Lower North Burnt Fork Creek

Final Report for the Montana DEQ Volunteer Monitoring Program

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North Burnt Fork Creek, July 2019

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Introduction

Project Overview

The goal of this monitoring effort was to better understand nutrient and thermal loading in lower North Burnt Fork Creek, Ravalli County, Montana. Trout Unlimited is currently developing projects in this area with potential to reduce nutrient and temperature impacts. The Bitterroot Watershed is a priority focus for Montana DEQ's non-point source pollution program. These data were added to the existing State water quality dataset on North Burnt Fork Creek and are being used by Trout Unlimited specifically to assess the potential for restoration projects to improve water quality.

Project Area Overview

North Burnt Fork Creek travels from the Sapphire mountains, north-west to the Bitterroot River near Stevensville, Montana. It is a 303(d)-listed stream, impaired for Total Nitrogen and Total Phosphorus, with pervious sampling data highlighting the lower two miles as the areas of nutrient exceedance (Montana DEQ, 2014). Additionally, North Burnt Fork Creek regularly dewaters along its lowest 0.5 miles within Lee Metcalf Wildlife Refuge. Throughout the 2019 field season, Trout Unlimited monitored nutrients, total suspended solids (TSS), temperature and flow in the lower watershed to better understand current conditions and inform restoration decisions.

Table 1: Project Goals, Questions, Objectives and Analyses

<table>
<tr><th>Goal</th><th>Question</th><th>Objective</th><th>Data Analysis</th></tr>
<tr><td rowspan="3">Goal 1. Evaluate water quality (nutrient) trends along lower North Burnt Fork Creek</td><td rowspan="3">What are the longitudinal trends of nutrient concentrations along lower North Burnt Fork Creek?</td><td rowspan="3">At 6 locations in North Burnt Fork Creek, collect nutrient samples (TPN, TP, and NO_{2+3}) and flow measurements, three times from July – September.

At 4 locations in lower North Burnt Fork Creek, install stage/temperature loggers and collect flow data to develop rating curves.</td><td>Plot nutrient concentrations by river mile evaluate longitudinal trends.</td></tr>
<tr><td>Compare nutrient concentrations to Montana's numeric nutrient standards (Circular DEQ-12A)</td></tr>
<tr><td>Plot annual hydrograph and temperature over time at the four continuous water stage monitoring locations</td></tr>
</table>

Goal	Question	Objective	Data Analysis
Goal 2: Evaluate trends in flow and temperature along lower North Burnt Fork Creek	Where is most of North Burnt Fork flow lost within Lee Metcalf? Does this correlate with temperature increases?	Conduct flow measurements at least 3x between June and September at six locations along lower North Burnt Fork Creek.	Plot flow and temperature over time; Plot flow and temperature over river mile (longitudinal trends)
		Install continuous temperature loggers at seven locations along lower North Burnt Fork Creek.	

Project Team and Responsibilities

Christine Brissette is a Project Manager with Trout Unlimited, with extensive water quality and flow experience. Grant Flaming served as a Big Sky Watershed Corps member in 2019 and now works as a Project Assistant for Trout Unlimited. Due to the need to access private property, volunteers were not used on this project.

Table 2: Project Team Roles and Responsibilities

Role	Person(s)
Develop Sampling and Analysis Plan (SAP)	Christine Brissette
Oversee monitoring personnel	Christine Brissette
Training monitoring personnel	Christine Brissette
Review field forms	Christine Brissette & Grant Flaming
Lab coordination (e.g., bottle orders, shipping notifications, lab EDDs)	Christine Brissette
Ship or deliver samples to lab	Christine Brissette
Review data quality	Christine Brissette & Grant Flaming
Upload data into MT-eWQX database	Grant Flaming
Write final report	Christine Brissette & Grant Flaming

Completed Field Activities

A total of three field visits were conducted between August 23and October 17, 2019 to collect water samples at the six locations listed in Table 3 and shown in Figure 1, below. Temperature and flow measurements were collected at the time of sampling. Samples were collected from four sites on Lee Metcalf National Wildlife Refuge and two sites on private property around the intersection of the Burnt Fork and the irrigation Supply Ditch.

In addition to water quality monitoring, Trout Unlimited collected continuous hourly temperature data at six sites using Hobo Temp Pro V2 loggers and hourly stream stage data at four sites using Solinst Levelogger Junior pressure transducers. Synoptic low measurements were used to develop rating curves and modeled hydrographs for all sites. Flow and temperature data collection on EL-East and EL-West began in Spring 2019. All sampling activities, locations and dates are outlined in Figure 1 and Table 4 below.

Table 3: Monitoring Sites

Site Name	River Mile	Site Description	Latitude	Longitude	Rationale for Site Selection
EL-East	4.7	North Burnt Fork Creek, East Side of Ellison Ranch	46.520945	-114.073058	Upstream agricultural site; Private landowner permission
EL-West	4.6	North Burnt Fork Creek, West Side of Ellison Ranch	46.521873	-114.073487	Upstream agricultural site; Private landowner permission
LM-Southern* Boundary	1.8	North Burnt Fork Creek, Southern Boundary of Lee Metcalf	46.534096	-114.097913	Temperature entering Lee Metcalf; Previous FWP monitoring site
LM-1	1.3	North Burnt Fork Creek, above walking path/culverts	46.539182	-114.094571	Determine influence of alternate flow path
LM-2	0.8	North Burnt Fork Creek, South of golf course boundary, on Lee Metcalf	46.545435	-114.095648	Determine influence of alternate flow path; Previous FWP monitoring site
LM-3	0.3	North Burnt Fork Creek, above slough	46.553492	-114.097158	Determine water quality at confluence with Bitterroot, above slough influence
LM-4	0.1	North Burnt Fork Creek, Mouth	46.555128	-114.097577	Determine water quality at confluence with Bitterroot, below slough influence; Previous FWP monitoring site

*No water quality data collected. Temperature logger deployed

Planned vs. Actual Sampling

Sampling generally proceeded as planned. Due to a delay in obtaining a Special Use permit for monitoring on Lee Metcalf National Wildlife Refuge, sampling was conducted between August 23, 2019 and October 17, 2019 rather than mid-July to mid- September as originally proposed. This still allowed Trout Unlimited to collect data at a range of flows, including times with high and low irrigation demand, as originally planned.

Figure 1: Map of Monitoring Sites

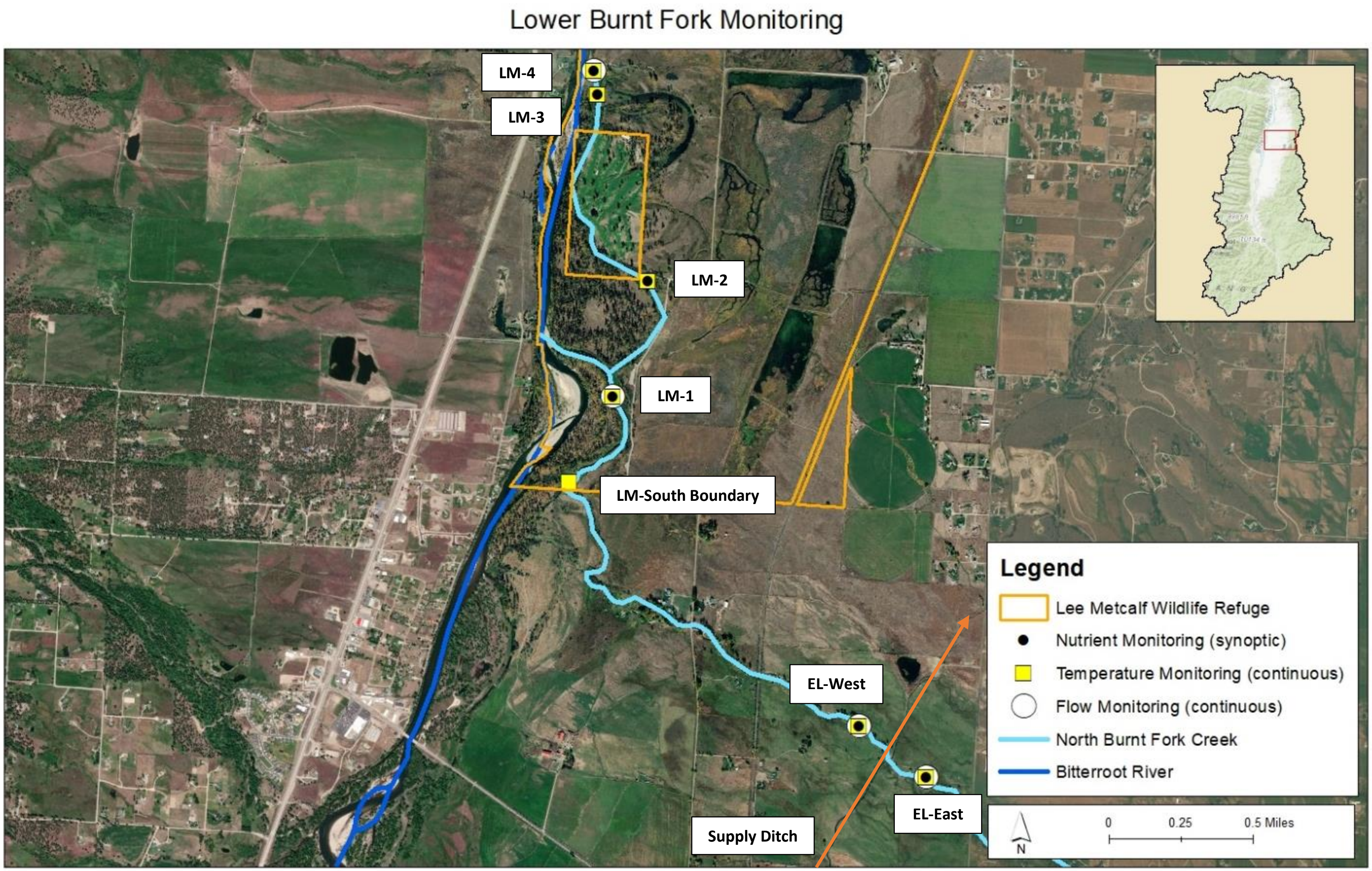


Table 4: Summary Table of Monitoring Activities

Site	Dates Visited								
	4/29	5/17	6/5	7/12	7/25	8/12	8/23	9/10	10/17
EL-East	Q, T		Q, T*		Q, T		N, TSS, Q, T	N, TSS, Q, T	N, TSS, Q, T
EL-West	Q, T	T*	Q, T		Q, T		N, TSS, Q, T	N, TSS, Q, T	N, TSS, Q, T
LM-Southern Boundary						T**	T	T	T
LM-1						T*	N, TSS, Q, T	N, TSS, Q, T	N, TSS, Q, T
LM-2						T**	N, TSS, Q, T	N, TSS, Q, T	N, TSS, Q, T
LM-3						T**	N, TSS, Q, T	N, TSS, Q, T	N, TSS, Q, T
LM-4						T*	N, TSS, Q, T	N, TSS, Q, T	N, TSS, Q, T

Q – Discharge T – Temperature N – Nutrients TSS – Total Suspended Sediment

*Hourly temperature and water stage logger deployed **Hourly temperature logger deployed

Analysis and Results

Streamflow

In order to contextualize temperature and water quality data, it is important to understand the underlying patterns of streamflow and water management in lower North Burnt Fork creek. Hourly stream stage data (stilling wells instrumented with Solinst Levellogger Junior pressure transducers) and synoptic flow measurements were used to develop rating curves for four sites in the project area. These rating curves were then used to model discharge at each site.

Modeled hydrographs of North Burnt Fork Creek show discharge fluctuations related to runoff, rainfall and irrigation management. Flows in North Burnt Fork creek are heavily impacted by their agricultural setting. There are numerous irrigation diversions and two large canal systems above our upstream-most site (EL-East). In 2019, irrigation began in June and ran through autumn. Irrigation demand decreased in mid-July and mid-September for haying, which resulted in increased streamflow. The hydrograph downstream of the Supply Ditch (Figure 3) is substantially altered by demand for irrigation water. Flows alternated between severe dewatering and large pulses of unseasonably high flows when the ditch was spilling excess water.

Throughout Lee Metcalf National Wildlife Refuge, LM-1 and LM-4 (Figures 4 and 5) display similar peaks in mid and late September, albeit with a more buffered response at LM-4, likely due to the influence of groundwater recharge throughout the lower reaches of the Refuge. This groundwater-influenced hydrograph at LM-4 exhibits unique trends from those at LM-1, such as decreasing flows in August and early September and relatively stable flows throughout the final week of monitoring.

Figure 2

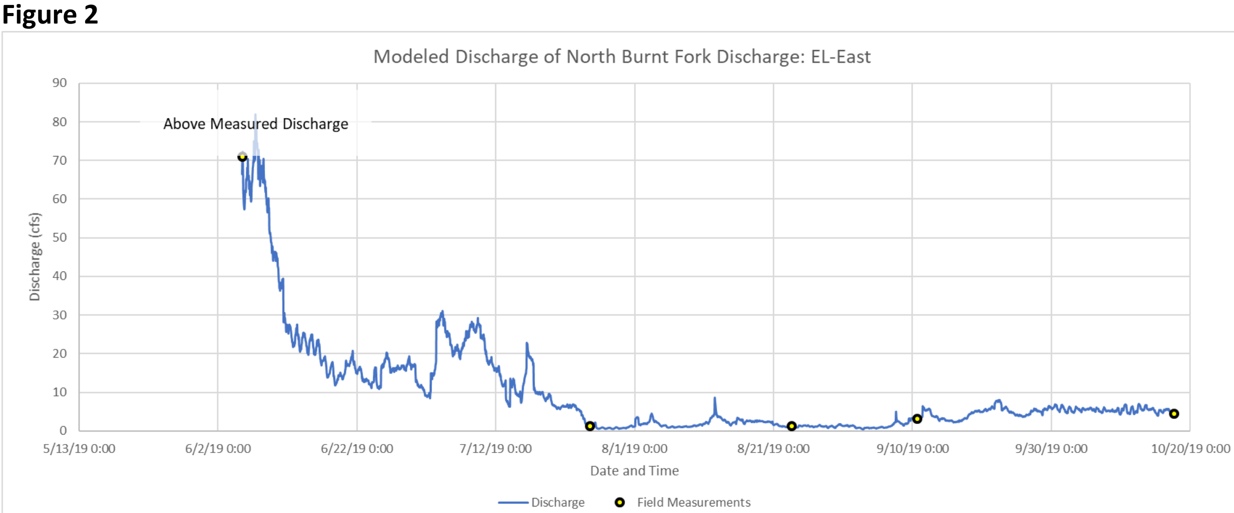


Figure 3

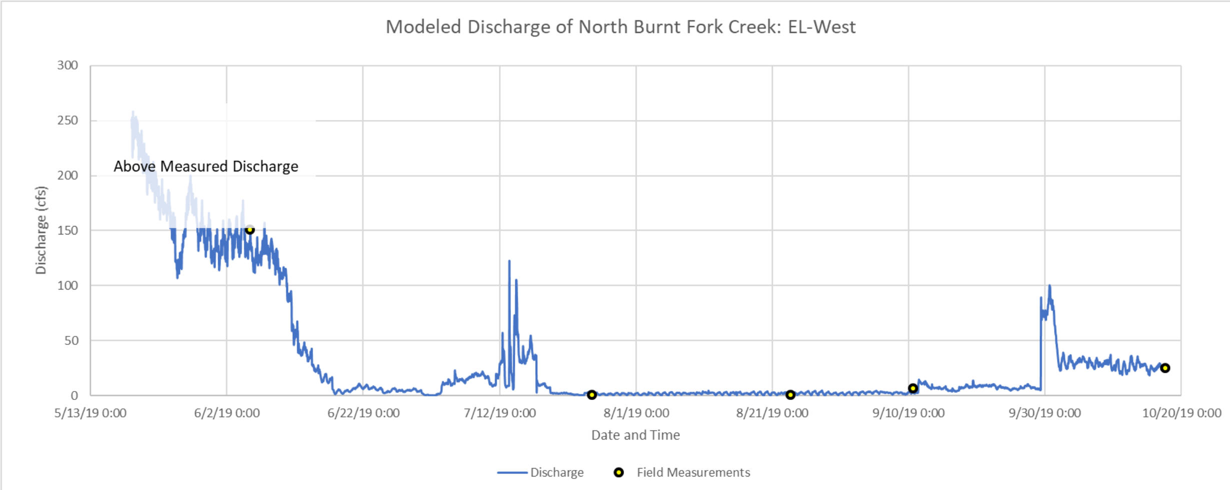


Figure 4

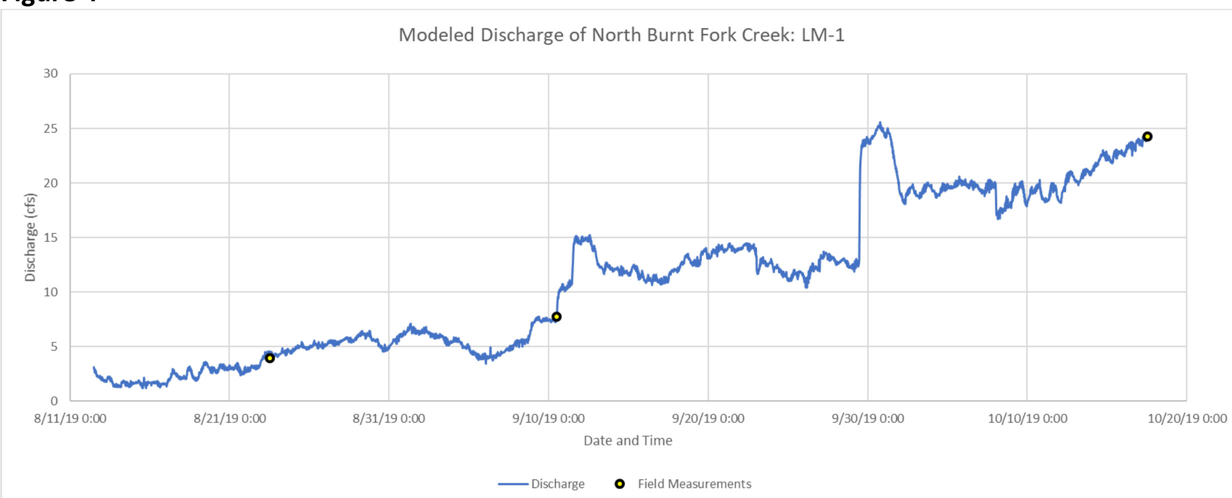
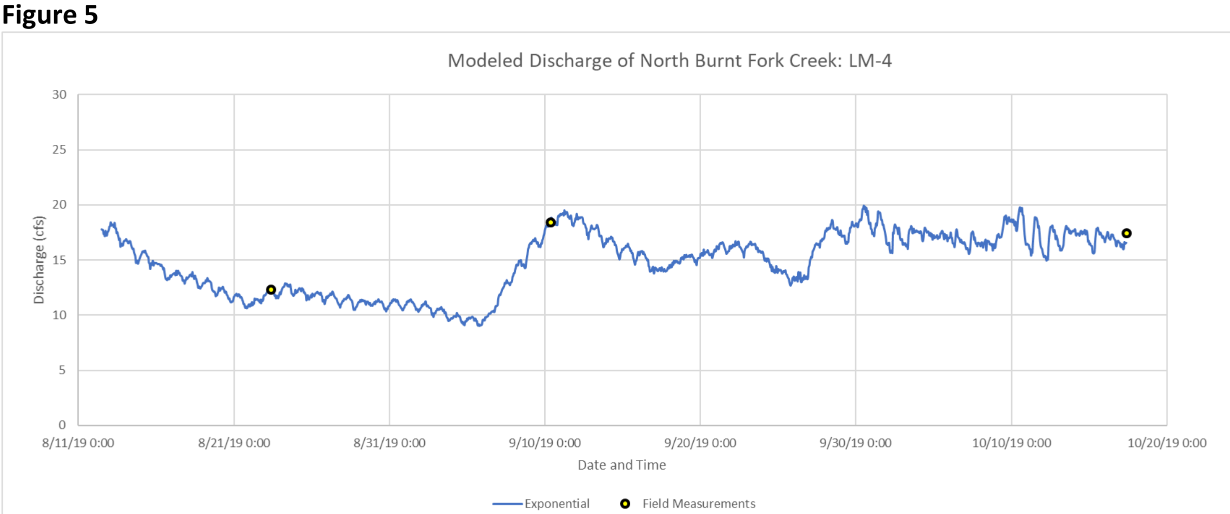


Figure 5



Water Quality

Water quality lab results are summarized in Table 5 below. Samples were collected and analyzed by Energy Labs following the procedures outlined in our Sampling and Analysis Plan. Results are plotted in Figures 6 through 9 with “River Mile” on the x-axis and “Concentration” on the y-axis, illustrating longitudinal trends over the project area.

Table 5: Lab Results

Site Name (River Mile upstream to down-stream)	**Total Suspended Solids** (mg/L)			**Total Nitrogen** (mg/L)			**Nitrate + Nitrite** (mg/L)			**Total Phosphorus** (mg/L)		
	8/23	9/10	10/17	8/23	9/10	10/17	8/23 **D**	9/10	10/17	8/23	9/10	10/17
EL-East (mile 4.7)	2 **J**	4	0.4 **J**	0.16	0.24	0.07	N.D.	N.D.	N.D.	0.06	0.058	0.02
EL-West (mile 4.6)	3.2 **J**	8	3.2 **J**	0.28	0.27	0.25	N.D.	N.D.	0.11	0.058	0.049	0.018
LM-1 (mile 1.3)	11	3.2 **J**	0.4 **J**	0.21	0.25	0.12	0.009 **J**	N.D.	0.02	0.053	0.046	0.013
LM-2 (mile 0.8)	1.6 **J**	1.2 **J**	2 **J**	0.34	0.36	0.21	0.29	0.24	0.11	0.032	0.043	0.025
LM-3 (mile 0.3)	3.2 **J**	2 **J**	1.2 **J**	0.19	0.2	0.13	0.04	0.06	0.04	0.017	0.015	0.012
LM-4 (mile 0.1;mouth)	4	5	1.8 **J**	0.18	0.26	0.14	0.05	0.05	0.03	0.019	0.021	0.014

J – Estimated value. The analyte was present but less than the reporting limit of the instrument.
D – Reporting limit increased due to sample matrix

Total Suspended Solids

Concentrations of total suspended solids in North Burnt Fork Creek are plotted by River Mile in Figure 6. Concentrations were higher below the Supply Ditch (EL-West) than above (EL-East) on all three days of sampling. At both sampling locations suspended sediment levels were negatively correlated with discharge, with the lowest concentrations occurring during the highest flows. With the exception of a substantial outlier at LM-1 on August 23rd, suspended sediment concentrations decrease downstream until LM-2, just south of Whitetail Golf Course. This area also demonstrates buffered streamflow and temperature responses relative to upstream sites, pointing towards likely groundwater influence. Downstream from LM-2, suspended sediment levels increased until the mouth of North Burnt Fork Creek at LM-4. On each day of sampling, concentrations of suspended sediment were higher at LM-4 in Lee Metcalf National Wildlife Refuge than farther upstream at EL-East.

Total Nitrogen

Concentrations of Total Nitrogen are plotted by River Mile in Figure 7. Total nitrogen is measured as the sum of all present forms of nitrogen, including ammonia, organic, and reduced nitrogen, as well as nitrate-nitrite (EPA, 2013). On all three dates of collection, Total Nitrogen concentrations in North Burnt Fork Creek were higher below the Supply Ditch (EL-West) than above (EL-East). Despite these elevated levels of Total Nitrogen below the Supply Ditch which consistently hovered near water quality standards, the Montana DEQ standard of 0.275 mg/L was only exceeded during the first sampling event on August 23rd. Moving downstream through Lee Metcalf National Wildlife Refuge, Total Nitrogen concentrations generally decreased except for LM-2, just upstream of Whitetail Golf Course. Concentrations at LM-2 were 44-75% higher than a half mile upstream at LM-1 and exceeded water quality standards on August 23rd and September 10th.

Nitrate + Nitrogen

Nitrate + Nitrite concentrations are plotted by River Mile in Figure 8. Interestingly, Nitrate + Nitrite concentrations remained low (often undetectable) until the lowest reaches of North Burnt Fork Creek. During all sampling periods, a sharp increase was detected at LM-2, just above Whitetail Golf Course (similar to TN results). Although North Burnt Fork Creek does not have a clearly specified water quality standard for Nitrate + Nitrite, this downstream increase in concentrations during the first two field visits marks a clear departure from upstream nutrient characteristics.

Total Phosphorus

Concentrations of Total Phosphorus are plotted by River Mile in Figure 9. During the first two sampling events on August 23rd and September 10th, the DEQ water quality standard of 0.025 mg/L Total Phosphorus were exceeded at all sites except LM-3 and LM-4. Demand for irrigation water was high during these times and North Burnt Fork Creek streamflow was extremely low. Conversely, when demand for irrigation water fell in October and North Burnt Fork Creek experienced increased discharge total phosphorus concentrations did not exceed the water quality standard at any of the sampling locations.

Additionally, during the irrigation season (August and September measurements), phosphorus concentrations decreased downstream of LM-1. This marks the start of the Northward channel, increases in flow along its path from influxes of groundwater. The lowermost stretch of North Burnt Fork Creek, represented by sampling sites LM-3 and LM-4, demonstrates a highly buffered response to upstream phosphorus levels that consistently exceeded water quality standards at LM-2 and LM-1. This lowermost stretch, meanwhile, did not exceed water quality standards during any sampling events.

Figure 6: Total Suspended Solids

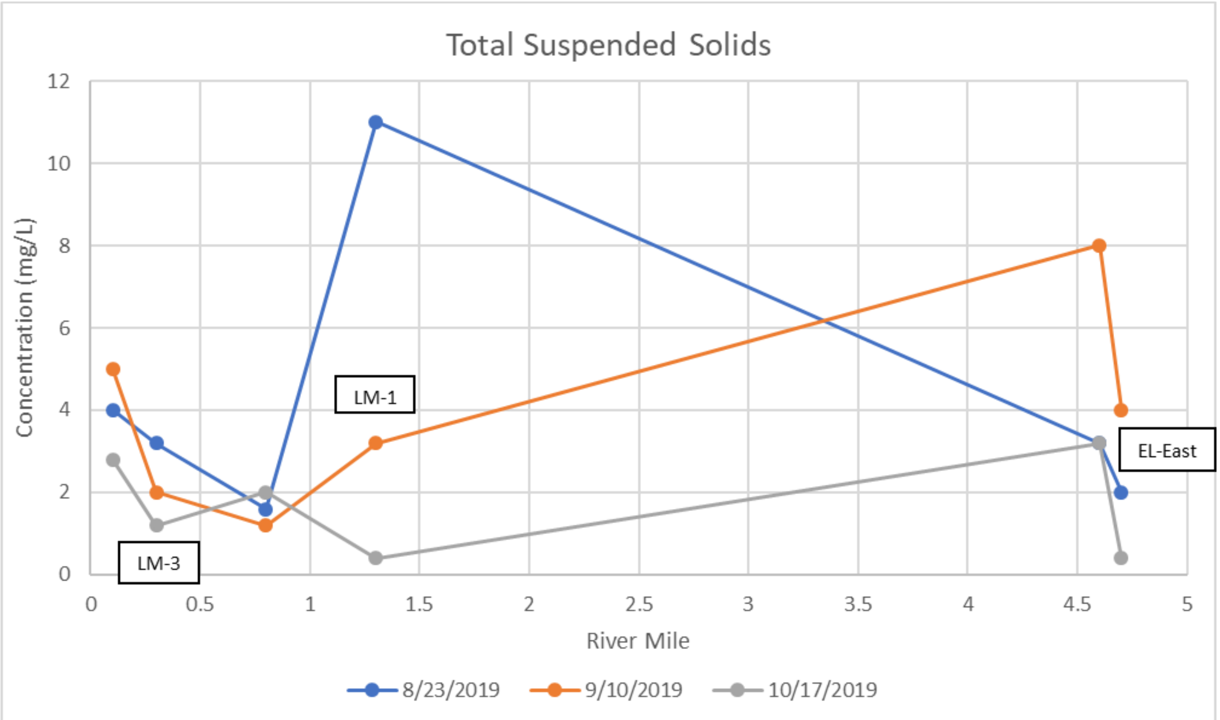


Figure 7: Total Nitrogen

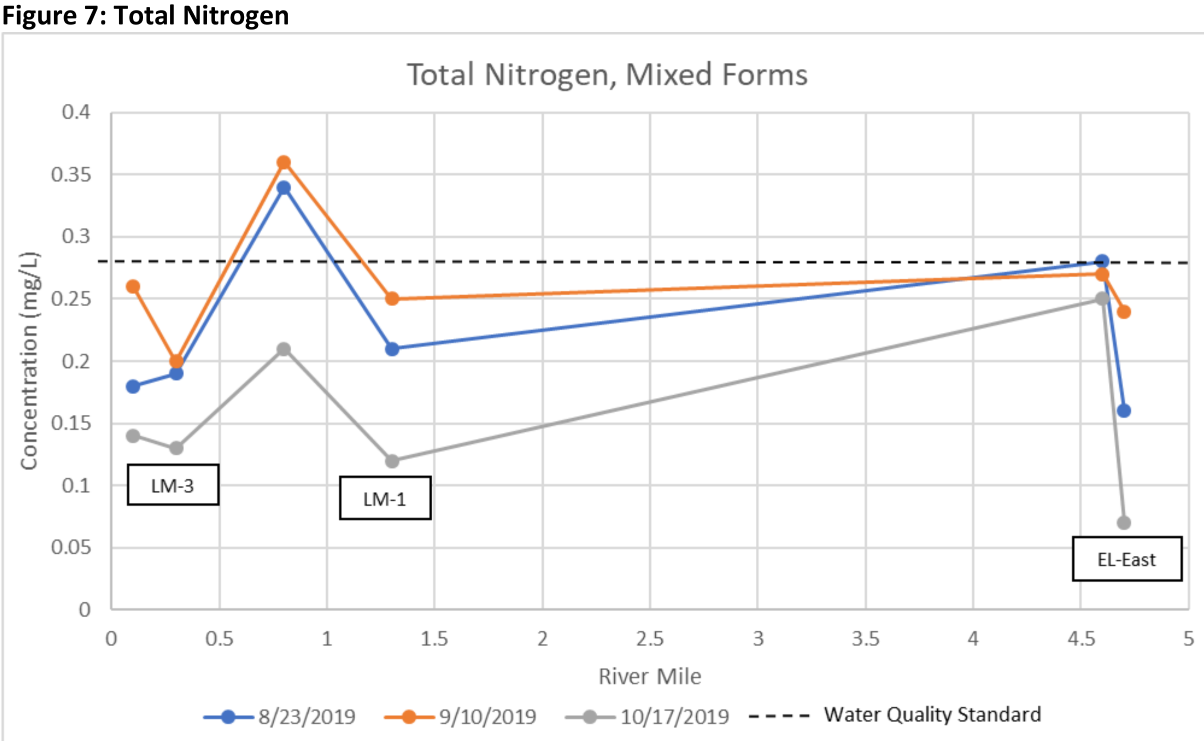


Figure 8: Nitrate + Nitrite (note, "Not detected" samples are plotted as Concentration = 0)

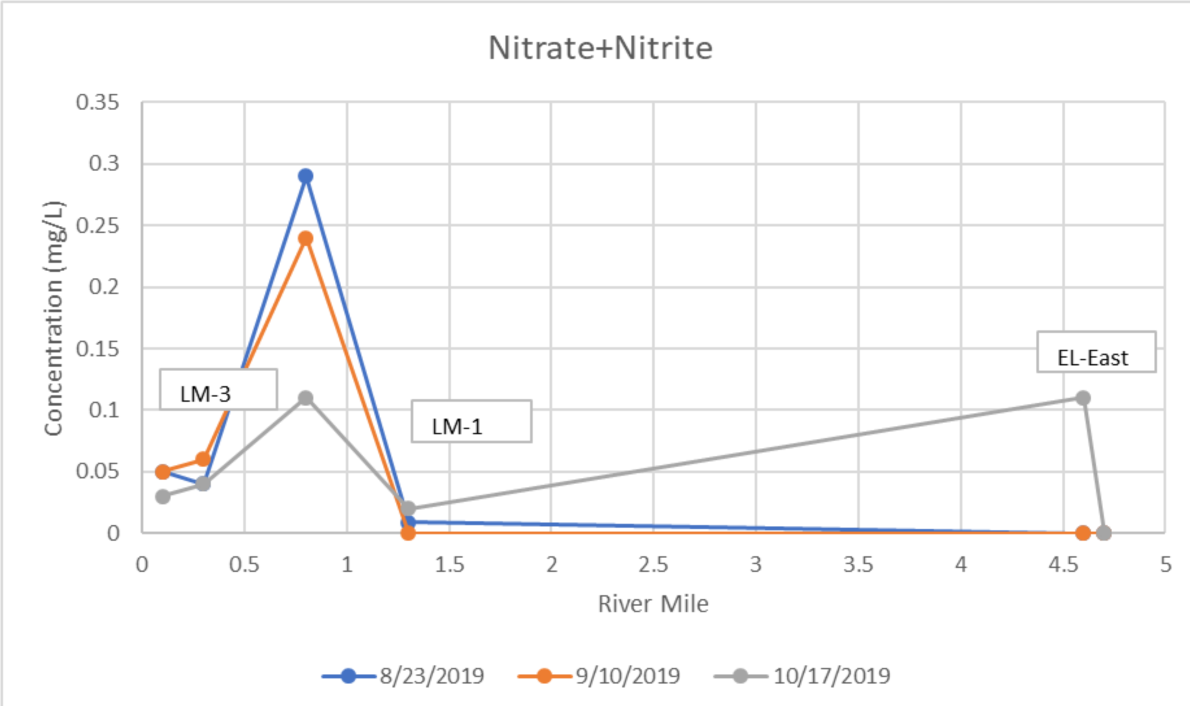
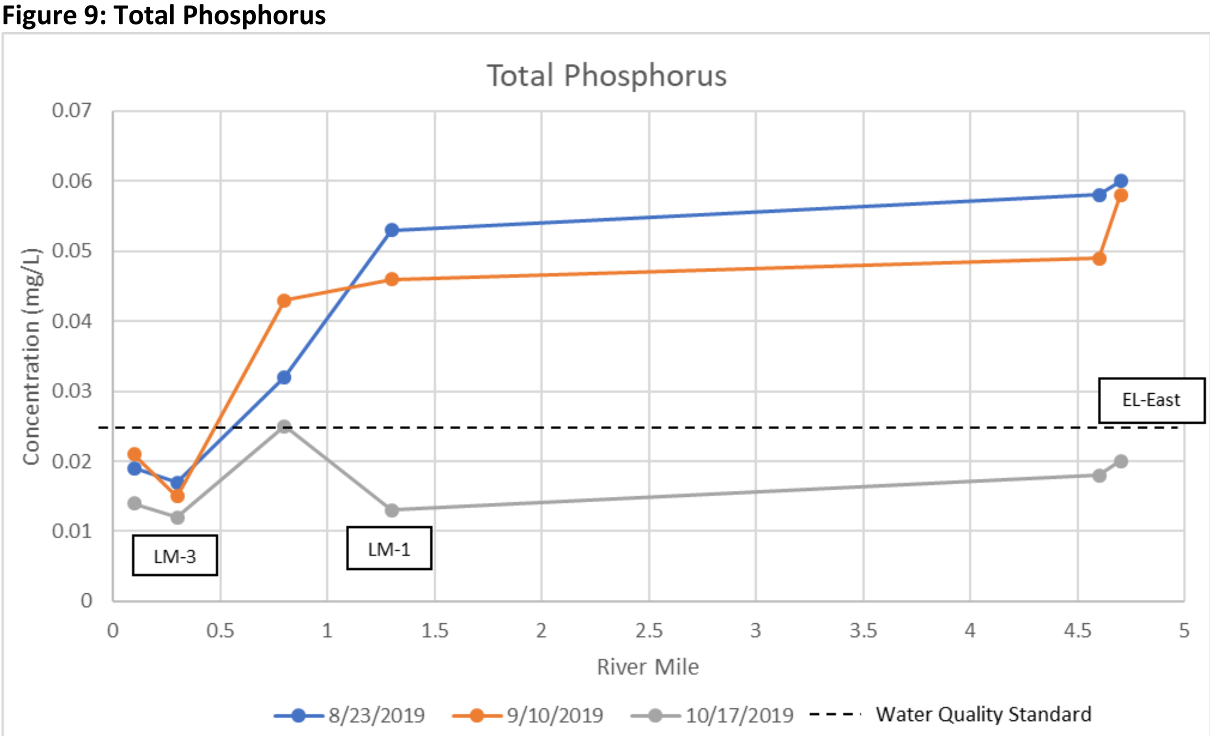


Figure 9: Total Phosphorus



Temperature

Hourly temperature measurements were collected at six sites using Hobo Pro V2 and Solinst Levelogger Junior loggers. These data are plotted in Figures 10 and 11. Temperatures are generally higher below the Supply Ditch at EL-West than those above at EL-East. Both sites exhibit high temperatures overall and high diel temperature fluctuations, especially during mid-summer. Mid-day temperatures frequently reached 75 degrees Fahrenheit in late July and early August. Minimum daily temperatures remained in the upper 50s on most days.

Trout Unlimited was unable to accurately characterize August temperatures at EL-West from late-July until early-September because extremely low flows failed to keep the logger submerged. Field measurements during this period consistently showed warmer temperatures at EL-East than at EL-West. At EL-West, afternoon temperatures on 7/25/2019 and 8/23/2019 were 62 and 68 degrees F respectively. At EL-East on these same dates and within 30 minutes of the EL-East reading, temperatures were 70 and 72 degrees F.

Because of the data gap at LM-4, we are unable to characterize warming or cooling trends between the Elliston property and Lee Metcalf National Wildlife Refuge during the low flow period. It is worth noting, though, that increasing flows between EL-West and LM-1 may represent influxes of cooler groundwater or irrigation return flows during this time period.

On Lee Metcalf Wildlife Refuge, temperature increases overall between LM-Southern Boundary and LM-4 (mouth). However, seasonal and diel temperature fluctuations varied greatly, likely due to groundwater influences and riparian cover.

Minimal temperature variation occurs between the Southern Boundary of the refuge and LM-1, just upstream of the channel split near the Wildlife viewing area. At this point most of the water flows through the culverts and out to the Bitterroot River west of LM-1. However, the Northward channel sends a small quantity water North towards the golf course and our remaining sampling sites (LM-2 thru LM-4).

During the summer, water cools from LM-1 to LM-2, just south of Whitetail Golf Course. LM-2 is characterized by low seasonal and diel temperature fluctuations (ranging from 50-57 degrees in August and September) and increased streamflow likely associated with groundwater. Substantial canopy cover also provided riparian shading- a characteristic not seen at other monitoring locations. Towards the end of September, a sudden drop in temperature was seen across all monitoring locations in North Burnt Fork Creek. Following this drop in temperatures, LM-2 remained substantially warmer than other sites.

Temperatures in the lowest reaches of North Burnt Fork Creek were monitored above and below Barn Slough. Trout Unlimited was interested in whether this slough, fed largely by groundwater, contributed meaningful quantities of cold water to North Burnt Fork Creek. However, temperature plots do not show noticeable differences in max daily temperatures or seasonal temperatures above and below the slough. In fact, field measurements demonstrate that surface water from the slough was 3 degrees warmer than Burnt Fork Creek on August 23, 2019 (Slough: 63 degrees F; Burnt Fork: 60 degrees F).

Throughout late August and early September, maximum daily temperatures were generally 3-5 degrees warmer at the mouth than at the start of the Northward channel at LM-1. Most of this temperature increase occurred downstream of LM-2, where temperatures stabilized in the mid 50s. From early August to early September, temperatures at the mouth of the creek fluctuated between approximately 60-70 degrees Fahrenheit, with a total of seven days exceeding 70 degrees.

Figure 10

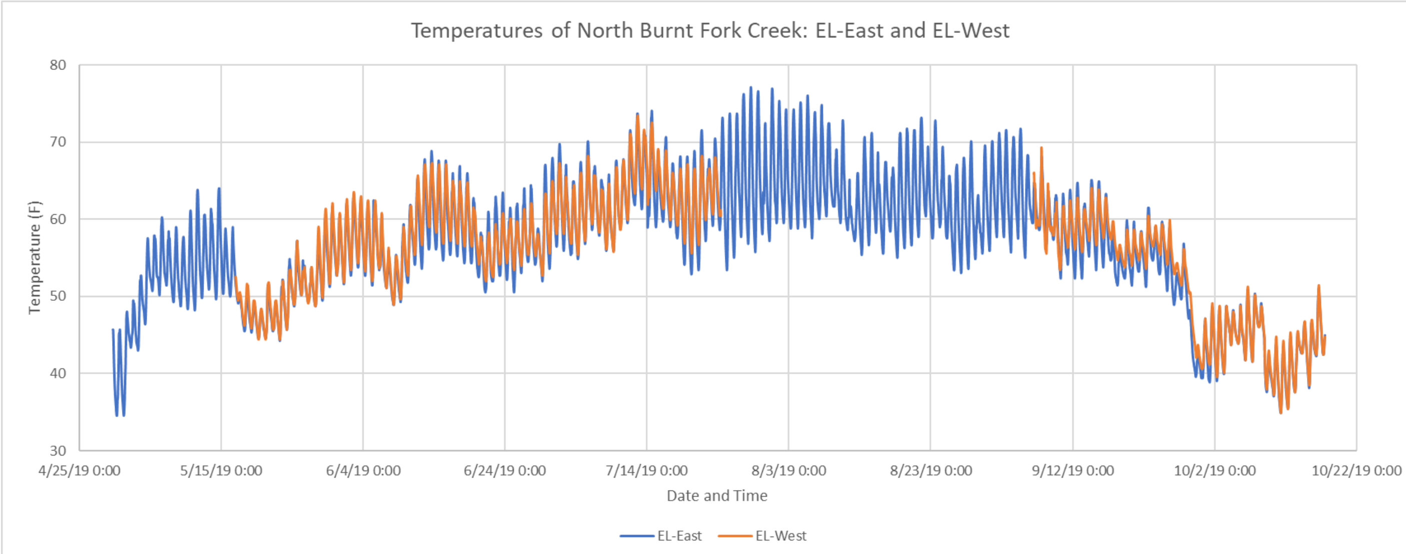
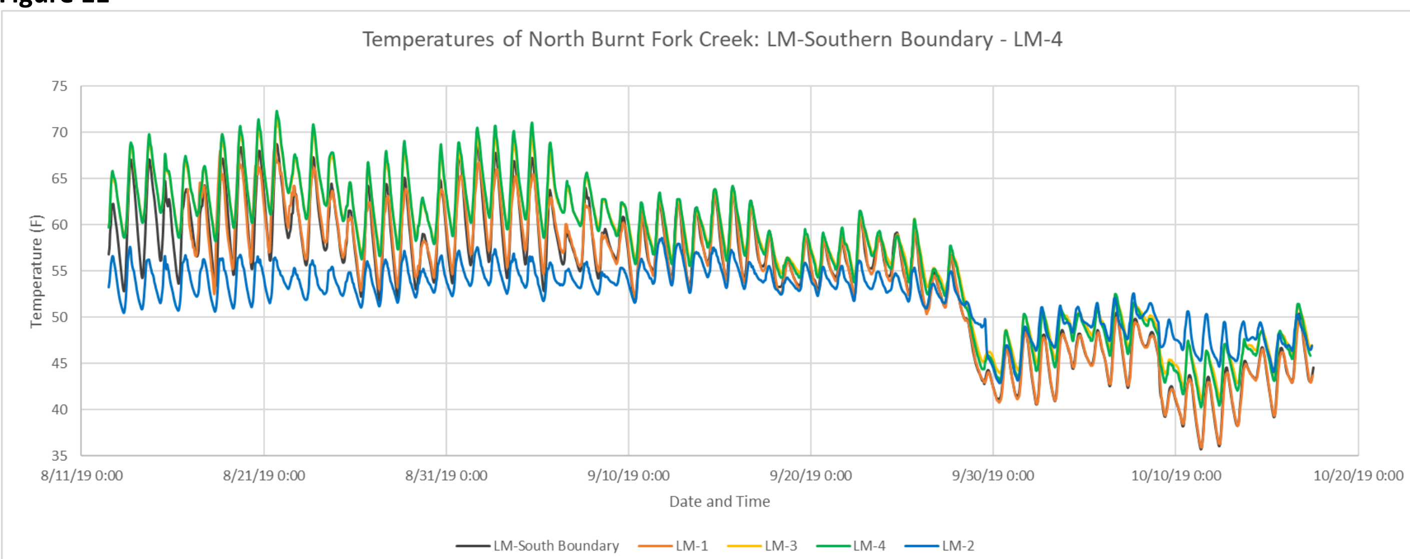


Figure 11



Discussion of Objectives and Management Implications

This project was initiated to better understand longitudinal trends in water quality in lower North Burnt Fork Creek to help design and assess the potential benefits of several projects in the area. The research objectives stated in the SAP are limited to specific monitoring tasks (e.g. Install continuous temperature loggers at seven locations) which were all met. This section, instead, will focus on our monitoring questions, management implications and additional questions that arose as a result of this monitoring effort.

Question 1: *What are the longitudinal trends of nutrient concentrations along lower North Burnt Fork Creek?*

As described in the Results section, nutrient concentrations varied greatly throughout the studied reaches of North Burnt Fork Creek. Concentrations were generally lower at both EL-East and EL-West when local irrigation demand was low and discharge in North Burnt Fork Creek increased. This suggests that higher flows tend to dilute nutrient concentrations in North Burnt Fork Creek, bringing them well below water quality standards set forth by the Montana Department of Environmental Quality. However, on each day of sampling Total Suspended Sediments and Total Nitrogen were present in notably higher concentrations immediately below the Supply Ditch at EL-West than above at EL-East.

Given the close proximity of the EL-East and EL-West sampling locations, the sudden change in Total Nitrogen and Total Suspended Solids concentrations likely results from differing origins of water in the creek above and below the ditch. During periods of high demand for irrigation water the Supply Ditch captures the vast majority of streamflow at their intersection, while the stream below the ditch is fed mostly by ditch water from the Bitterroot River released through the diversion structure.

Longitudinal trends in nutrient concentrations were complex throughout Lee Metcalf National Wildlife Refuge, where the creek undergoes many changes including a channel split, varied canopy cover and the influences of groundwater. Apart from an unexplained outlier in Total Suspended Sediments at LM-1 on August 23, concentrations of suspended sediments, Total Phosphorus, and Total Nitrogen decreased between EL-West and LM-1. This was especially true for Total Phosphorus as highly elevated concentrations at EL-East and EL-West fell below DEQ water quality standards after entering the Refuge.

Moving downstream through the Northward channel, Montana DEQ water quality standards were only exceeded at LM-2 by high concentrations of Total Nitrogen on August 23 and September 10. Higher flows on October 17 likely diluted concentrations of Total Nitrogen at all monitoring sites in the refuge, and brought levels at LM-2 in compliance with standards.

Although North Burnt Fork Creek lacks a clearly specified water quality standard for Nitrate + Nitrite, concentrations between LM-1 and LM-4 displayed a prominent spike in August and September. Considering that inorganic fertilizer is a common source of nitrates in surface and drinking water, management practices at Whitetail Golf Course may explain the sudden increase in Nitrate + Nitrite. Additionally, all forms of nitrogen in water tend to be converted to nitrates over time, offering another possible explanation for the spike (Water Quality Association, 2013). As with the other nutrients, however, these concentrations were greatly reduced by higher October flows, resulting in little to no increase throughout the lowest reaches of the creek.

Management Implications

One project under consideration is to replace the irrigation infrastructure at the Supply ditch to reduce co-mingling of water sources and eliminate fish passage barriers while maintaining necessary water management for the Ditch users. Our data indicates that such a project may, in fact, reduce TSS and nitrogen levels. However, co-mingled water generally met water quality standards for TN and reduced TP. Additionally, flow and temperature data indicate that the Supply Ditch provides additional flow, and generally cooler water during critical low flow periods. Any design to upgrade infrastructure or manage ditch flow would have to ensure that these benefits were maintained or improved.

Management decisions must be made according to clearly identified management priorities that weigh the benefits and consequences of various outcomes. For instance, if low flows and high temperatures are identified as the highest priority issues in North Burnt Fork Creek, flow supplementation with water from the Supply Ditch may offer a solution, especially considering that the increases in Total Suspended Sediments and Total Nitrogen below the ditch did not exceed water quality standards. It is important to note that Trout Unlimited did not collect water quality data throughout spring runoff and early summer. This information could play an important role in informing management priorities and decisions.

Nutrient data collected on Lee Metcalf National Wildlife Refuge are sufficiently complex that they are not currently impacting management decisions on lower North Burnt Fork Creek. One point of discussion is the deposition of fine sediment in North Burnt Fork creek above the culverts at the channel split/wildlife viewing area. While these undersized culverts are causing sedimentation locally, they are helping to fulfil the geomorphic role of floodplains, trapping sediment before it enters the Bitterroot River. The removal of these culverts could increase sediment (and associated nutrient) loading to the Bitterroot River. Beaver dams throughout Lee Metcalf provide a similar sediment trapping function and may offer a natural alternative with improved fish passage

Question 2: *Where is most of North Burnt Fork flow lost within Lee Metcalf? Does this correlate with temperature increases?*

Flows in North Burnt Fork creek are heavily impacted by their agricultural setting including dewatering from irrigation as well as irrigation return flows in lower reaches.

The hydrograph downstream of the Supply Ditch (Figure 3) is substantially altered by demand for irrigation water. Flows alternated between severe dewatering and large pulses of unseasonably high flows when the ditch was spilling excess water. Downstream of the Supply Ditch, North Burnt Fork Creek consists of a single channel until LM-1 in Lee Metcalf National Wildlife Refuge. At this point, most of the water passes under a walking path through two large culverts, flowing westward and joining Bitterroot River shortly thereafter. Just upstream of the walking path and culverts, however, a small channel carries water north through the refuge. Referred to as the “Northward channel” in this report, the first stretch of this channel frequently goes dry during periods of dewatering for irrigation demand, though this was not seen in 2019. Dewatering causes habitat fragmentation and can trap organisms in areas with unsuitable habitat and high temperatures during periods of low flow.

Stream temperatures throughout most of the study area from mid-July to late-August regularly reached daily maximums of 65-75 degrees F, with higher temperatures at the upstream-most sampling locations. These temperatures represent extremely stressful conditions for cold water fishes, especially native species of concern such as Westslope Cutthroat Trout, which have low lethal temperature thresholds relative to rainbow trout and other non-natives (Bear, 2005). Despite the relatively cool summer temperatures in 2019, these temperature fluctuations resulted from critically low flows and a lack of shade stemming from riparian cattle grazing and reed canary grass suppression of riparian trees and shrubs.

Groundwater inflows throughout the Refuge also had a notable influence on streamflow and temperature. Groundwater is likely sourced from irrigation return flows higher in the valley, ponds on the Refuge or subsurface flowpaths of the Bitterroot River. Most of the Refuge is located within the historic Bitterroot floodplain and is likely hydrologically connected to the river. Summer flows consistently increased between EL-West and LM-4. The split at LM-4 reduces flows in the “northward channel” initially, with most water being re-directed West towards the Bitterroot along the “short path.” However, groundwater contributions substantially increase streamflow along the Northward channel, beginning around LM-2. On August 23, 2019, flows increased by 11 cfs over the lower 0.7 miles (1.29 cfs at LM-2 to 12.33cfs at LM-4). Diel temperature fluctuations and maximum daily temperatures throughout August and early September were lowest at LM-2, ranging from 50-57 degrees Fahrenheit. Forest canopy also provides shade in this reach, minimizing the effects of thermal radiation on stream temperatures. This increase in flow and its associated decrease in stream temperature offers essential refugia to aquatic organisms during hot, low-flow periods.

Interestingly, the beneficial thermal effects of cold groundwater were no longer observed at LM-3 and LM-4 despite increases in streamflow. These locations displayed large diel temperature fluctuations as well as the warmest temperatures observed in the refuge, with daily maximums at or near 70 degrees Fahrenheit throughout August and early September. The creek was monitored directly upstream of the mouth of the Barn Slough with the intention of isolating its effect on stream temperatures. The top of the Barn Slough has previously been observed to have cold water temperatures. However, the slough did not provide cold water inflows to North Burnt Fork Creek. In fact, field measurements demonstrate that surface water from the slough was 3 degrees warmer than Burnt Fork Creek on August 23, 2019 (Slough: 63 degrees F; Burnt Fork: 60 degrees F at 10:45 am). The slough is a large, open water body with high solar radiation. It is likely that slough water is stratified, with warm water on top and colder water below, and that this warmer water is the source of surface flow into North Burnt Fork Creek.

Management Implications

Current restoration discussions center on removing the channel split at LM-1 to restore fish passage and consolidating flow into one channel, either the “short path” which flows westward directly to the Bitterroot River, or the longer Northward channel which flows north through the Refuge for over a mile before joining the Bitterroot River. There are benefits and costs to both options.

Short path: The “short path” would generally offer cooler water temperatures by avoiding thermal loading found along the Northward channel which has little riparian cover and increases in temperature despite increasing in flow. Additionally, this option is likely the most geomorphically stable, avoiding a sharp turn in the stream orientation. The short path, however, would reduce stream length and isolate the beneficial groundwater inflows seen near LM-2. If the “short path” was constructed, the Northward channel would become a slough of the Bitterroot river, still providing habitat and thermal refugia, but not connected to North Burnt Fork Creek.

Northward channel: If all water were directed along the norward channel, it is possible that cooler temperatures would be maintained due to increased flows. It is important to note, however, that this option would need to be accompanied by restoration efforts to increase riparian vegetation and reduce thermal loading from solar radiation. Additionally, modifications to the Barn Slough outlet could allow cooler water to be released into the creek. A formal topographic survey and geomorphic assessment would be needed to determine the viability of this option.

It is also important to note that the Bitterroot River is actively eroding to the east, towards North Burnt Fork Creek at a rate of 11-19 feet per year. This migration is natural but is likely accelerated by channel straightening upstream of the Refuge. North Burnt Fork Creek historically met the Bitterroot River at different locations as the Bitterroot channel migrated east to west, accessing different portions of the floodplain. Future migration should be accounted for in the decision of where to restore North Burnt Fork's channel.

Conclusions

These data provide substantial insight into the benefits and costs of various proposed restoration projects on North Burnt Fork Creek. Trout Unlimited will continue to work with resource managers to develop our understanding of the system, define our goals for management and restoration and proceed with project development as appropriate.

References

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