Loveland Water and Power

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Big Thompson River Watershed Source Water Quality Conditions

Spring 2023

July 17, 2023

Common Acronyms

CB-T	Colorado-Big Thompson Project
CPF	Cameron Peak Fire
CFS	Cubic Feet per Second
LWP	Loveland Water and Power
mg/L	Milligrams per liter (parts per million)
$CaCO_3$	Calcium carbonate
NTU	Nephelometric Turbidity Unit
North Fork	North Fork of the Big Thompson River
SU	Standard Units
SWMP	Source Water Monitoring Program
TOC	Total Organic Carbon
ug/L	Micrograms per liter (parts per billion)
uS/cm	Microsiemens per centimeter
WQL	Loveland Water and Power Water Quality Laboratory

Executive Summary

Spring 2023 water quality conditions were similar to those documented over the previous five years and effects of the Cameron Peak Fire (CPF), which occurred in fall 2020, were still readily apparent in some locations. Water quality parameters that continue to be affected by the results of the CPF include increased turbidity, pH, dissolved manganese, dissolved iron, and nitrate. These impacts were particularly notable in the area surrounding the North Fork Big Thompson River, which was the most severely burned area of the Big Thompson River Watershed. Also of note in spring 2023 were the elevated pH levels at the CB-T sampling locations which could be a result of the East Troublesome Fire. Conversely, total copper and organic carbon were somewhat increased in the sites associated with the North Fork Watershed compared to spring 2022. Both of these parameters decreased substantially after the CPF and the fact that they are increasing may suggest that the effects of the CPF may be beginning to dissipate. Sampling from additional sites in the North Fork Watershed in spring 2023 confirm that many of the changes in water quality in the Big Thompson River originated in the Miller Fork as a result of the CPF. Although the water quality changes resulting from the CPF were challenging from a water treatment perspective, in terms of avoiding water with elevated turbidity among other issues, they provide a template for expected changes that will occur in the event of the next wildfire. Despite the continued challenges, LWP Drinking Water Treatment staff were able to continue providing high quality drinking water.

Loveland Water and Power Source Water Monitoring Program

The purpose of the Loveland Water and Power (LWP) Source Water Monitoring Program (SWMP) is to collect, analyze, and interpret water quality data that are of interest with regard to drinking water, wastewater, recreation, and aquatic ecosystems. These data are used to identify and quantify current issues, document management successes, evaluate regulatory compliance, evaluate the appropriateness of current water quality standards, and identify issues that may present themselves.

One central component of the SWMP is the source water sampling and analysis that is accomplished by staff at the Loveland Water and Power Water Quality Laboratory (WQL). LWP has collected operational source water data for over 30 years and a more targeted set of parameters for nine years from the three water sources utilized for drinking water (Colorado-Big Thompson Project, Big Thompson River, and Green Ridge Glade Reservoir). The values for these targeted parameters are available in a short amount of time due to in-house laboratory capacity, and therefore can be used to inform more immediate water system operational decisions.

Water quality information is routinely collected from 15 sites. Of these sites, two are intake locations at the Loveland Water Treatment Plant (river intake and reservoir intake), two are tributary sites (Fall River and North Fork Big Thompson River), seven are associated with the Colorado-Big Thompson River project (CB-T), and four are mainstem river sites (Table 1, Figure 1). Three additional sites were added beginning in spring 2023. One of these locations is located upstream of the Estes Park Sanitation District outfall (by the Rocky Mountain National Park visitor center). Another site added in spring 2023 is located on the North Fork of the Big Thompson River (North Fork) upstream of the confluence with the Miller Fork. The Miller Fork has been a substantial contributor of water affected by the CPF to the mainstem of the Big Thompson River. The site located above the confluence of the Miller Fork with the North Fork will assist in providing context for Miller Fork contributions. The final site is in the Miller Fork itself, just above the confluence with the North Fork. Sample collection at the three additional sites began in April 2023. All these sites are located upstream of the Loveland drinking water intake and therefore water quality results from these locations have implications for Loveland water treatment and drinking water quality.

Table 1. Big Thompson Watershed sampling location descriptions.

Site Name	Type	Description
S-BTR-10	River	Big Thompson River below Mary's Lake Bridge
S-BTR-15	River	Rocky Mopuntain National Park Visitor Center
S-BTR-20	River	Downstream of Olympus Dam
S-BTR-30	River	Big Thompson mainstem above confluence with North Fork
S-BTR-40	River	Mainstem Big Thompson at Narrows Park
S-BTR-50	River	Mainstem Big Thompson at Viestenz-Smith Park
S-BTT-10	Tributary	Fall River Court bridge
S-BTT-15	Tributary	North Fork Big Thompson above Miller Fork Confluence
S-BTT-17	Tributary	Miller Fork at Streamside Drive
S-BTT-20	Tributary	North Fork Big Thompson at Storm Mountain Road
S-CBT-10	CB-T	Near gate at East Portal
S-CBT-20	CB-T	Shore of Mary's Lake
S-CBT-30	CB-T	Shore of Pinewood Reservoir
S-CBT-40	CB-T	Shore of Flatiron Reservoir
S-CBT-50	CB-T	Downstream of Flatiron Reservoir
S-CBT-60	CB-T	Hansen canal near outlet to Green Ridge Glade Reservoir
S-LNN-10	Lab Line	River line in laboratory
S-LNN-20	Lab Line	Reservoir line in laboratory

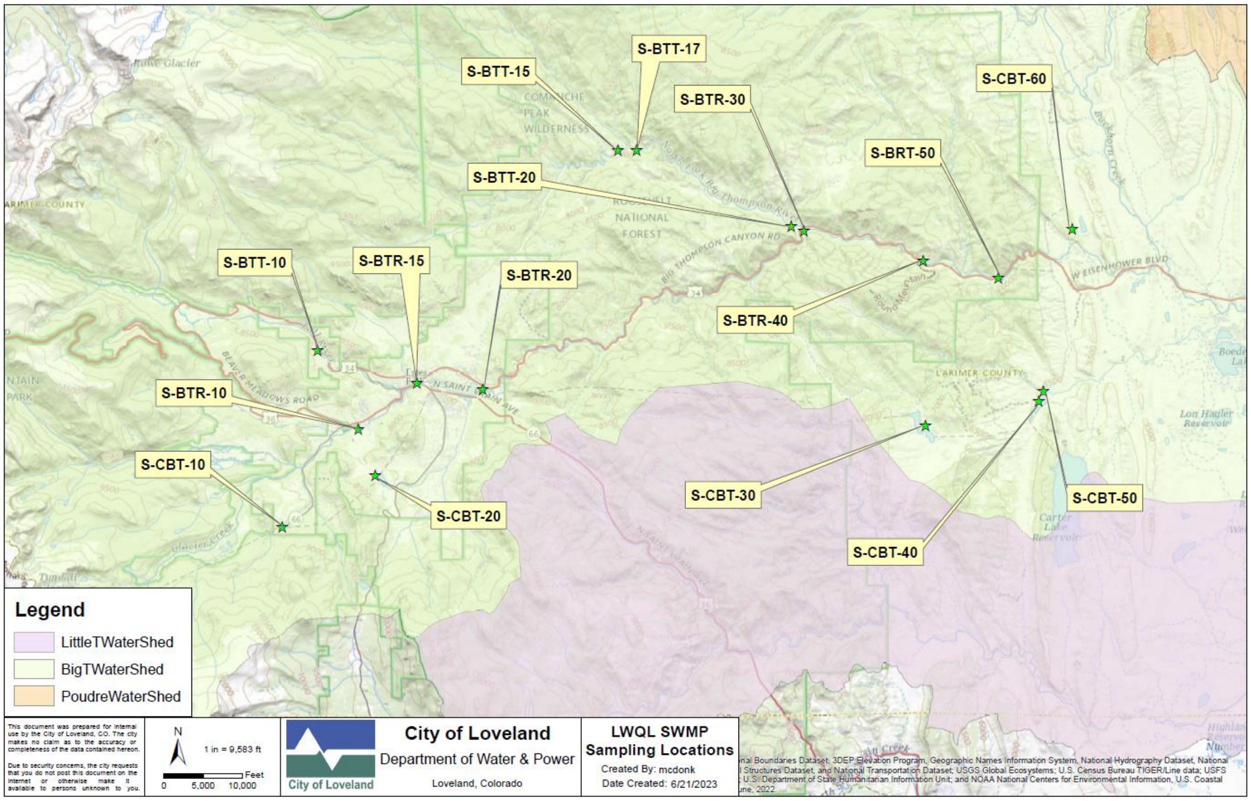

Figure 1. 2023 Source Water Monitoring Program water quality sampling sites.

Objective

The objective of these seasonal reports is to provide a description of notable events and a summary of important water quality parameters for those interested in the water quality of the Big Thompson River. These reports do not summarize all the water quality parameter data collected by the WQL and are not meant to represent a quantitative statistical analysis of the data.

These comparisons provide the opportunity to understand recent conditions relative to the previous five-year time period and to established water quality standards. While water quality conditions have changed on time scales greater than five years, this relatively short time period provides context for recent conditions. Examination of longer-term trends and conditions can be found in LWP Big Thompson River Annual Reports. The results and findings presented in this report only represent source water and not the treated drinking water that is delivered to our customers. Drinking water information and the annual Consumer Confidence Report can be found on our website. (https://www.lovelandwaterandpower.org/city-government/departments/water-and-power/water-quality)

For this report, the term “spring” is defined as the months of February, March, and April. This time period is representative of relatively stable flow conditions prior to runoff and snowmelt which generally occur primarily in May, June, and the first part of July. Average values were calculated from all samples collected during these months in 2023 and compared to the average value of all samples collected during these months from 2018 through 2022.

Summary Conditions

Water quality conditions in spring 2023 were generally similar to conditions experienced over the past five years and although effects of the CPF are clearly apparent, these effects may be beginning to dissipate. Conditions were somewhat cool with average precipitation. The CPF and the East Troublesome Fire continued to impact various water quality parameters including turbidity, pH, dissolved manganese, dissolved iron, and nitrate. These impacts were particularly notable in the area surrounding the North Fork, which was the most severely burned area of the Big Thompson River Watershed. Also of note in spring 2023 were the elevated pH levels at the CB-T sampling locations. These stations may be experiencing elevated pH levels since ash is generally basic and the East Troublesome Fire may continue to contribute ash to these sites. However, these elevated concentrations were generally lower than they were during spring 2022. Increases in manganese, iron, and pH can make water treatment more difficult and can result in discoloration and taste and odor issues if the water is not treated adequately. While elevated nitrate can have negative health consequences, the levels observed in spring 2023 were much lower than levels that might cause health concerns. However, elevated nitrate can be beneficial to algal growth and increase algal abundance which may result in taste and odor issues or even issues with toxicity. Increased turbidity is problematic because it is an indicator of high sediment load and as such, it can force LWP to use different sources of drinking water before overloading the capacity of the water treatment plant. Although changing water sources can be logistically challenging given physical and water quality constraints, LWP is fortunate to have multiple separate sources of water that can be utilized. Turbidity levels are also positively associated with total organic carbon (TOC) levels which can require additional water treatment efforts and may lead to unwanted disinfection byproducts (Allen et al. 2022). Conversely, somewhat higher TOC and total copper concentrations in sampling locations most associated with the CPF are consistent with fire recovery. Total copper and TOC concentrations were lower immediately following the fire and seem to be increasing back to levels measured prior to the fire. Additionally, while nitrate levels continue to be high at fire impacted sites, they are approximately 10-20% lower than the same sites in spring of 2022. Although fire recovery seems to be beginning, fire impacts can be expected to continue for the next several years and despite the challenges, LWP Drinking Water Treatment staff are expected to be able to continue providing high quality drinking water.

Spring 2023 sampling conditions affected some of the data available and subsequent comparisons with five-year average values. First, water levels in Pinewood Reservoir were extremely low, such that sampling was not possible in the spring months of 2023. In addition, it was not possible to sample in February and March at a number of the sampling locations higher in the watershed (S-BTR-10, S-BTR-30, S-BTT-20, and S-BTR-50) due to ice conditions. As such, spring 2023 average values for water quality at these stations may appear higher or lower than the five-year average value simply due to the fact that February and March data were unavailable. Therefore, information from these locations should be interpreted with care.

Water Quality Parameters

Precipitation

The amount of precipitation is directly proportional to the amount of water present in the Big Thompson River. In addition, the amount of precipitation can provide an indication of the relative quality of the water as large rain events and runoff often result in increased turbidity and decreased water quality.

Precipitation in spring 2023 was approximately average compared to the previous five-year time period (Figure 2). However, there was substantially above average snowpack in the Big Thompson River watershed during the winter and early spring. Snowpack was 126% of the average snow-water content (1991-2020) (Northern Water 2023). Since flow, water availability for municipal and agricultural use, and aquatic community health all depend to some degree on the amount of precipitation and snowpack, values experienced in 2023 were a welcome occurrence. However, these increases only resulted in values being near the five-year average value.

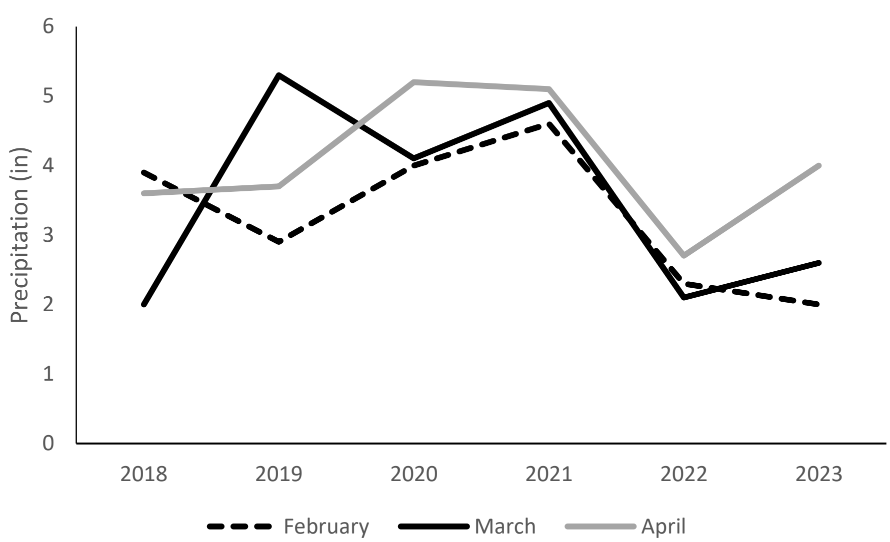

Figure 2. Monthly precipitation by year at the Bear Lake Natural Resources Conservation Service Snow Telemetry (SNOTEL) station.

Temperature

Aquatic organisms have preferred temperature ranges. These ranges can vary widely, and species with similar temperature tolerances are often associated with one another. Some organisms require relatively cold water to survive, particularly during spawning, egg/larval growth, and development. Consequently, elevated water temperatures can cause mortality as well as reduced reproduction and growth. Conversely, water temperatures can be too low for optimal growth and survival of some species, particularly those found in the lower reaches of the Big Thompson River.

In addition, temperature is of interest to water treatment operators because the temperature of the water influences the speed at which chemical reactions used to treat drinking water take place. Chemical reactions generally take longer to complete in colder water.

Spring 2023 temperatures were somewhat lower than average values in the past five years (Figure 3). Given the generally increasing temperatures in Colorado and the region, somewhat cooler temperatures in spring 2023 are closer to average historic values.

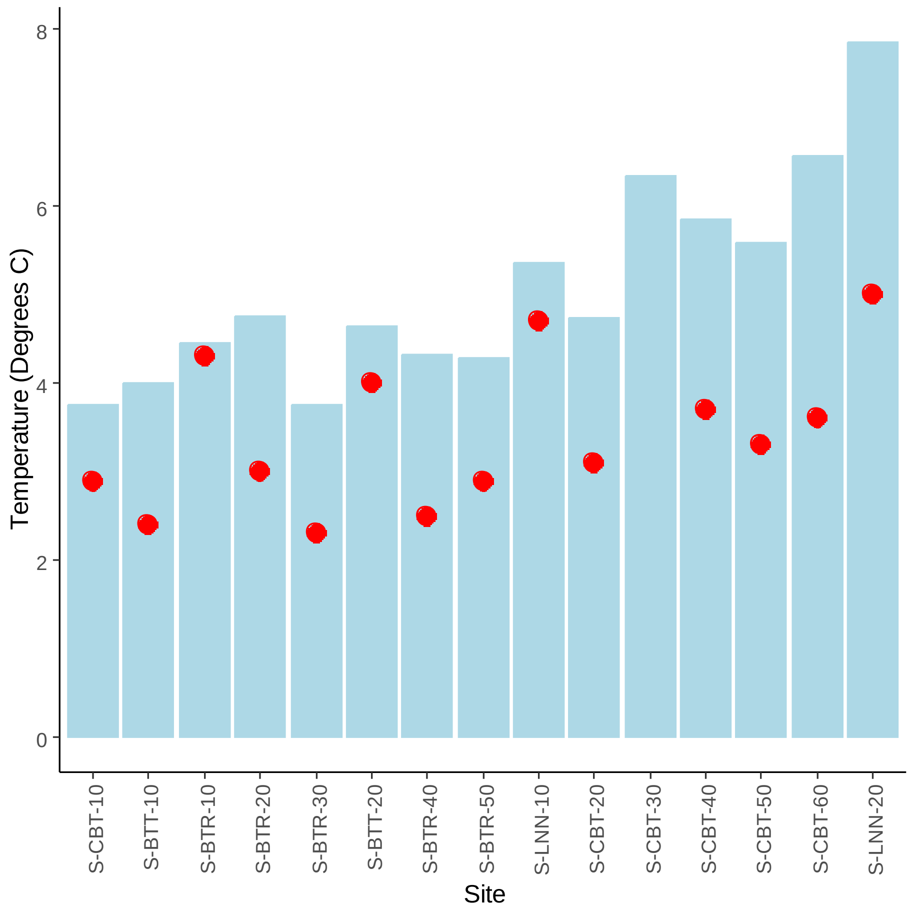

Figure 3. Average water temperature values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Turbidity

Turbidity is a general measurement of water clarity, measured as NTU (Nephelometric Turbidity Unit). Water with higher turbidity levels has a greater number of suspended particles in it and is less clear. Elevated turbidity has negative impacts on municipal water treatment plants and aquatic communities. LWP alters the location of their water collection to avoid high levels of turbidity as it is an indicator of high sediment load. Turbidity levels are also positively associated with total organic carbon (TOC) levels which in turn require additional water treatment efforts.

Elevated turbidity can have negative direct and indirect effects on aquatic organisms and can be associated with high concentrations of some metals. Elevated turbidity and suspended sediment can also have negative effects on density and species richness of macroinvertebrates. Growth of trout species such as rainbow trout (*Oncorhynchus mykiss*) is negatively associated with increased turbidity and increased turbidity can lead to increased mortality as well. Effects of elevated turbidity become more severe with longer exposure.

Turbidity levels in spring of 2023 were near average values for most locations although levels were considerably higher in the North Fork (Figure 4). The area in the North Fork watershed above the sampling site was included in the area that was most severely burned during the CPF in fall of 2020. Increased turbidity resulting from the aftereffects of wildfire can persist for a number of years (Rhoades et al. 2011) and the elevated turbidity level in the North Fork is likely due to these continued effects. Although the average turbidities at the sites near the canyon mouth actually remained somewhat elevated, they appear relatively low compared to the five-year average values due to very high turbidities that occurred during highway 34 construction activities near Drake, CO in March of 2018, which increased overall average values.

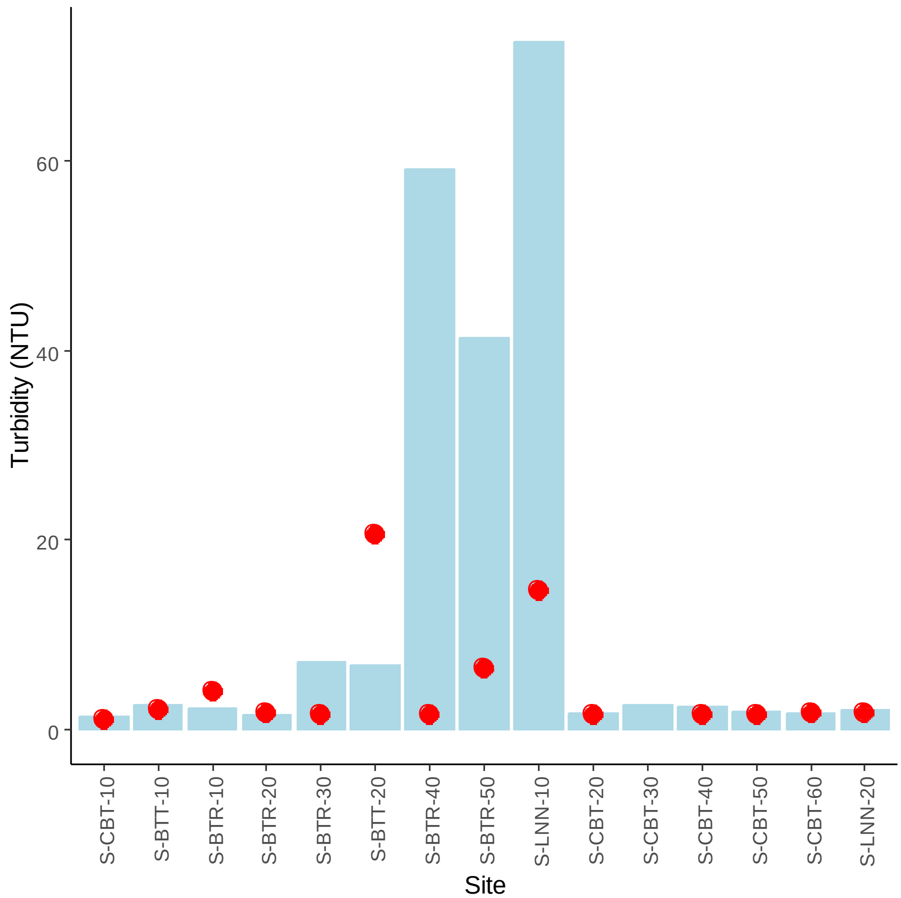

Figure 4. Average turbidity values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

pH

The pH value (SU, Standard Units) measures how acidic or basic the water is. A pH value of 7 is considered neutral, with lower values considered acidic and higher values considered basic. Colorado Regulations 31 and 38 establish a pH of 6.5 as a minimum and 9 as a maximum to protect aquatic life. Generally, pH values increase as water moves from the headwaters to lower in the watershed because additional dissolved materials become present in the water. The pH level also impacts the efficacy of alum coagulation in drinking water treatment with the optimal range being between 6 and 8. Outside this pH range, coagulation is less efficient in removing particles present in the water.

Mean pH values were somewhat elevated for virtually all sites in spring 2023 (Figure 5). These elevated values were particularly notable in the sites associated with the CB-T. Higher pH values mean that the water was more basic in 2023 than in previous years. While these increases seem to be modest, pH is measured on a log scale so that a pH increase of one is equivalent to the water being 10 times more basic. White ash from wildfires is generally basic (Rodela et al. 2022). Since all the sites continue to receive some amount of ash from either the CPF or the East Troublesome Fire, it is reasonable to expect pH levels to be somewhat higher than historic values for several years. Although the pH values were somewhat elevated in 2023, none of the values exceeded standards set to protect aquatic life.

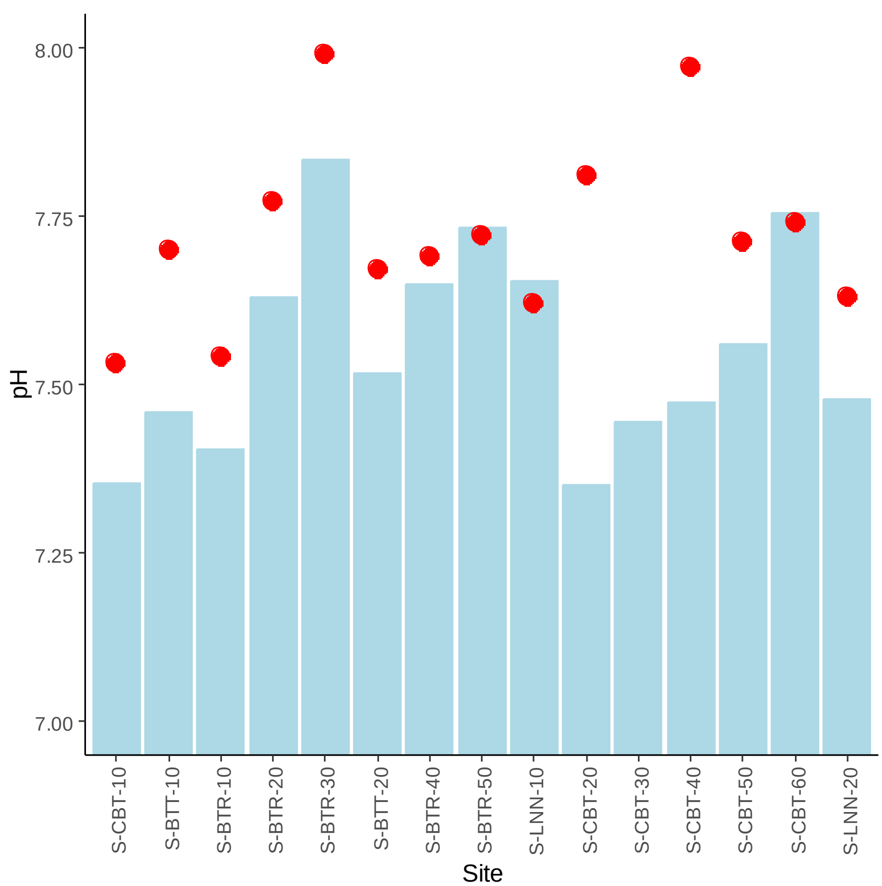

Figure 5. Average pH values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Dissolved Oxygen

Dissolved oxygen levels are important to aquatic life and drinking water facilities and are affected by a number of factors such as temperature, altitude, turbulence, and biological activity. Turbulent cold water at a low altitude can have higher levels of dissolved oxygen than still warm water at a higher altitude. Biological activity (particularly photosynthesis) can increase dissolved oxygen during the day as photosynthesis occurs and can decrease dissolved oxygen levels at night when respiration dominates. Often, biological activity has no net effect on dissolved oxygen levels, but it can increase the daily range of values with wider ranges being associated with greater biological activity.

Virtually all aquatic organisms require dissolved oxygen to survive with the necessary concentration differing by species. For example, many fish species in the upper portion of the Big Thompson River have evolved to live in cold water streams and require higher concentrations of dissolved oxygen (e.g., cutthroat trout *Oncorhynchus clarki*) than those that evolved to persist in the lower warm water portion of the river (e.g., plains killifish *Fundulus zebinus*). Aquatic organisms can experience mortality if the dissolved oxygen levels drop below their threshold level for even a short time. Although some life stages require higher levels of dissolved oxygen, a minimum threshold to support most aquatic life is approximately 6 mg/L (ppm, parts per million). In addition, dissolved oxygen levels regulate the degree to which some elements (like manganese) remain in solution. Relatively high dissolved oxygen levels allow these elements to precipitate out of the water column and make drinking water treatment easier.

Spring 2023 dissolved oxygen levels were generally above historic averages across sites (Figure 6). Cold water can hold a greater amount of dissolved oxygen than warm water so somewhat higher dissolved oxygen concentrations may have been caused by the relatively cold ambient temperatures present in spring 2023. All values were substantially above standards associated with aquatic life which is a positive indication for aquatic ecosystems in the Big Thompson River Watershed.

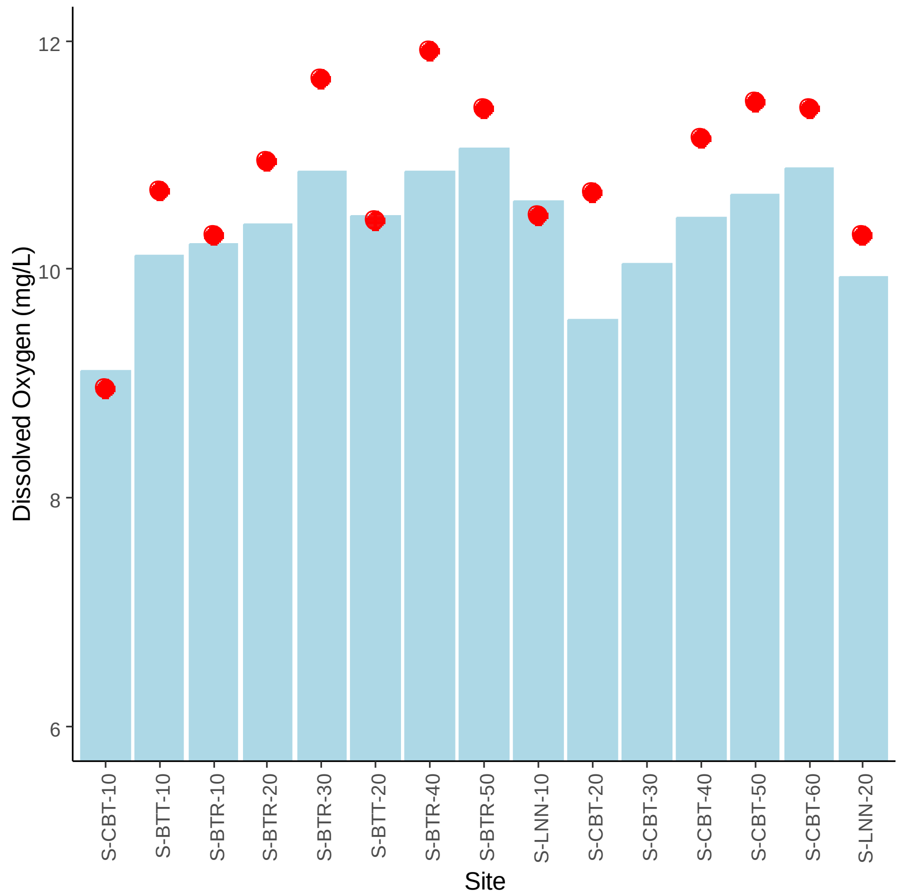

Figure 6. Average dissolved oxygen values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Alkalinity

Alkalinity is a measure of the ability of water to neutralize acid and resist declines in pH. Alkalinity is generally determined by the amount of calcium carbonate in water. Calcium carbonate provides buffering capacity to protect aquatic life from acidic conditions and decreases the ability of water to corrode distribution pipes. Conversely, water treatment plants (including Loveland Water and Power) often use flocculation techniques to purify water and these techniques are generally optimized by altering the pH (Naceradska et al. 2019). High alkalinity makes this pH adjustment more difficult and requires higher doses while low alkalinity can cause incomplete chemical reactions and poor flocculation.

Differences between average values in spring 2023 and average spring values over the previous five years were relatively small. However, spring 2023 alkalinity levels in both S-BTR-10 (Mary's Lake Bridge) and S-BTT-20 (North Fork) appear to be somewhat lower than the five-year average value. The only spring sample for these two locations occurred in April. Samples in February and March were not taken due to ice conditions. Higher temperatures can cause decreased alkalinity due to increased influence of snowmelt (Hill and Neal 1997). The fact that the only alkalinity values available for these two sites was from the warmest of the three months included in the mean value may be the cause of these apparently lower values.

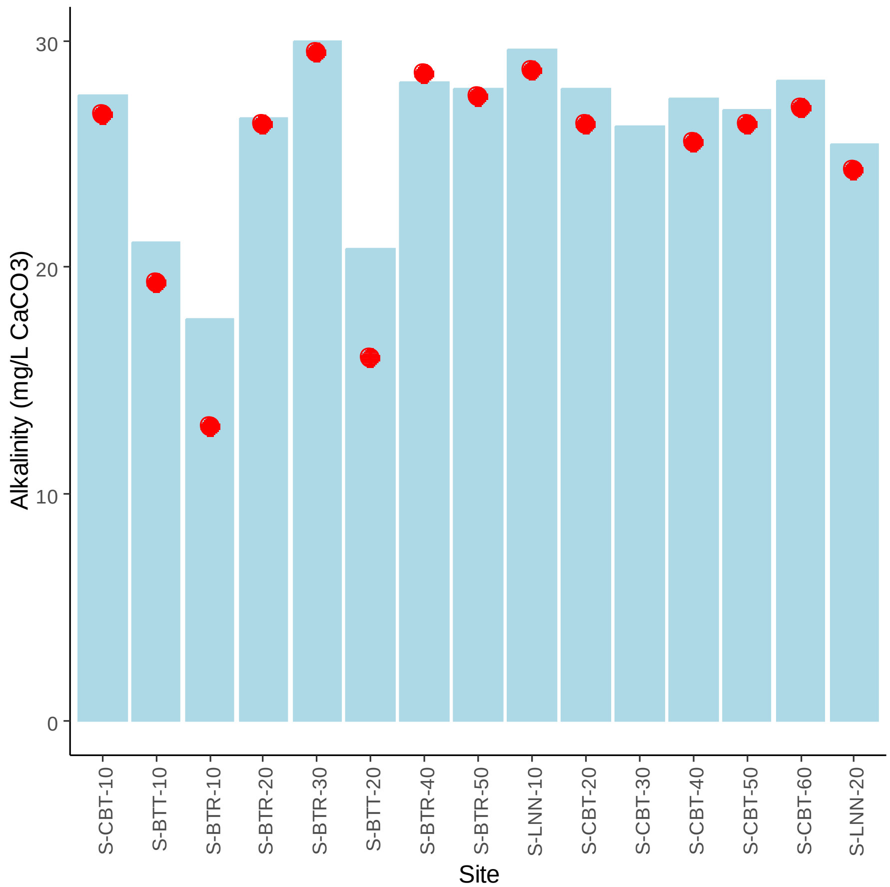

Figure 7. Average alkalinity values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Manganese

Manganese is an element that is considered beneficial to human health at low levels and is one of the least toxic elements. However, elevated levels can cause non-health related effects such as bad taste and staining of clothes and plumbing fixtures. Elevated manganese levels can also cause problems for water distribution systems. Specifically, manganese may cause buildup in water distribution pipes. The relative toxicity of manganese to aquatic life is based on the hardness of the water, but manganese levels of concern to aquatic life are much higher than those present in the Big Thompson River.

As with the average turbidity levels measured in spring of 2023, the values for dissolved manganese measured in spring 2023 in the sites near the canyon mouth (Figure 7) are lower than average, likely due to very high turbidities in March of 2018 as a result of highway 34 construction activities near Drake, CO. High levels of turbidity are often associated with high concentrations of dissolved metals. In addition, increased dissolved manganese levels have been associated with the aftereffects of wildfire. As such, elevated levels in the North Fork are likely due to continued effects of the CPF.

The EPA has a “secondary” standard of 0.05 mg/L (ppm) for dissolved manganese. This level does not make water unsafe to drink, but the water may be aesthetically unpleasing due to a reddish/black/brown color which can stain laundry, plumbing, sinks, and showers. Although the mean total manganese value at site S-BTT-20 (North Fork) was above this secondary standard, dissolved manganese values were substantially lower and dilution in the main stem Big Thompson reduced this concentration prior to reaching the LWP drinking water intake.

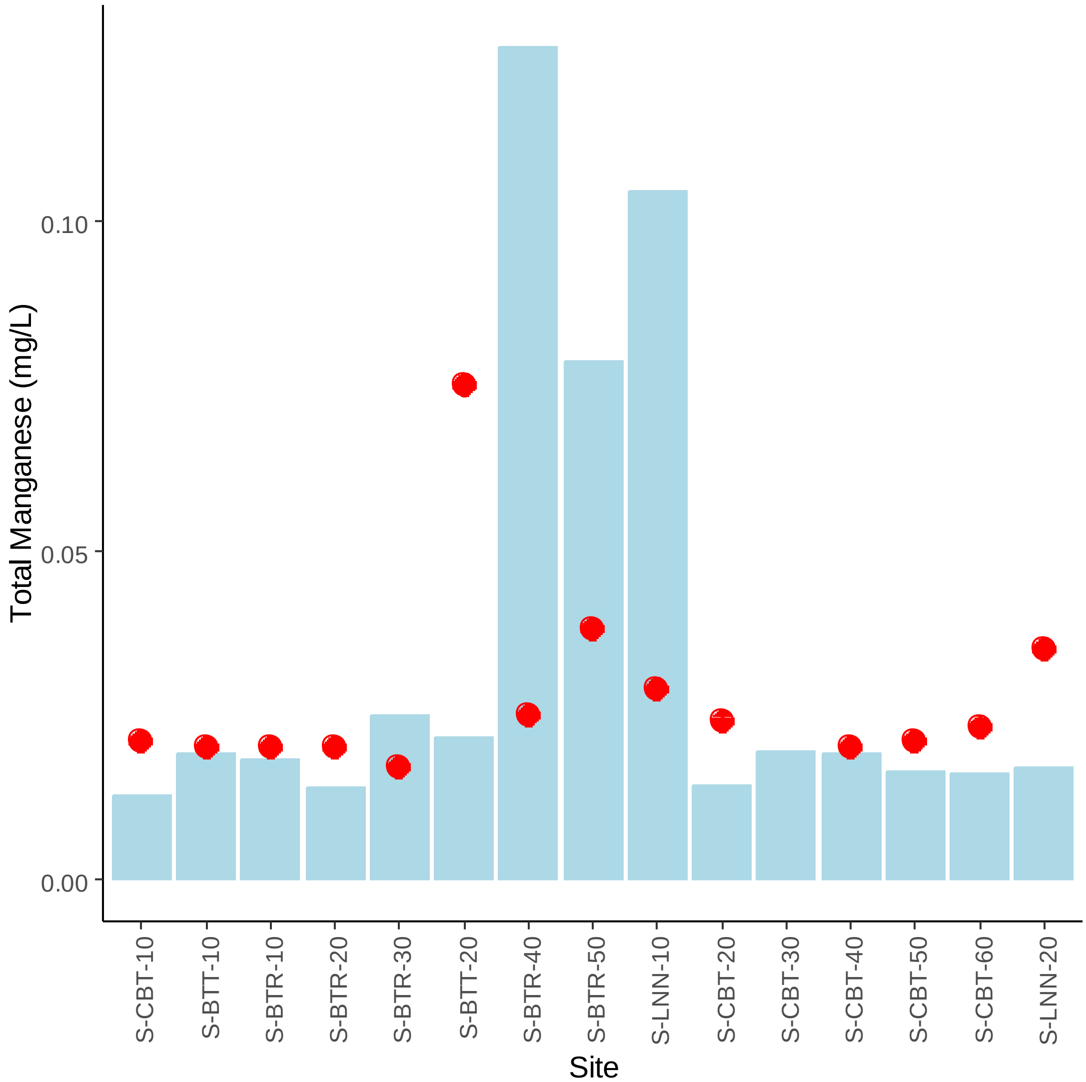

Figure 7. Average total manganese values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Copper

Copper is of interest primarily due to its potential effects on aquatic life. While copper is an essential nutrient, it can cause chronic and acute effects to aquatic life at higher concentrations. Acute effects include mortality; chronic effects include reduced survival, growth, and reproduction. Copper toxicity is determined in part by the hardness of the water. Copper toxicity to aquatic organisms is lower when hardness is higher because dissolved copper is less bioavailable when hardness is high.

Total copper levels were somewhat below five-year average values in spring 2023 (Figure 8). In part, this could be due to somewhat lower tree mortality caused by bark beetles in recent years (USDA 2019) which would result in decreased copper in the Big Thompson River. Tree mortality caused by bark beetles may result in copper, which is naturally taken up and stored by trees, being released into surface water upon their death (Fayram et al. 2019). Regardless of the cause, lower copper levels are a positive indication of improving conditions for aquatic communities in the Big Thompson River Watershed. However, the mean total copper concentration in Spring 2023 at site S-BTT-20 (North Fork) is approximately 20% higher than the same period last year. This circumstance is an indication that the North Fork watershed Is recovering from fire effects. There was a dramatic decrease in total copper concentration in the first spring after the full fire effects were apparent (i.e. spring 2022) at this location. The average total copper concentration was 3.5 mg/L in spring 2020 and 1.9 mg/L in spring 2022. The effects of the fire on pre-runoff (spring) water quality in 2021 were likely to be small as most of the watershed remained frozen or snow covered. Increases in copper levels towards historic levels may be indicative of watershed recovery in this case. Unfortunately, there is the possibility that the trees killed by the fire may continue to release the copper that they have taken up over the years and release it into the watershed thereby increasing total copper levels even above historical averages.

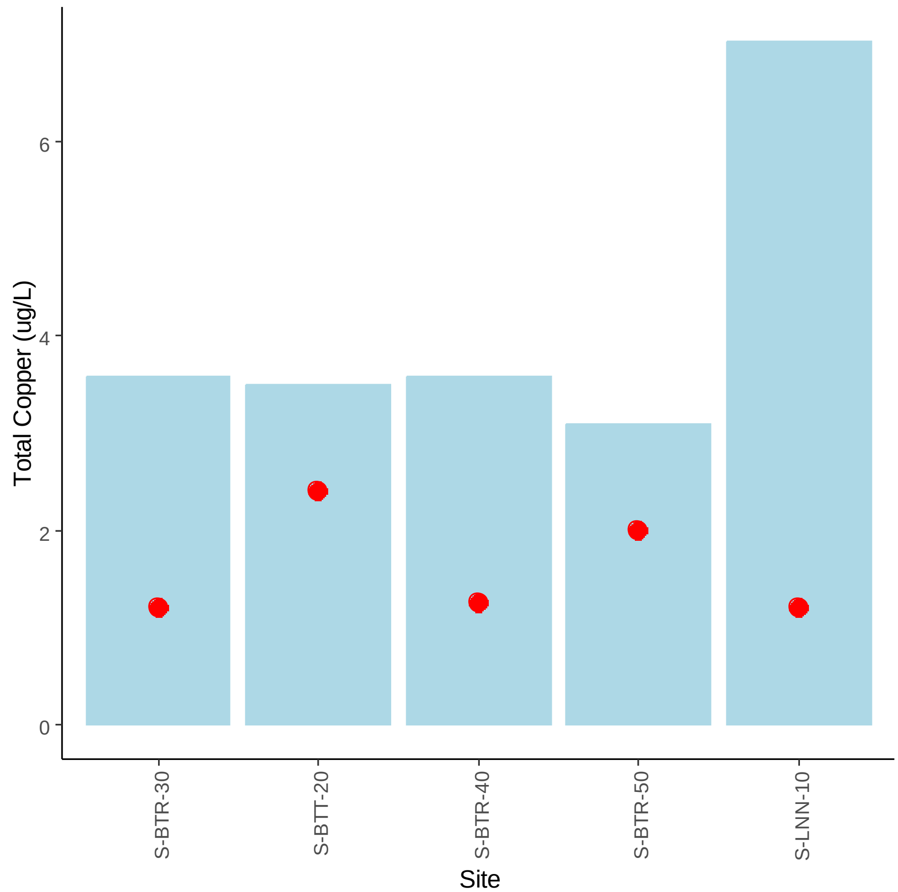

Figure 8. Average total copper values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Iron

Iron is common in surface water, although it is usually present at levels that are harmless to people and to aquatic life. However, water discoloration and staining issues can occur in water with dissolved iron levels greater than 3000 ug/L (ppb), and the drinking water standard is a 30-day average value of 300 ug/L (ppb). Detrimental effects to aquatic life can occur when levels of dissolved iron are above 1000 ug/L (ppb). The levels of dissolved iron that can affect aquatic life are dependent in part on the hardness of the water. Less dissolved iron is necessary to negatively affect aquatic life in water with lower hardness values than in water with higher hardness values.

Average total iron concentrations in spring 2023 were somewhat elevated in the S-BTT-20 (North Fork) and downstream to site S-BTR-50 (Narrows Park) compared to the five-year historic average (Figure 9). The area in the North Fork watershed above the sampling site was included in the area that was most severely burned during the CPF in fall of 2020. Increased iron concentrations resulting from the aftereffects of wildfire can persist for a number of years and the elevated total iron level in the North Fork is likely due to the continued effects of the wildfire, including increased turbidity.

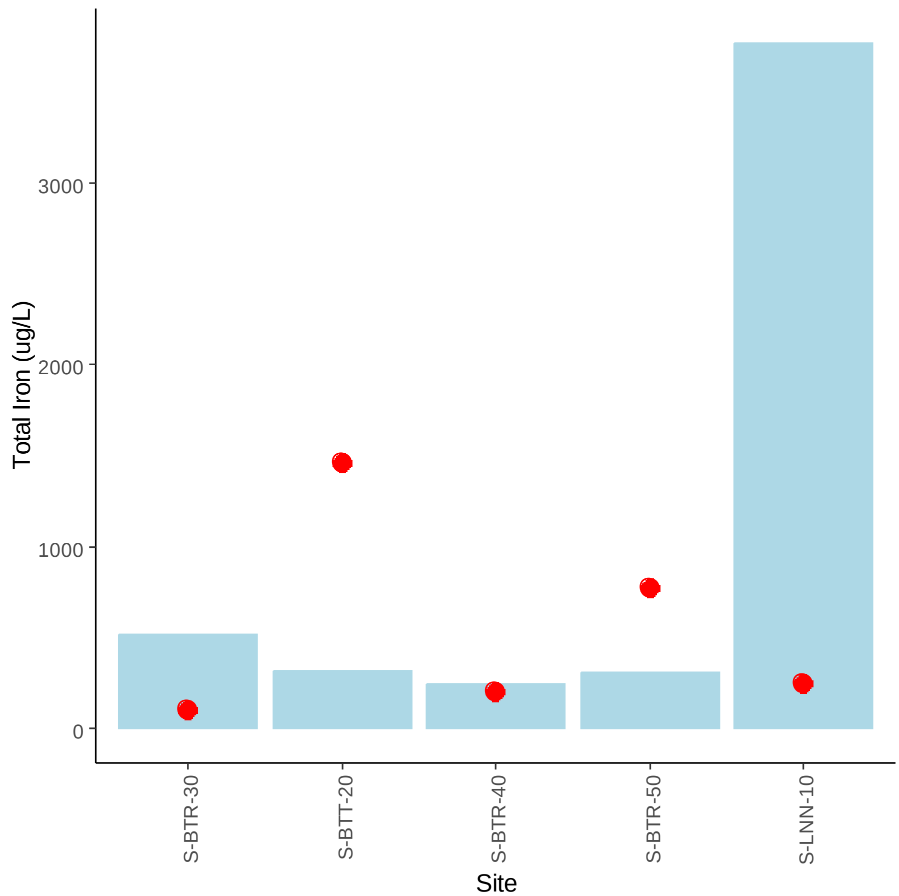

Figure 9. Average dissolved iron values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Nitrate

Nitrate and nitrite are of interest due to the role they play in aquatic plant growth and their potential effects on human health. Nitrate, along with ammonia, is a form of nitrogen that is available for immediate uptake by algae and is therefore of interest due to its role in determining the productivity of a given waterbody. At higher concentrations (e.g. >10 mg/L (ppm)), nitrate can be of concern in drinking water because it can reduce the oxygen-carrying capacity of hemoglobin in humans and create a condition known as methemoglobinemia, particularly in those under two years of age. Nitrite is also available for uptake by algae but is rarely present at high concentrations.

Spring 2023 nitrate concentrations were generally elevated at most sites compared to the five-year spring average values (Figure 10). The elevated values seen in the mainstem and tributaries may be the continuing effects of the CPF and the East Troublesome fire (increased nitrate can be an after effect of wildfire) (Rust et al. 2018).

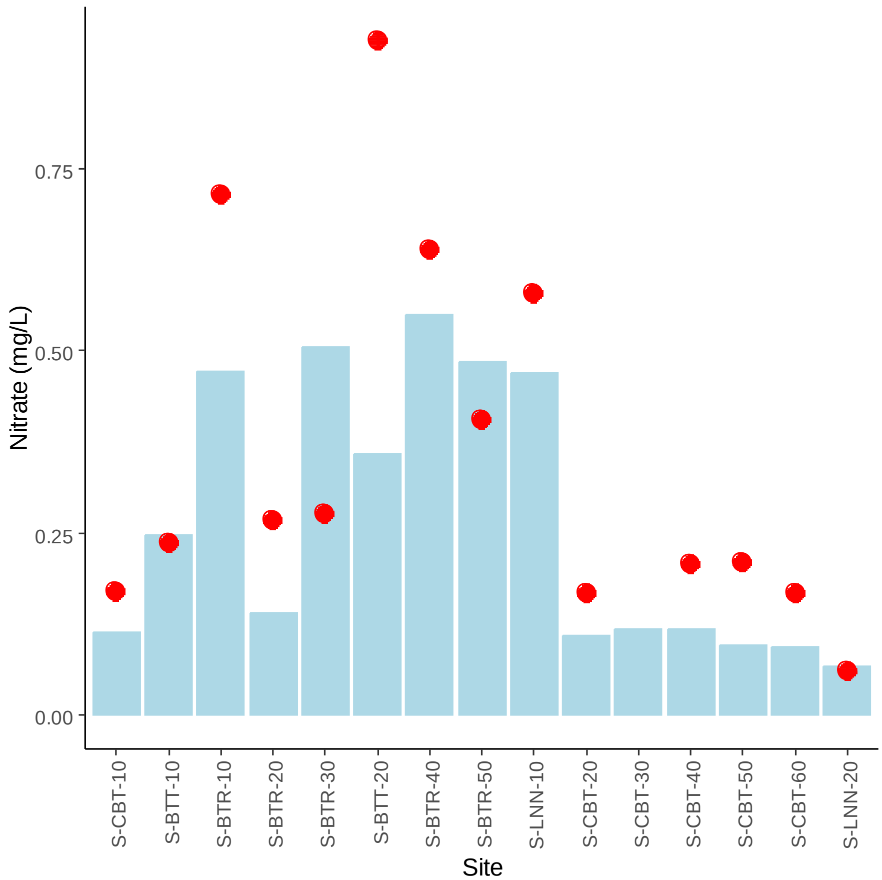

Figure 10. Average nitrate values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Orthophosphate

Orthophosphate is a dissolved form of phosphorus and is the only form that is immediately available for uptake by algae. Algal populations are often limited by orthophosphate concentrations and are of concern due to the ability of some algal species to produce toxins and to negatively affect drinking water taste and odor. Therefore, elevated orthophosphate levels can be of concern. Sources of orthophosphate include the decay of plant debris and other organic matter; the minerals that make up rocks, soils, and sediments in the watershed; wastewater treatment plant effluent; failing individual sewage disposal systems; runoff from fertilized agricultural lands and urban areas; and erosion of stream channels, dirt roads, construction sites, and other land surfaces.

Spring 2023 orthophosphate concentrations were generally low and close to the five-year average values for most sites (Figure 11). However, concentrations were substantially higher at site S-BTT-20 (North Fork) and downstream. Sites downstream from the confluence with the North Fork (sites S-BTR-40 and S-BTR-50) also had somewhat elevated orthophosphate levels but were below the five-year average values due to the very high orthophosphate levels associated with Highway 34 construction in 2018.

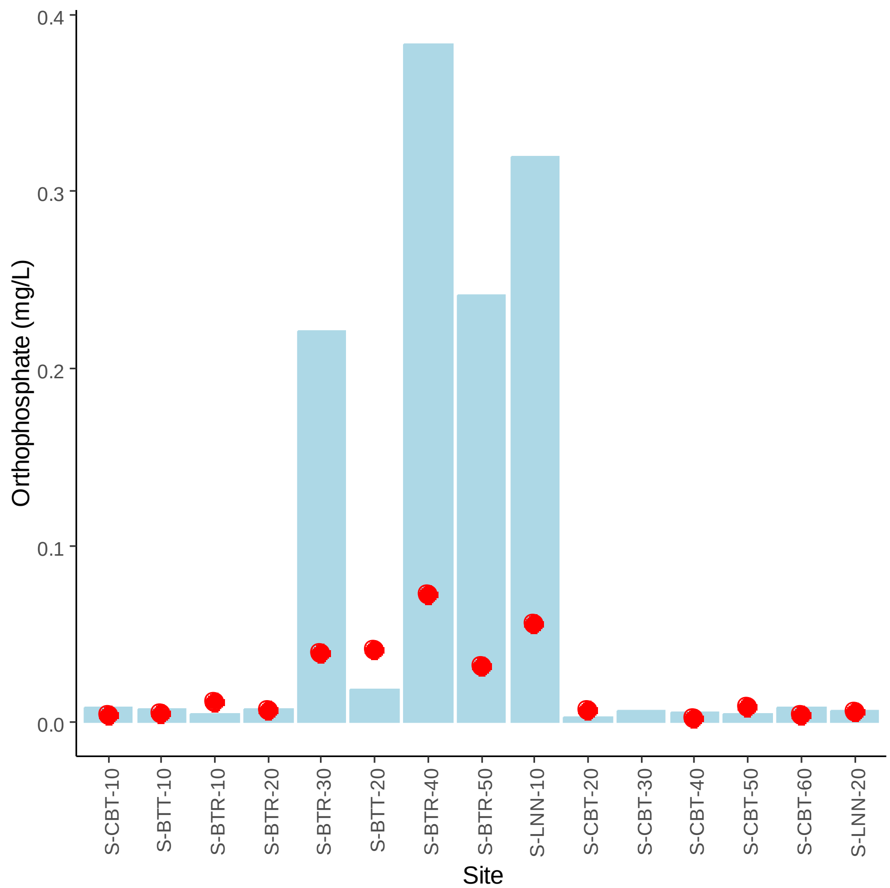

Figure 11. Average orthophosphate values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Total Organic Carbon (TOC)

TOC is a measure of the amount of dissolved and particulate organic matter in a water sample. Dissolved organic carbon compounds are the result of the decomposition of organic matter such as algae, terrestrial plants, animal waste, detritus, and organic soils. The higher the carbon or organic content of a water body, the more oxygen is consumed as microorganisms break down the organic matter.

Although TOC is not a direct human health hazard, the dissolved portion of the TOC can react with chemicals (chlorine and others) used for drinking water disinfection to form disinfection by-products (Allen et al. 2022) that are regulated as potential carcinogens (e.g. chloroform CHCl3). As such, TOC levels are of concern to drinking water treatment facilities.

Spring 2023 TOC values were near five-year average values (Figure 12). However, sites S-BTR-10 (Mary's Lake Bridge) and S-BTT-20 (North Fork) average TOC concentrations were above the five-year averages. The relatively high TOC value at site S-BTT-20 is likely related to the high turbidities in spring 2023. The cause of the relatively high TOC value at site S-BTR-10 is unknown. Although elevated TOC may be related to the elevated turbidity, the fact that TOC levels are elevated, regardless of cause, is a sign of forest recovery in a post-fire environment. In severely burned areas, organic carbon is often reduced compared to unburned areas (Rhoades et al. 2019).

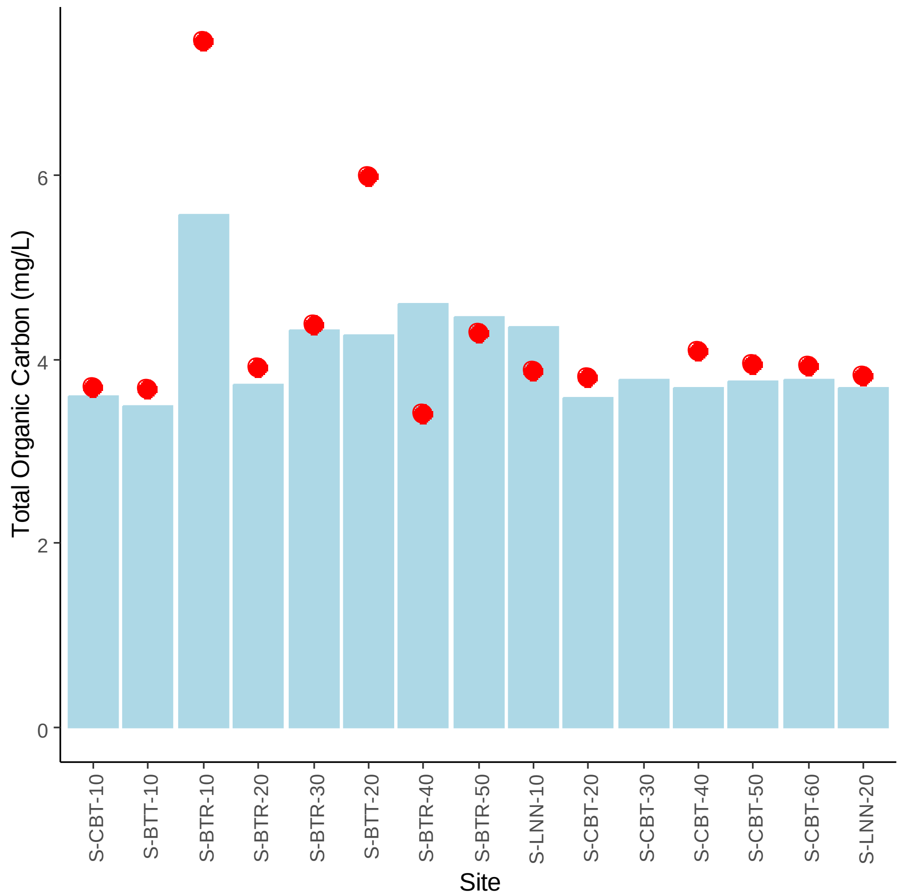

Figure 12. Average total organic carbon values for the months of February through April 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP.

Water Quality Contributions of Miller Fork

In April 2023, we began collecting samples from two additional sites that were selected to further characterize the effects of the CPF and the water quality contributions of the Miller Fork in general. One site (S-BTT-17) is located in the Miller Fork itself, just above the confluence with the North Fork. The other site (S-BTT-15) is located in the North Fork above the confluence with Miller Fork. Examining data from these two sites in conjunction with an existing site in the North Fork below the confluence with Miller Fork (S-BTT-20), we can develop a better understanding of the water quality contributions of Miller Fork.

Although only one month of data is currently available, some marked contributions of the Miller Fork are apparent. The most notable results from April 2023 included nutrients (nitrate and orthophosphate), turbidity, and total manganese (Figure 13). These water quality parameters were 300-700% higher in the Miller Fork than they were in the North Fork upstream of the confluence. These elevated contributions from Miller Fork were apparent at the downstream sampling location in the North Fork as well as in the mainstem Big Thompson. Even three years after the CPF, water quality parameters continue to be substantially impacted. As mentioned previously, these and other effects of the fire have negative effects on source water quality.

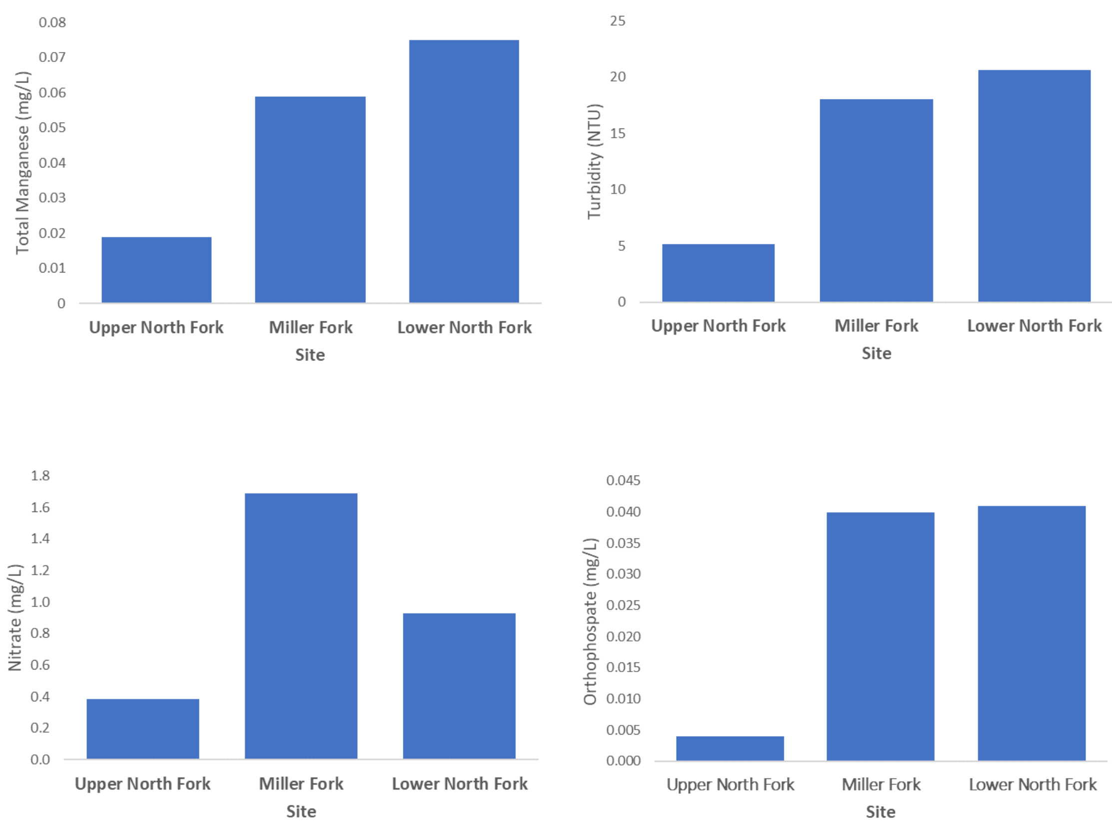

Figure 13. Values of water quality parameters in sampling stations above, in, and below the confluence of Miller Fork and North Fork in April 2023.

Conclusions

LWP continued to provide high quality drinking water that met or exceeded all drinking water regulations despite ongoing impacts from the CPF in spring 2023. There are some indications that water quality effects of the CPF are beginning to dissipate although fire effects will likely continue for several additional years. The potential effects of some, such as increased nitrate levels, are unknown at this time. LWP is attempting to mitigate these effects by partnering with organizations such as the U.S. Forest Service, Big Thompson Watershed Coalition, Coalition for the Poudre River Watershed, and Ayers Associates to construct point mitigation projects in affected areas. LWP is now focusing efforts on mitigating the effects of the next wildfire in the Big Thompson Watershed by partnering with groups such as the Big Thompson Watershed Coalition and the Larimer Conservation District to conduct forest management projects. The purpose of these projects is to reduce the overall occurrence of wildfires and for those that do occur, to reduce the severity of their impact. Although water quality continued to be relatively good despite these effects, we expect that these efforts, along with natural regenerative processes, will result in improved water quality in the coming years.

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Office
Loveland Service Center
200 North Wilson Avenue
Loveland, CO 80537
Public Water System Identification
Number: CO0135485
Office Hours: 8 a.m. to 5 p.m.
Monday-Friday

Contact Us
(970) 962-3000
LWPInfo@cityofloveland.org
www.lovelandwaterandpower.org

Loveland Water and Power