Upper Hawkesbury River Water Quality Monitoring Program 2021 - 2022

Summary Report

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Background

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 part of the upper Hawkesbury River that falls within the Hawkesbury City Council Local Government Area (LGA) over the 2021-2022 financial year. 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 DPIE to adhere to these protocols and to also address locally relevant issues.

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 number of potential users in a report card style format. This summary report presents the report card grades for the 2021–2022 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 standarised report card and grades that other councils can adopt.

Methods

Monitoring 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 statewide estuarine MER program have been used to develop trigger values specific to NSW estuaries (OEH, 2016). Trigger values are derived from the 80th percentile of all turbidity and chlorophyll-a data collected in each estuary type (e.g., river, lake, 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 trigger values established for coastal rivers (<10 psu) that were generated from the statewide estuarine water quality dataset (OEH, 2018) that were used in this report.

It should be noted that a trigger value for chlorophyll-a of 7µg/l has been adopted instead of the standard trigger value of 4.8 µg/l (OEH 2016) which is normally applied to upper reaches of rivers with a salinity of less than 10psu. 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 7µg/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 4.8µg/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). DPIE 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.

*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)

Indicators	Rivers Upper
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

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Sampling and Analysis

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).

Sites and Timing

Water quality sampling was carried out at 5 zones along main river stem and within 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 2021 and June 2022. Sampling at this frequency allows both monthly and seasonal variability in water quality to be assessed. Due to Covid lockdown, however, sampling could not be conducted from July 2021 to September 2021. Sampling was scheduled for the last week of Febuary, however this trip had to be postponed due to heavy rainfall, which then led to major flooding in early March. As a result, the February sampling was missed and the March sampling was pushed back to early April.

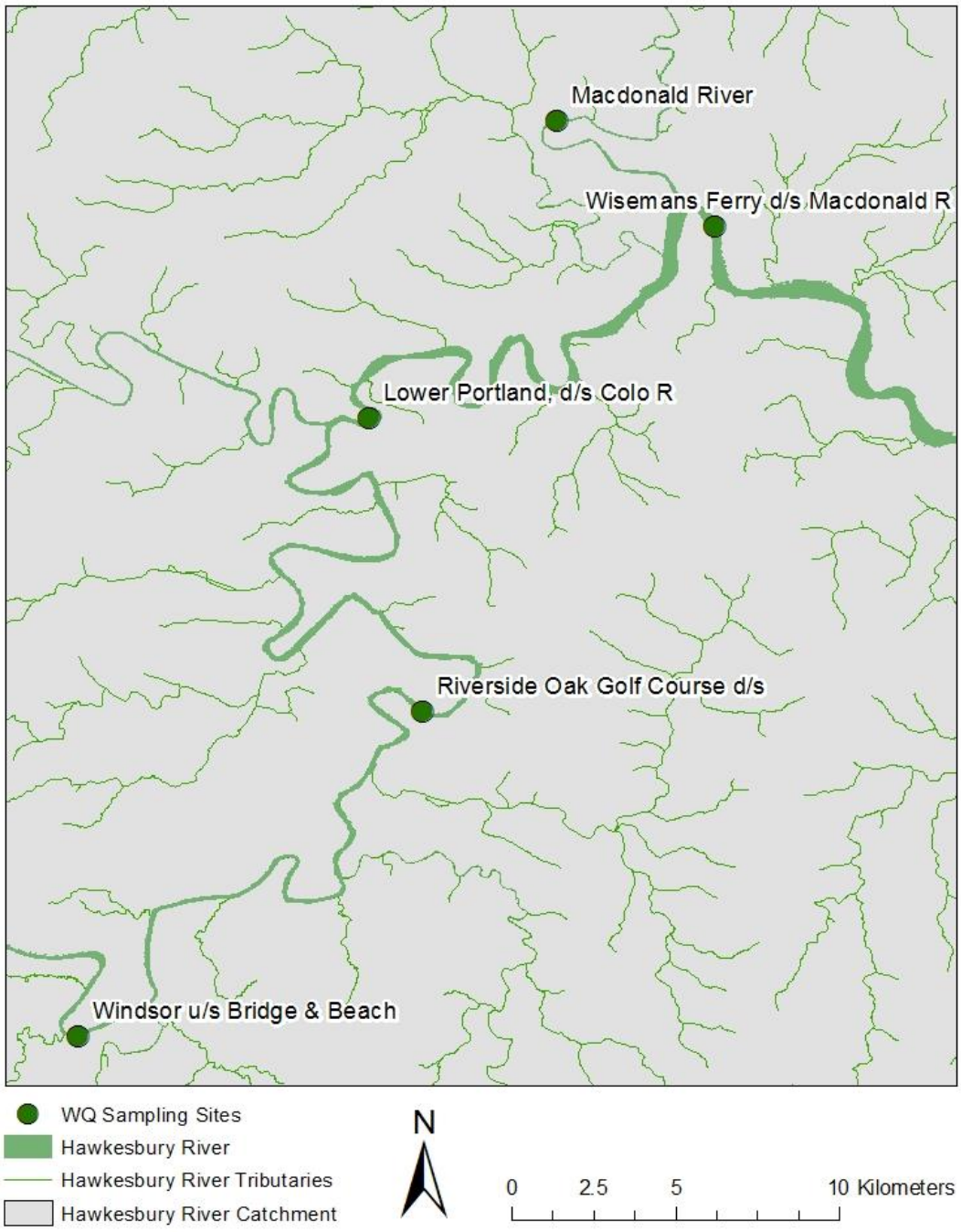


Figure 1: Locations of sampling zones in the Upper Hawkesbury River for the 2021 – 2022 monitoring program

Calculation of Report Card Grades

Water quality data collected in the monitoring program were used to calculate a report card grade for a number of sites in the Hawkesbury River. Grades for water quality are calculated by calculating how often and to what extent the values for turbidity and chlorophyll-a exceed the statewide 80th percentile trigger value. A comprehensive description of how the grades are calculated is available in the NSW MER protocols (OEH, 2016). As noted earlier, a trigger value of 7µg/l chlorophyll-a has been adopted for sites in the upper Hawkesbury instead of the standard trigger value of 4.8 µg/l for upper coastal rivers (OEH 2016).

Results

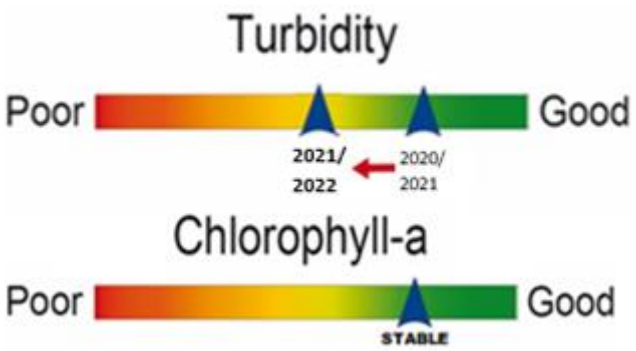
Report Card Grades

Wisemans Ferry (downstream of Macdonald River)

Overall water quality at Wisemans Ferry remained good during the most recent round of sampling. The trigger value for chlorophyll-a was exceeded on two of the six sampling trips used to calculate the grades and remained good. The decline in turbidity grade was driven by the trigger value for turbidity being exceeded on five occasions. The mean salinity recorded at Wisemans Ferry was 0.628ppt, which was significantly lower than that recorded in previous years. A maximum recorded salinity of 1.6ppt was recorded at Wisemans Ferry in October 2021. This site normally exhibits brackish estuarine conditions however the water remained completely fresh (<0.1ppt) from November 2021 through to June 2022.

Table 2: Calculated grades at Wisemans Ferry during the 2021-2022 monitoring period.

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**

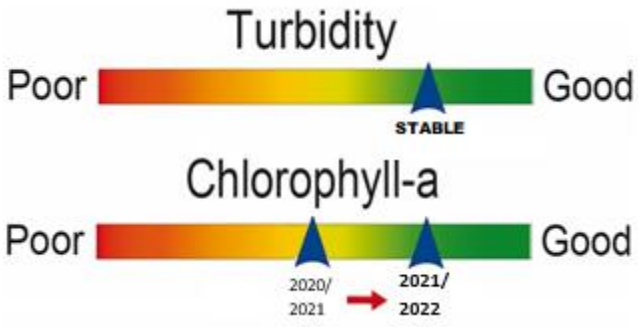


Lower Portland (downstream of Colo River)

Overall water quality observed at the Lower Portland zone remained good during 2021-2022. Only one moderate exceedance of the trigger value was recorded for chlorophyll-a resulting in an improvement in grade from fair in 2020-2021 to good in the most recent round of sampling. Despite the trigger value for turbidity being exceeded on five of the six sampling occasions over summer/autumn, it retained a good grade with only minor exceedances. Salinity recorded at Lower Portland was below 0.2ppt, with a mean salinity of 0.09ppt.

Table 3: Calculated grades at Lower Portland during the 2021-2022 monitoring period.

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**

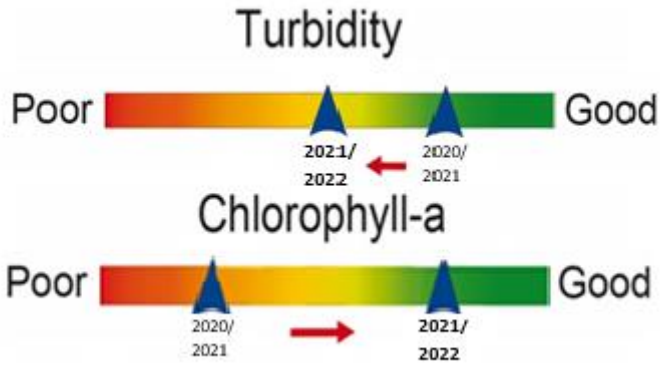


Riverside Oaks (downstream of golf course)

Overall water quality at Riverside Oaks improved from fair in 2020-2021 to good in the 2021-2022 sampling period. This improvement was driven by a two-grade improvement in the chlorophyll-a grade, from poor in 2020-2021 to good in 2021-2022. Only two trigger value exceedances were recorded for chlorophyll-a over summer/autumn. The turbidity grade decreased to fair in 2021-2022, with the trigger for turbidity exceeded on all but one occasion over summer/autumn. Salinity recorded at Riverside Oaks was generally below 0.2ppt, with a mean salinity of 0.11ppt.

Table 4: Calculated grades at Riverside Oaks during the 2021-2022 monitoring period.

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**

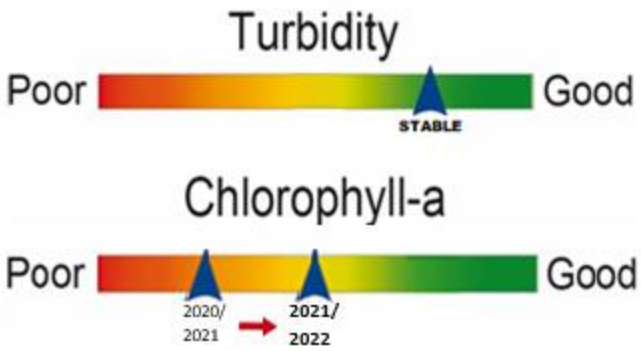


Windsor (upstream of Windsor Bridge)

Overall water quality at Windsor remained fair in the 2021-2022 sampling period, despite an improvement in grade from poor in previous years to fair in 2021-2022 for chlorophyll a. While only one trigger value exceedance was recorded for chlorophyll a, on this occasion the trigger value was exceeded by nearly 450%. The trigger value for turbidity was exceeded on three sampling occasions over summer/autumn, however most of these exceedances were minor to moderate resulting in the grade for turbidity remaining stable (good). Salinity recorded at Windsor was below 0.2ppt, with a mean salinity of 0.09ppt.

Table 5: Calculated grades at Windsor during the 2020-2021 monitoring period.

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**

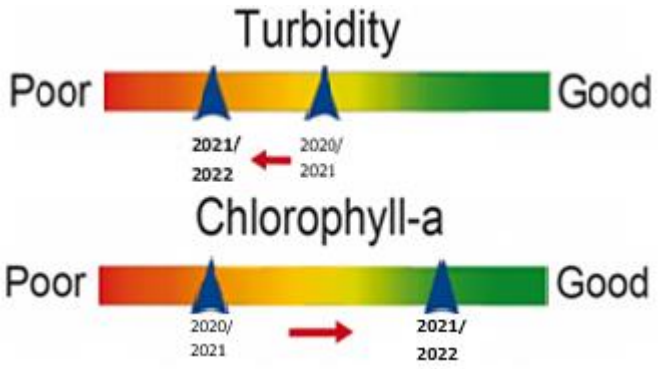


Macdonald River

Overall water quality in the Macdonald River remained fair in 2021-2022. We saw a two-grade improvement from poor to good for the chlorophyll-a grade during 2021-2022, with only two moderate exceedances recorded. Turbidity decreased a grade from fair in 2020-2021 to poor in 2021-2022, as the trigger value was exceeded on all but one occasion over the summer/autumn. The mean salinity recorded at the Macdonald River site was 0.15ppt, with a minimum salinity 0.07 ppt. A maximum recorded salinity of 0.44ppt was recorded in October 2021. Like the Wisemans Ferry site, this site normally exhibits brackish estuarine conditions however the site remained completely fresh (<0.1ppt) from November 2021 through to June 2022.

Table 6: Calculated grades in the Macdonald River during the 2021-2022 monitoring period.

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**



Summary

Overall, we saw the overall water quality grade remaining stable at all sites apart from Riverside Oaks, which improved from fair in 2020-2021 to good in the 2021-2022 sampling period. The chlorophyll-a grades generally improved in 2021-2021 with all sites receiving a good grade except for Windsor which received a fair grade. The turbidity grade decreased at Wisemans Ferry, Riverside Oaks and Macdonald River, while the grade at Lower Portland and Windsor remained stable (good).

It has been shown that chlorophyll-a concentrations within the Hawkesbury are generally flow dependent. The improvements we saw in chlorophyll-a grades were driven by the increase flows we had during 2021-2022. The increased flows were a result of a combination of well above average rainfall, combined with continual water releases from Warragamba Dam. Increased flows resulted in increased turbidity in the upper Hawkesbury River leading to the decline in turbidity grade observed at Wisemans Ferry, Riverside Oaks and Macdonald River.

While the overall water quality at the Macdonald River zone remained stable at fair, we saw another decline in the turbidity grade at this site, with this site graded as poor in 2021-2022. This is surprising for this site as generally the Macdonald River zone had performed better than those in the main river stem due to its catchment being much less disturbed than that of the main river stem and many of the tributaries feeding into it. The Macdonald River and its catchment were impacted heavily by the March 2022 flood event, more so than the major flood in 2020 and 2021.

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 2021-2022 in the Upper Hawkesbury Water Quality monitoring program was dominated by very high flows (top 5 percent) as a result of increased rainfall, combined with numerous water releases from Warragamba Dam (Table 2 and Figure 2). Flow conditions leading up to and at the time of sampling are important for determining primary drivers in the system (e.g., residence times, external vs internal nutrient supply, external TSS inputs etc.) that in turn impact on health indicators.

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	26/10/2021	423	320	350
Trip 2	2/12/2021	7875	19565	13925
Trip 3	22/12/2021	4162	7607	14810
Trip 4	12/01/2022	12980	17293	10727
Trip 5	6/04/2022	8791	17507	18167
Trip 6	28/04/2022	8106	8102	9104
Trip 7	12/05/2022	7788	5616	6791
Trip 8	15/06/2022	4337	6986	7639

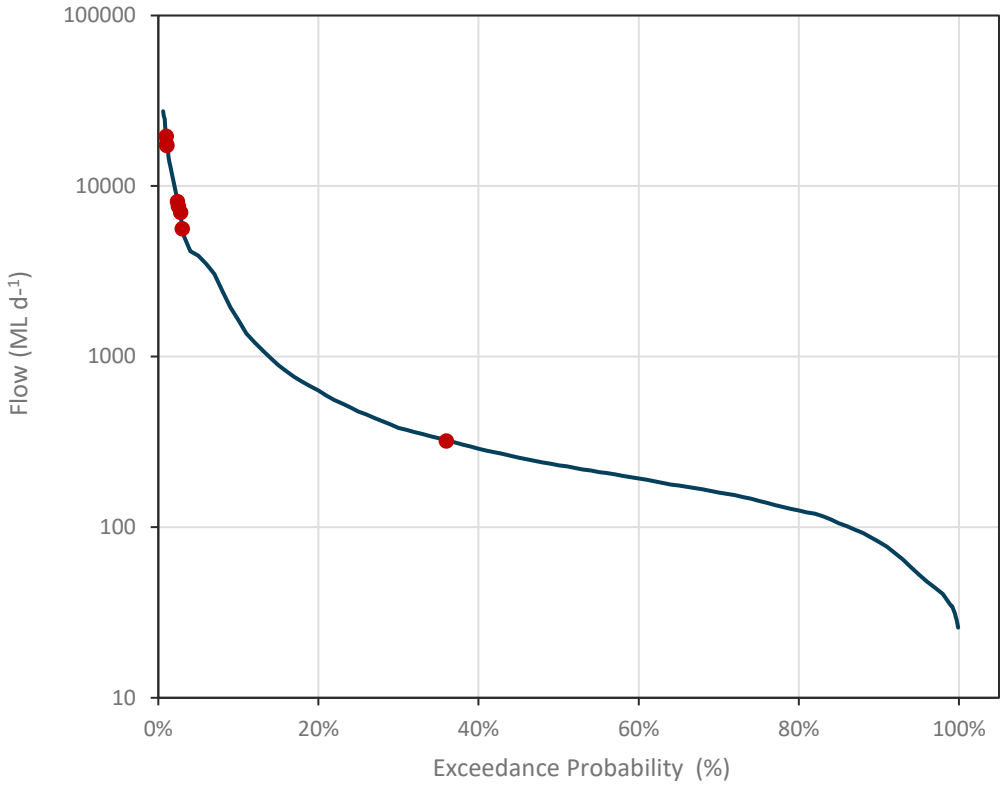


Figure 2: Flow exceedance curve for Nepean River at Penrith Weir (blue line), showing flows during sample times (orange dots).

System State

During the study period (October 2021 to June 2022) the Hawkesbury River was flow dominated. During this sampling season we saw flows in the top 5% of the flow exceedance curve for all but the first sampling trip in October 2021 (Table 7 and Figure 2). This resulted in typically brackish estuarine conditions at the Wisemans Ferry site being absent with water remaining completely fresh from November 2021 through to June 2022 (Figure 5 and Figure 6).

Due to Covid 19 lockdown the first sample event didn't occur until the end of October 2022. Flow at this time was moderate, with slight brackish estuarine conditions extending to Wisemans Ferry. The second sampling trip occurred at the beginning of December, following a period of high flows from rainfall and dam releases from Warragamba in November which resulted in the brackish/freshwater interface being displaced downstream of Wisemans Ferry. All remaining sampling occasions occurred during high flows (top 5% of the flow exceedance curve) as a result of rainfall and dam releases. Two flood peaks were experienced in the first half of 2022 (early and mid-March 2022) resulting in major flooding of the upper Hawkesbury River and tributaries. This also limited our ability to sample water quality and resulted in no sampling being conducted in February & March. The final sampling on 15/6/2021 occurred following average rainfall, however continued dam releases from Warragamba kept flow high (Table 7).

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). Phytoplankton biomass was slightly elevated throughout the upper to mid tidal pool following seven weeks of lower flows in September and October 2021 (Figure 5), as residence times increased and water clarity improved. We saw a slight increase in phytoplankton biomass at all sites in December 2021, following a small decrease in flow and an increase in water temperature associated with the onset of summer

With flows recorded in the top 5% of the flow exceedance curve for all but the first sampling trip in October 2021 (Table 7 and Figure 2), we generally observed relatively low phytoplankton biomass during the 2021 to 2022 sampling period (Figure 3 and Figure 5).

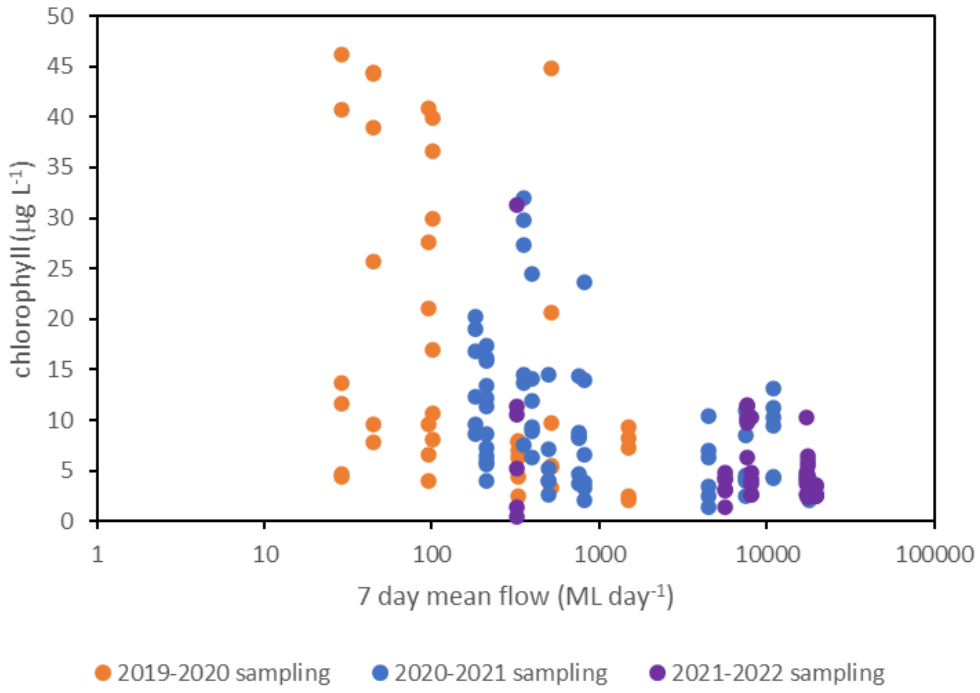


Figure 3: Flow vs chlorophyll-a for all site sampled as part of the 2019-2020 (represented by orange dots), 2020-2021 (represented by blue dots) and 2021-2022 (represented by purple dots) Upper Hawkesbury water quality monitoring program.

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 in McDonald River was highly variable (Figure 5 and Figure 6), with large spikes observed following increase in flows (Figure 5).

Turbidity tends to increase throughout the system during floods/freshets, with rapid recovery at the brackish/freshwater interface due to flocculation/sedimentation (Figure 4 and Figure 5).

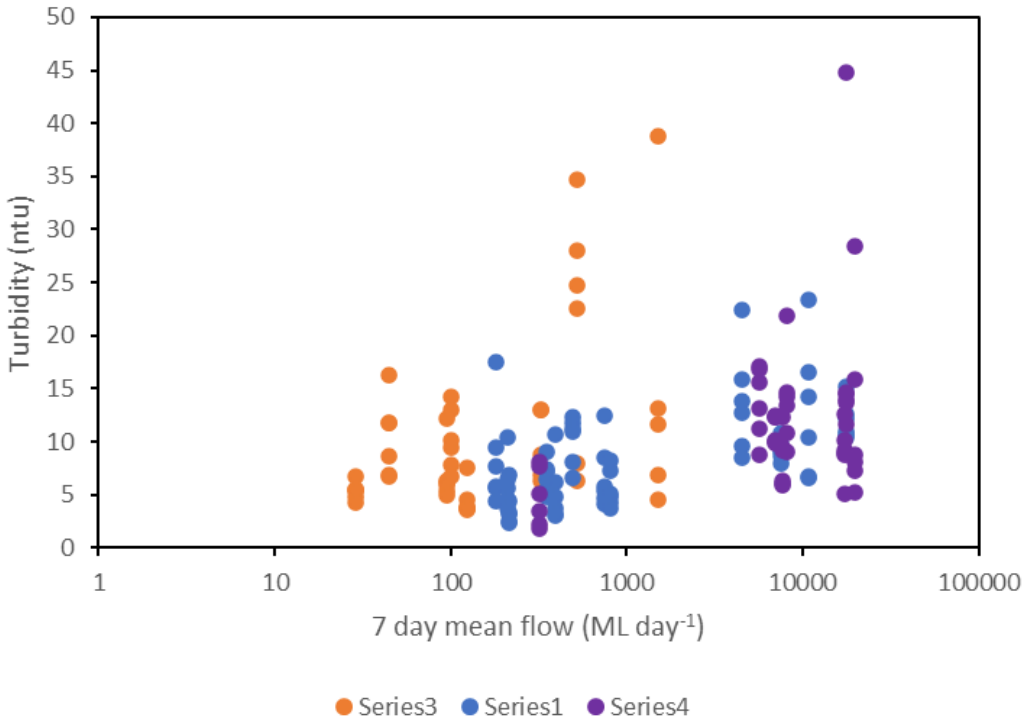


Figure 4: Flow vs turbidity for all site sampled as part of the 2019-2020 (represented by orange dots), 2020-2021 (represented by blue dots) and 2021-2022 (represented by purple dots) Upper Hawkesbury water quality monitoring program.

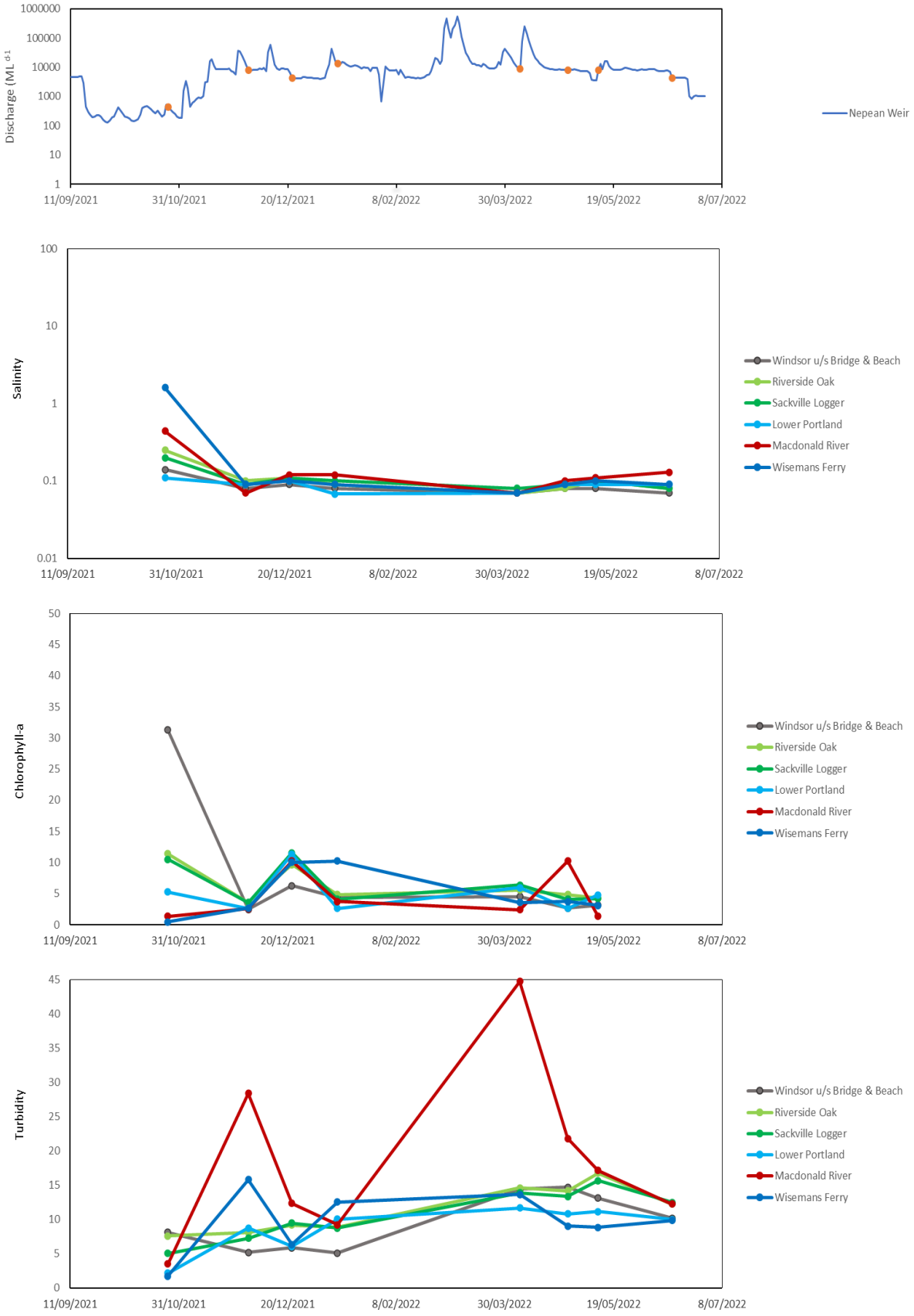


Figure 5: Temporal trends in water quality across monitoring sites during the 2021-2022 sampling period.

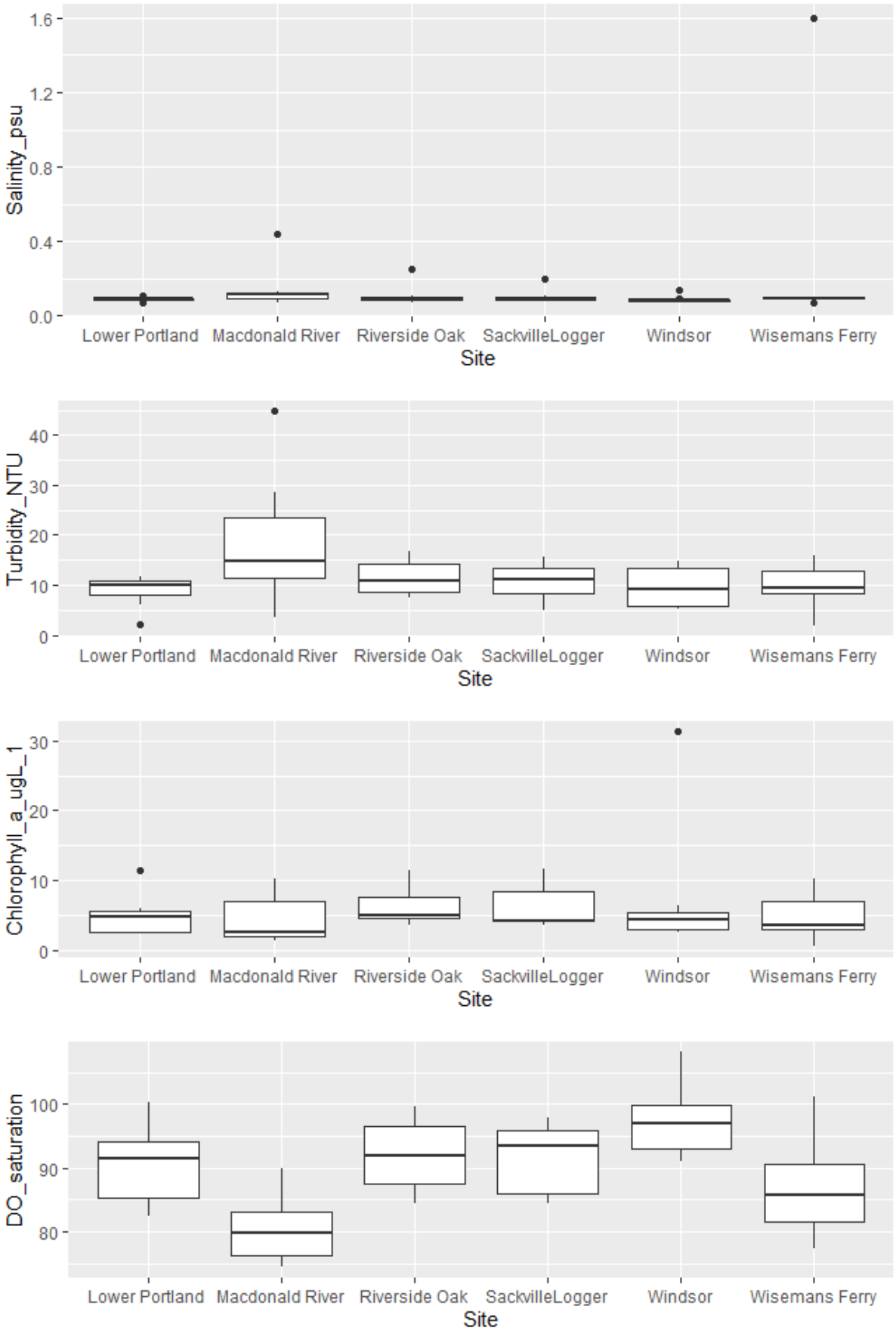


Figure 6: Spatial trends in water quality across monitoring sites during the 2021-2022 sampling period.

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