2019 Monitoring Report for Cascade Reservoir and the North Fork Payette River (HUC 17050123) between Payette Lake and Cascade Reservoir

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Background

In 1996 the Environmental Protection Agency (EPA) approved the Cascade Reservoir Phase I implementation plan (DEQ, 1996) for a Cascade Reservoir total maximum daily load (TMDL), followed by Phase II in 1998 (DEQ, 1998). The implementation plan (Phase I and Phase II) assessed mostly nutrient inputs to Cascade Reservoir through several tributaries, and was mostly driven by the reservoirs issues with excessive blue-green algae growth. In 2005 EPA approved a TMDL for the Payette River (17050122) and the North Fork Payette River (17050123). This TMDL addressed over 2,100 square miles of watersheds, and developed sediment and temperature load allocations in many of the tributaries. In 2011 an addendum to the Cascade Reservoir Tributary TMDL was written to develop sediment load allocations for Gold Fork River, Boulder Creek, and Mud Creek. In 2018 a five year review was written for the Cascade Reservoir Watershed to determine the extent to which water quality targets established in the Phase II TMDL and Cascade Reservoir Tributary TMDL are being achieved. The five year review indicates nutrient levels in the reservoir have remained mostly unimproved dating back to 1993. The reservoir experienced a massive cyanobacterial bloom in the summer of 2018, resulting in a health advisory for the reservoir that lasted from September through October. The advisory sparked a conversation between the public and managing agencies that resulted in additional sampling during the 2019 field season. The sampling encompassed the reservoir and NF Payette River between Payette Lake and Cascade Reservoir. This NF Payette River assessment unit (AU 17050123) was 303(d) listed in the 2016 Integrated Report based on combined biota and habitat bioassessments, requiring further assessment.

Purpose

This document is intended as a brief reporting of data collected in 2019 from both Cascade Reservoir and the NF Payette River between Payette Lake and Cascade Reservoir.

NF Payette River (ID17050123SW016_04)

The NF Payette River was monitored at three sites longitudinally from Payette Lake to Cascade Reservoir. Three sites were chosen to represent three different sections of the AU. All final monitoring locations are shown in Table 1 and Figure 2. Site NFP_1 was moved at the beginning of sampling due to accessibility issues, while NFP_2 and NFP_3 sites remained the same as indicated in the original sampling plan. Each site hosted an Onset Tidbit v2 continuous temperature logger, which collected measurements every fifteen minutes. NFP_3 hosted two temperature loggers for QA/QC purposes. All loggers were quality checked with a NIST data logger prior to deployment, and again after removal. Each site was sampled biweekly for ambient levels of total phosphorus (TP), Total Kjeldahl Nitrogen (TKN), Dissolved Oxygen (DO), pH, Conductivity, and *E. coli*.

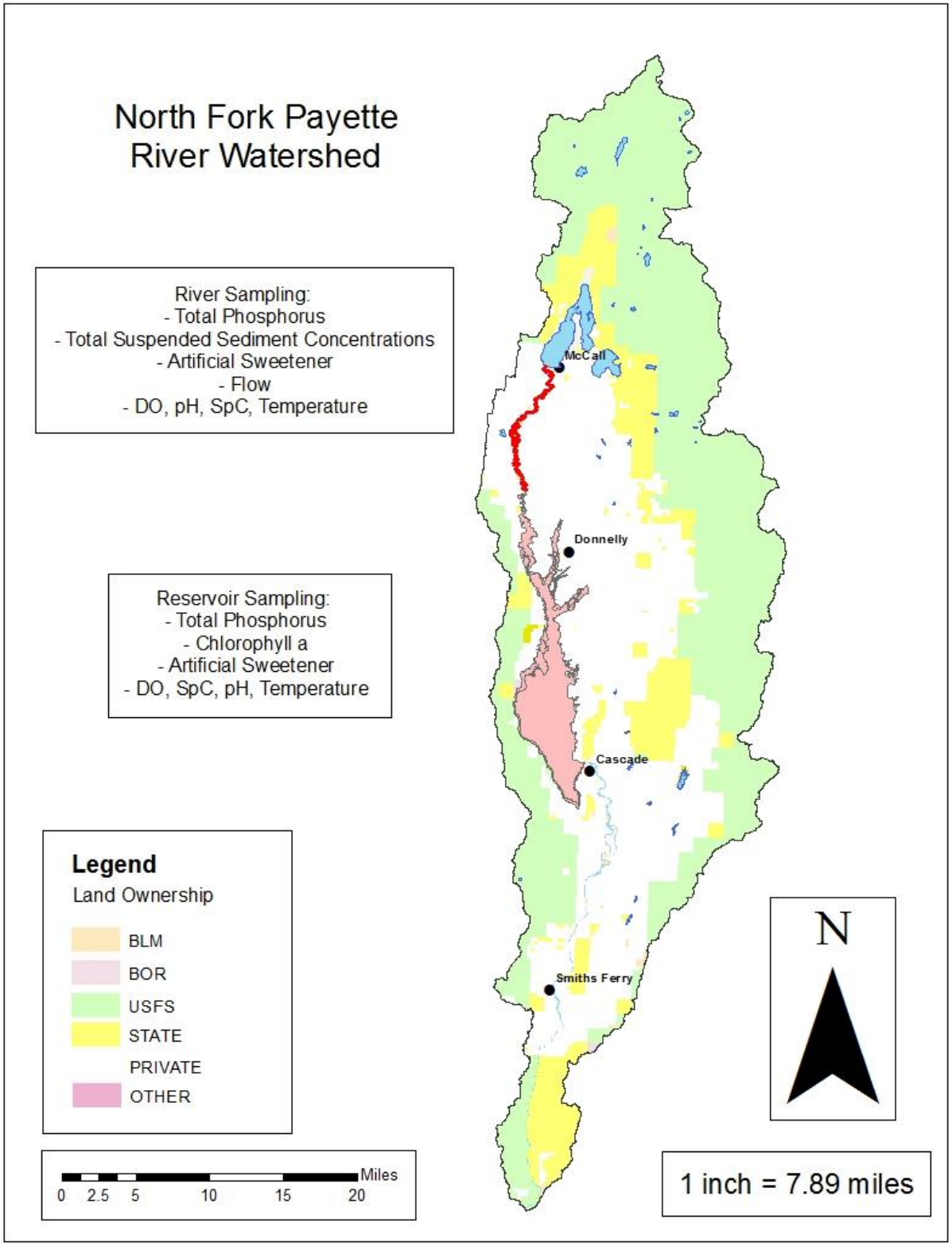


Figure 1. NF Payette River Watershed

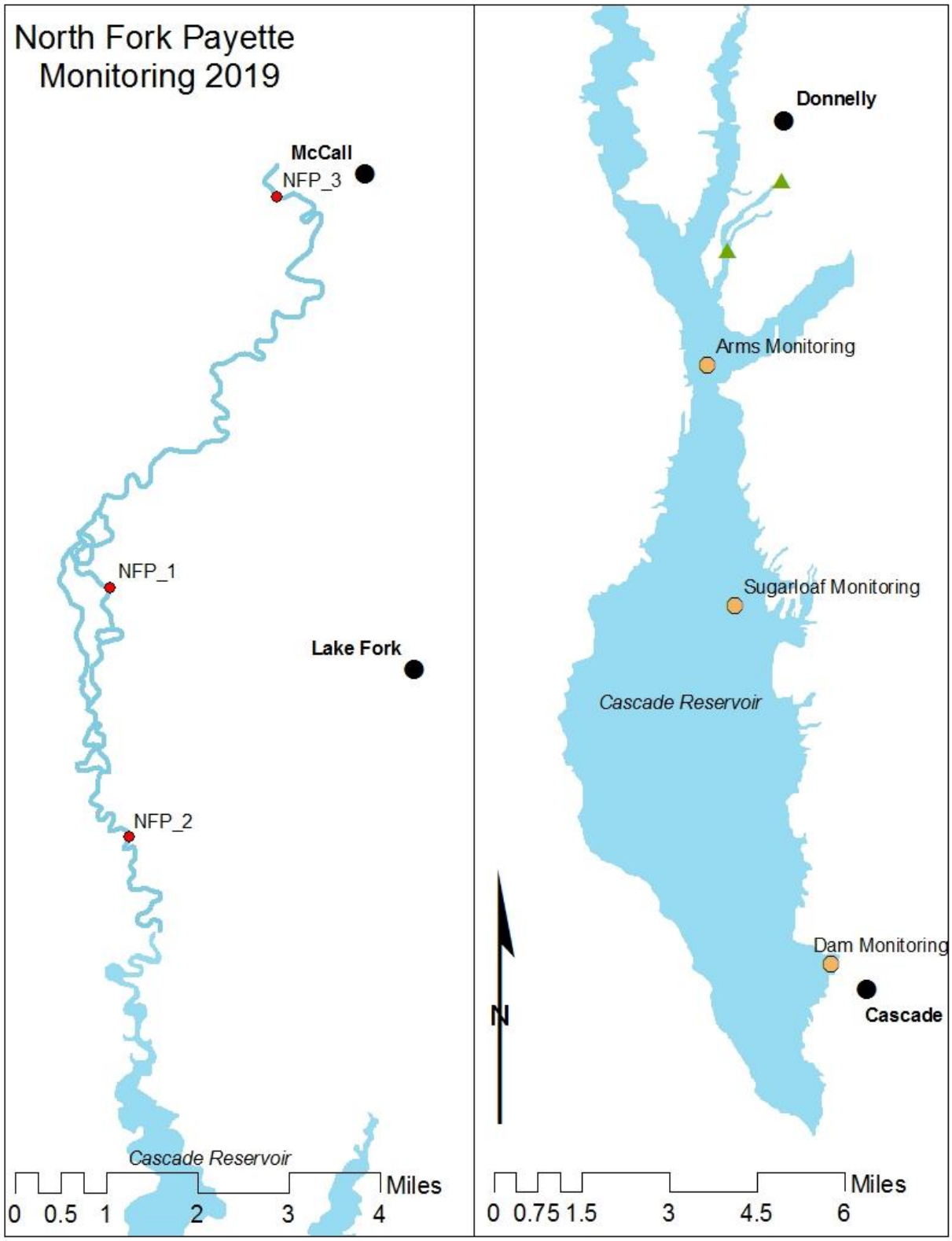


Figure 2. Sampling locations for both the NF Payette River and Cascade Reservoir

Table 1. NF Payette River monitoring locations and parameters.

North Fork Payette River (NFP_1)	ID17050123SW016_04	44.84452	-116.15354	TP, TKN, DO, TSS, pH, Conductivity, *E. coli*, Temp	Continuous for Temperature, Bi-Weekly for all others
North Fork Payette River (NFP_2)	ID17050123SW016_04	44.805	-116.1478	TP, TKN, DO, TSS, pH, Conductivity, *E. coli*, Temp	Continuous for Temperature, Bi-Weekly for all others
North Fork Payette River (NFP_3)	ID17050123SW016_04	44.9076	-116.1193	TP, TKN, DO, TSS, pH, Conductivity, *E. coli*, Temp	Continuous for Temperature, Bi-Weekly for all others

Nutrients

TP and TKN were sampled to represent nutrient concentrations in the NF Payette River. The Cascade Reservoir TMDL sets a TP target at ≤0.025 mg/L for the reservoir and surrounding tributaries. There is currently no TMDL target set for nitrogen concentrations.

The total phosphorus concentrations measured at all sites in the NF Payette River never exceeded the 0.025 mg/L target set for the reservoir and tributaries, as shown in Figure 4. The lowest concentrations were observed at NFP_3, which were consistently measured at non-detect limits (<0.010 mg/L). This site is roughly 700 meters from the Payette Lake outlet, and therefore can likely be explained by the low phosphorus concentrations within the lake. The highest concentrations of total phosphorus were observed at NFP_1, which is located ~9 miles from the Payette Lake outlet. This site falls well below the municipal influences of McCall, and is near the start of larger cattle and agricultural operations. NFP_2 is located closest to Cascade Reservoir. Though it has the potential for the highest accumulation of phosphorus out of all the sites, it does sit in a low-gradient meandering section with large in-channel sediment deposits. As a depositional section of the river, it is possible that phosphorus falls out of suspension and is stored in riverbed sediments before entering the reservoir.

All sites fall well under the target value established in the Cascade Reservoir TMDL, and therefore phosphorus levels are not considered to be a contributing issue in the NF Payette 303(d) listing. TKN, though not included in the Cascade Reservoir TMDL, is a good indicator of organically available nitrogen in the system. We do not have a target or numeric criteria set for TKN, but observed concentrations are not uncharacteristic for a watershed like the NF Payette River.

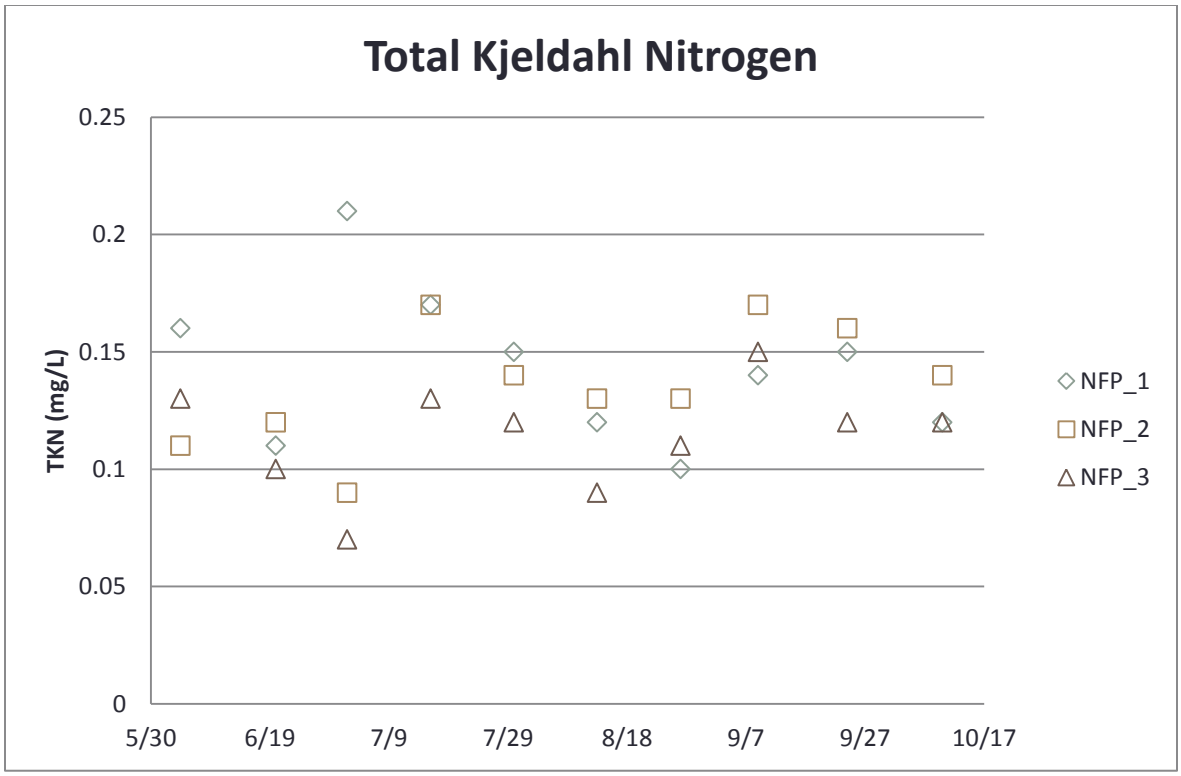


Figure 3. Total Kjeldahl Nitrogen observations across three sites on the NF Payette River in 2019

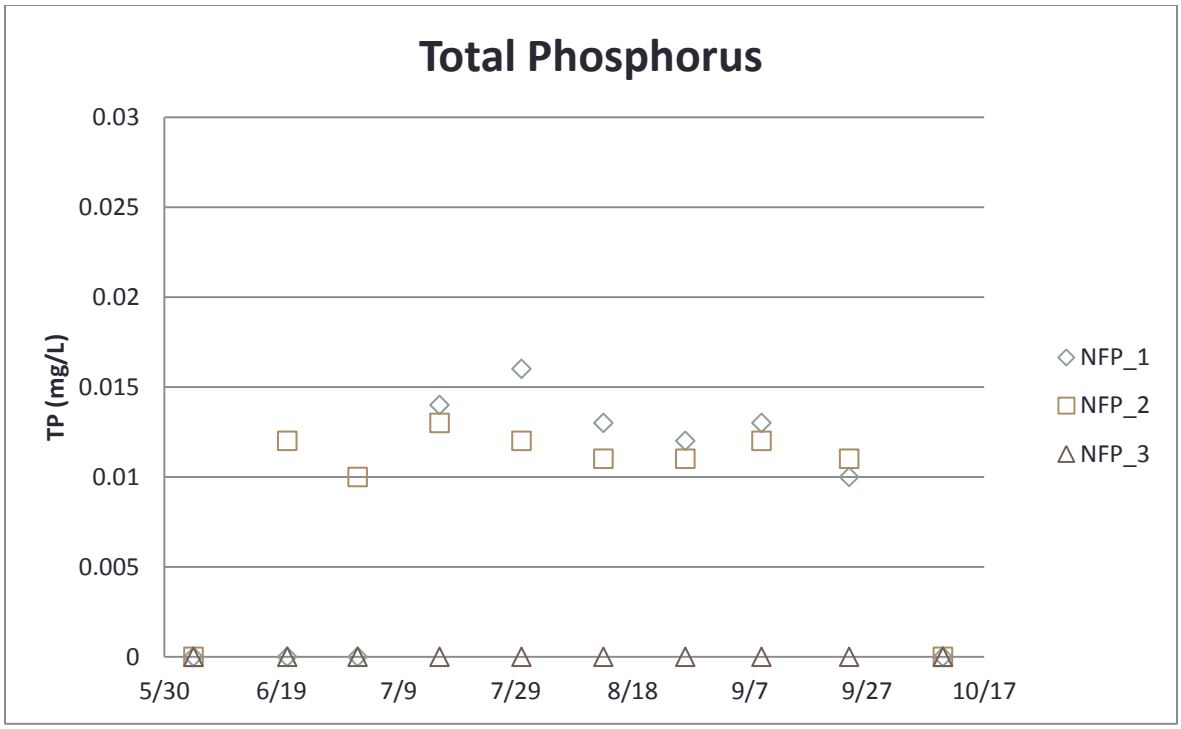


Figure 4. Total phosphorus observations across three sites on the NF Payette River in 2019

E. coli

E. coli was sampled biweekly at all three sites throughout the summer (Figure 5). The highest observed concentration of *E. coli* occurred at NFP_1, equaling 72 colony forming units per 100 milliliters of water (CFU/100 mL). *E. coli* concentrations remained very low throughout sampling, and a geometric mean was never calculated because the single sample maximum for primary contact recreation was never met (406 CFU/100 mL). *E. coli* does not appear to be an impairment to the NF Payette River, and may also provide content for sourcing nutrients.

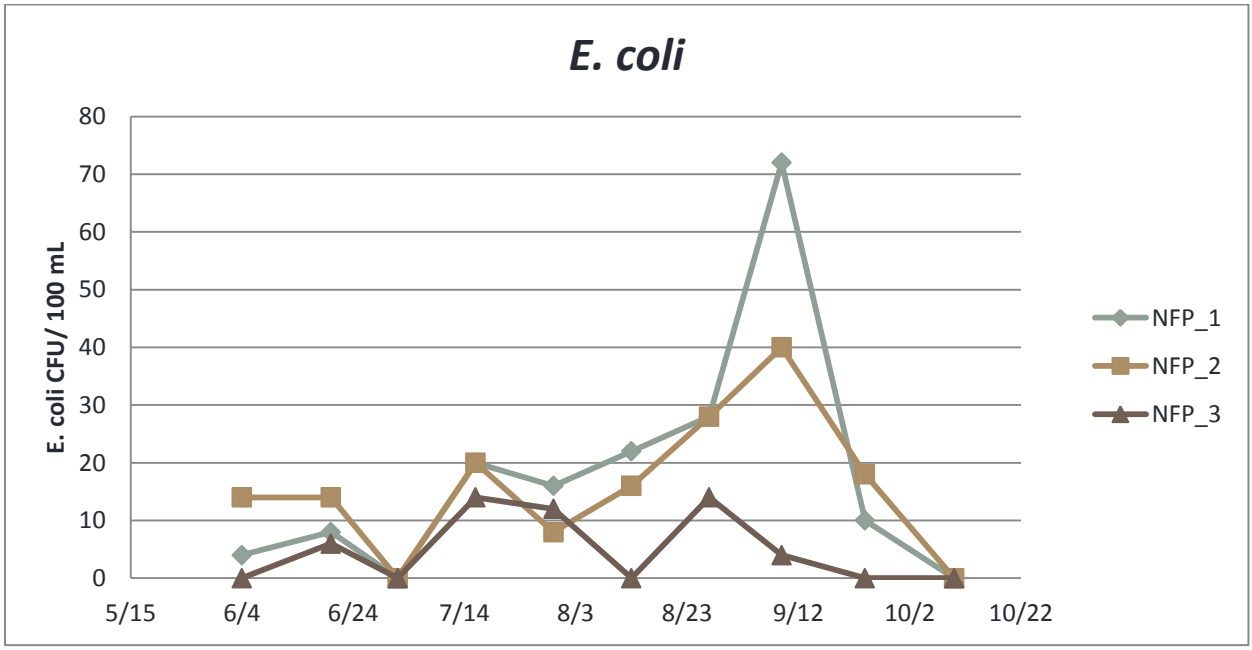


Figure 5. *E. coli* concentrations measured at all three sites of the NF Payette River in 2019

Dissolved Oxygen

Idaho criteria (IDAPA 58.01.02.250.02a) require a minimum of 6 mg/L of dissolved oxygen at all times for aquatic life support. Dissolved oxygen in the NF Payette River was observed to be higher than 6 mg/L throughout most of the monitoring (Figure 6), however, one sample collected from NFP_3 on 7/16/2019 falls at 5.9 mg/L. Because it is a single sample that falls within +/- 0.1 mg/L of the criteria, it is not considered significant without additional measurements indicating low DO. There is a peak in DO just over 16 mg/L in early October which is likely a result of cooler water temperatures and thus higher solubility, while other peaks in DO occurring in June-August are likely attributed to primary production. Additional data could be used to correlate DO levels with plant production, such as chlorophyll – a concentrations. The data indicates that dissolved oxygen is not impaired in the NF Payette River throughout the critical period.

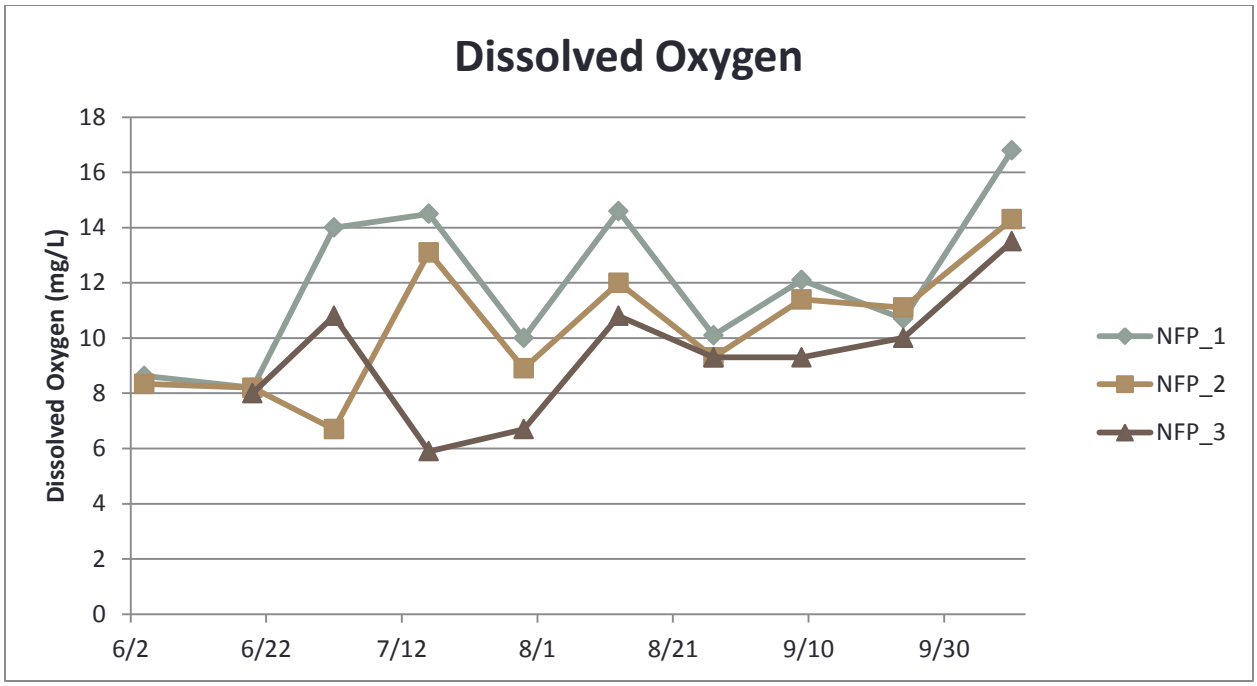


Figure 6. dissolved oxygen concentrations measured at all three sites in the NF Payette in 2019

Total Suspended Solids

Total suspended solids were measured at each site biweekly throughout the summer. Looking at measured concentrations and flow measured at USGS station at McCall, ID (USGS 13239000), loads were estimated for each sampling day (Figure 7). Day one of sampling occurred on June 4, 2019, and day ten occurred on October 10, 2019. The highest TSS loads occurred during the first day of sampling, likely due to higher spring flows, but dropped significantly with flow and remained consistently low throughout the remainder of the summer.

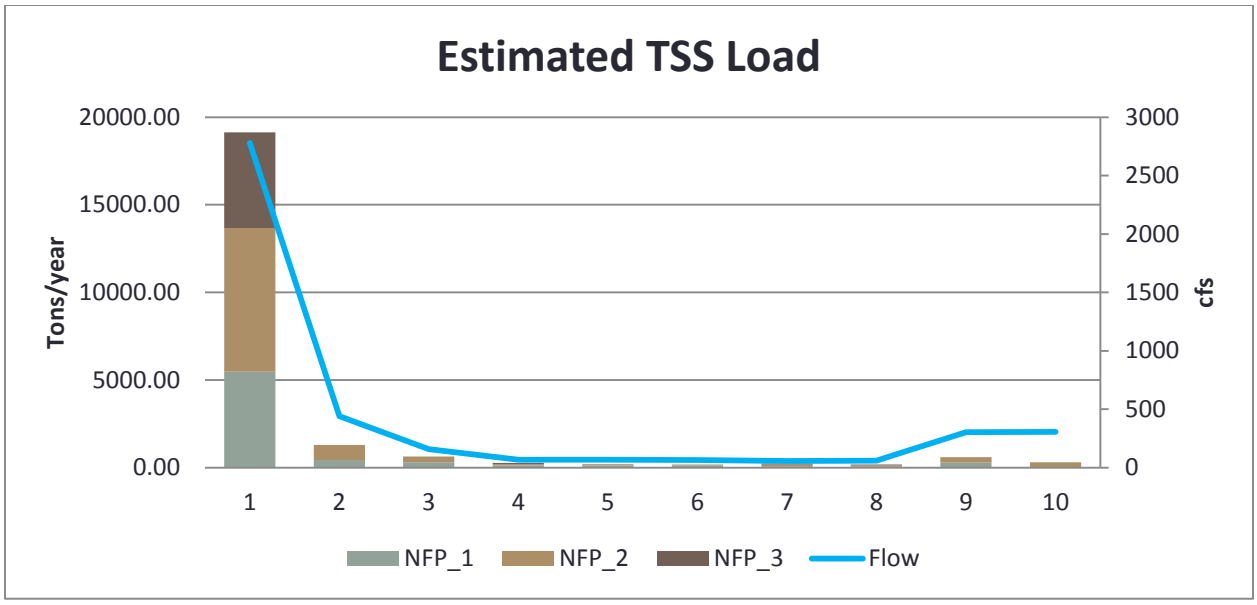


Figure 7. Estimated TSS load for all sites for each sampling day.

Monitoring also indicates a higher average load produced at NFP_2 (Figure 8), which is the most down-river site located at Smylie Lane Bridge. There are several factors that could be contributing to that higher average. Being the furthest down-river site there could be a higher volume of water moving through the site, however, the site sits in a lower gradient depositional zone; apparent from the large meanders and depositional bars found throughout much of the river bed. A more likely contributing factor could be an increased prevalence of eroding banks observed between NFP_1 and NFP_2. Further streambank erosion inventories would need to be assessed for a better understanding of scale and distribution of bank erosion.

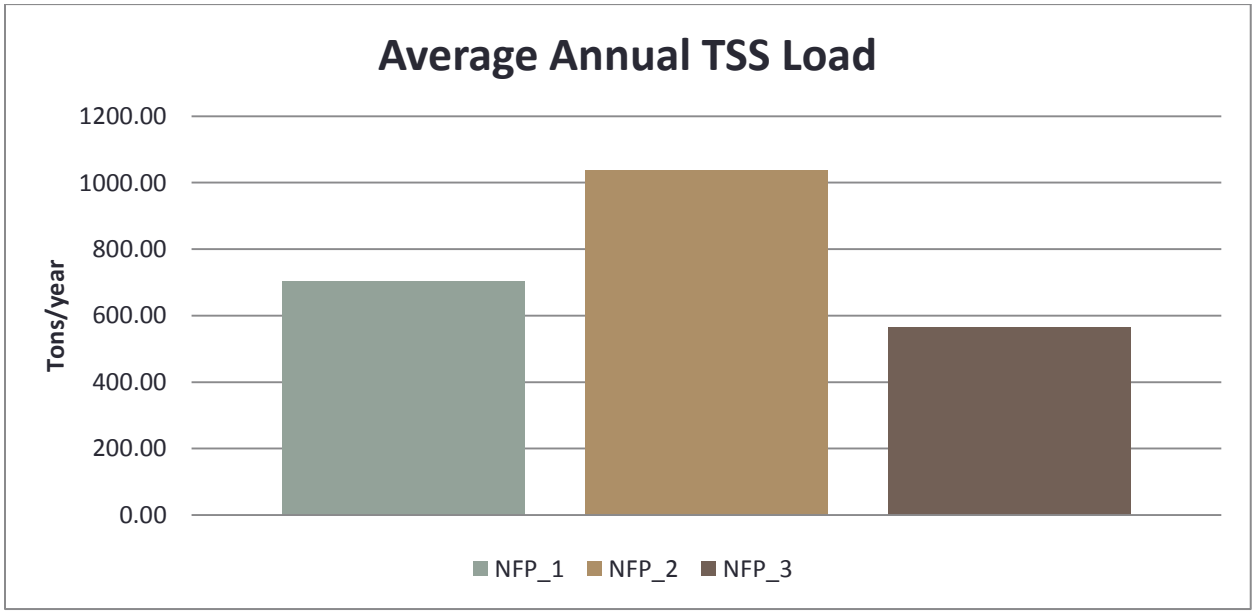


Figure 8. Average annual TSS loads estimated from TSS samples collected between June and October.

Conductivity

Conductivity is not covered in Idaho's water quality standards, but can be a good indicator of total dissolved solids (TDS). Additionally, conductivity can be a good indicator of water quality and inputs to the water. Higher conductivity can be indicative of higher inputs of pollutants, such as fertilizers and industrial byproducts. Extremely high conductivity can be indicative of poor fish presence and diversity. It is important to note that conductivity remained extremely low throughout monitoring at all sites, as shown in Figure 9. NFP_3 stayed remarkably consistent between 15 and 20 µS/cm, while NFP_1 and 2 saw an increase at the beginning of sampling and decrease again at the end of sampling. The increase seen at 1 and 2 could be correlated with decreases in flow and increases again at the end of the season; assuming water coming from Payette Lake has relatively low conductance and is essentially diluting the river. Although the lower conductivity makes it difficult to assess fish diversity and size distributions, it also further supports the findings on low nutrients. It is likely the background conditions for conductivity in the area are low.

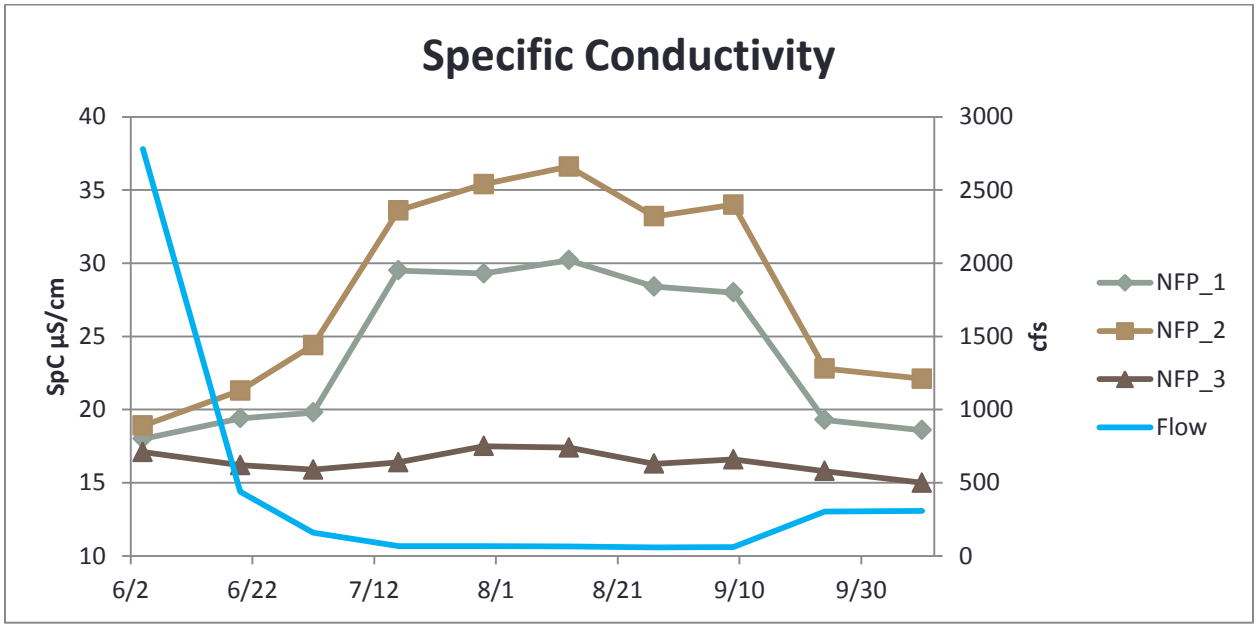


Figure 9. Measured specific conductivity at all sites throughout the summer, with flow.

Water Temperature

Water temperature was collected at all three sites from June-October using Onset Tidbits. During the sampling, water levels dropped significantly on two different occasions leaving two gaps in the data. Temperature data was compared with an additional duplicate logger at site NFP_3, and loggers were quality checked pre and post deployment using a NIST logger with similar specifications. Sites were assessed for Cold Water Aquatic Life (COLD), which requires water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C (IDAPA 58.01.02.250.02b). Sites were also assessed for Salmonid Spawning (SS), which requires water temperatures of thirteen (13) degrees C or less with a maximum daily average no greater than nine (9) degrees C (IDAPA 58.01.02.250.02fii).

NFP_1

The highest daily maximum temperature observed at NFP_1 was 24.6°C, exceeding the COLD criteria by over 2°C; while the mean daily maximum was 18.6°C. The highest daily average was 21.7°C and the mean daily average was 16.5°C. The maximum COLD criterion of 22°C was exceeded in 24% of the observations, and the average 19°C criteria was exceeded in 36% of the observations. The maximum Salmonid Spawning criterion of 13°C was exceeded 95% of the time, and the average 9°C criteria was exceeded 100% of the time. Twenty one days were evaluated under the Salmonid Spawning period.

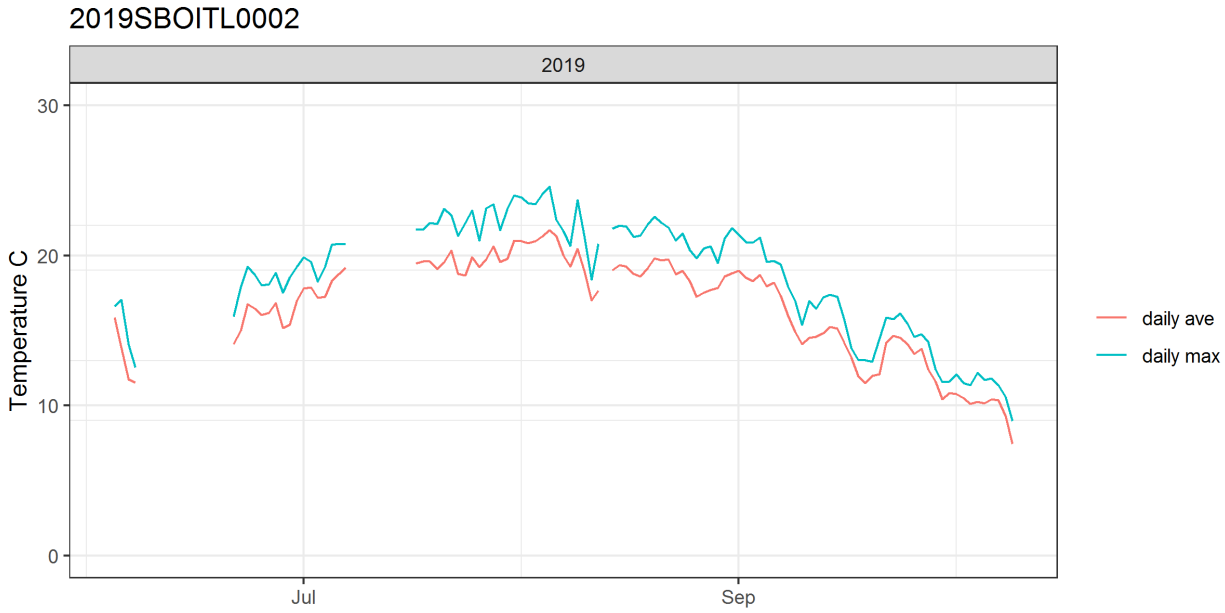


Figure 10. Daily average and maximum temperatures observed throughout the summer of 2019 at NFP_1.

NFP_2

The highest daily maximum temperature observed at NFP_2 was 24.5°C, exceeding the COLD criteria by over 2°C; while the mean daily maximum was 17.8°C. The highest daily average was 21.4°C and the mean daily average was 15.5°C. The maximum COLD criterion of 22°C was exceeded in 19% of the observations, and the average 19°C criteria was exceeded in 24% of the observations. The maximum Salmonid Spawning criterion of 13°C was exceeded 24% of the time, and the average 9°C criteria was exceeded 78% of the time. Thirty six days were evaluated under the Salmonid Spawning period.

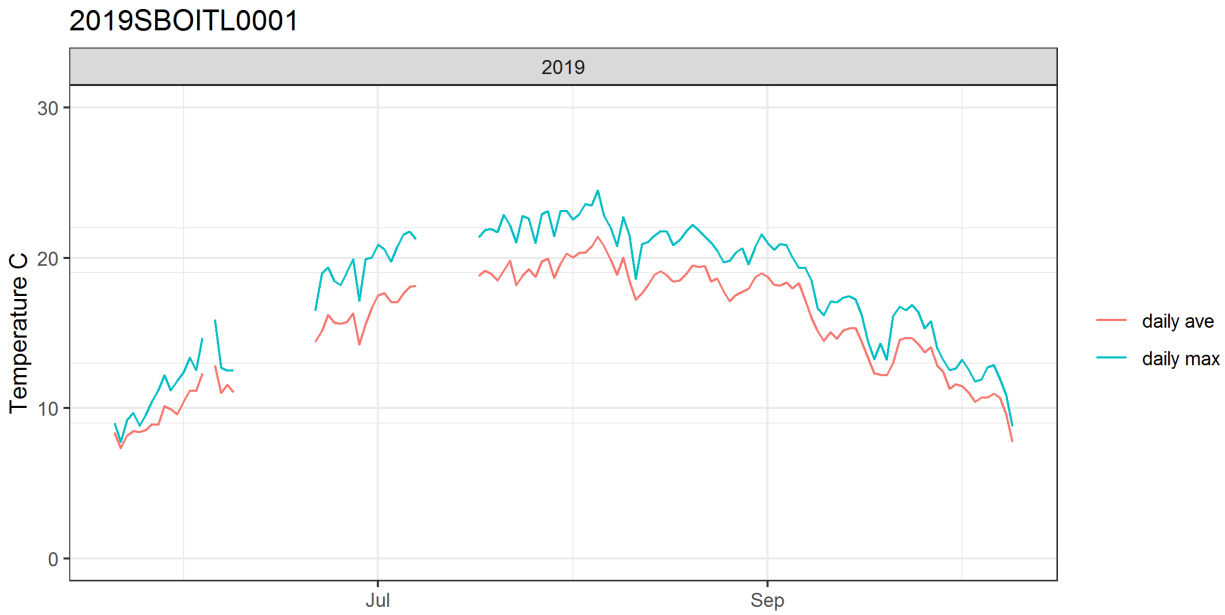


Figure 11. Daily average and maximum temperatures observed throughout the summer of 2019 at NFP_2.

NFP_3

The highest daily maximum temperature observed at NFP_3 was 24°C, exceeding the COLD criteria by 2°C; while the mean daily maximum was 17.8°C. The highest daily average was 22.5°C and the mean daily average was 16.7°C. The maximum COLD criterion of 22°C was exceeded in 29% of the observations, and the average 19°C criteria was exceeded in 64% of the observations. The maximum Salmonid Spawning criterion of 13°C was exceeded 50% of the time, and the average 9°C criteria was exceeded 72% of the time. Thirty six days were evaluated under the Salmonid Spawning period.

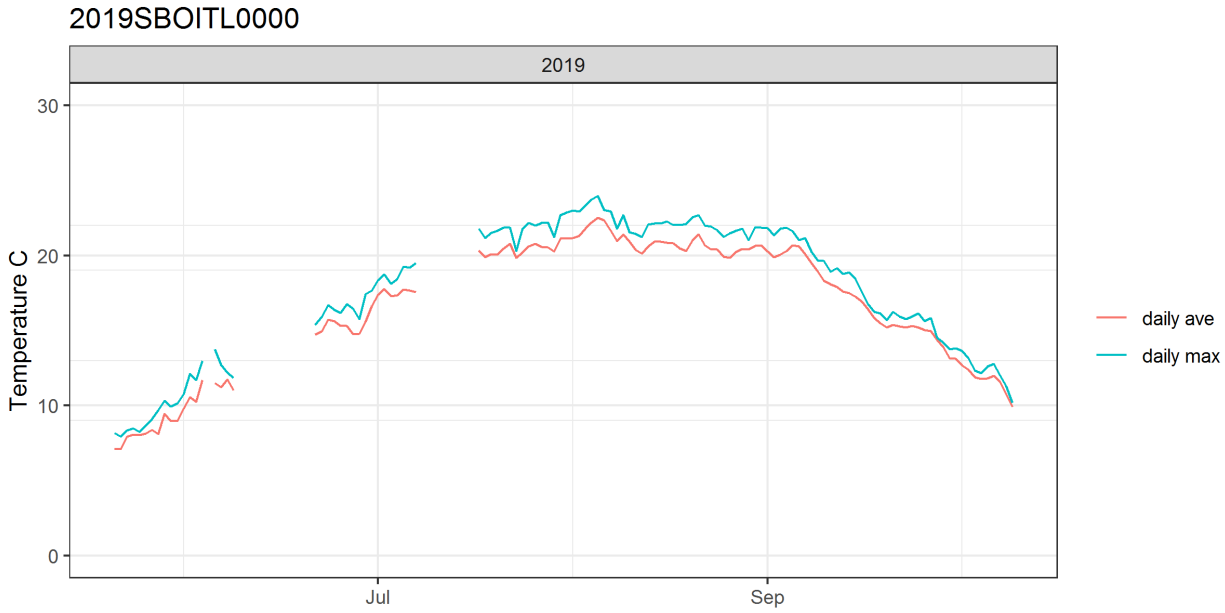


Figure 12.Daily average and maximum temperatures observed throughout the summer of 2019 at NFP_3.

Summary

All sites reached temperatures over 24°C, which is 2°C or more over the maximum temperature for cold water aquatic life support. The warmest temperatures were observed in August where daily averages were observed over 20°C (Appendix A). A breakdown of exceedance probability for both COLD support and Salmonid Spawning support are shown in Table 2. It is again important to note that due to water levels fewer days were observed at NFP_1 during Salmonid Spawning. Although observed days are less than the 45 outlined in WBAG3 (DEQ, 2016), the exceedance probabilities observed are concerning and could be cause to move the AU's Combined Biota 303(d) listing to a category 5 Temperature TMDL.

Table 2. Water temperature statistics collected from all sites during the summer 2019 sampling.

	NFP_1	NFP_2	NFP_3
Highest Daily Maximum	**24.61**	**24.48**	**23.95**
Maximum 7-Day Maximum	**23.80**	**23.32**	**23.27**
Mean Daily Maximum	**18.63**	**17.82**	**17.82**
Highest Daily Average	**21.68**	**21.41**	**22.52**
Mean Daily Average	**16.53**	**15.54**	**16.73**
Lowest Daily Minimum	**6.38**	**6.84**	**6.20**
Mean Daily Minimum	**14.43**	**13.31**	**15.79**
Highest Daily Diurnal	**6.96**	**7.96**	**5.49**
Mean Daily Diurnal	**4.20**	**4.51**	**2.02**
COLD Exceedance (22 C)	**24%**	**19%**	**29%**
COLD Exceedance (19 C)	**36%**	**24%**	**64%**
SS Exceedance (13 C)	**95%**	**56%**	**50%**
SS Exceedance (9 C)	**100%**	**78%**	**72%**

Cascade Reservoir (ID17050123SW007L_0L)

Cascade Reservoir was monitored monthly at three sites throughout the summer; two historical (Sugarloaf and Dam) and one new site (Arms) seen in Figure 2. A five year review for the reservoir and its tributaries was completed in 2018, which highlights targets set in the TMDL for the reservoir and its tributaries, as well as current status of those waterbodies. Although data was collected from 2015-2017 in preparation for the five year review, the reservoir was added to the monitoring list out of interest in recently active cyanobacterial blooms, and in an effort to archive more annual data in some of our high priority lakes and reservoirs. The reservoir currently has a pH and Total Phosphorus TMDL, first written

in 1999. Over time the TMDL would include many of the tributaries to the reservoir, and multiple implementation plans have been developed in an effort to minimize inputs to both the reservoir and its tributaries.

pH

The Cascade Reservoir TMDL uses Idaho Water Quality Standards (IDAPA 58.01.02.250.01a) to determine appropriate pH values in the reservoir, and defines the range as being within six point five and nine point zero (6.5-9.0). The pH data was collected at all three sites using a YSI Exo multiparameter sonde, and depth profiles were estimated using average pH collected throughout the summer(Figure 13 - Figure 15). Data indicates the average pH falls within the established range more often than not. pH data at the Arms Confluence site indicates all averages fall within the standard range, while the data shows averages that fall outside the range at Sugarloaf and the Dam. For averages outside the range, all fall below six point five (6.5) and all occur at depths below ten meters. All three sites display a noticeable decrease in pH as depth increases, with some of the lower averages occurring near the reservoir bottom. Table 3 through Table 5 show sample frequency at each site, along with minimum and maximum pH values observed at each depth.

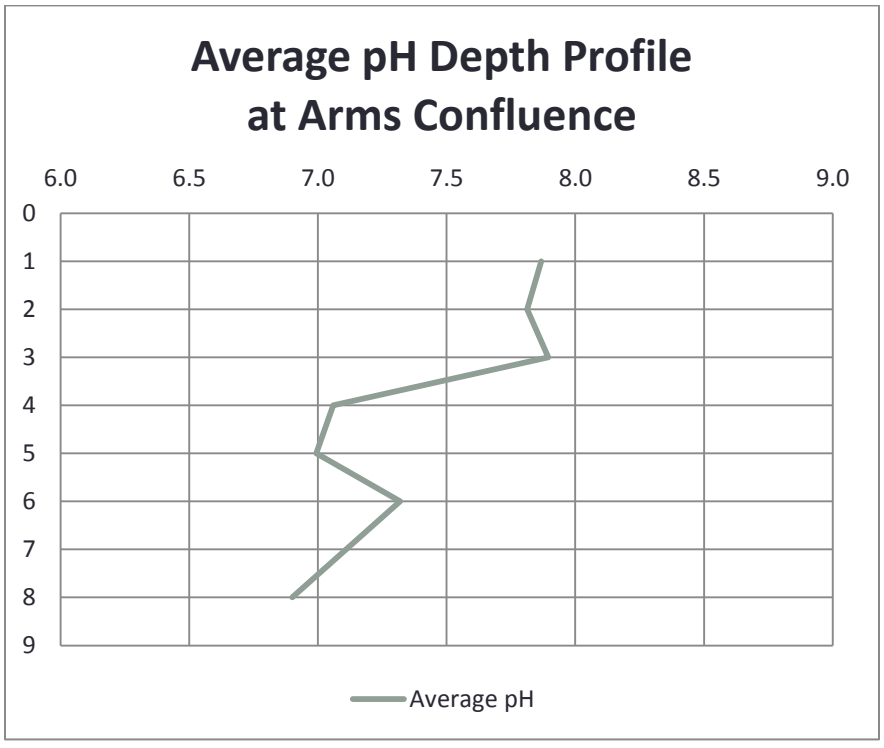


Figure 13. Average pH Depth Profile estimated at the confluence of the Cascade Arms site.

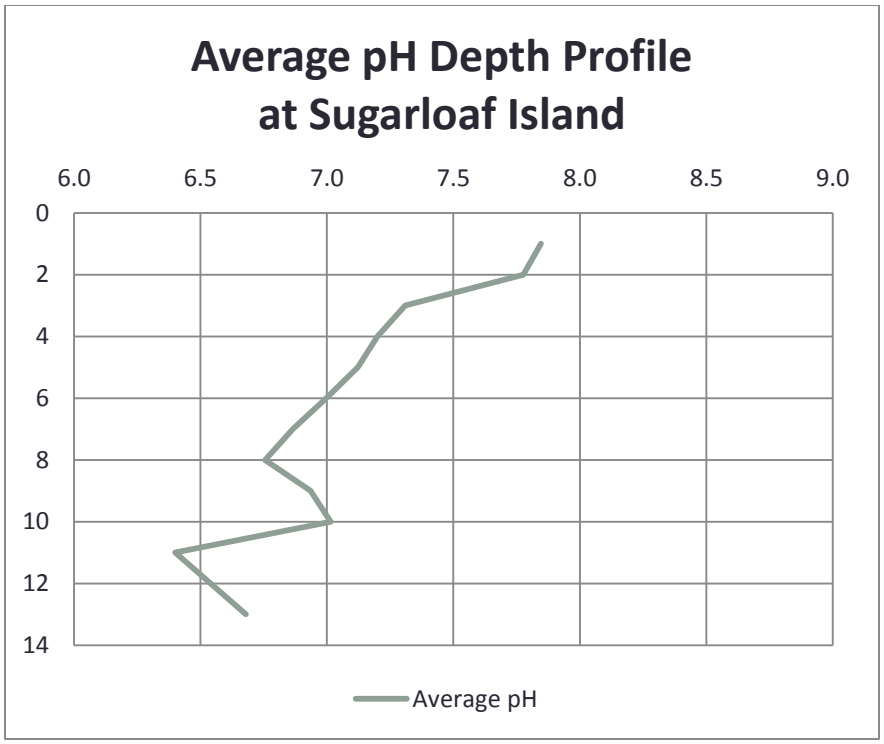


Figure 14. Average pH Depth Profile estimated at the west side of Sugarloaf Island in Cascade Reservoir.

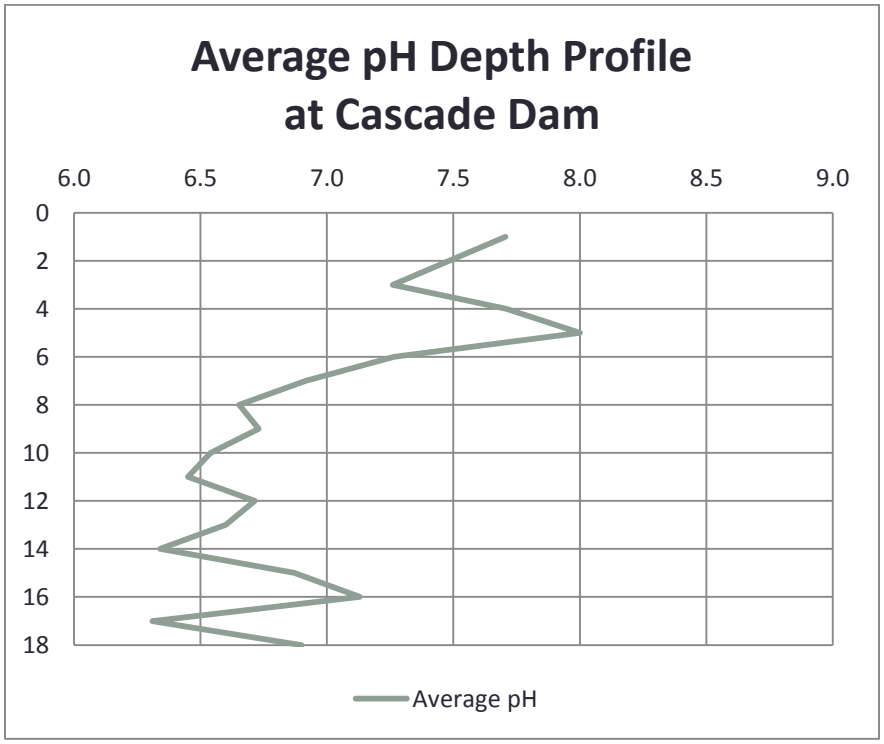


Figure 15. Average pH Depth Profile estimated at the Cascade Dam.

Table 3. Depth sampling frequency and pH data collected at the Arms Confluence on Cascade Reservoir.

Depth (m)	n	Mean pH	Max pH	Min pH
1	5	7.9	9.0	6.9
2	3	7.8	8.8	6.9
3	2	7.9	8.4	7.4
4	1	7.1	7.1	7.1
5	3	7.0	7.5	6.6
6	2	7.3	8.3	6.4
8	1	6.9	6.9	6.9

*n = sample population

Table 4. Depth sampling frequency and pH data collected at Sugarloaf Island on Cascade Reservoir.

Depth (m)	n	Mean pH	Max pH	Min pH
1	5	7.8	8.7	7.4
2	3	7.8	8.4	7.2
3	1	7.3	7.3	7.3
4	2	7.2	7.4	7.0
5	4	7.1	7.4	6.8
6	3	7.0	7.3	6.7
7	4	6.9	7.0	6.6
8	4	6.8	7.0	6.5
9	2	6.9	7.1	6.8
10	2	7.0	7.3	6.7
11	1	6.4	6.4	6.4
13	1	6.7	6.7	6.7

*n = sample population

Table 5. Depth sampling frequency and pH data collected at the Dam on Cascade Reservoir.

Depth (m)	n	Mean pH	Max pH
1	5	7.7	8.5
3	3	7.3	7.4
4	3	7.7	8.3
5	2	8.0	8.3
6	4	7.3	7.7
7	3	6.9	7.2
8	3	6.7	7.0
9	4	6.7	7.1
10	1	6.5	6.5
11	2	6.5	6.5
12	4	6.7	7.0
13	1	6.6	6.6
14	1	6.3	6.3

15	3	6.9	7.1
16	1	7.1	7.1
17	1	6.3	6.3
18	1	6.9	6.9

*n = sample population

Total Phosphorus

Total phosphorus (TP) data was collected and presented in the 2018 Cascade Reservoir Five Year Review (DEQ, 2018). Data was collected in 2015 and 2016, and it shows that TP concentrations are typically higher at the bottom of the reservoir than the top. Due to budget restrictions, 2019 samples were composited from the entire water column into one sample. Although this does not describe concentrations at the bottom and top of the reservoir, it does give us insight into the overall average TP concentrations in the water column from top to bottom. With the knowledge that higher TP concentrations likely occur toward the bottom of the reservoir, the target of 0.025 mg/L set in the TMDL should apply to the entire water column. Additionally, chlorophyll-a concentrations were sampled for comparison to previous data.

Table 6. TP composite samples and Chlorophyll-a concentrations averaged across each site. Target set for TP is 0.025 mg/L.

	Arm		Sugarloaf		Dam	
Date	**TP (mg/L)**	**Chl –a (µg/L)**	**TP (mg/L)**	**Chl –a (µg/L)**	**TP (mg/L)**	**Chl –a (µg/L)**
6/12/2019	0.034	1.7	0.016	1.6	0.021	1.7
7/11/2019	0.013	4.9	0.019	2.1	0.028	2.3
8/14/2019	0.024	15.1	0.048	8	0.06	5.9
9/10/2019	0.046	38.5	0.035	14.7	0.123	7.8
10/15/2019	0.066	7.3	0.031	19.8	0.027	17.2
Average	**0.0366**	**13.5**	**0.0298**	**9.24**	**0.0518**	**6.98**

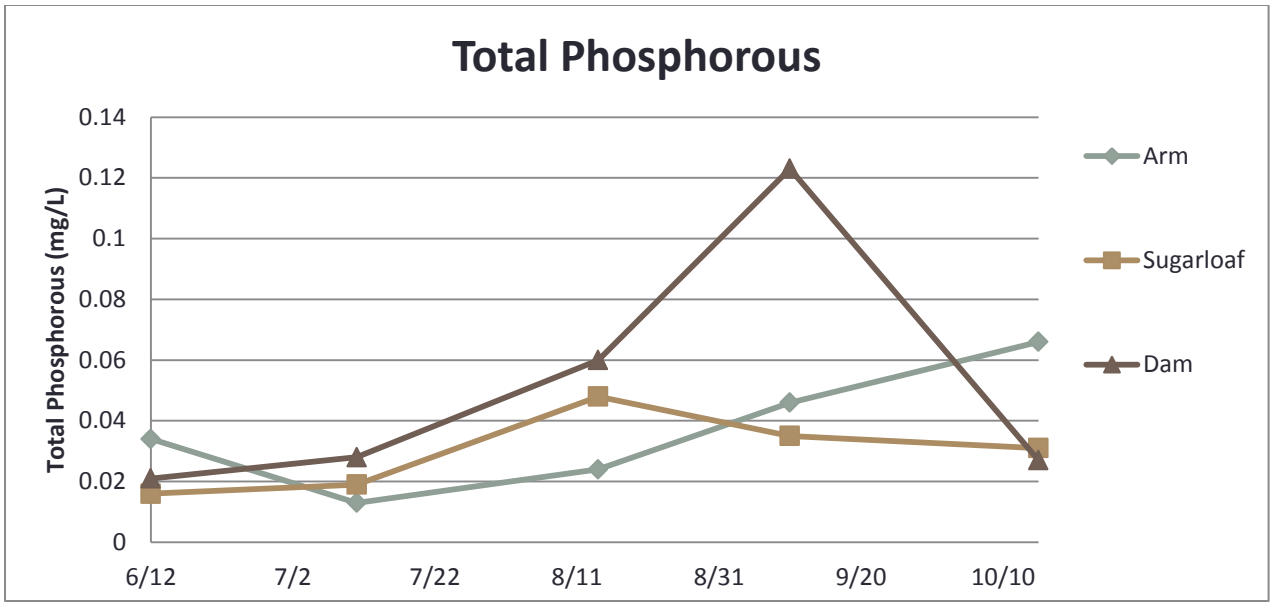


Figure 16. Total phosphorus concentrations collected at all sites throughout monitoring. Concentrations are representative of composite samples collected from the entire water column.

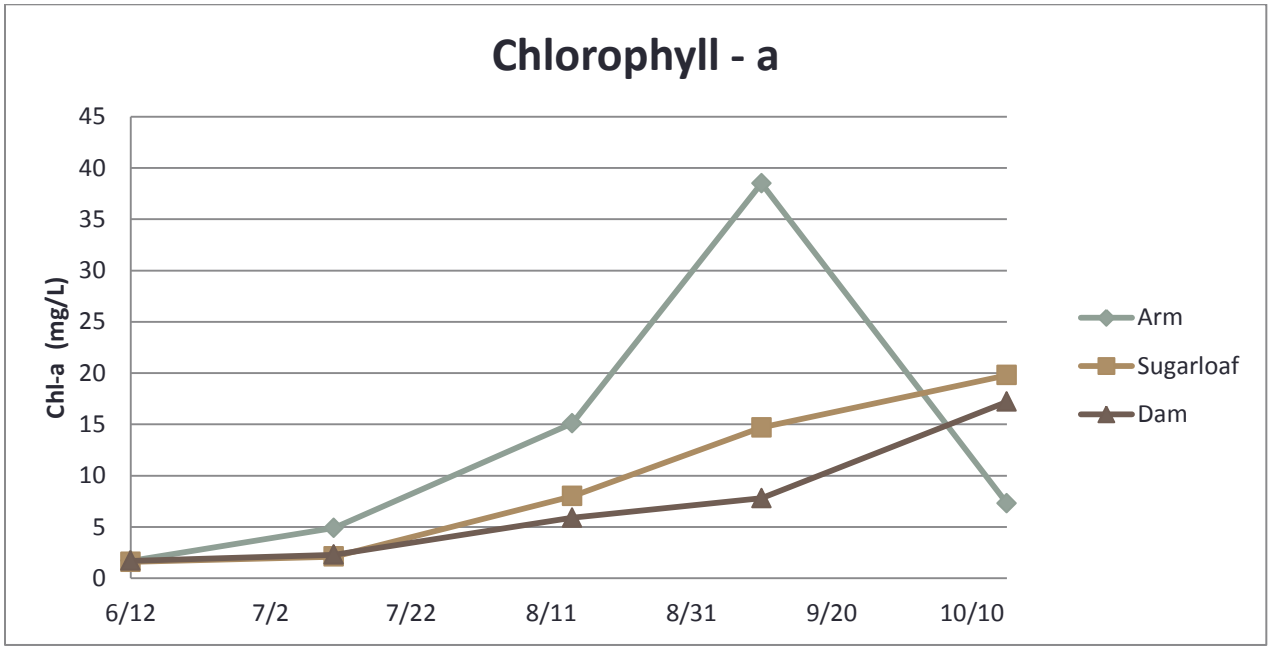


Figure 17. Chlorophyll-a concentrations collected at all sites throughout monitoring. Concentrations are representative of composite samples collected from the entire water column.

Data collected at all three sites indicate that the target of 0.025 mg/L TP is still not being met throughout the reservoir. The data does show a trend that suggests TP concentrations are lower in the spring and increase throughout the summer, which may be a result of dilution and changes in water storage. This trend may also suggest that TP entering the reservoir from tributaries is less significant than TP being stored in the reservoir contemporaneously. Chlorophyll-a concentrations follow a similar

pattern to TP, with lower concentrations in the spring and early summer. This is likely a result of decreased water levels and increased nutrient concentrations promoting plant growth.

Phycocyanin (Cyanobacteria)

Phycocyanin is a pigment-protein similar to chlorophyll-a that is produced exclusively by cyanobacteria. The pigment can be measured using a fluorescence-based sensor, which measures the concentrations of the phycocyanin pigment. Results are reported in Relative Fluorescent Units (RFU), with higher RFU's correlating to higher concentrations of cyanobacteria. Several things can be noted from the phycocyanin data collected. The first is that all sites measured no phycocyanin during June sampling. Secondly, phycocyanin was measured in July at all sites, but the highest measurements came from the Arms site at lower depths. This appears to be a trend, where data suggests the cells concentrations we see on the surface are significantly less than those found at lower depths; i.e. phycocyanin measured at the surface in October is up to seven times less than phycocyanin measured near the bottom of the reservoir. This is likely linked to warming temperatures at the bottom of the lake during the month of October in comparison to surface temperatures, and the likelihood of higher nutrient content at the bottom of the reservoir. Finally, all three sites display progressive relevance of phycocyanin throughout the summer; meaning lower measurements at the beginning of monitoring and progressively higher measurements towards the end of monitoring. Each site also suggests that the progression of cell densities at the bottom of the reservoir may be exponential in comparison to what we are seeing at the surface (Figure 18 - Figure 20). A health advisory regarding cyanobacteria in the reservoir was issued in September and persisted through to November. Cyanotoxin and cell count results for the reservoir and river are shown in Appendix B and Appendix C.

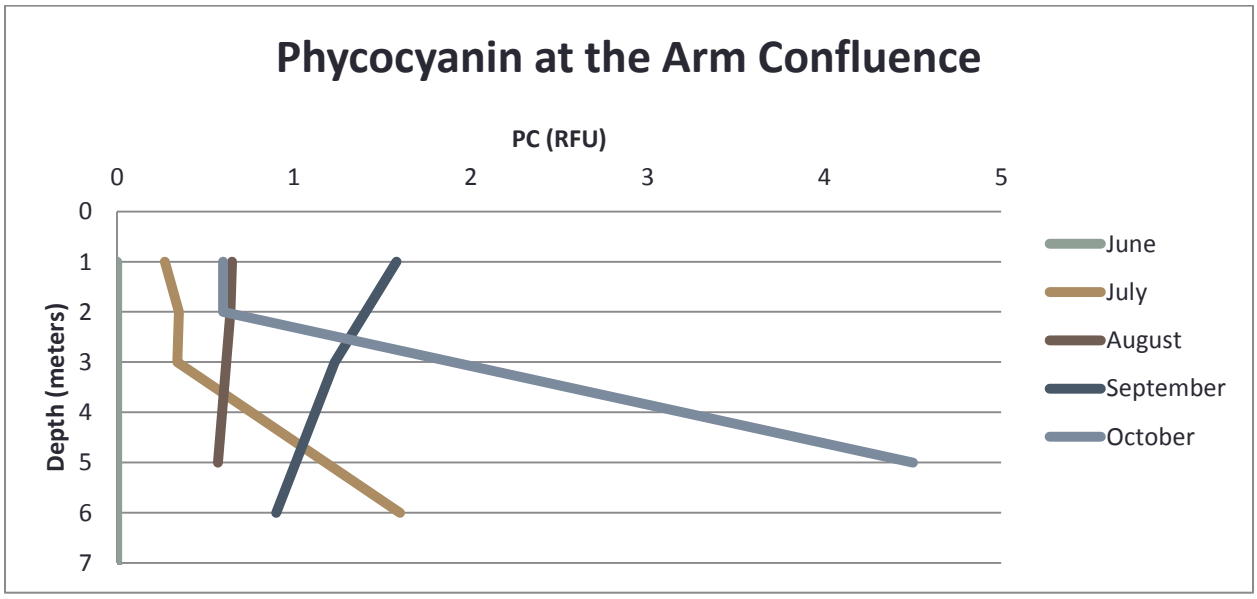


Figure 18. Phycocyanin measurements at the Arms Confluence site on Cascade Reservoir. Phycocyanin was measured in RFUs and it correlated with cyanobacteria cell densities.

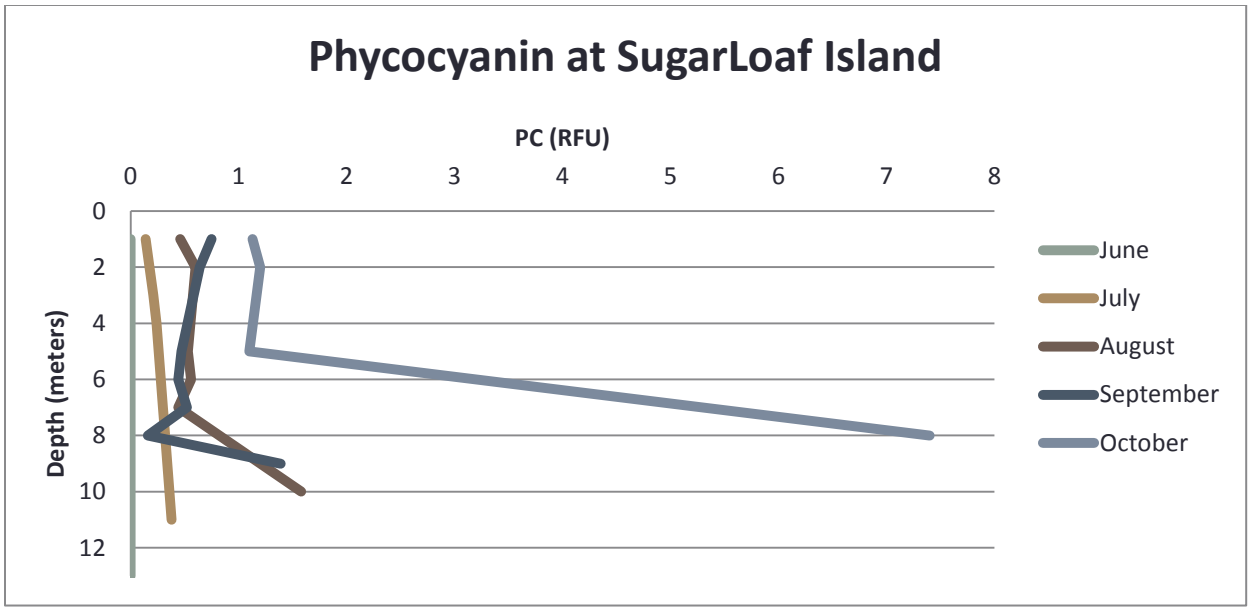


Figure 19. Phycocyanin measurements at the Sugarloaf Island site on Cascade Reservoir. Phycocyanin was measured in RFUs and it correlated with cyanobacteria cell densities.

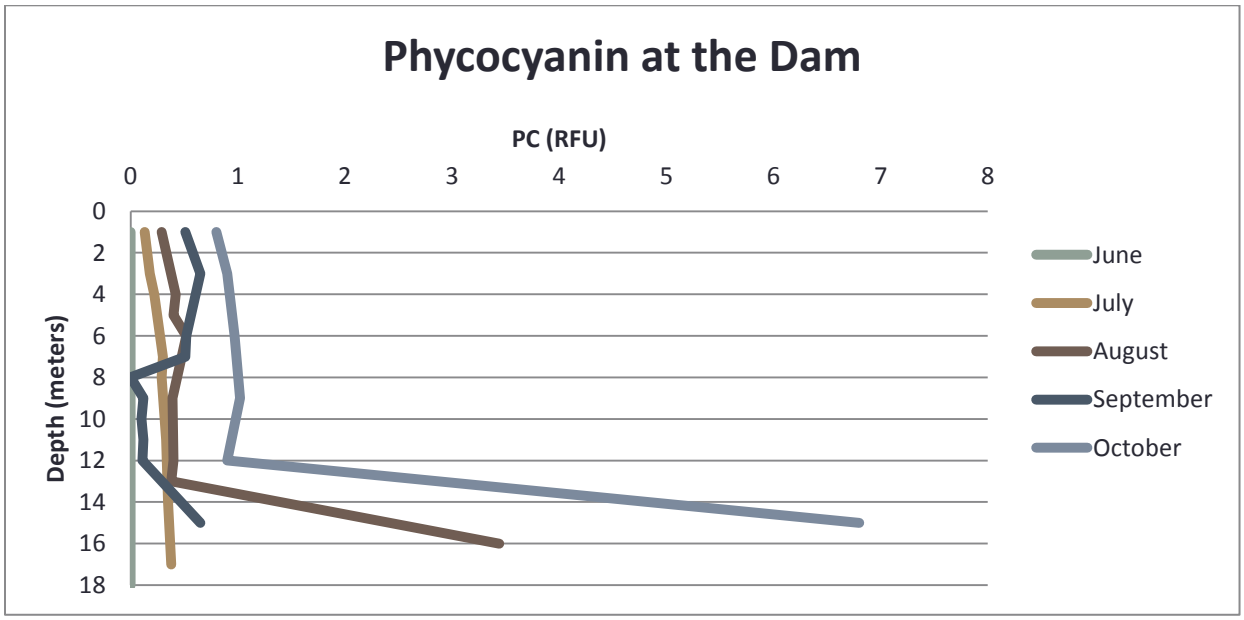


Figure 20. Phycocyanin measurements at the Dam site on Cascade Reservoir. Phycocyanin was measured in RFUs and it correlated with cyanobacteria cell densities.

More in-depth cyanobacteria monitoring with phycocyanin measurements could yield a better understanding of the dynamics of bloom development and progression in Cascade Reservoir.

Conclusions

Assessment unit ID17050123SW016_04 was monitored from early June to early October in 2019, in an effort to assess the AUs Combined Biota/Habitat Bioassessments 303(d) listing. The assessment unit is thought to have been listed due to a failing River BURP score in 2014. The score indicates a low fish metric, likely due to a lack of size and species diversity observed in the river. Idaho Fish and Game has expressed interest in future studies to identify fish migration patterns between Cascade Reservoir and the NF Payette, as it is thought that many of the salmonids in the system are adfluvial. An adfluvial population could explain an inverted bell curve for size distribution. Fish migration patterns and behaviors need to be studied further to support adfluvial reasoning.

Data collected during 2019 indicates the AU is fully supporting primary contact recreation, but does not support cold water aquatic life criteria or salmonid spawning criteria as a result of temperature exceedance probabilities. Data suggests dissolved oxygen and sediment are likely not impairments to the NF Payette, nor do nutrient levels appear to be in excess. It is important to note that conductivity in the NF Payette is very low, ranging between 0 and 40 µS/cm, which has made it difficult to perform fish surveys using electrofishing methodology. This may also contribute to poor fish scores, which may not be truly representative of actual population diversity.

Water temperature is likely the only impairment to the AU, as maximum cold water criteria was shown to be exceeded in more than 10% of the observed days throughout monitoring. DEQ's Water Body Assessment Guidance document (DEQ, 2016) states that "A frequency of exceedance greater than 10% always supports an impairment listing", while observations of less than ten percent of valid, applicable, representative measurements are defined as "infrequent" and may require additional evidence of impairment. The data does not indicate impairment in any other parameter but temperature, and therefore can be associated with the 303(d) listing.

Data collected in Cascade Reservoir suggests the reservoir is still some time away from meeting its target for total phosphorus at 0.025 mg/L. Data does show higher TP concentrations measured later in the summer and lower in the spring. This may suggest that there is a dilution factor playing into TP concentrations in the reservoir as flow from tributaries decreases throughout the summer, or that inputs to the reservoir from external sources increase throughout the summer; i.e. grazing and seasonal residence use are increased throughout the summer. The data may also suggest a significant portion of the TP measured in the reservoir is sourced from reservoir itself as opposed to the tributaries feeding it, but further analysis on monthly TP inputs from tributaries and the concentration of TP in reservoir bottom sediments could provide expanded insight to that hypothesis. Additionally, there may be a benefit in nitrogen sampling to look at N:P ratios throughout the summer, and how that progression may correlate with cyanobacteria growth.

pH averages measured in the reservoir are mostly meeting the standard range set in the original TMDL; however, some depths still experience out-of-range averages on the lower side of the pH scale. These lower pH levels at lower depths may be a result of increased photosynthetic processes occurring near the bottom of the reservoir, and simultaneously increased decomposition.

Phycocyanin data collected from the reservoir during monitoring provides a unique look at cell densities throughout the water column and multiple sites in Cascade Reservoir. The reservoir has experienced consecutive summers with health advisories, and the public is becoming more concerned with this reoccurrence. A more in-depth look at cyanobacteria with higher frequency monitoring may provide a better understanding of how and where blooms develop in the reservoir. It may be of value to collect data on nitrogen concentrations in the reservoir as well, as the N:P ratio may be of value in further understanding the ecosystem dynamics surrounding cyanobacteria in Cascade Reservoir.

References

DEQ (Idaho Department of Environmental Quality). 1996. *Cascade Reservoir Phase I Watershed Management Plan.* Boise, ID: DEQ. Available at https://www.deq.idaho.gov/media/452836-_water_data_reports_surface_water_tmdls_cascade_reservoir_cascade_reservoir_phase1_noapps.pdf Appendices available at https://www.deq.idaho.gov/media/452830-_water_data_reports_surface_water_tmdls_cascade_reservoir_cascade_reservoir_phase1_apps.pdf

DEQ (Idaho Department of Environmental Quality). 1998. *Cascade Reservoir Phase II Watershed Management Plan.* Boise, ID: DEQ. Available at https://www.deq.idaho.gov/media/452867-_water_data_reports_surface_water_tmdls_cascade_reservoir_cascade_reservoir_phase2_noapps.pdf Appendices available at https://www.deq.idaho.gov/media/452870-_water_data_reports_surface_water_tmdls_cascade_reservoir_cascade_reservoir_phase2_apps.pdf

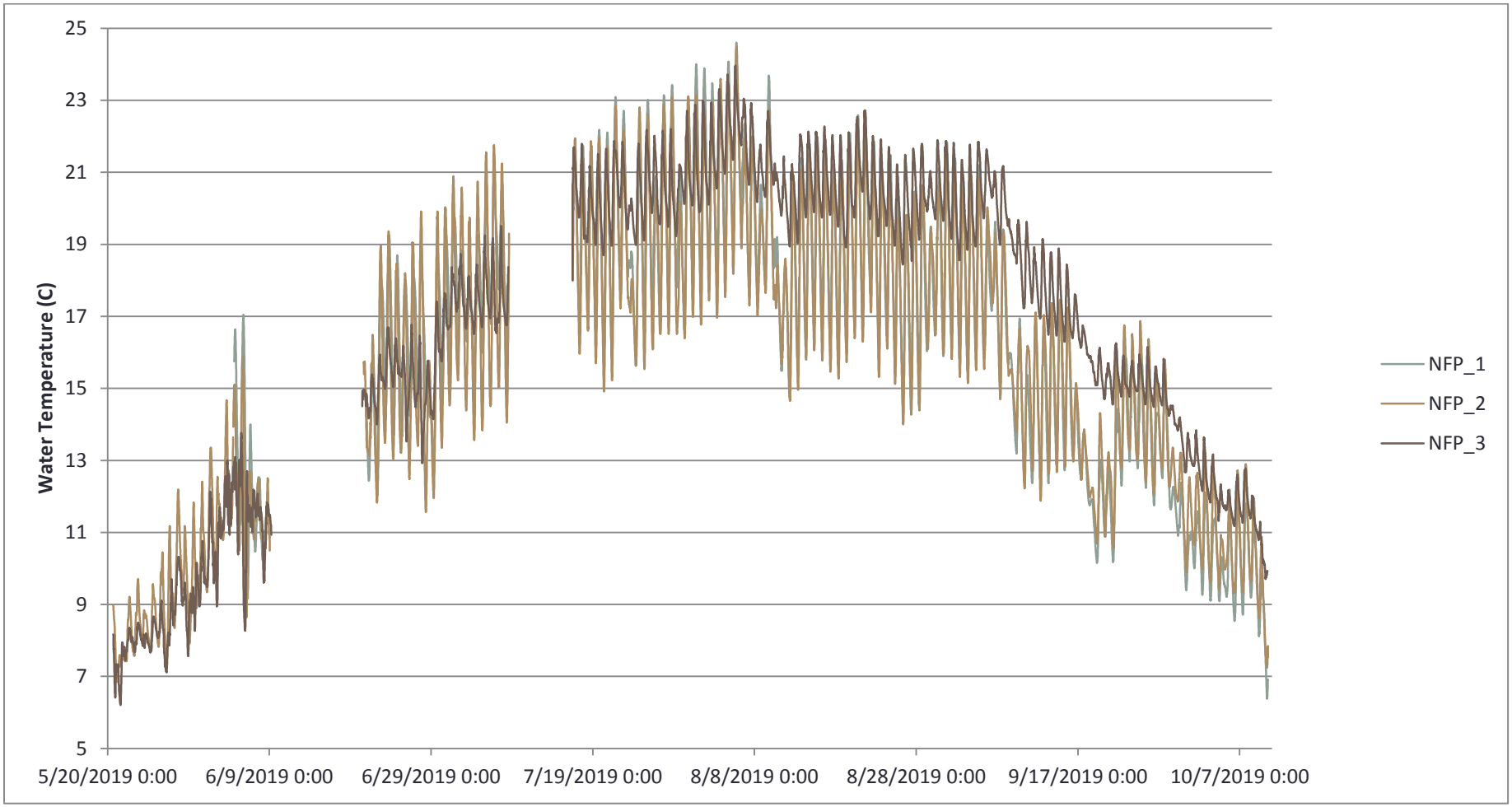
DEQ (Idaho Department of Environmental Quality). 2016. *Water Body Assessment Guidance – 3rd Edition.* Boise, ID: DEQ. Available at https://www.deq.idaho.gov/water-quality/surface-water/monitoring-assessment/

DEQ (Idaho Department of Environmental Quality). 2018. *Cascade Reservoir Watershed: TMDL Five-Year Review.* Boise, ID: DEQ. Available at https://www.deq.idaho.gov/media/60181465/cascade-reservoir-watershed-tmdl-five-year-review.pdf

DEQ (Idaho Department of Environmental Quality). 2019. *Quality Assurance Project Plan: Payette River Monitoring: Payette River and Cascade Reservoir.* Boise, ID: DEQ. Available through request.

Appendices

Appendix A. Water temperature collected at all three monitoring sites on the NF Payette River.



Appendix B. Cyanobacteria and Cyanotoxin measurements taken from Cascade Reservoir in 2019.

Sample ID	Sample Date	Collection time	Lat.	Long.	Laboratory	HAB Taxa	HABTaxaValue1 (cells/mL)	Analyte1	DL	AnalyteValue1 (µg/L)
1909009-03	4-Sep	13:05	44.5927	-116.0931	U.S. Bureau of Reclamation	N/A	N/A	Microcystin	<	2.00
1911001-01	24-Oct	10:52	44.5170	-116.0555	U.S. Bureau of Reclamation	N/A	N/A	Microcystin	<	0.40
1911001-02	31-Oct	14:34	44.5170	-116.0555	U.S. Bureau of Reclamation	N/A	N/A	Microcystin	<	0.40
	4-Sep	13:05	44.5927	-116.0931	Advanced Eco-Solutions	Dolichospermum sp.	2,230,000	N/A		

Appendix C. Cyanotoxin measurements taken from the North Fork Payette River below Cascade Reservoir.

Sample ID	Sample Date	Collection time	Lat.	Long.	Laboratory	HABTaxa	HABTaxaValue1 (cells/mL)	Analyte1	DL	AnalyteValue1 (µg/L)
1909065-01	24-Sep	14:30	44.5250	-116.0480	U.S. Bureau of Reclamation	N/A	N/A	Microcystin		0.63