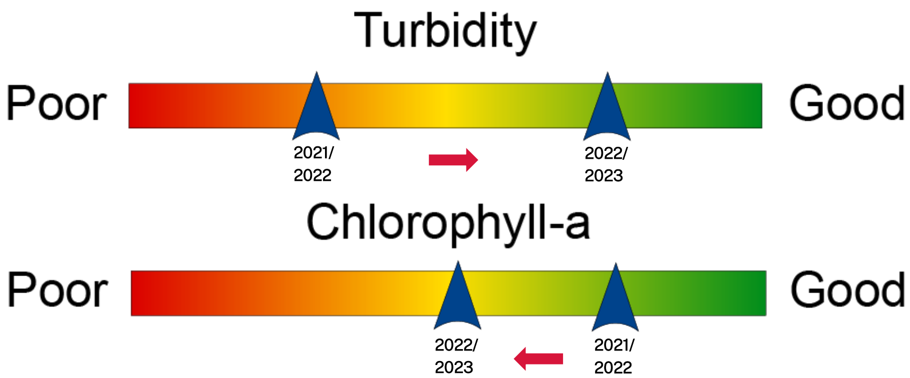
### 3.1.5 Macdonald River

Overall water quality in the Macdonald River remained fair in 2022-2023. Chlorophyll-a grade decreased from good during 2021-2022 to fair, with four minor to moderate exceedances recorded. There was a two-grade improvement from poor to good in turbidity grade, as the trigger value was exceeded on only two occasions over the summer/autumn period.

The mean salinity recorded at the Macdonald River site was 0.24 psu, with a minimum salinity 0.09 psu. A maximum recorded salinity of 1.03 psu was recorded in March 2023 (Figure 6, Figure 7). Like the Wisemans Ferry site, this site normally exhibits brackish estuarine conditions, however, the site remained relatively fresh (<0.15ppt) from July 2022 through to December 2022.

**Table 6: Calculated grades in the Macdonald River during the 2022-2023 monitoring period and previous years for comparison. A sliding scale diagram of the turbidity and chlorophyll-a grades for 2022-23 (relative to 2021-22 grades) is shown below**

| Sampling Period | Turbidity | Chlorophyll-a | Overall Water Quality |
|---|---|---|---|
| 2018 - 2019 | B | B | B |
| 2019 - 2020 | B | B | B |
| 2020 - 2021 | C | D | C |
| 2021 - 2022 | D | B | C |
| **2022 - 2023** | **B** | **C** | **C** |



# 4 Summary and Discussion

The overall water quality grade for Wisemans Ferry, Lower Portland and Riverside Oaks declined in 2022-2023, dropping a grade from good in 2021-2022 to fair in 2022-2023. Water quality at Windsor and Macdonald River remained fair. The chlorophyll-a grades deteriorated at all sites, dropping two grades at Lower Portland and Riverside Oaks to poor, and by one grade at Macdonald River, Wisemans Ferry (to fair) and Windsor (to poor). Conversely, the turbidity grade at all sites was good with an improved grade at Wisemans Ferry, Riverside Oaks and Macdonald River, while Lower Portland and Windsor remained stable.

It has been shown that chlorophyll-a concentrations within the Hawkesbury are generally flow dependent and likely to be related to longer residence times of the water bodies. The decline of the chlorophyll-a grades was driven by the decrease in river flows during the second half of the 2022-2023 sampling period. Less flow means longer residence times, which leads to an increase in algal abundance as algae have more time to utilise the nutrients in the water column to fuel growth. The reduction in river flows resulted from of a return to average rainfall and fewer water releases from Warragamba Dam. Conversely, decreased river flows resulted in lower turbidity in the upper Hawkesbury River leading to the improved turbidity grade observed at Wisemans Ferry, Riverside Oaks and Macdonald River.

The Macdonald River and its catchment were impacted heavily by the March 2022 flood event. While the overall water quality at the Macdonald River zone remained stable at fair, there was a two-grade improvement in the turbidity grade, with the site graded as good in 2022-2023. This was a return to expected conditions as generally the Macdonald River zone has performed better than those in the main river stem due to the catchment being considerably less modified than the catchments of the main river stem and the many tributaries feeding into it.

### 4.1.1 Flow Conditions

Chlorophyll-a concentrations within the Hawkesbury have been shown to be flow dependent, with high concentrations often linked to low flow conditions (Figure 3). The sampling conducted during 2022-2023 for the Upper Hawkesbury Water Quality Monitoring Program was dominated by very high flows (top 5 percent) from July to November. This was because of increased rainfall combined with numerous water releases from Warragamba Dam. Mid to low flows occurred from December 2022 to May 2023 (Table 2, Figure 2). Flow conditions leading up to, and at the time of, sampling for water quality is important for determining primary drivers in the system (e.g., residence times, external versus internal nutrient supply and total suspended solids inputs from the catchment etc.), that in turn impact on health indicators. Flows (megalitres per day) recorded at Penrith Weir and sampling dates for the Upper Hawkesbury River water quality monitoring program are shown in Figure 5.

Table 7: Nepean River flows (ML $d^{-1}$) at Penrith Weir on the sample times (instantaneous) and for the preceding 7 and 14 days (means).

| Sampling Trip no. | Sampling Date | Instantaneous | 7-day mean | 14-day mean |
|---|---|---|---|---|
| Trip 1 | 27/07/2022 | 14345 | 15427 | 13759 |
| Trip 2 | 19/08/2022 | 5496 | 6462 | 9339 |
| Trip 3 | 28/09/2022 | 4115 | 4059 | 4073 |
| Trip 4 | 31/10/2022 | 6827 | 15684 | 12274 |
| Trip 5 | 24/11/2022 | 7915 | 9031 | 12688 |
| Trip 6 | 15/12/2022 | 187 | 2329 | 3200 |
| Trip 7 | 30/01/2023 | 341 | 549 | 368 |
| Trip 8 | 01/03/2023 | 243 | 279 | 269 |
| Trip 9 | 20/03/2023 | 299 | 338 | 228 |
| Trip 10 | 19/04/2023 | 349 | 382 | 388 |
| Trip 11 | 11/05/2023 | 344 | 528 | 661 |

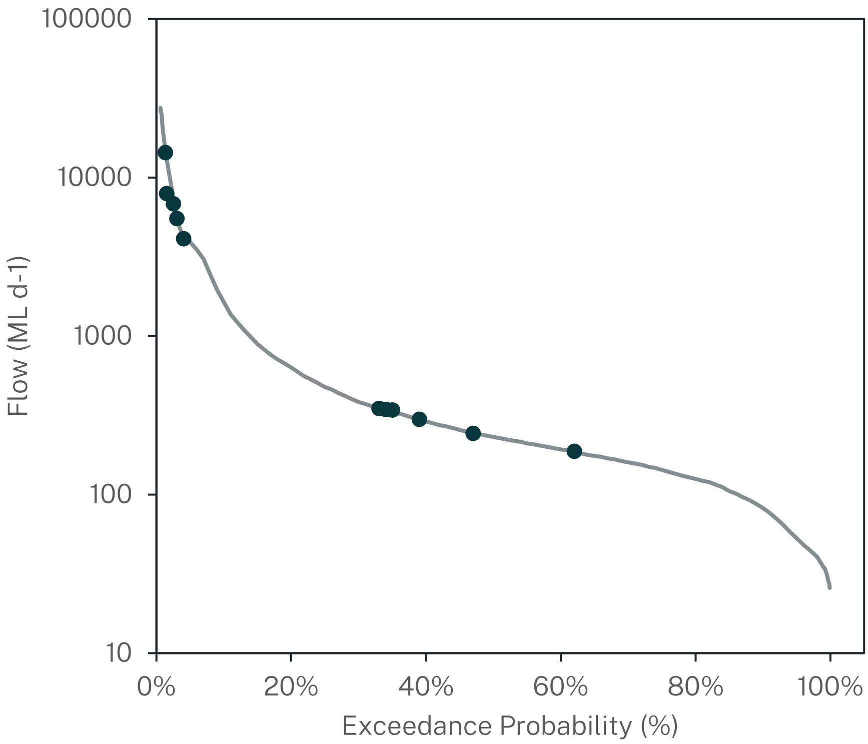



**Figure 2: Flow exceedance curve for Nepean River at Penrith Weir (grey line), showing flows during sample times (black dots).**

### 4.1.2 System State

During the study period (July 2022 to June 2023) the Hawkesbury River had flows in the top 5% of the flow exceedance curve from July to November 2022, and medium flows in the 33-62% range from December 2022 to May 2023 (Table 7, Figure 2). This resulted in the typically brackish estuarine conditions at the Wisemans Ferry site shifting to completely fresh water, except for March and April 2023 (Figure 6).

The first sample event occurred at the end of July 2022, flow at this time was high following a period of heavy rainfall and a dam release from Warragamba in July. This resulted in the brackish/freshwater interface being displaced downstream of Wisemans Ferry. A second dam release occurred in August which was followed by heavy rainfall in October and a subsequent third dam release in November, which maintained the high flows recorded. Low to average rainfall from December onwards and no further dam releases resulted in the flow decreasing for the remaining period (Table 7).

### 4.1.3 Chlorophyll

The general trends in chlorophyll-*a* over the study period follow our conceptual understanding in tidal pool processes; decreased flow = increased chlorophyll-a (Figure 3). With flows recorded in the top 5% of the flow exceedance curve from July to November, we observed relatively low phytoplankton biomass. Phytoplankton biomass generally increased throughout the second half of the sampling period as residence times increased and water clarity improved following lower flows from December 2022 to May 2023 (Figure 6, Figure 7). We saw a peak in phytoplankton biomass at all sites where the decrease in flow and an increase in water temperature associated with summer coincided.

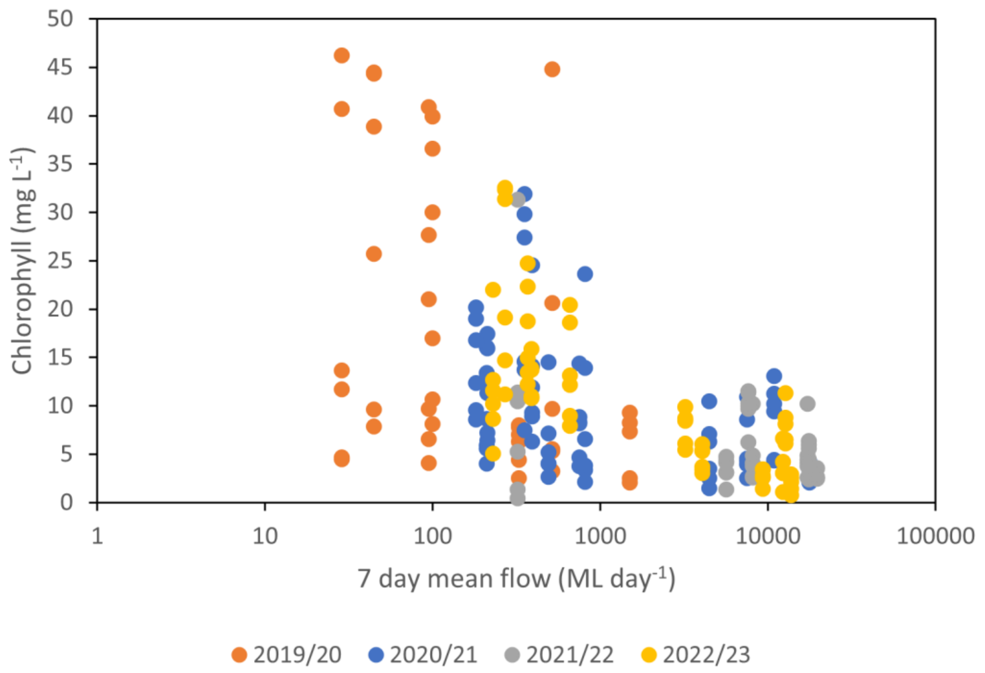



**Figure 3: Flow vs chlorophyll-a for all sites sampled as part of the 2019-2020 (represented by orange dots), 2020-2021 (represented by blue dots), 2021-2022 (represented by grey dots) and 2022-2023 (represented by yellow dots) Upper Hawkesbury water quality monitoring program**

## 4.1.4 Turbidity

Trends in turbidity are driven by spatial factors throughout the bulk of time, with episodic large spikes due to high-flow inputs of diffuse material. Turbidity in the Windsor reach during low flows are commonly low relative to other reaches, due to a combination of lower phytoplankton biomass, lower tidal currents, and trapping of particulates by macrophytes. Generally, we have observed turbidity in the Wisemans Ferry reach during low flow to be primarily associated with the tidally driven resuspension of inorganic sediments. Turbidity throughout the system was variable, with large spikes observed following increase in flows (Figure 6, Figure 7).

Turbidity tends to increase throughout the system during high flow periods, with rapid recovery at the brackish/freshwater interface due to flocculation/sedimentation (Figure 4, Figure 6).

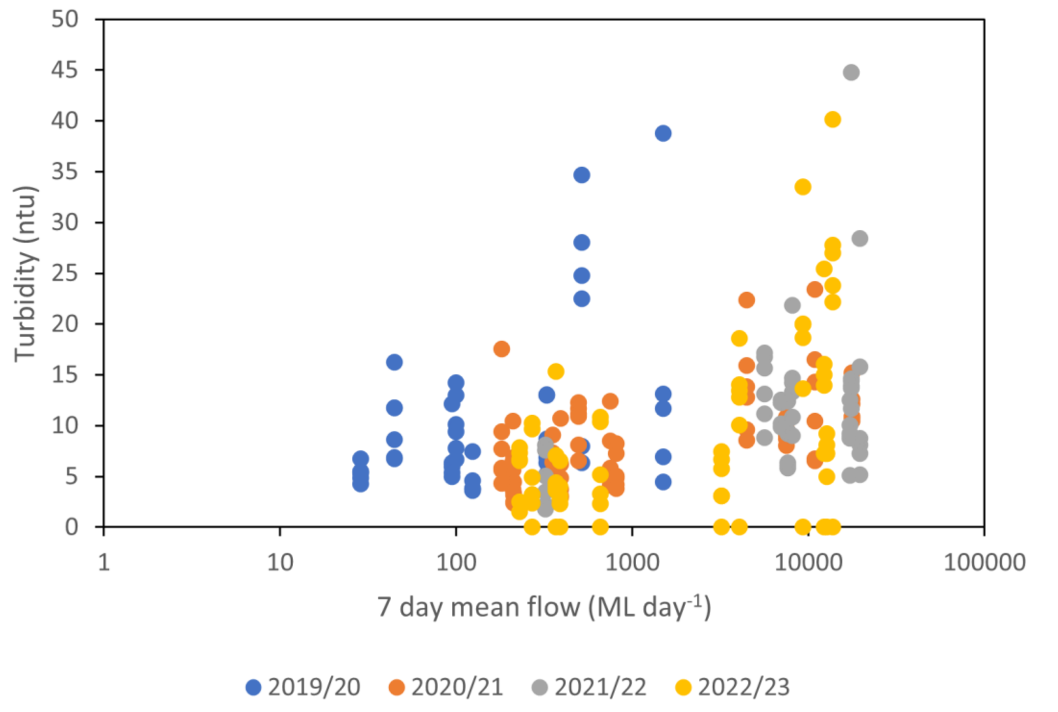



**Figure 4: Flow vs turbidity for all sites sampled as part of the 2019-2020 (represented by blue dots), 2020-2021 (represented by orange dots), 2021-2022 (represented by grey dots) and 2022-2023 (represented by yellow dots) Upper Hawkesbury water quality monitoring program.**

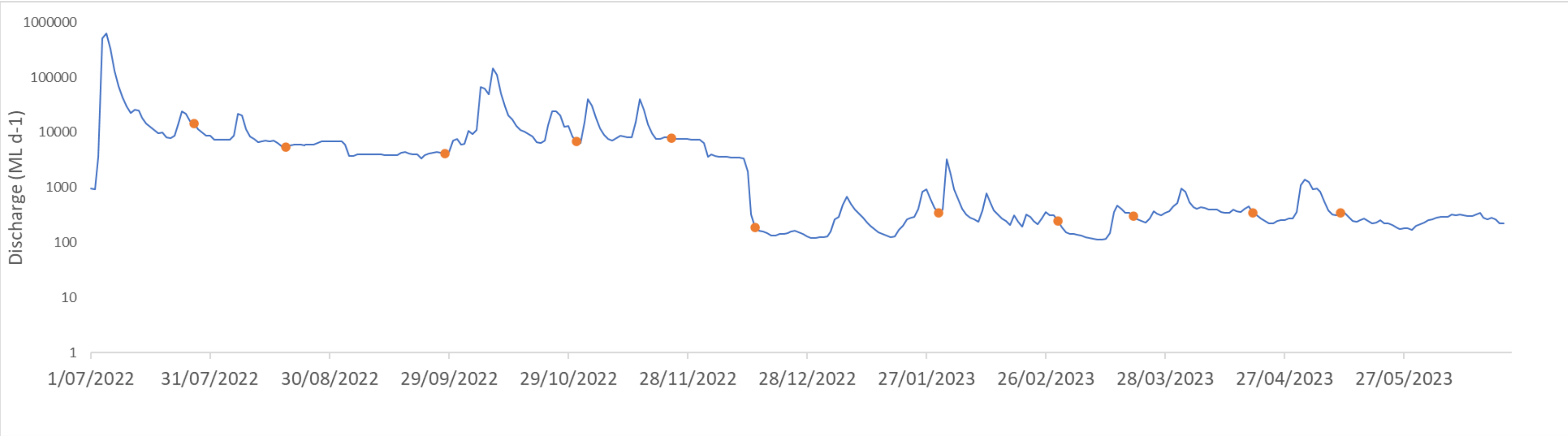



Figure 5: Flow rate (megalitres per day, ML day$^{-1}$) recorded at Nepean Weir (blue line) and water quality sampling dates (orange dots).

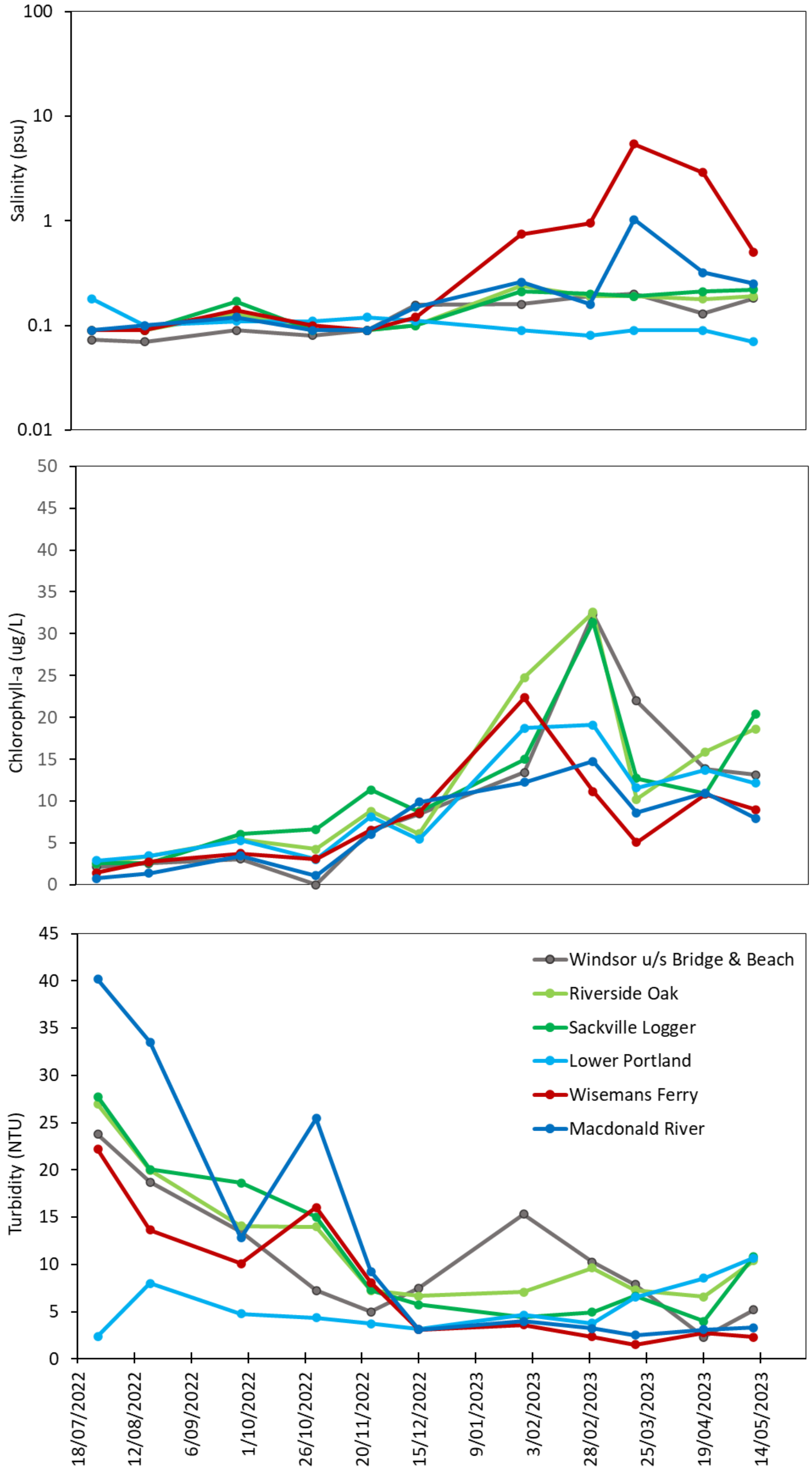



Figure 6: Temporal trends in salinity (psu), chlorophyll-a ($ug.L^{-1}$) and turbidity (ntu) at monitoring sites during the 2022-2023 sampling period (sampling dates indicated by circles)

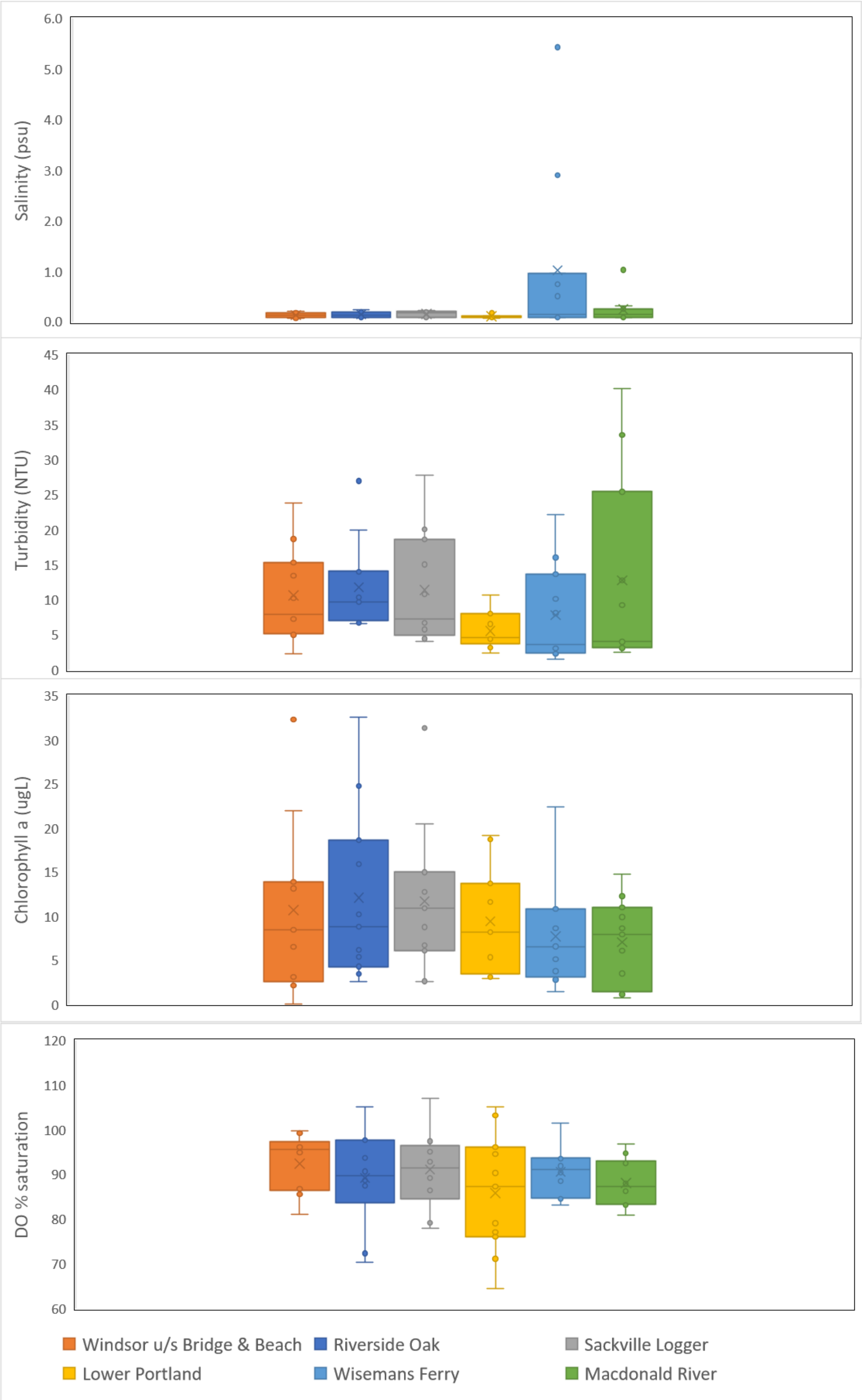



Figure 7: Variation in salinity (psu), chlorophyll-a (µg.L$^{-1}$), turbidity (NTU) and dissolved oxygen (percent saturation) at the six monitoring sites during the 2022-2023 sampling period. Data is presented as box and whisker plots of the upper and lower quartiles (top and bottom of box) and the median is a line inside the box.

# 5 References

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