Loveland Water and Power

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Big Thompson River Watershed Source Water Quality Conditions

Spring 2024

August 1, 2024

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

Water quality conditions in Spring 2024 were generally similar to conditions documented during the spring periods between 2019 and 2023. The concentrations of many parameters were elevated in the past two or three years due to the Cameron Peak Fire. The fact that many parameters were now close to five-year average concentrations indicates continued recovery of the watershed from the fire. Although many water quality parameters are beginning to return to historic conditions, some parameters (such as copper and nitrate) continue to show an influence of the fire. Copper levels declined substantially after the fire and have persisted at very low levels. Nitrate has generally been elevated during the post-fire period. Water temperatures were near or somewhat below five-year average values. However, water temperatures during the five-year reference period included the fourth, sixth, and ninth warmest years on record in Colorado (1886-present).

Loveland Water & Power drinking water intake. The Home Supply Canal visible on the far side of the Big Thompson River.

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 of interest to drinking water, wastewater, recreation, and aquatic ecosystems. These data are used to identify and quantify current issues, document management successes, evaluate regulatory compliance, assess 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 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. Consequently, results 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 April 2023. One location is 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, upstream of the confluence with the Miller Fork. The Miller Fork has been a substantial contributor of water affected by the Cameron Peak Fire (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. 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 Mountain 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

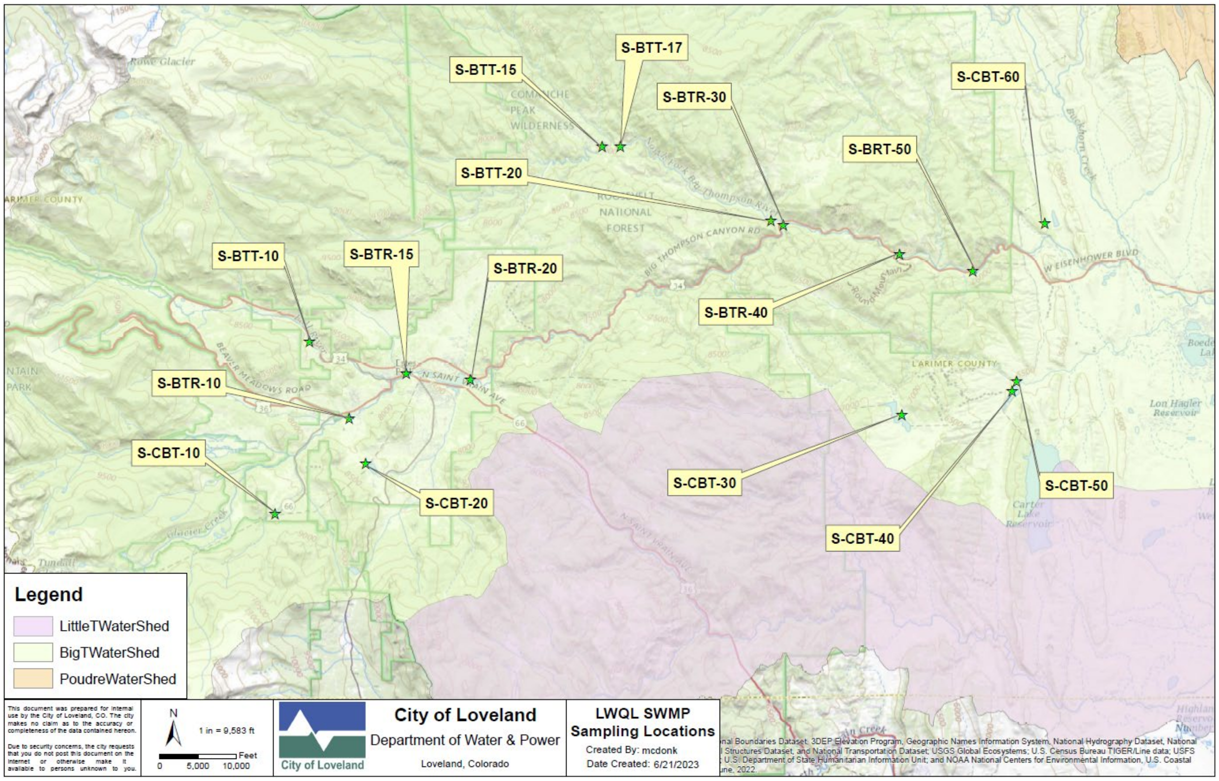

Figure 1. 2023 Source Water Monitoring Program water quality sampling sites.

Objective

The objective of these seasonal reports is to describe notable events and summarize 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 data collected by the WQL and do not represent a quantitative statistical or regulatory analysis of the data.

Evaluation of current data with historical data provides the opportunity to understand recent conditions relative to the previous five-year 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. Comparisons for the three sites that were sampled beginning in 2023 are included, but 2024 data are compared only to the previous year. Examination of longer-term trends and conditions can be found in LWP Big Thompson River Annual Reports. Figures associated with each water quality parameter are color-coded to represent different components of the source water system. Sites with the same color are likely to be more similar than sites of different colors. In the figures, blue bars indicate sites located in the mainstem of the Big Thompson River, light blue bars indicate sites that are located in tributaries to the Big Thompson River, and aqua blue bars represent sites located in the Colorado-Big Thompson Project.

The results and findings presented in this report only represent source water and not the treated drinking water delivered to our customers. Drinking water information and the annual Consumer Confidence Report are 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. Baseline conditions and increasing influence of runoff drive water quality conditions during this period. Average values were calculated from all samples collected during these months in 2024 and compared to the average value of all samples collected during these months from 2019 through 2023.

Summary Conditions

Spring 2024 water quality conditions showed continued recovery from the Cameron Peak Fire, although a few parameters continued to be substantially impacted. This observation aligns with general observations of the recovery of watersheds from wildfire as water quality conditions can return to baseline conditions within a few years or as many as 15 or more years after a wildfire (Rust et al. 2018, Paul et al. 2022). Some water quality parameters continued to reflect the effects of the Cameron Peak Fire (CPF), which occurred in the fall of 2020, although the magnitude of the effect on parameters such as turbidity, pH, manganese, nitrate, and orthophosphate appears to be diminished somewhat compared to fall 2022 and indicate watershed recovery. All of these parameters generally increase after a wildfire, but not always significantly (Rust et al. 2018). Specifically, between fall 2022 and fall 2023 average total manganese decreased from 0.149 to 0.035 ug/L, pH decreased from 7.45 to 7.36 SU, and orthophosphate decreased from 0.183 to 0.0004 mg/L. However, other parameters, such as iron and copper, continue to be substantially affected by the CPF. Total iron concentrations continued to be elevated and total copper concentrations continued to be lower than they have been historically.

Generally, total copper concentrations tend to increase in a post-wildfire environment (Rust et al. 2018), but like most water quality effects of wildfire, these results are very location-specific, with results in some watersheds demonstrating a decrease after a wildfire and others demonstrating increases. In the case of the CPF in the Big Thompson watershed, total copper concentrations declined, and these lower concentrations persist. This result is one of the few positive effects of the CPF on water quality. These impacts were particularly notable in the area surrounding the North Fork. Sampling from additional sites in the North Fork Watershed in 2023 continues to demonstrate that many of the changes in water quality in the Big Thompson River originated in the Miller Fork due to the CPF. However, the magnitude of these contributions appears to be slightly smaller in fall 2023 than in summer 2023.

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. Although some water quality challenges persist, they appear to be diminishing, and LWP Drinking Water Treatment staff were able to continue providing high-quality drinking water.

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 indicate the relative quality of the water, as large rain events and runoff often result in increased turbidity and decreased water quality. Precipitation in spring 2024 was approximately average compared to the previous five-year period (Figure 2).

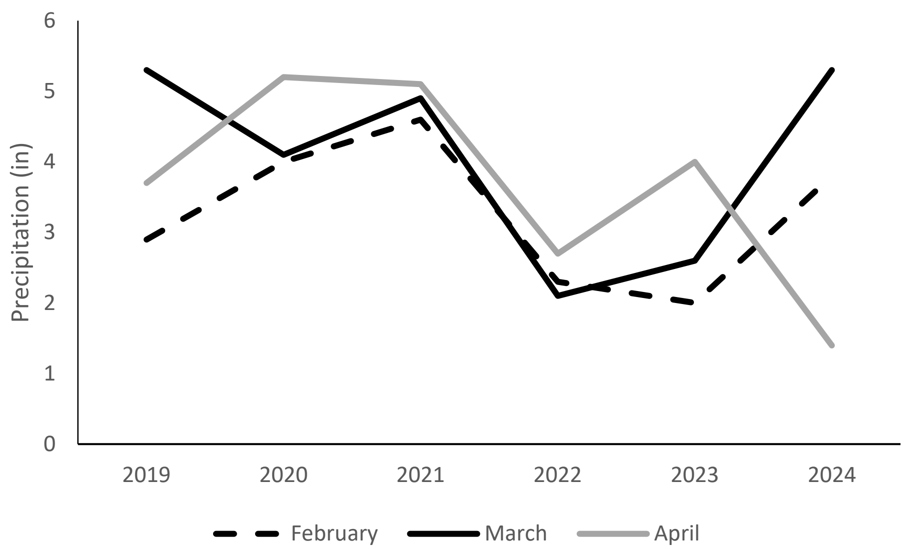

Figure 2. Monthly precipitation by year at the Bear Lake Natural Resources Conservation Service Snow Telemetry (SNOTEL) station.

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 and 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 occur. Chemical reactions generally take longer to complete in colder water.

Similar to precipitation, spring 2024 temperatures were close to and in some cases somewhat below average values from the past five years (Figure 3).

Big Thompson River near the Loveland Water & Power drinking water intake.

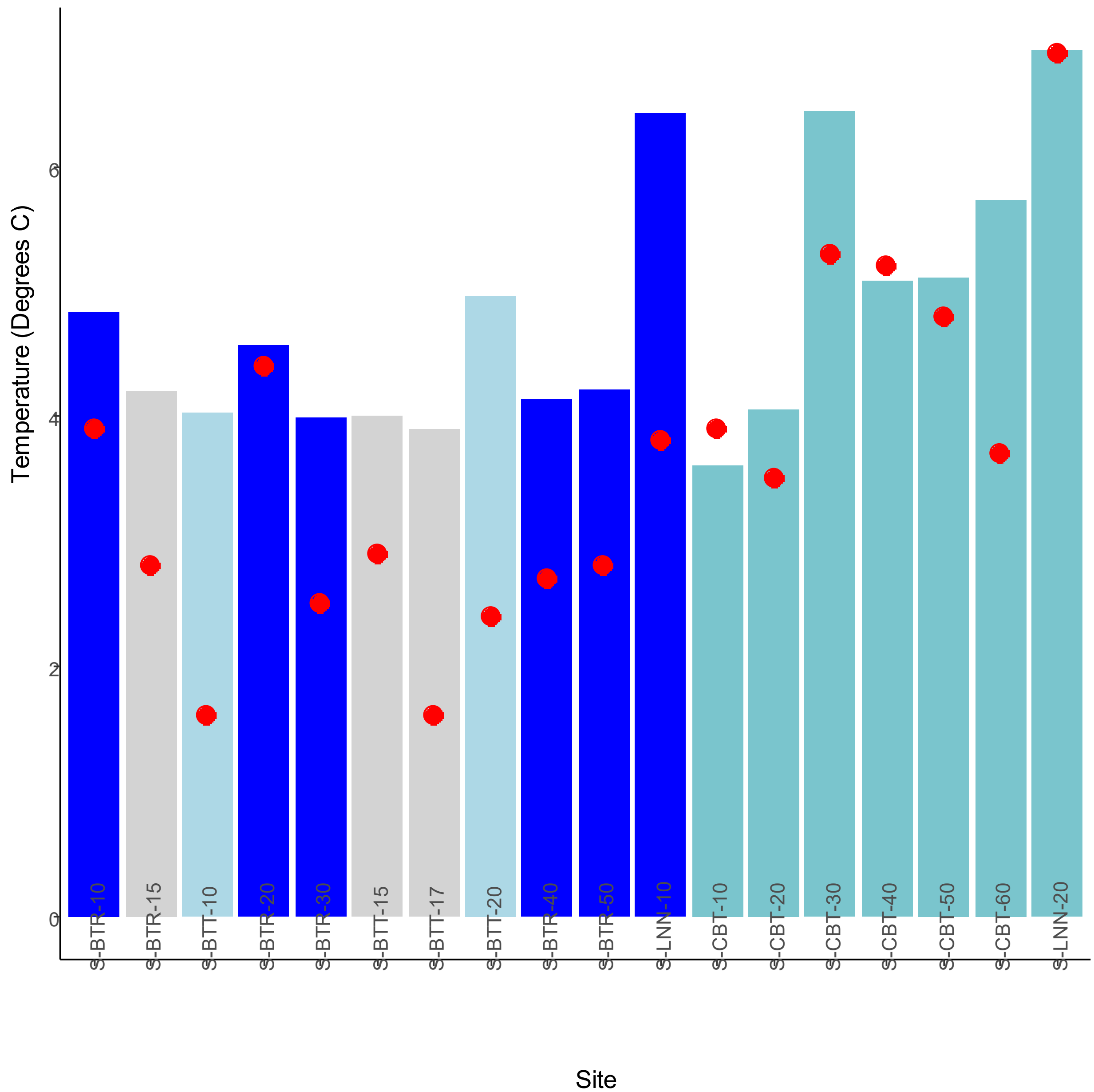

Figure 3. Average water temperature values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

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 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 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 the 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 the spring of 2024 were near five-year average values at most sites, but at sites where data collection started in 2023, values were somewhat lower in 2024 than they were in 2023 (Figure 4). Near-average values in the North Fork (S-BTT-20) and lower values seen in the Miller Fork (S-BTT-17) and North Fork above the confluence with Miller Fork (S-BTT-15) in spring 2024 compared to spring 2023 are consistent with watershed recovery. Five-year average values in the North Fork include two years pre-fire and three years post-fire. Post-fire turbidities in the North Fork were substantially elevated. Therefore, the fact that spring 2024 values are near average indicates that 2024 values were lower than they have been in the post-fire environment. The area Miller Fork (S-BTT-17) watershed was among the most severely burned areas during the CPF in the fall of 2020 and lower values seen at this site, as well as a site S-BTT-15, seen in spring 2024 compared to spring 2023 is also consistent with watershed recovery from wildfire.

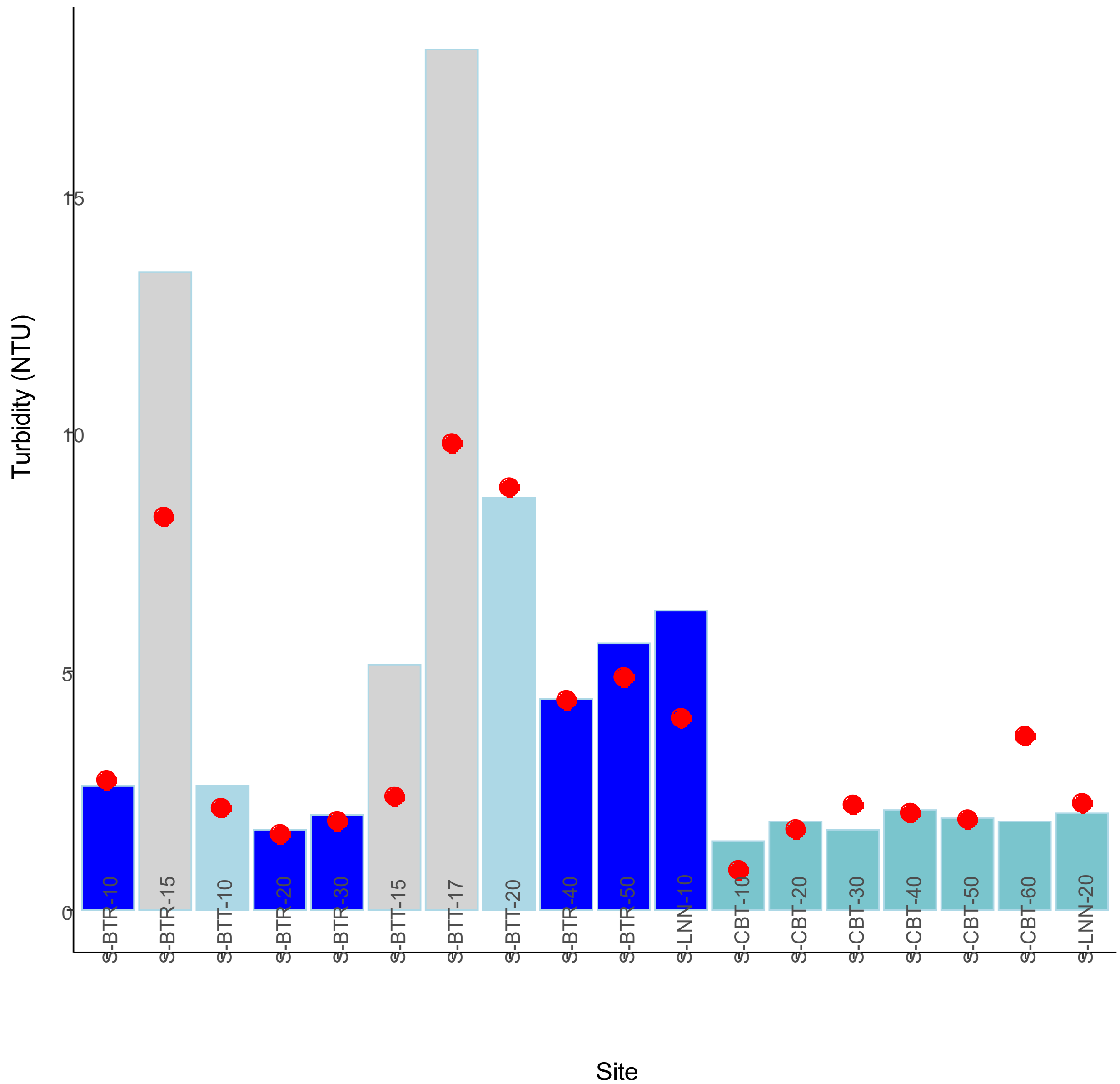

Figure 4. Average turbidity values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

pH

The pH value (SU, Standard Units) indicates how acidic or basic 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. A maximum pH of 9 is also the Colorado Regulation 31 standard for drinking water supplies. 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 lower than five-year average values at most sites in spring 2024 (Figure 5). These lower values are consistent with watershed recovery from wildfire as white ash from wildfires is generally basic (Rodela et al. 2022). Since all the sites continue to receive lower and lower amounts of ash from the CPF or the East Troublesome Fire as time goes on, it is reasonable to expect pH levels to continue to decline in coming years.

North Fork of the Big Thompson River

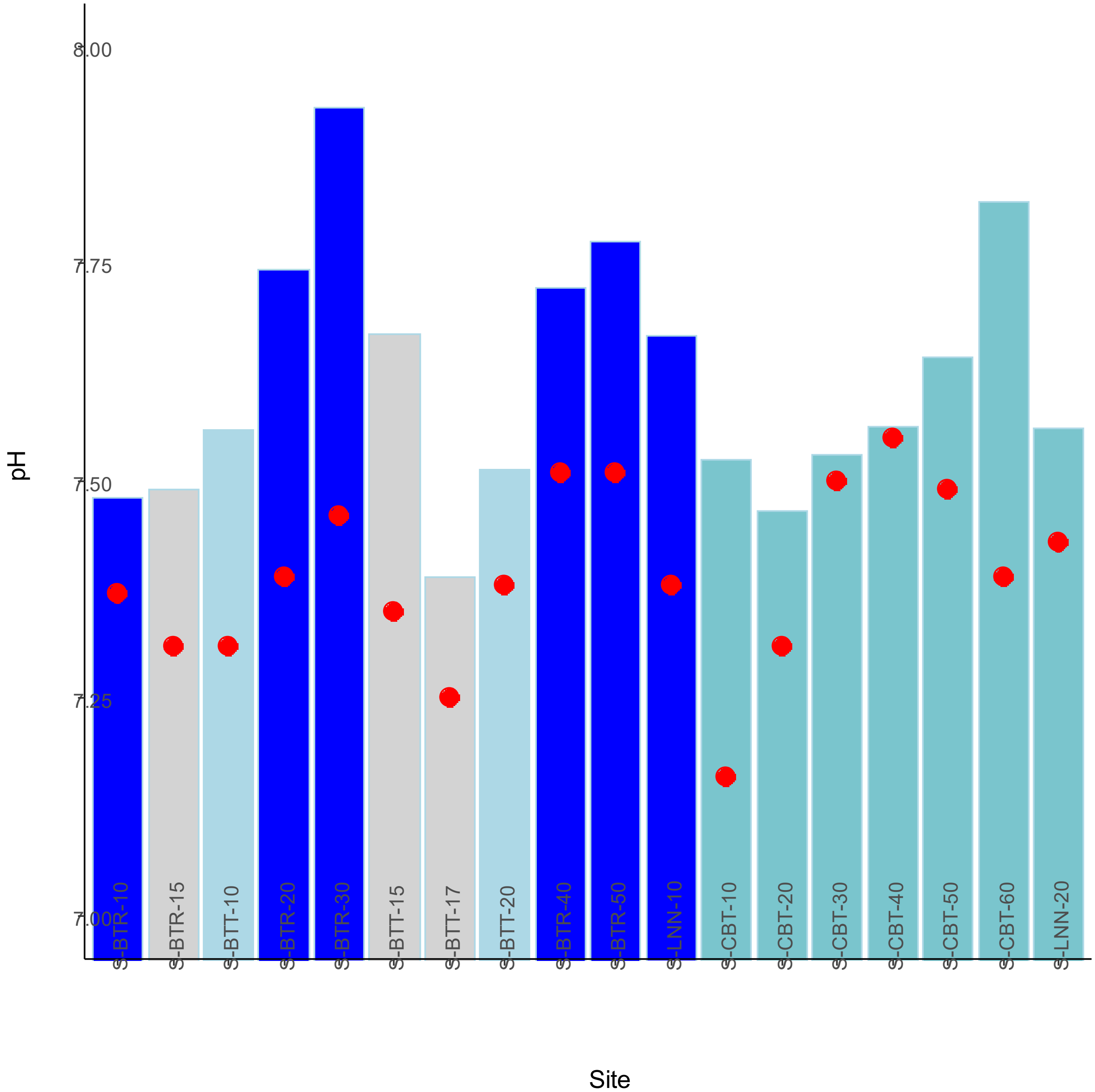

Figure 5. Average pH values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

Dissolved Oxygen

Dissolved oxygen levels are important to aquatic life and drinking water facilities and are affected by several factors such as temperature, altitude, turbulence, and biological activity. Turbulent cold water at a low altitude can have higher dissolved oxygen levels than still, warm water at a higher altitude. Biological activity (particularly photosynthesis) can increase dissolved oxygen during the day as photosynthesis occurs and decrease dissolved oxygen levels at night when respiration dominates. Biological activity often 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 clarkii*) 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 dissolved oxygen levels, 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, making drinking water treatment easier.

Spring 2024 dissolved oxygen levels were generally near historic averages across sites (Figure 6). Although dissolved oxygen concentrations were generally near historical values, the spring 2024 dissolved oxygen concentration at the East Portal site (S-CBT-10) was notably below the five-year average value. The cause of this observation is unclear. However, the average spring dissolved oxygen concentration for this location of 8.4 mg/L is still well above any applicable standards for aquatic life use.

Side channel near Loveland Water & Power drinking water treatment plant.

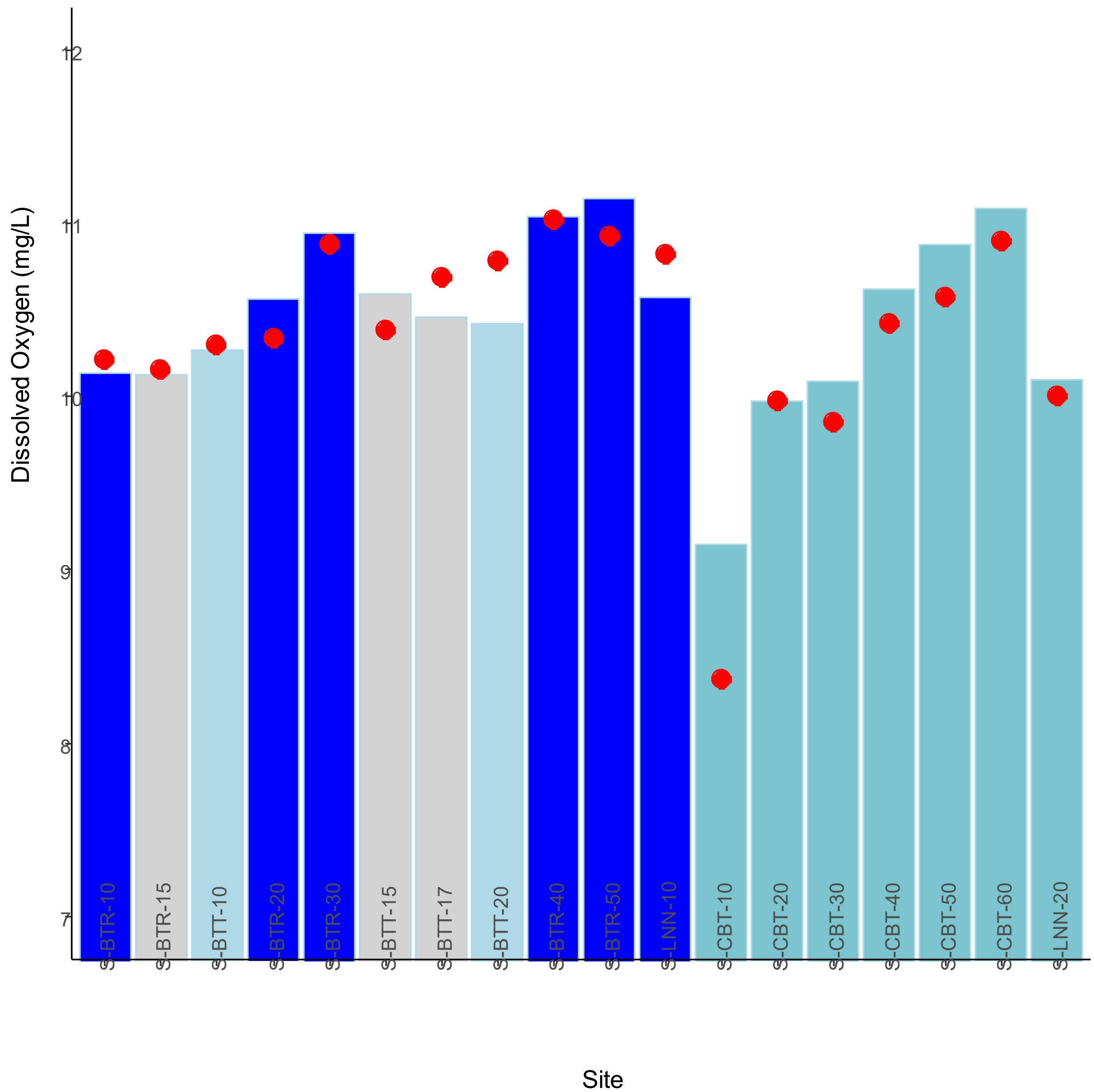

Figure 6. Average dissolved oxygen values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

Alkalinity

Alkalinity is a measure of the ability of water to neutralize acid and resist declines in pH and 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 often 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 2024 and average spring values over the previous five years were small (Figure 7). However spring 2024 average values appear higher than spring 2023 values at both sites most affected by the CPF (S-BTT-15 and S-BTT-17). This result is consistent with recovery from wildfire as alkalinity values generally decline after a wildfire (Rust et al. 2018) and increase during recovery.

Big Thompson River at Viestenz-Smith Park.

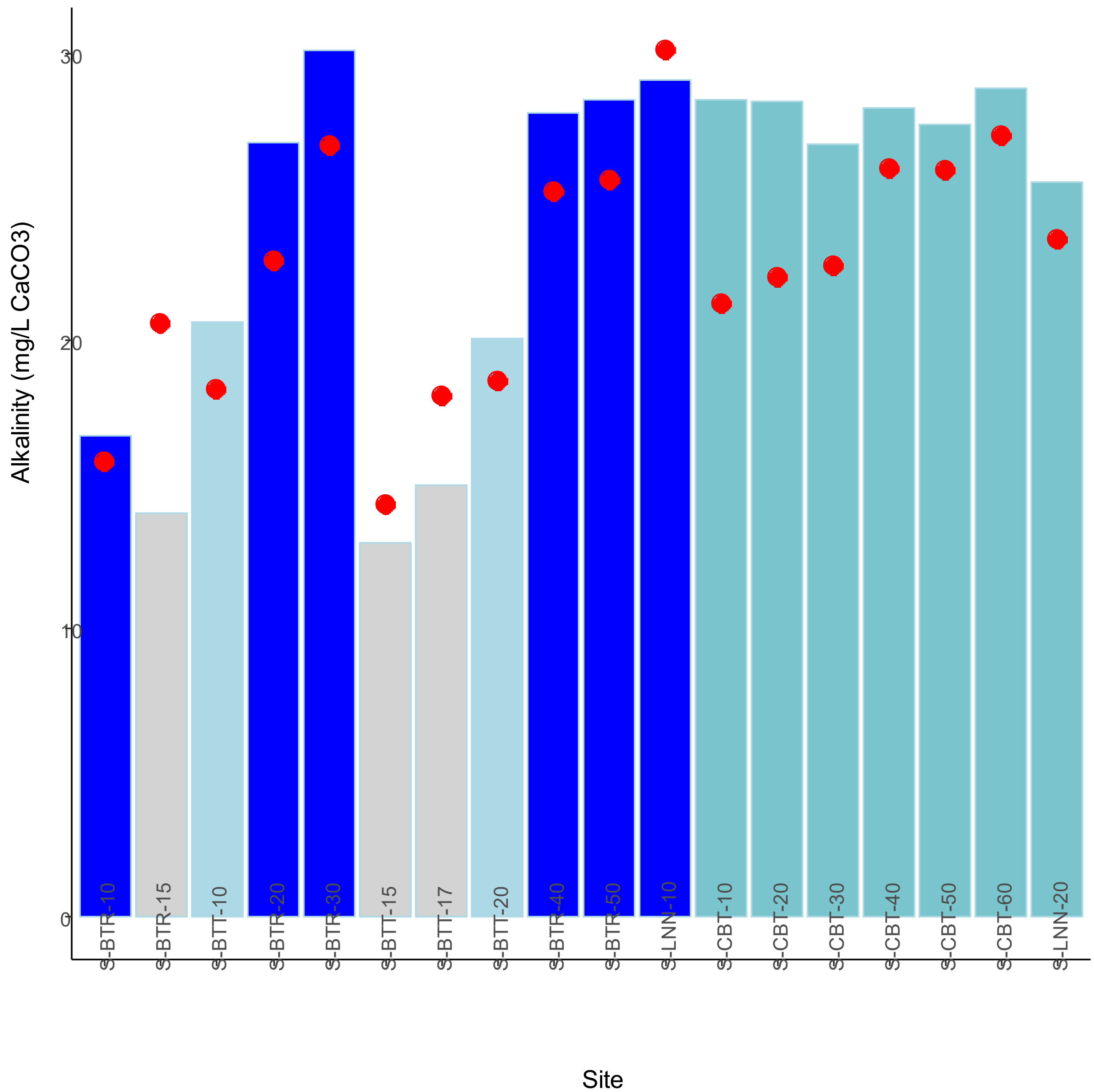

Figure 7. Average alkalinity values for the months of August through October 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

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.

Concentrations of manganese measured in areas associated with the CPF, such as the North Fork (S-BTT-20), (Figure 8) continued to be high relative to other sites but spring 2024 average values were lower than five-year average values. Increased manganese levels have been associated with the aftereffects of wildfire and the fact that they appear to be declining is consistent with ongoing recovery of the watershed from the CPF.

The EPA has a “secondary” standard of 0.05 mg/L (ppm) for 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 manganese concentrations were somewhat elevated at some sites, only one site had values above the standard (S-BTR-15). The cause of elevated manganese concentrations at site S-BTR-15 is unclear, but the 2024 average value is driven primarily by one value of 0.064 mg/L from a sample taken in March.

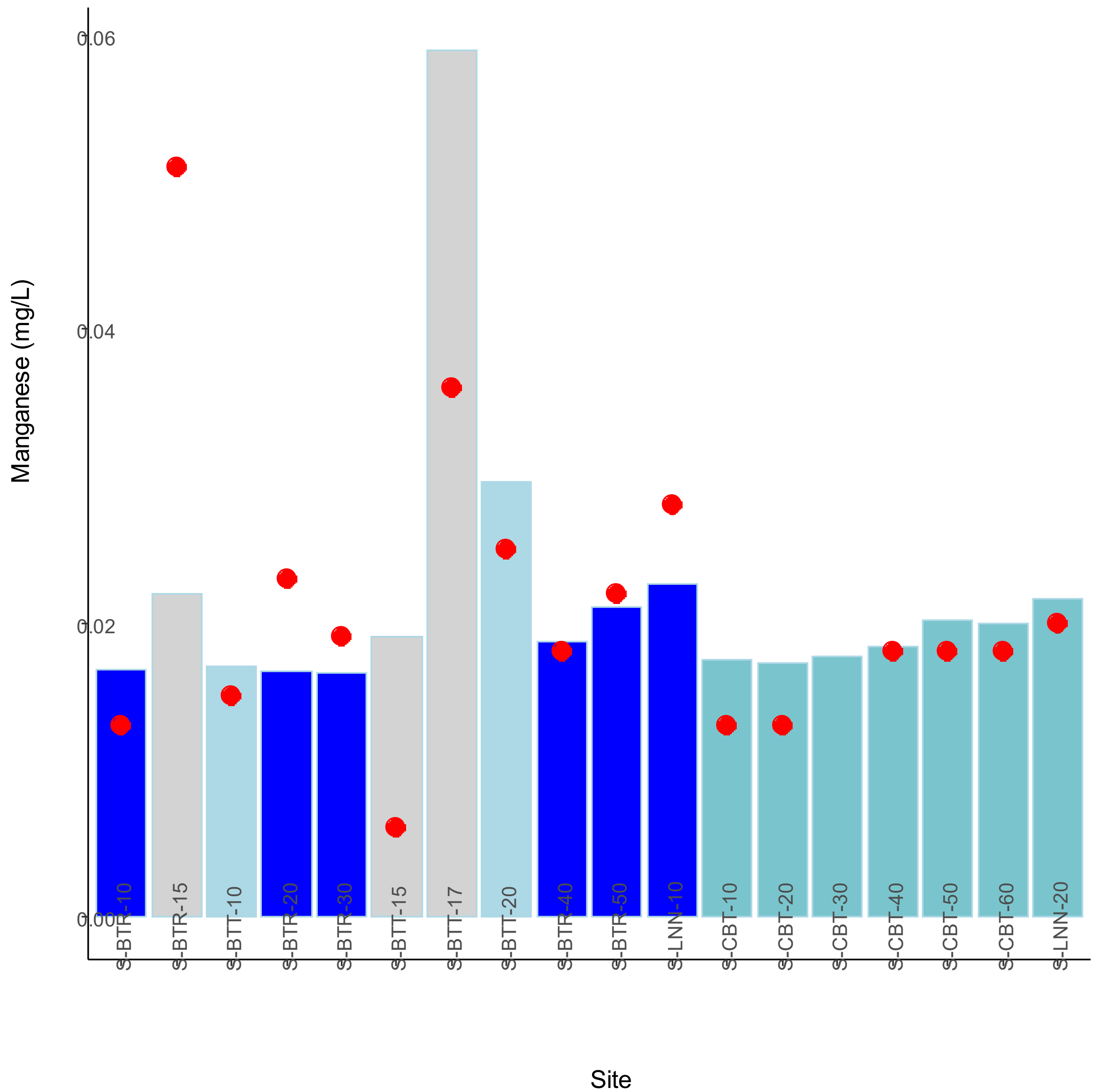

Figure 8. Average manganese values for the months of February through April 2019-2023 and the 202 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

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 in spring 2024 were below five-year average values (Figure 9) and total copper levels were generally lower in the post-CPF period. While these lower levels indicate continued effects of the CPF, they are also positive from a water quality perspective and represent one of the few positive outcomes of the CPF. There was a dramatic decrease in total copper concentration in the first spring after the full fire effects were apparent (i.e. summer 2021) at locations impacted by the fire and these lower levels seem to continue to persist. .

Aerial view of the Big Thompson River at Viestenz-Smith Park.

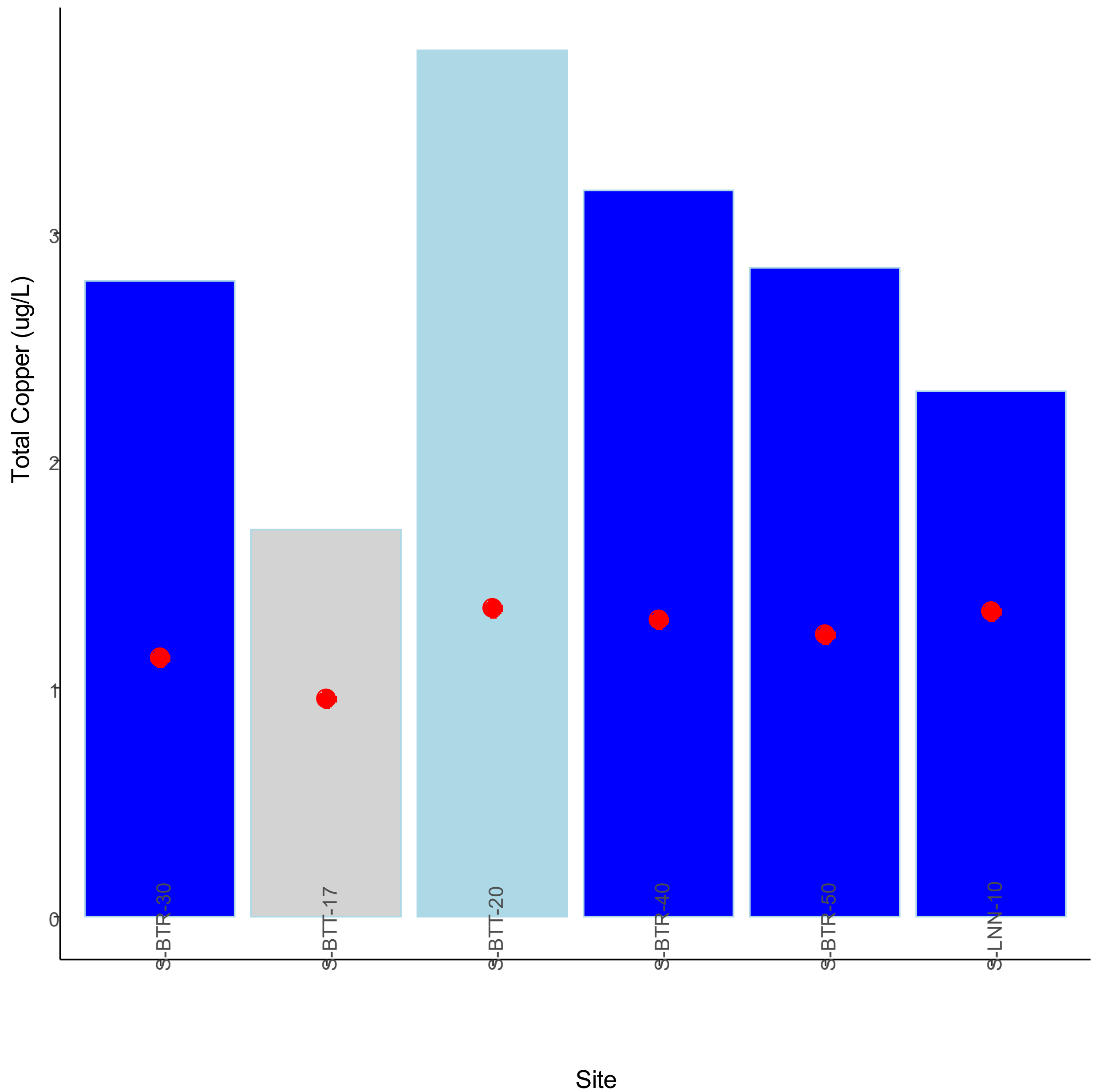

Figure 9. Average total copper values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Light blue bars indicate tributary sites and blue bars indicate mainstem sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

Iron

Iron is common in surface water, although it is usually present at levels that are harmless to people and aquatic life. However, water discoloration and staining issues can occur in water with dissolved iron levels greater than 3,000 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 2024 are generally near five-year average values at most sites (Figure 10). 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 and total iron levels have been elevated at this location in the years since the fire. The fact that spring 2024 values were generally somewhat low, indicates that the watershed is continuing to recover from the fire.

Aerial view of the Big Thompson River at Viestenz-Smith Park.

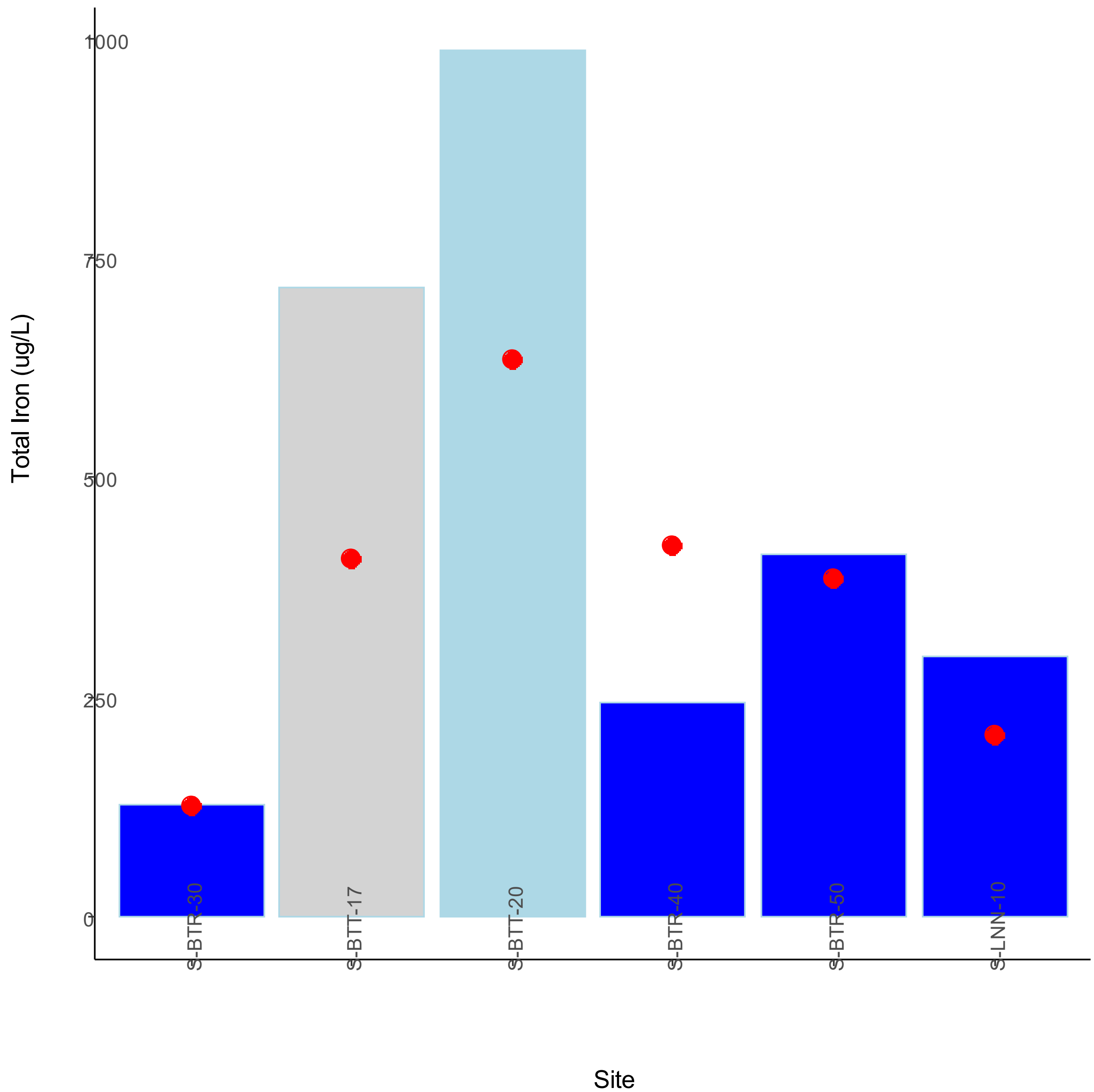

Figure 10. Average total iron values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Light blue bars indicate tributary sites and blue bars indicate mainstem sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

Nitrate

Nitrate and nitrite are of interest due to their role 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.

Nitrate concentrations in spring 2024 were slightly above five-year average values: however, values at sites that began to be sampled in 2023 had slightly lower nitrate concentrations in spring 2024 than in spring 2023 (Figure 11). Although spring 2024 values appeared near average or slightly above average, concentrations at sites most directly affected by the CPF were lower when compared to average values in spring of 2022 and 2023. Given that elevated nitrate can and has been an aftereffect of the CPF (Rust et al. 2018), near average values are another positive indication that the Big Thompson watershed is recovering from the CPF.

Fall River just upstream of Fall River Court Bridge.

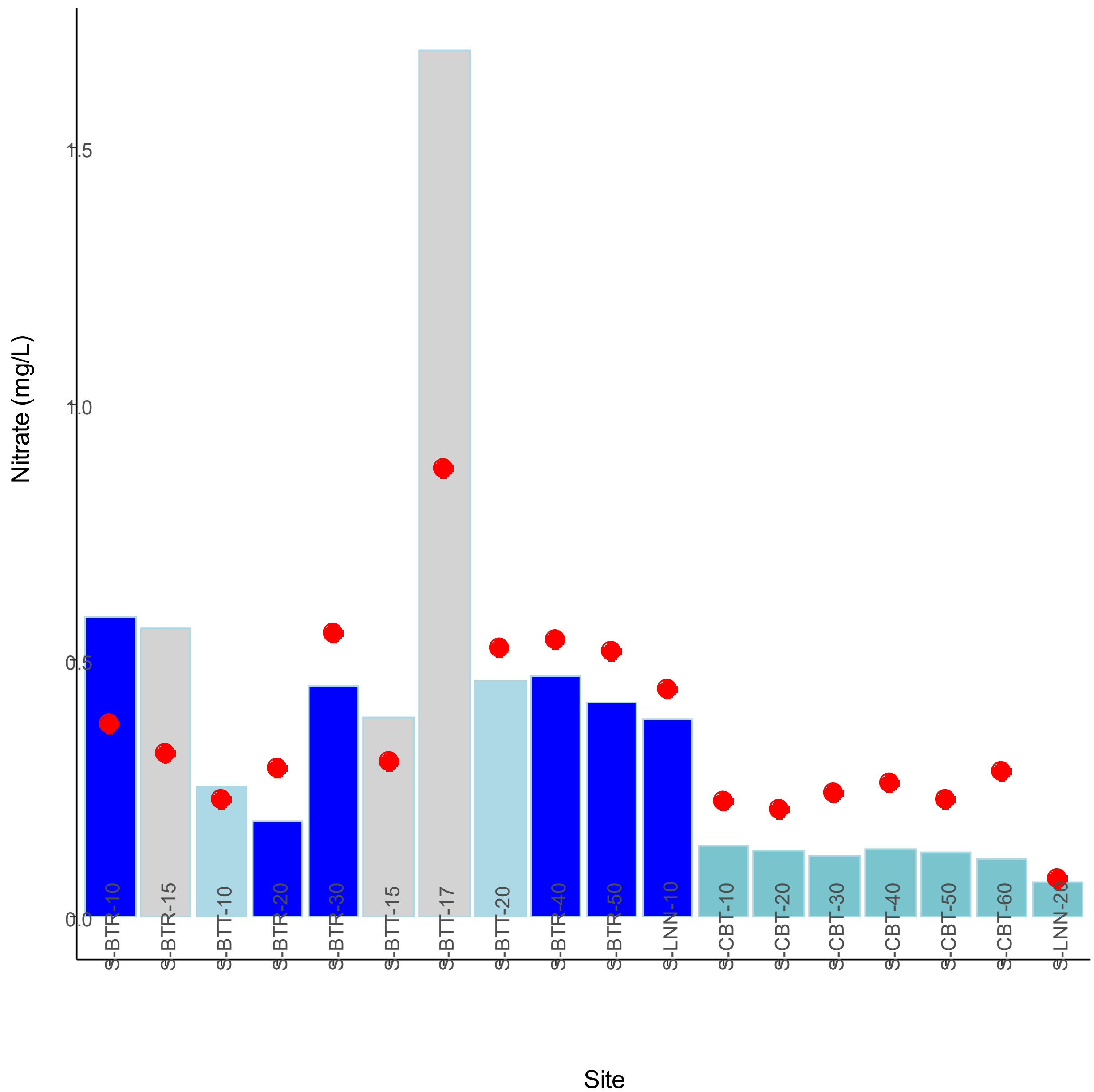

Figure 11. Average nitrate values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

Orthophosphate

Orthophosphate is a dissolved form of phosphorus and is the only form that is immediately available for uptake by algae. Orthophosphate concentrations often limit algal populations 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 2024 orthophosphate concentrations were generally low compared to the five-year average values for most sites (Figure 12). This result is positive from a water quality perspective. These low and declining concentrations of orthophosphate have been observed in the last year and hopefully will persist.

Big Thompson River in the Big Thompson River Canyon.

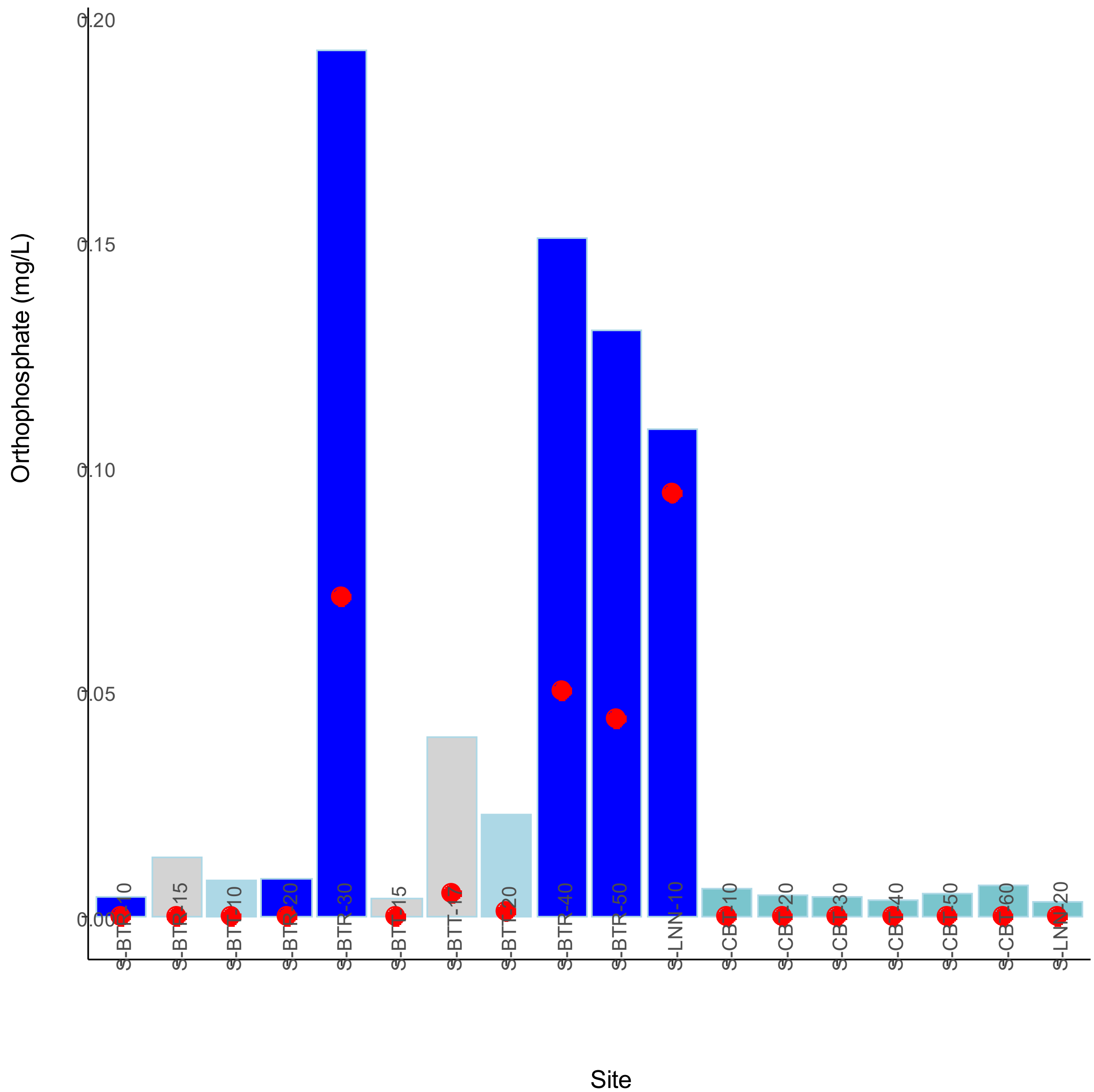

Figure 12. Average orthophosphate values for the months of February through April 2019-2023 and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

Total Organic Carbon (TOC)

TOC is a measure of the amount of dissolved and particulate organic matter in a water sample. Organic carbon compounds result from 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 $CHCl_3$). As such, TOC levels are of concern to drinking water treatment facilities.

Spring 2024 TOC values were very similar to five-year average values at virtually all sites (Figure 13). Organic carbon is often reduced in severely burned areas compared to unburned areas immediately after a fire (Rhoades et al. 2019). Near-average TOC values suggest that TOC concentrations have increased modestly from lows immediately following the CPF and this observation is consistent with fire recovery.

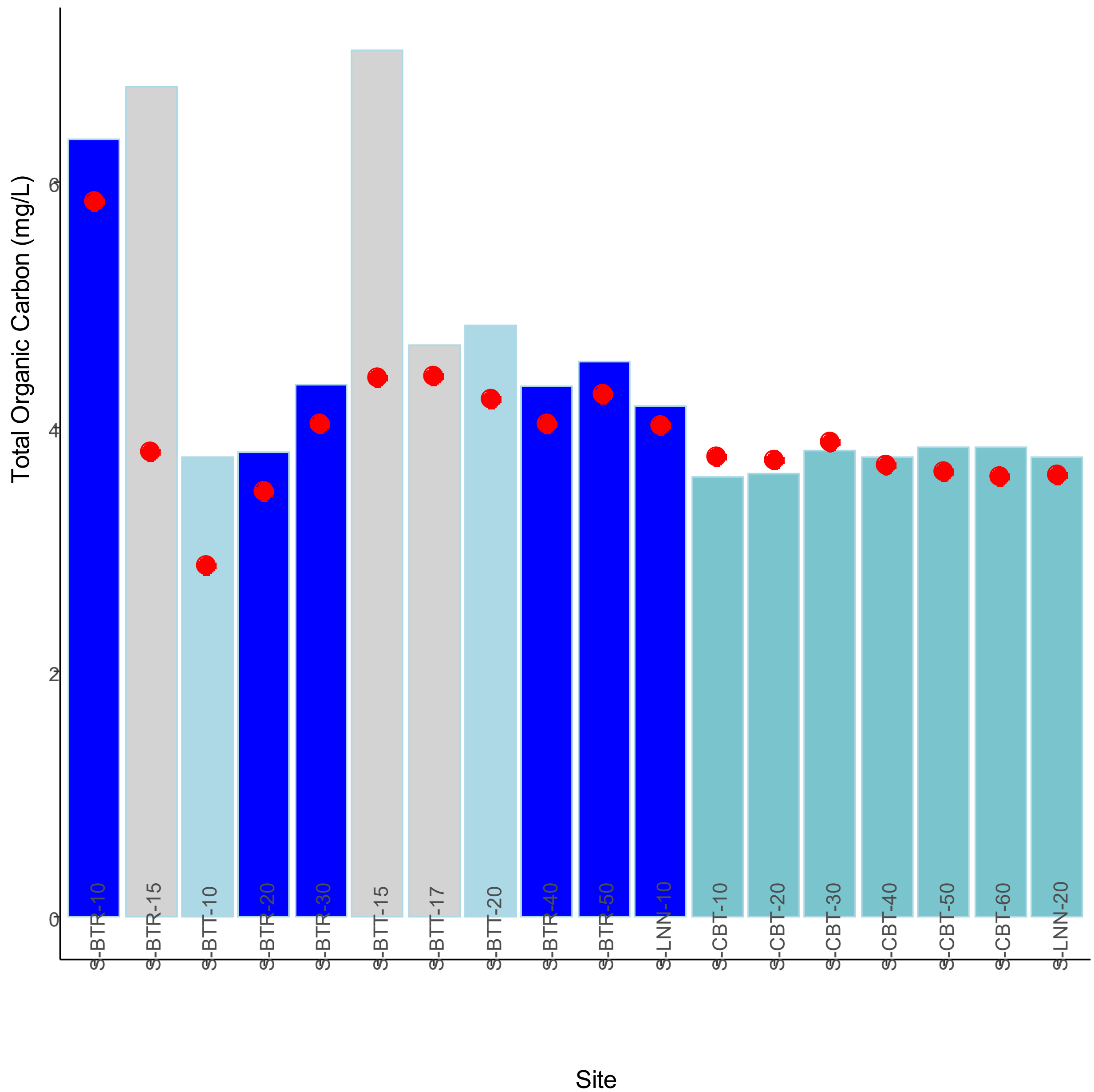

Figure 13. Average total organic carbon values for the months of February through April 2019-2023 (blue bar) and the 2024 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites. Grey bars indicate sites where data collection began in 2023. In these cases, the grey bar represents average 2023 values and the red dot represents the average 2024 value.

Conclusions

There are some indications that the water quality effects of the CPF are beginning to dissipate, and the watershed is recovering from the fire. However, some fire effects are apparent and will likely continue for 2-5 years or more. The continued improvement of some water quality parameters, such as turbidity, manganese, and iron, is a welcome observation both in terms of drinking water quality and the environment for aquatic communities in the Big Thompson River. The long-term effect of several parameters that continue to demonstrate fire effects, such as increased nitrate concentrations and decreased copper concentrations, are unknown at this time. here is some evidence to suggest nitrate levels may be starting to decline somewhat which is a welcome result from a water quality perspective. 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, primarily through tree thinning (Figure 14). The purpose of these projects is to reduce the overall occurrence of wildfires and to reduce the severity of their impact for those that do occur. Although water quality continued to be relatively good despite fire effects, we expect that these efforts, along with natural regenerative processes, will continue to result in improved water quality in the coming years.

Figure 14. An example of forest management in the Big Thompson River watershed. The forest on the left side of the road has been thinned to historic tree density. The forest on the right side of the road has not been treated.

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