

ANNUAL BITTERROOT MAINSTEM LONG-TERM TRENDS MONITORING REPORT

2021



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1. 2021 QA/QC Report for Bitterroot River Monitoring (MDEQ)

1.0 INTRODUCTION

This report presents 2021 nutrient and benthic algae monitoring results from the Bitterroot River Long-Term Trends Monitoring Project (BTMP) collected by the Bitterroot River Protection Association (BRPA), under guidance from the Montana Department of Environmental Quality (MDEQ), and in partnership with the Clark Fork Coalition (CFC), which assists with data management and reporting. This report also summarizes and presents results of quality assurance and quality control analysis by MDEQ. The purpose of the report is to present monitoring results and assess compliance with water quality targets.

2021 represented the third year of what is envisioned as a long-term monitoring effort on the Bitterroot River. Further analysis of annual results from this monitoring program will be accomplished on a five-year schedule with a statistical evaluation and trends analysis. The first 5-year trends report is anticipated in 2024 and will include data from 2019 through 2023.

2.0 HISTORY AND BACKGROUND

MDEQ completed Total Maximum Daily Loads (TMDLs) for the Bitterroot River watershed beginning with the 2003 Upper Lolo Creek TMDLs. The Bitterroot Headwaters TMDLs (the West and East Forks of the Bitterroot River) were completed in 2005. In 2011, DEQ completed the Bitterroot Temperature and Tributary Sediment TMDLs and in 2014 completed the remaining Bitterroot Watershed TMDLs.

In 2019, the Bitterroot watershed became the Water Quality Division's Nonpoint Source Program priority watershed for a 2-3 year timeframe (MDEQ 2019a). More detail about concurrent water quality improvement activities and objectives can be found within the Pilot Level I Priority: Bitterroot Watershed Protect Plan (MDEQ 2019b). A major focus of the priority project includes tracking nutrient trends on the mainstem Bitterroot River, which led to the creation of the BTMP.

3.0 MONITORING PROGRAM

The sampling design and primary objective of this monitoring effort is to detect long-term trends in nutrient and benthic algae chlorophyll concentrations in the Bitterroot River. Additional details on the project's objectives can be found in the Quality Assurance Project Plan (MDEQ 2021).

The objectives will be met by:

1. **Summer monitoring:** The BRPA collects nutrient samples, TSS, and field constituents in summer at six sites on the Bitterroot River on eight sampling occasions – twice monthly, July through October.
2. **Benthic algae monitoring:** The BRPA, with assistance from the UM Watershed Health Clinic, collects summer benthic algae samples for chlorophyll-*a* and ash-free dry weight at six sites on the Bitterroot River in early August and September.

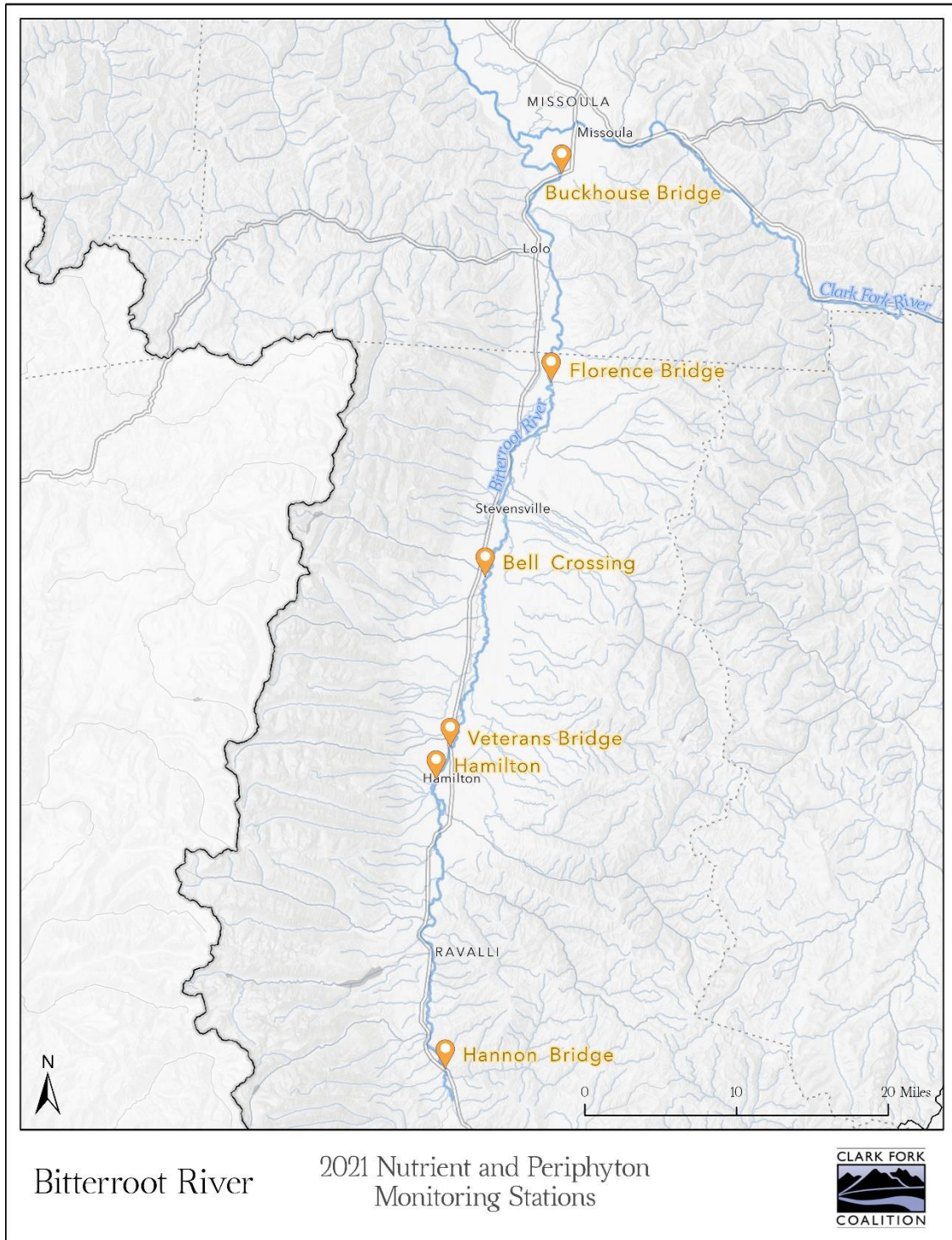
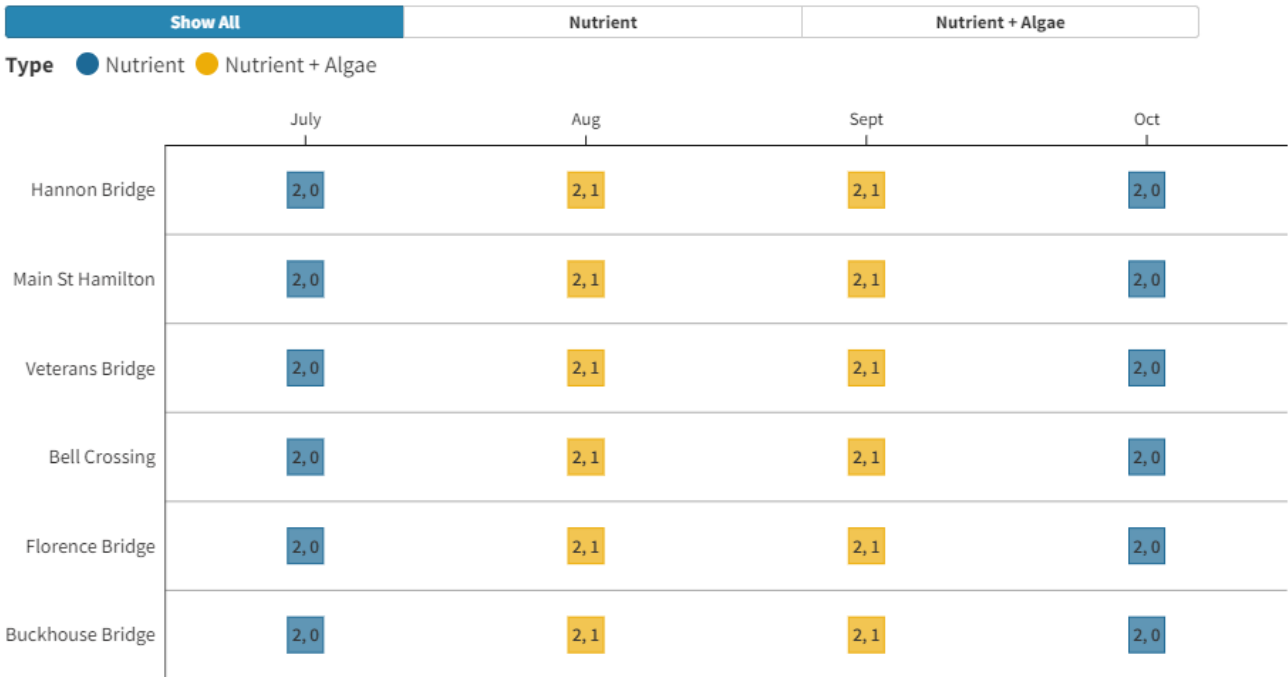


Figure 1. 2021 Bitterroot River Nutrient and Periphyton Monitoring Sites.

2021 Bitterroot River: Nutrient and Benthic Algae Sampling Frequency

Counts of Samples per Month (Nutrient, Benthic Algae)



Note: Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 2. Count of samples and type of monitoring conducted at each station for the 2021 Bitterroot River nutrient and benthic algae monitoring season. [Interactive graphic link.](#)

Specifically, the BTMP measures:

- Nutrients: total phosphorus (TP), total persulfate nitrogen (TPN), nitrate + nitrite nitrogen (NO₂+NO₃-N), ammonia nitrogen (NH₃+NH₄-N), and soluble reactive phosphorus (SRP).
- Total Suspended Solids (TSS).
- Field parameters: water temperature (°C), dissolved oxygen (mg/l), pH (standard units), redox potential (mv), specific conductance (µs/cm), total dissolved solids (mg/l), and turbidity (NTU).
- Benthic algae: chlorophyll-*a* (mg/m²) and ash-free dry weight (g/m²).

All nutrient samples were analyzed by Energy Laboratory in Helena, MT, and benthic algae samples were analyzed by the UM Watershed Health Clinic. Sampling, QA/QC and analytical methods are described in the QAPP (MDEQ, 2022). The **QA/QC Report for 2021 Bitterroot Mainstem Long-Term Nutrient Trends Monitoring** is attached to this report. Monitoring station locations are displayed in both **Table 1** and **Figure 1**. Nutrient samples were collected at all six stations twice a month from July to October, with monthly algae sampling in August and September, as displayed in **Figure 2**. Rationale for sampling locations is explained in more detail in the QAPP (MDEQ, 2022).

All 2021 project data are available in interactive format on the project website:

<https://storymaps.arcgis.com/stories/e1f6335c0e61443182e545c2cf240a80>. This StoryMap, created by the Clark Fork Coalition, presents data from this report along with other nutrient monitoring efforts in the region. Additionally, most figures presented in this report are available in a digital and interactive format as well (linked in this document).

Table 1: BTMP Monitoring Locations, from upstream to downstream

Station	Name/Location	Latitude	Longitude
COMBITR02	Bitterroot River at Buckhouse Bridge	46.83194	-114.05306
COMBITR03	Bitterroot River at Florence Bridge	46.63309	-114.05096
BITR-C05BITRR24	Bitterroot River at Bell Crossing	46.4436	-114.12630
COMBITR04	Bitterroot River at Veterans Bridge, Hamilton*	46.2792	-114.1606
BITR-C05BITRR03	Bitterroot River at Main Street, Hamilton	46.2475	-114.17722
BITR-C05BITRR06	Bitterroot River at Hannon Memorial Bridge	45.9725	-114.1411

*Veterans Bridge is not formally part of the BTMP. The site is part of a separate BRPA monitoring program and data from the site are included in this report courtesy of BRPA. Note that sites in Table 1 are listed in downstream to upstream order starting at Buckhouse Bridge.

4.0 DATA QA/QC SUMMARY

All laboratory and field data were reviewed and validated per guidance in the QAPP (Department of Environmental Quality, 2022) attached to this report. This section briefly summarizes the results. The overall project data had:

- 1 Total Nitrogen result had a result at or above the LRL
- 51 results J flagged for result value between the MDL and LRL, meaning they are estimated values.
- 2 Total Nitrogen, mixed forms results were B flagged for field blank contamination
- 14 Total Phosphorus results J flagged for MS/MSD failed high, expect high bias

No results during the 2021 field season were rejected for analysis. The overall project sample completeness rate for sites included in the QAPP is 98.9%, well over the required 90% in the SAP.

5.0 NUTRIENT TARGETS

The Total Maximum Daily Load (DEQ, USEPA 2014) established the following nutrient targets for the mainstem of the Bitterroot River:

- Total phosphorus as P: 30 µg/L
- Total Nitrogen as N: 300 µg/L

DEQ also uses 100 ug/L nitrate + nitrite as a benchmark for assessment purposes on the Bitterroot River. When concentrations are equal or greater than 100 ug/L during the growing season it can be assumed that the stream is saturated for nitrate and detrimental eutrophication impacts may ensue (Suplee 2013).

Although no targets currently exist for algal growth in the Bitterroot River, targets developed for the Clark Fork River as part of the Voluntary Nutrient Reduction Program may be useful to provide context for interpretation of chlorophyll-a results and are included here for that purpose:

- (Summer mean) - Benthic 100 mg/square meter algal chlorophyll-a

- (Maximum) - Benthic 150 mg/square meter algal chlorophyll-a

6.0 NUTRIENT RESULTS

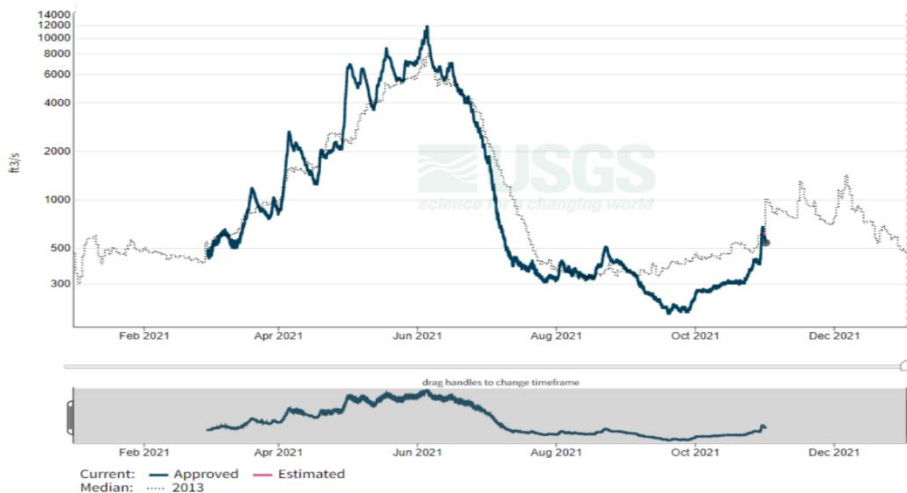
Streamflow conditions during spring runoff and summer months influence nutrient concentrations and algal densities. Years with less-than-average peak flows and early summer low flows typically see higher algal densities, and conversely, years with higher peak flows tend to produce less algal density. **Figure 3** presents three 2021 annual hydrographs (including the median daily flow for the period of record at each site) from stations in the study area, arranged upstream to downstream, to provide context for interpreting nutrient and algae results (USGS, 2021).

In general, discharge in the Bitterroot River during 2021 closely tracked with the historical average, though the rising limb of all three hydrographs included several mini-peak flow events on the way to the actual annual peak, which at all three locations was slightly higher than average. Summer and early fall saw slightly lower than average discharge at all three locations, except for a short event of higher than average flows in late August (**Figure 3**).

Bitterroot River near Missoula 12352500



Bitterroot River at Bell Crossing near Victor MT 12350250



Bitterroot River near Darby MT 1234400

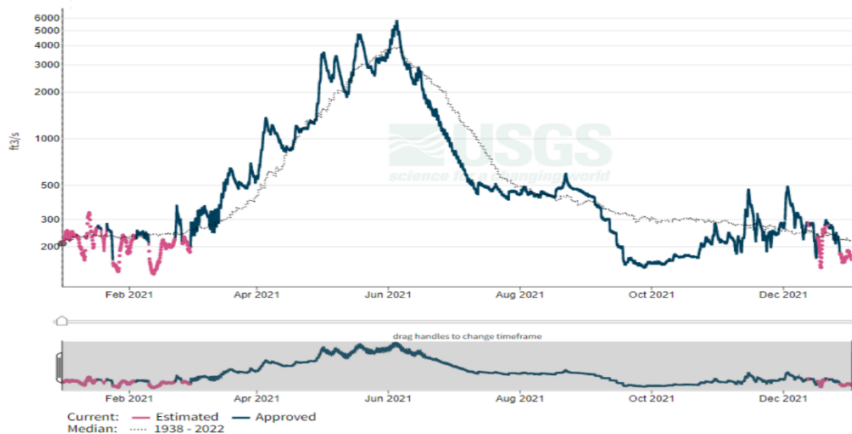


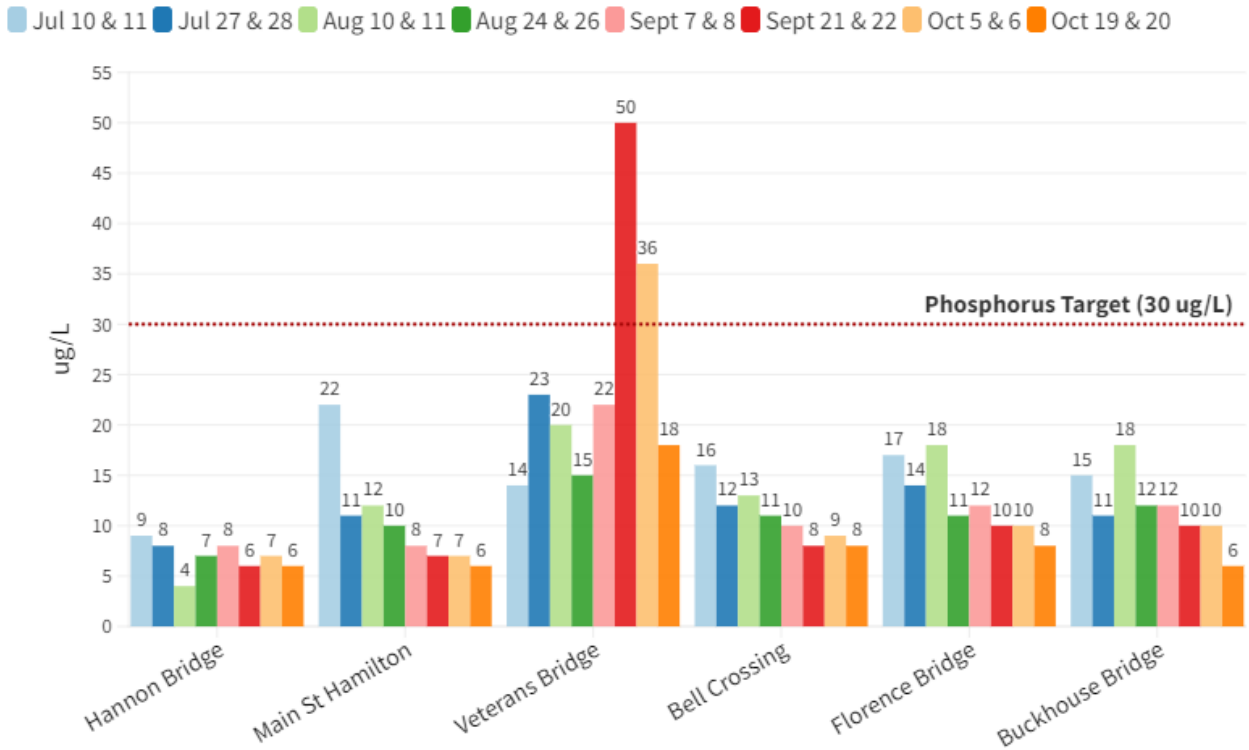
Figure 3. 2021 Hydrographs from USGS continuous monitoring stations (USGS, 2022).

6.1 TOTAL PHOSPHORUS

Results of total phosphorus (TP) monitoring are presented in **Figure 4**. TP concentrations were below the target of 30 ug/l on all but two occasions at the late September and early October monitoring events at the Veterans Bridge sampling locations in 2021. Concentrations were generally below 20 ug/l at all stations besides Veterans Bridge, except in early July at Main St with 22 ug/l.

2021 Bitterroot River: Total Phosphorus

July - October Sampling



Note: Sites appear in upstream to downstream order from Hannon to Buckhouse.

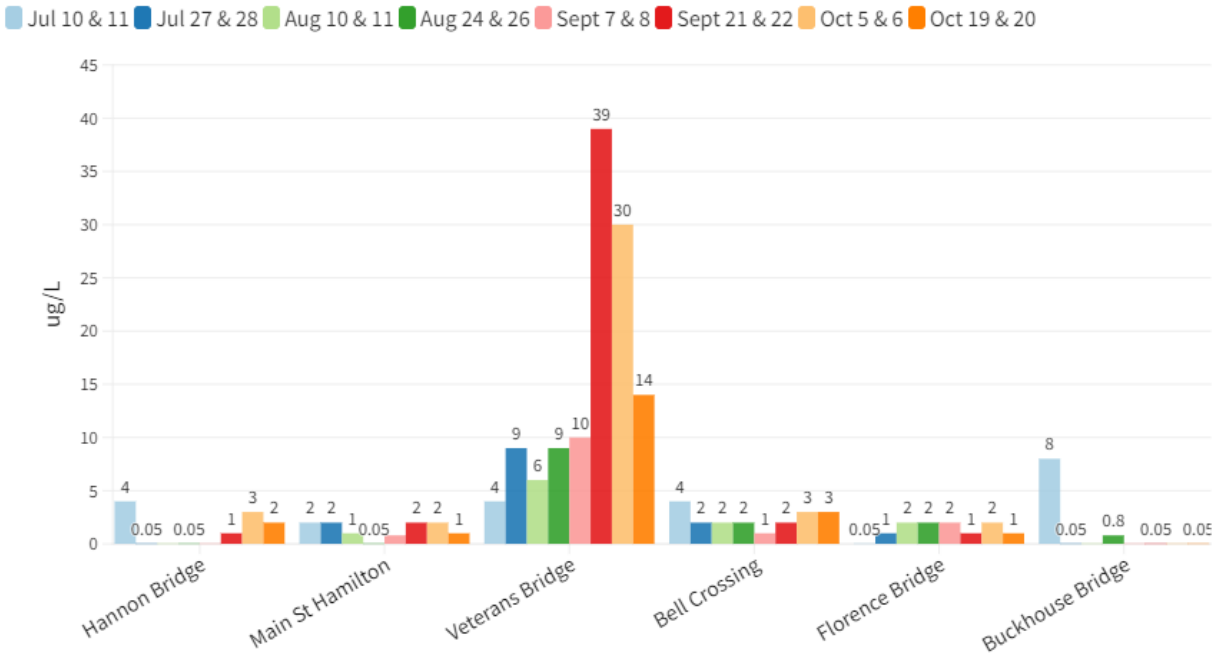
Figure 4. Bitterroot River: 2021 Total Phosphorous. [Interactive graphic link.](#)

6.2 SOLUBLE REACTIVE PHOSPHORUS

Soluble Reactive phosphorous (SRP) results are presented in **Figure 3**. SRP concentrations were generally 10 ug/l or less, except in late September through October at Veterans Bridge, where concentrations ranged from 14 to 39 ug/l.

2021 Bitterroot River: Soluble Reactive Phosphorus

July - October Sampling



Note 1: 40 of 48 SRP samples were flagged for exceeding method holding time. All samples are displayed in the figure.

Note 2: Samples below detection are shown at ½ the lower reporting limit of 1 µg/L.

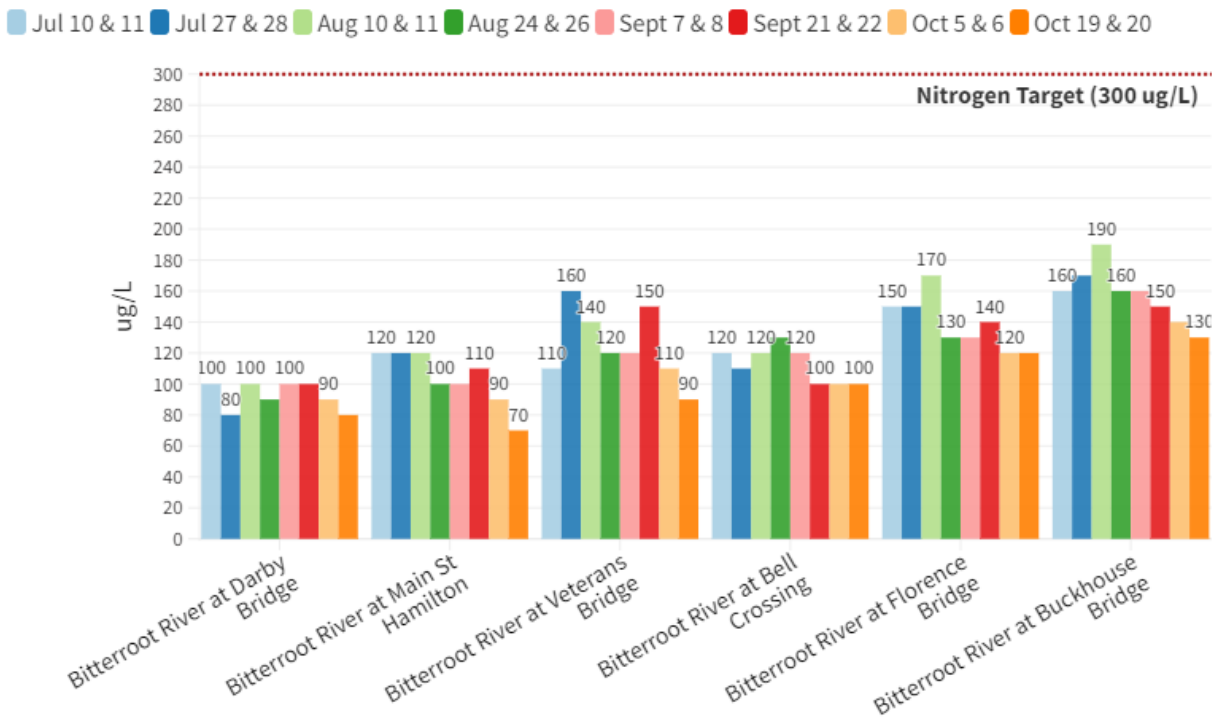
Figure 5. Bitterroot River: 2021 Soluble Reactive Phosphorus. [Interactive graphic link.](#)

6.3 TOTAL NITROGEN

Results of total persulfate nitrogen (TPN) monitoring are presented in **Figure 6**. TPN concentrations were below the target of 300 µg/l at all sites and on all occasions for 2021. TPN was slightly higher at the two downstream sites, Florence and Buckhouse, than it was at the four upper sites.

2021 Bitterroot River: Total Nitrogen

July - October Sampling



Note: Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 6. Bitterroot River: 2021 Total Persulfate Nitrogen. [Interactive graphic link.](#)

6.4 NITRATE + NITRITE

Results of nitrate + nitrite monitoring are presented in **Figure 7**. There are no numeric standards for nitrate + nitrite, but as discussed in Section 5.0, MDEQ uses 100 µg/L as a benchmark for assessment purposes. Nitrate + nitrite concentrations were well below this benchmark on all sampling occasions in 2021. Nitrate + nitrite as a percentage of total nitrogen is shown in **Table 2**.

Table 2: Nitrate + nitrite as a percentage of total nitrogen.

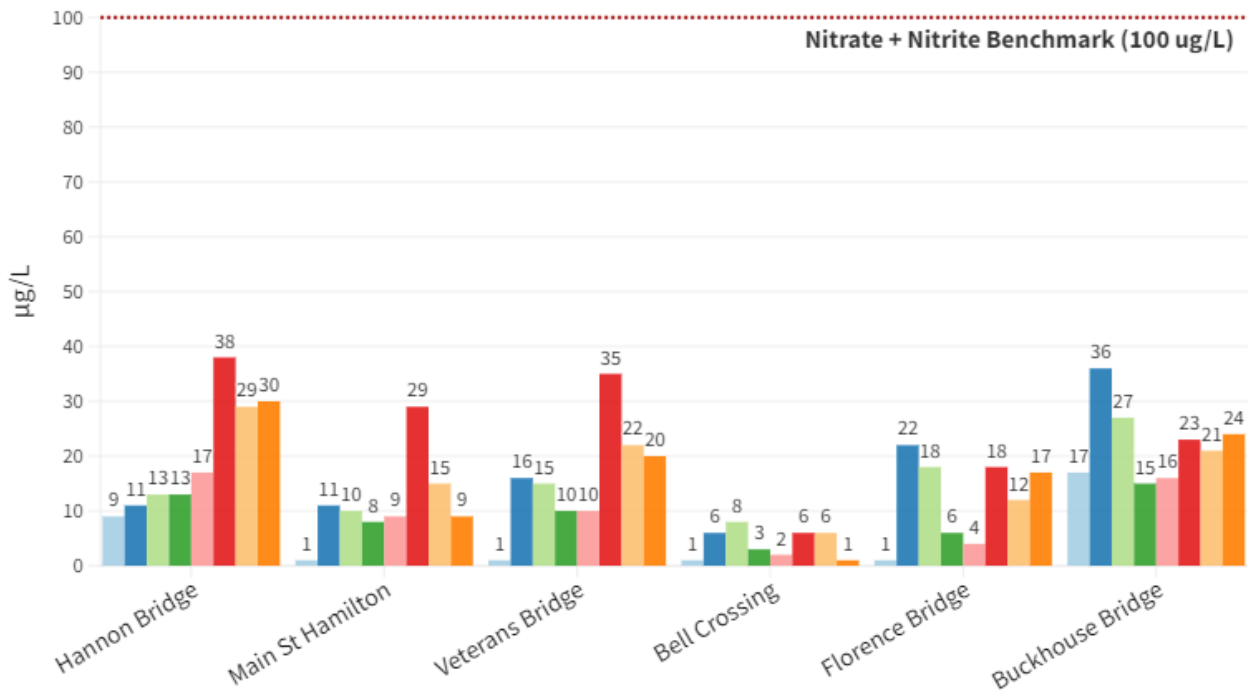
Site	Average Nitrate + Nitrite	Average Total Nitrogen	Mean Percentage Nitrate + Nitrite of Total Nitrogen
Hannon	20	92.5	22%
Hamilton Main Street	11.5	103.75	11%
Veterans Bridge	16.13	125	13%
Bell Crossing	4.13	112.5	4%
Florence	12.25	138.75	9%
Buckhouse Bridge	22.38	157.5	14%

(Note: below detect values calculated at ½ detection limit)

2021 Bitterroot River: Nitrate + Nitrite

July - October Sampling

■ Jul 10 & 11
 ■ Jul 27 & 28
 ■ Aug 10 & 11
 ■ Aug 24 & 26
 ■ Sept 7 & 8
 ■ Sept 21 & 22
 ■ Oct 5 & 6
 ■ Oct 19 & 20



Notes: Samples below detection are shown at 1/2 the lower reporting limit of 2 µg/L. Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 7. Bitterroot River: 2021 Nitrate + Nitrite. [Interactive graphic link.](#)

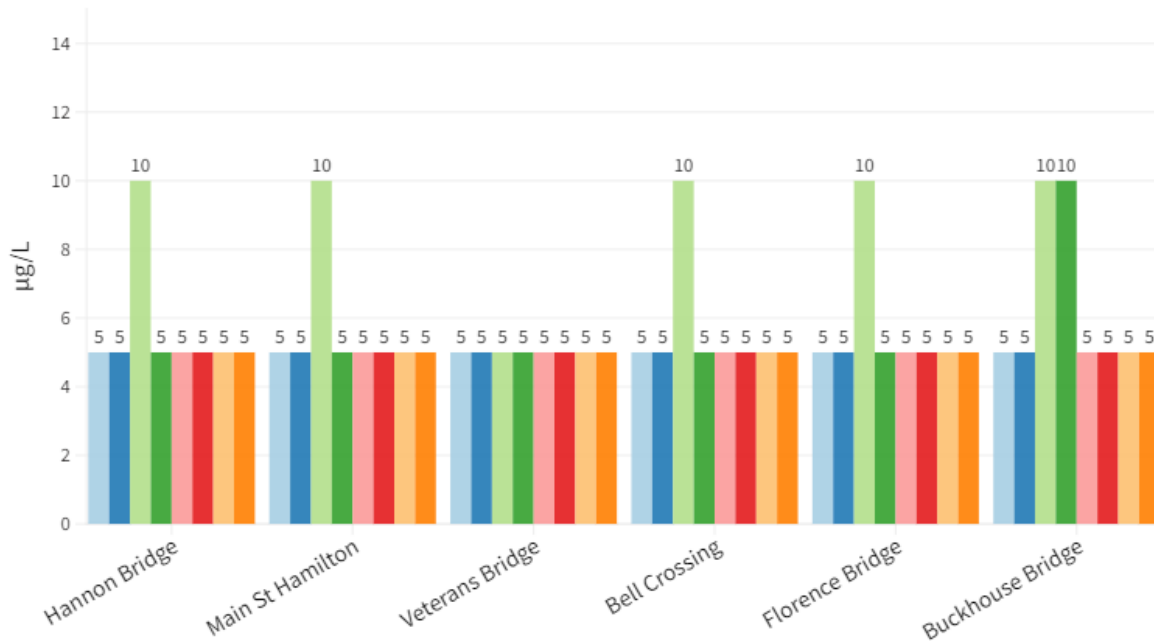
6.5 AMMONIA

Results of ammonia monitoring are presented in **Figure 8**. Concentrations were generally undetected (reported at ½ the lower reporting limit of 10 µg/L) with the highest recorded samples of 10 µg/L at 5 of the 6 stations.

2021 Bitterroot River: Ammonia

July - October Sampling

■ Jul 10 & 11
 ■ Jul 27 & 28
 ■ Aug 10 & 11
 ■ Aug 24 & 26
 ■ Sept 7 & 8
 ■ Sept 21 & 22
 ■ Oct 5 & 6
 ■ Oct 19 & 20



Notes: Samples below detection are shown at 1/2 the lower reporting limit of 10 µg/L. Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 8. Bitterroot River: 2021 Ammonia. [Interactive graphic link.](#)

7.0 NITROGEN – PHOSPHORUS RATIOS

Since the observation of Redfield (1934 and 1958) that marine phytoplankton contains a molecular C:N:P ratio of 106:16:1 (40:7:1 by mass), the relative concentrations of N and P have been used to estimate which of these nutrients might be limiting, preventing additional primary production (algae growth) in aquatic ecosystems. Redfield also recognized that the ratio is an average with considerable variation by species, season, and environment. A departure from this ratio is assumed to imply nutrient deficiency such that by identifying which nutrient is responsible for enhanced algae growth, management actions can be directed toward the nutrient with the highest impact.

It is important to note that the C:N:P ratios in the above literature for benthic algae are for the internal contents of the algal matrix (cellular C:N:P concentration), not water column concentrations. The C:N:P of the benthic algal material is a much better estimator of nutrient limitation than water column TN:TP ratio. This is especially true for benthic algae; while water column total nutrients can be good estimators of optimal stoichiometry for phytoplankton (where suspended algal biomass is a large fraction of the total nutrients in the water column) benthic algae are more loosely coupled with the water column and respond only to bioavailable nutrients.

Total nitrogen-phosphorus ratios (by mass) were calculated for 2021 water column chemistry results and are shown below in **Figure 9**. The N:P Redfield ratio (by mass) is 7:1, and the color-coded thresholds in **Figure 9** are based on the following from Suplee and Watson (2013): *“Studies of benthic algae show that it is necessary to move some distance above or below the Redfield ratio in order to be strongly convinced that a lotic waterbody is P or N limited (Dodds, 2003). When a benthic algal Redfield ratio (by mass) is <6, N limitation is suggested, and when it is >10 P limitation is indicated (Hillebrand and Sommer, 1999). Thus, there is a range of N:P values between about 6 and 10 where one can state, for practical purposes, that algal growth is co-limited by N and P.”*

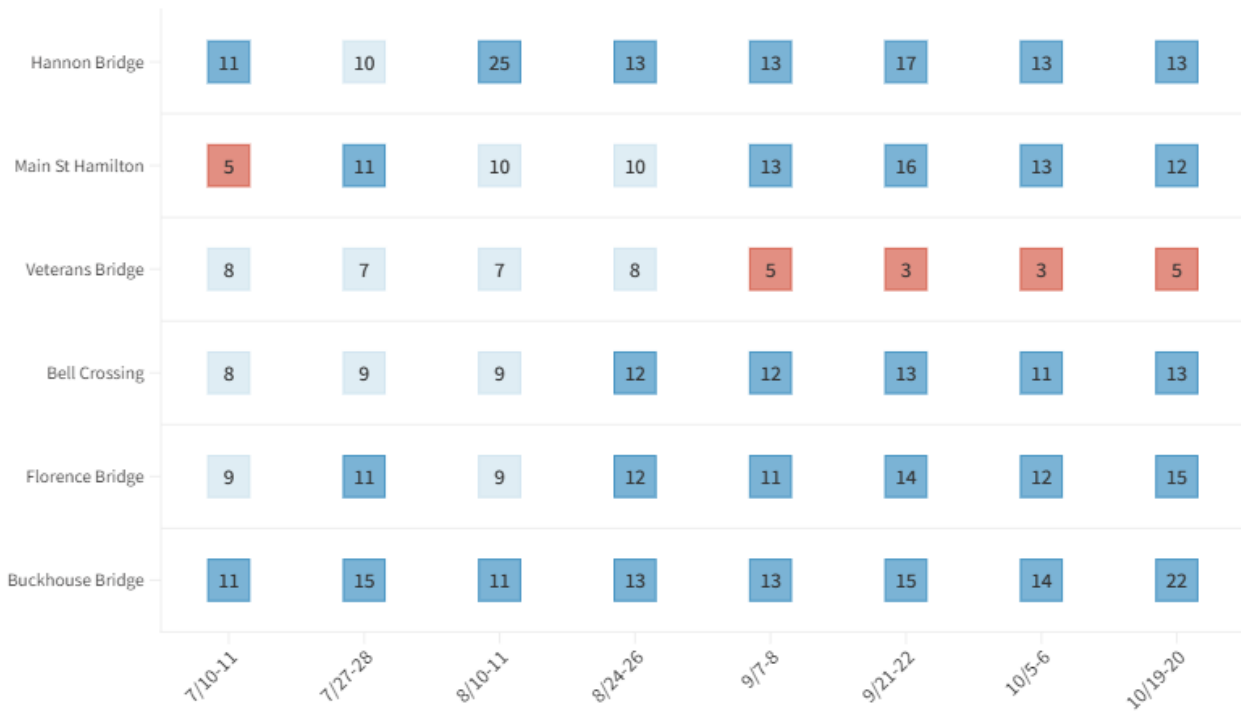
We also include dissolved N: P ratios (by mass) in **Figure 10** with caveats: the Redfield ratio is based on total N: P and the dissolved N:P ratios are simply presented for comparison.

For total N:P ratios, phosphorous limitation was far more common than nitrogen limitation. Nitrogen limitation was evident in only 5 of 48 samples, primarily at Veterans Bridge at the end of the summer/fall. In contrast, 31 samples suggested phosphorous limitation and another 12 were indeterminate. Dissolved N:P ratios were more suggestive of nitrogen limitation, particularly at the two midstream sites of Veterans Bridge and Bell Crossing, where no phosphorous limitation was apparent. At the most upstream and downstream sites, Hannon and Buckhouse, estimated nutrient limitation was more phosphorous limited.

2021 Bitterroot River: Mass-based Ratios for Total Nitrogen:Total Phosphorus in Water Column

July - October Sampling

Limited ● N Limited (< 6) ● N or P Limited (6-10) ● P Limited (> 10)



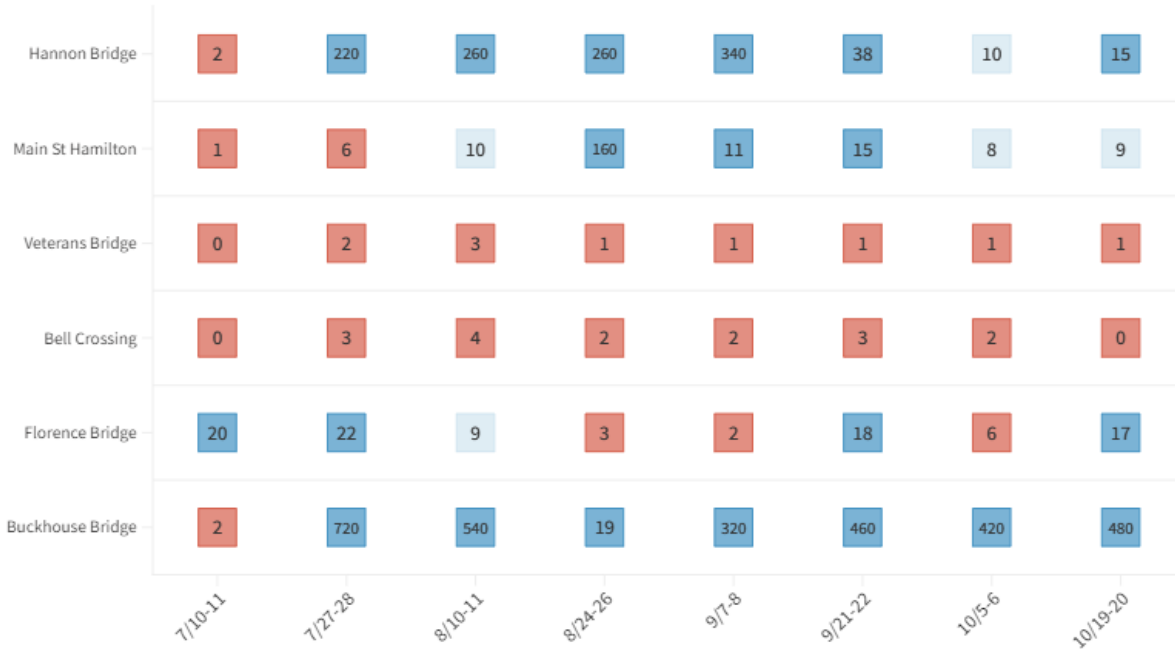
Note: Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 9. Bitterroot River: 2021 Mass-based N:P ratios for Total N:P. [[Interactive graphic link](#)]

2021 Bitterroot River: Dissolved N:P Ratios (Nitrate+Nitrite : Soluble Reactive Phosphorus) in Water Column

July - October Sampling

Limited ● N Limited (< 6) ● N or P Limited (6-10) ● P Limited (> 10)



Note : Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 10. Bitterroot River: 2021 Dissolved N:P Ratios. [\[Interactive graphic link\]](#)

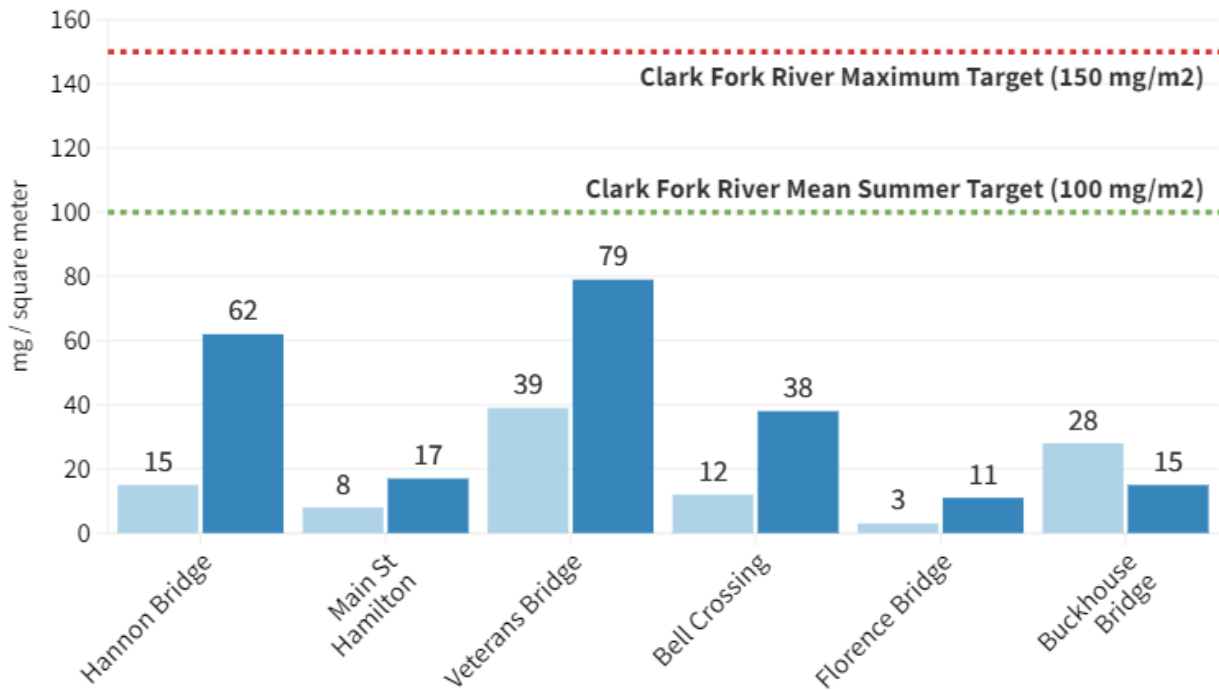
8.0 BENTHIC ALGAE RESULTS

Benthic algae were sampled according to the QAPP at all sites in August and September. Averages for chlorophyll-*a* and ash free dry weight from each sample date are shown in **Figures 11 and 12**. Although no numeric standards for benthic algae chlorophyll-*a* are established for the Bitterroot River, the targets developed for upper Clark Fork River include a summer maximum of 150 mg/m² and a summer mean of 100 mg/m². These targets are included here to provide context for interpreting the Bitterroot results. Chlorophyll-*a* concentrations in the Bitterroot were below both targets at all sites, with the highest concentrations found at Veterans Bridge and Hannon Bridge on the September 1 sampling. AFWD concentrations followed a similar pattern.

2021 Bitterroot River: Benthic Algae Chlorophyll-a

August & September Sampling

■ August 5 & 6 Chl-a ■ September 1 Chl-a

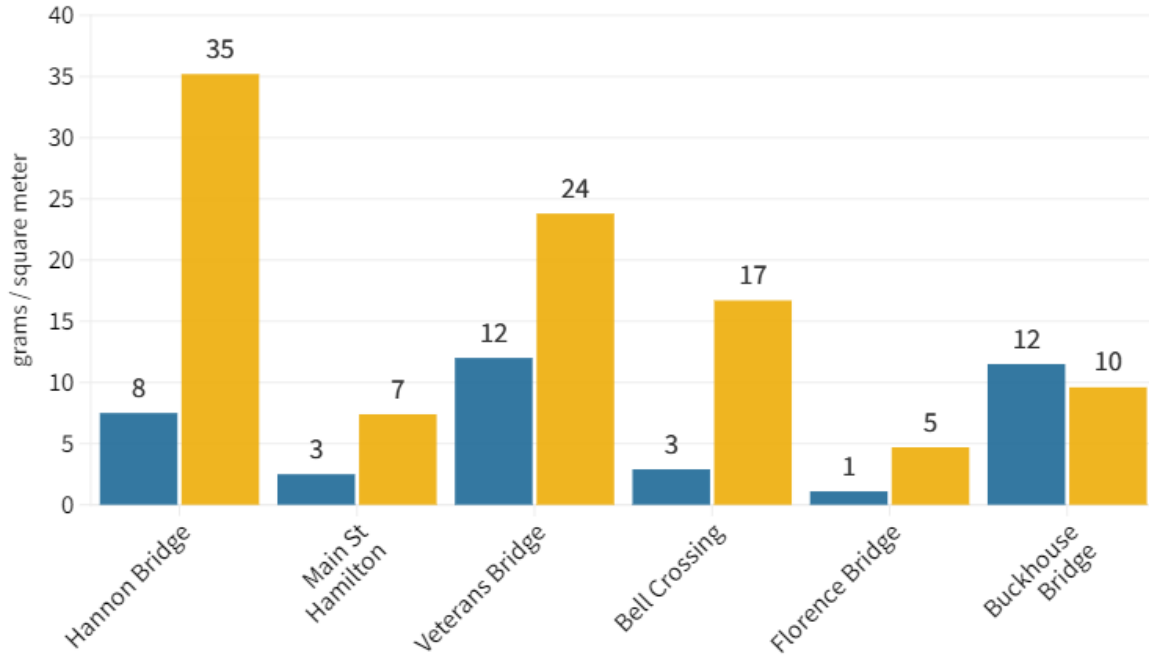


Note: Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 11. Bitterroot River: 2021 Benthic Algae Chlorophyll-a. [Interactive graphic link.](#)

2021 Bitterroot River: Benthic Algae Ash Free Dry Weight August & September Sampling

■ Aug 5 & 6 Weight ■ Sept 1 Weight



Note: Sites appear in upstream to downstream order from Hannon to Buckhouse.

Figure 12. Bitterroot River: 2021 Benthic Algae Ash Free Dry Weight. [Interactive graphic link.](#)

9.0 REFERENCES

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