Big Thompson River

Cooperative Monitoring Summary: Summer 2019

Andrew H. Fayram
Monitoring Program Manager
Big Thompson Watershed Forum

Big Thompson Watershed Forum

Summary of Summer 2019 Conditions

- A relatively large amount of snowpack and below-average temperatures caused the spring runoff period in the Big Thompson River to be extended, high, and delayed compared to historical conditions. These conditions continued into the first two months of the summer season with relatively high flows in July and August 2019. In September 2019, flows reverted to very near historical conditions.
- Summer water temperatures were below average compared to the previous five-year period. However, given that four of the five previous years were among the hottest years on record, conditions were still relatively hot in 2019.
- Manganese levels were generally lower than the five-year median. However, several measured values at site VT05 (Little Thompson River) were above the drinking water standard of 50 ug/L.
- Generally, most water quality parameters we examined here were near the five-year median values at all sites. This is an encouraging indication that the effects of construction activities on Highway 34 have dissipated.

Big Thompson Watershed Forum

Founded in 1997, the Big Thompson Watershed Forum (Forum) is a collaborative non-profit organization located in Loveland, Colorado. The Forum represents a wide range of interests, including private citizens, businesses, non-governmental organizations, and government agencies including our major funders (City of Loveland, the City of Fort Collins, the City of Greeley, and Northern Water). The mission of the Forum is to support the protection and improvement of water quality in the Big Thompson River Watershed through collaborative monitoring, assessment, and education/outreach projects. To learn more about the Forum visit http://btwatershed.org/about-btwf/.

The objective of seasonal reports is to provide a description of notable events and a summary of important water quality parameters with reference to historical conditions and to water quality standards to those interested in the water quality of the Big Thompson River. Although data presented in this report are expected to be accurate, they should be considered provisional. Data are considered provisional until United States Geological Survey (USGS) staff review the results and the lab comments. If data are unusually high or low or other issues with lab procedures transpired, the USGS may request that the lab re-run the samples. Once the data are considered to be valid, they are considered final. This process may take several months.

Sampling Program

The Forum contracts with the USGS in a cooperative monitoring program (http://btwatershed.org/cooperative-monitoring-program) to collect samples from 13 sites throughout the Big Thompson River watershed. Generally, water samples are collected from each site once per month (February through November) and are analyzed for 37 physical and chemical parameters related to water quality. In addition, to climatic variables we focus on eight components which reflect various aspects of water quality including those of interest to utilities (e.g. total organic carbon) and aquatic life in the river (e.g. temperature). Results are included for the summer of 2019 (defined as July, August, and September) and are compared to the same time period in previous years (2014-2018) and to established water quality standards for drinking water and aquatic life use. Although results may differ from long term averages given construction activities and the 2013 flood event, results presented here provide context for current conditions relative to the recent past. The sites we have included in this summary represent an overall picture of seasonal conditions in the Big Thompson River (Figure 1). We chose these sites to reflect general conditions in the river and excluded sites that are subject to sizeable changes that occur over short periods of time (such as below water treatment plants or at the mouths of tributaries).

Noteworthy Events

In September of 2013, a large rain event caused a 100-year flood event in the Big Thompson River causing substantial damage to roads and infrastructure in the watershed. Highway 34 is the primary road to the Town of Estes Park and Rocky Mountain National Park and in addition, is immediately adjacent to the Big Thompson River through much of the canyon section of the river. Highway 34 was heavily damaged in the flood. Although emergency repairs were completed quickly, longer term construction efforts to repair and improve Highway 34 began in 2016. Although some minor repair continues today, most of the construction was completed in early 2019 at an estimated cost of $280 million. These construction efforts have had an impact on water quality in the Big Thompson River, primarily by contributing to increased sediment loading into the river. There were declines in water quality during construction as indicated by parameters such as total organic carbon (TOC) and dissolved copper. Although water quality declined during this period, it appears that conditions are improving, and we are hopeful that this trend continues.

Summer 2019 General Conditions

Precipitation at the Bear Lake National Resources Conservation weather station in summer of 2019 was near to the long-term summer median value (1980-2018) (Figure 2). This station is located at approximately 9,500 feet of elevation in the headwaters of the Big Thompson River and is therefore reflective of conditions in the Big Thompson River.

Although the 2019 summer precipitation total was close to the median, snowmelt occurred slightly later than average resulting in a shift in the seasonal runoff pattern. Historically, peak flows at Moraine Park in Rocky Mountain National Park have occurred in early June while in 2019 peak flows occurred in late June which resulted in above average flows in July and August.

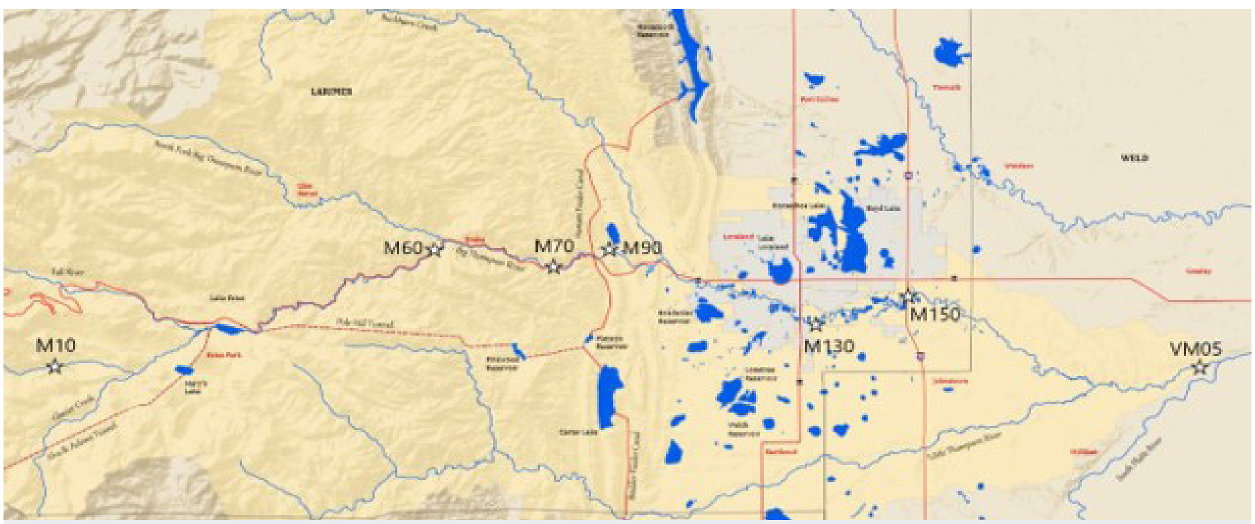


Figure 1. Sampling locations on the Big Thompson River.

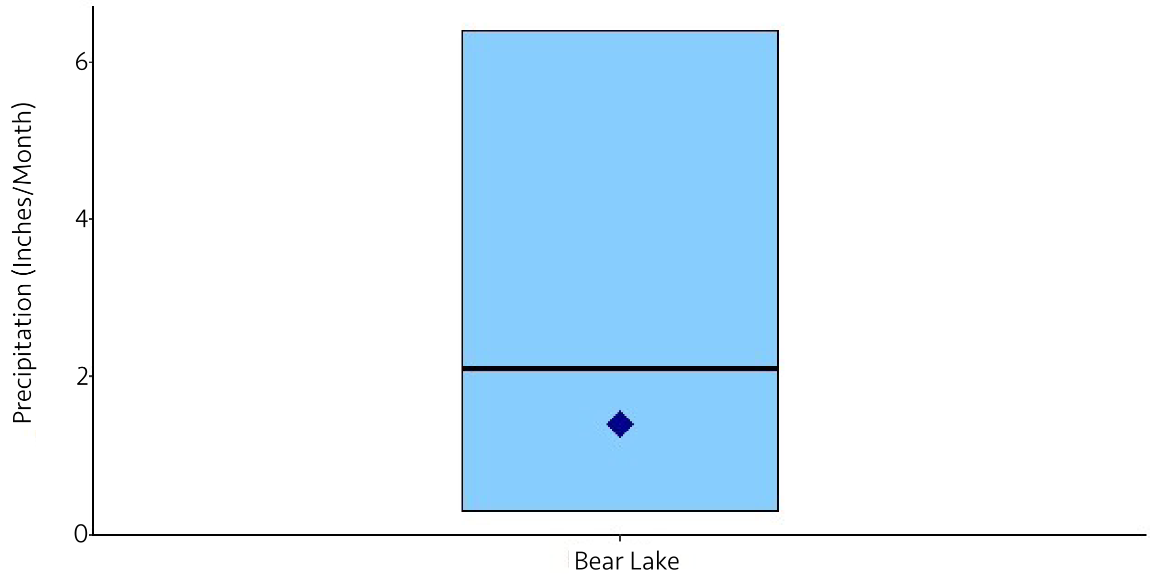


Figure 2. Range of historical median monthly precipitation in the summer at the National Resource Conservation Service Bear Lake site (blue box) located in the headwaters of the Big Thompson River (https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=322) (1990-2018) and the 2019 summer monthly precipitation median (blue diamond).

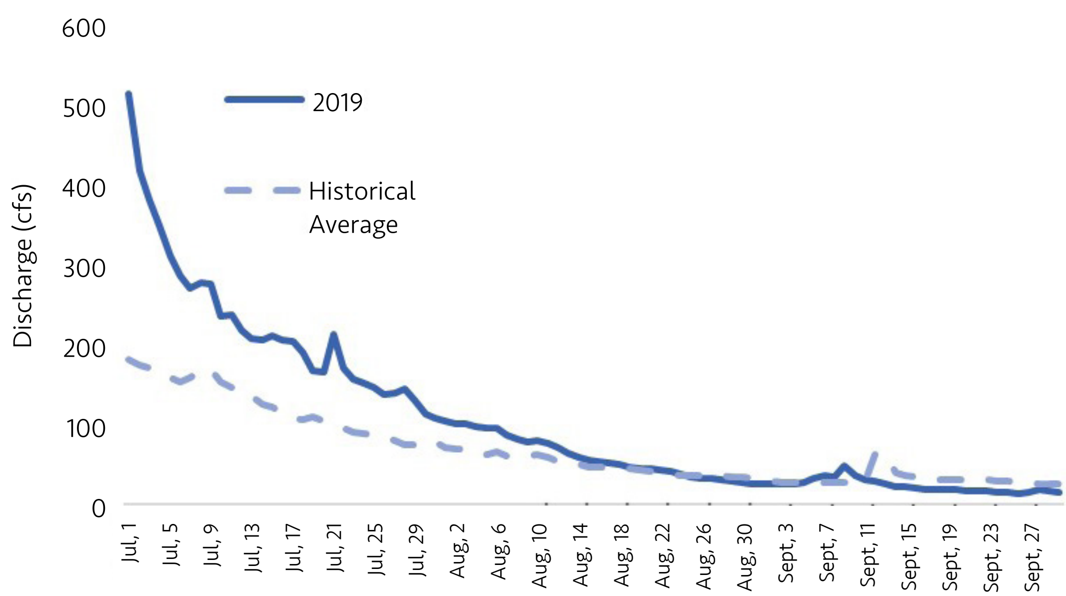


Figure 3. 2019 and historical daily flows in the summer at the USGS Moraine Park gage (https://waterdata.usgs.gov/nwis/uv?402114105350101).

Summer 2019 General Conditions

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 and egg and larval growth and development. Consequently, elevated water temperatures can cause reduced reproduction, growth, or mortality. 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.

Temperatures were near median values in summer 2019 compared to the previous five-year period (Figure 4). However, given that four of the five previous years represent among the hottest years on record, conditions were still very hot in 2019. While these values give us a general sense of thermal conditions, these values clearly do not represent other important components of temperature such as diurnal variation and the relationship between air and water temperature.

General Water Quality Indicators

Turbidity

Turbidity is essentially a measure of how transparent water is. 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. For example, the City of Loveland alters the location of their water collection when turbidity levels rise above 100 NTU. High turbidity generally means there is increased sediment present in the water. Accommodating sediment is a challenge to drinking water utilities. Turbidity levels are also positively associated with TOC levels which in turn require additional water treatment efforts. Elevated turbidity can have direct negative effects on aquatic organisms in addition to indirect effects such as increasing the levels of some dissolved metals. Elevated turbidity and suspended sediment can 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 which can also lead to increased mortality as well. Effects of elevated turbidity become more severe with longer exposure.

Turbidity generally increases with spring runoff and then declines in the summer season. Median turbidity values in summer 2019 were generally near the median values for the previous five years (Figure 4). Highway 34 construction activities had been substantially completed by spring 2019 and none of the measured values from the sites included in this report in the summer of 2019 were above 100 NTU.

pH

The pH value measures the hydrogen ion concentration in water and indicates 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.

pH values generally increase as water moves from headwaters to those lower in the watershed as additional dissolved materials become present in the water. However, the median summer pH and individual samples at each site were well within the range considered to be protective of aquatic life (Figure 4).

Dissolved Oxygen

Dissolved oxygen levels are important to aquatic life and drinking water facilities. 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 coldwater streams and require higher concentrations of dissolved oxygen (e.g. Cutthroat Trout *Oncorhynchus clarki*) than those who have evolved to persist in the lower warmwater portion of the river (e.g Johnny darter *Etheostoma nigrum*). 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 6 mg/L. In addition, dissolved oxygen levels regulate the degree to which some elements (like manganese and sulfur) remain in solution. Relatively high dissolved oxygen levels allow these elements to precipitate out of the water column and make drinking water treatment easier.

Dissolved oxygen levels decrease in a downstream direction and the sites closest to the confluence with the South Platte River (M150 and VM05) had levels lower in summer 2019 than the 2014-2018 median (Figure 4). However, median values at all the sites are well above levels that might be difficult for aquatic life.

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. In water treatment, low alkalinity can increase the ability of water to corrode distribution pipes.

Alkalinity levels were generally close to the median values of the past five-year period. However, alkalinity levels were somewhat low at the downstream sites of M130, M150, and VM05 relative to the five-year median (Figure 4).

Manganese

Manganese is an element that is considered beneficial to human health at low levels and is one of the least toxic elements, but elevated levels can cause taste and staining issues and issues for water distribution systems. Specifically, manganese can cause a brownish color to water and 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. The drinking water standard for manganese is 50 ug/L which is much lower than levels that might be of concern to aquatic life.

Although manganese levels were generally lower than the five-year median, several measured values at site VT05 (Little Thompson River) were above the drinking water standard of 50 ug/L (Figure 4). Although some values were above the drinking water standard, this circumstance does by no means constitute a reason for concern. Standardized methodology to determine drinking water quality have been established and related to 50 ug/L level. Values presented here are not in accordance to the much more statistically rigorous evaluations conducted by governmental agencies. However, given that several values were above the standard, it is important to continue to track these values in the future.

Copper

Dissolved 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.

Dissolved copper levels in summer 2019 were generally lower than the five-year median values (Figure 4). The lower dissolved copper values in the Big Thompson correlate with decreased pine beetle induced tree mortality in the past several years and decreased tree mortality seen in the last five years may have contributed to the decrease in dissolved copper. When trees die they deposit the copper they have taken up through the soil back into the soil and the watershed. Decreased tree mortality is beneficial to water quality in general.

Iron

Dissolved 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 levels of dissolved iron with levels greater than 3,000 ug/L. Detrimental effects to aquatic life can occur when levels of total iron are above 1,000 ug/L. 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. Note that values presented here reflect the amount of dissolved iron, which is by definition lower than or equal to total iron values.

Dissolved iron levels in summer 2019 were generally near five-year median values (Figure 4). No samples taken from any site in summer 2019 were above levels of concern to drinking water or aquatic life.

Orthophosphate

Orthophosphate is a dissolved form of phosphorus and is the only form that is immediately available for uptake by algae. 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.

Orthophosphate levels in the upper sites continue to be extremely low. In addition, although 2019 orthophosphate levels at the downstream sites of M150 and VM05 are higher than the upstream sites, these levels are considerably lower than the five-year median values (Figure 4). The relatively large range of orthophosphate levels at site M150 is related to the completion of a biological nutrient removal upgrade by the City of Loveland at its wastewater treatment facility. This upgrade was completed in 2018 and measures of nutrient related water quality parameters have been substantially lower since the upgraded facility has been operational.

Nitrate+Nitrite

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), 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 significant concentrations.

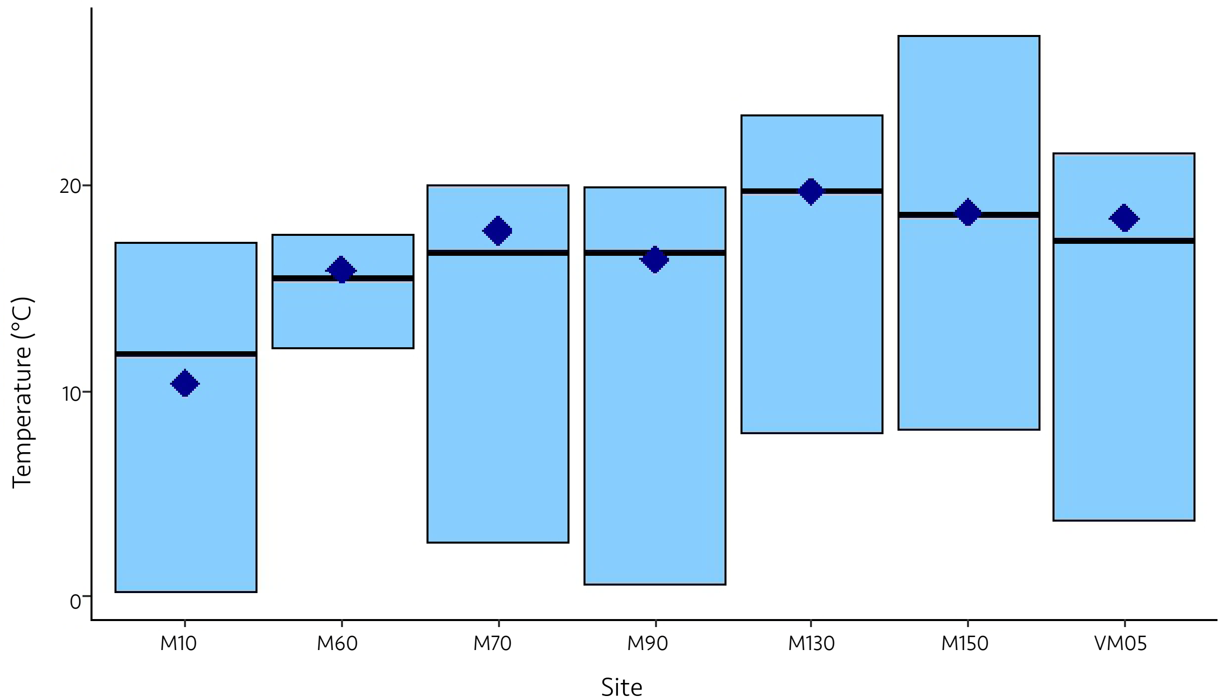
Nitrate+nitrite levels in the upper sites continue to be very low. Levels at sites in the lower river (M150 and VM05) while higher, were below five-year median values and were far from levels to be of concern to drinking water (Figure 4).

Total Organic Carbon

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 byproducts that are regulated as potential carcinogens (e.g. chloroform $CHCl_3$). As such, TOC levels are of concern to drinking water treatment facilities.

TOC levels in summer 2019 were very close to 2014-2018 median values for all sites. These results are encouraging given that turbidity and TOC values have been elevated in the past several years due to construction activities.



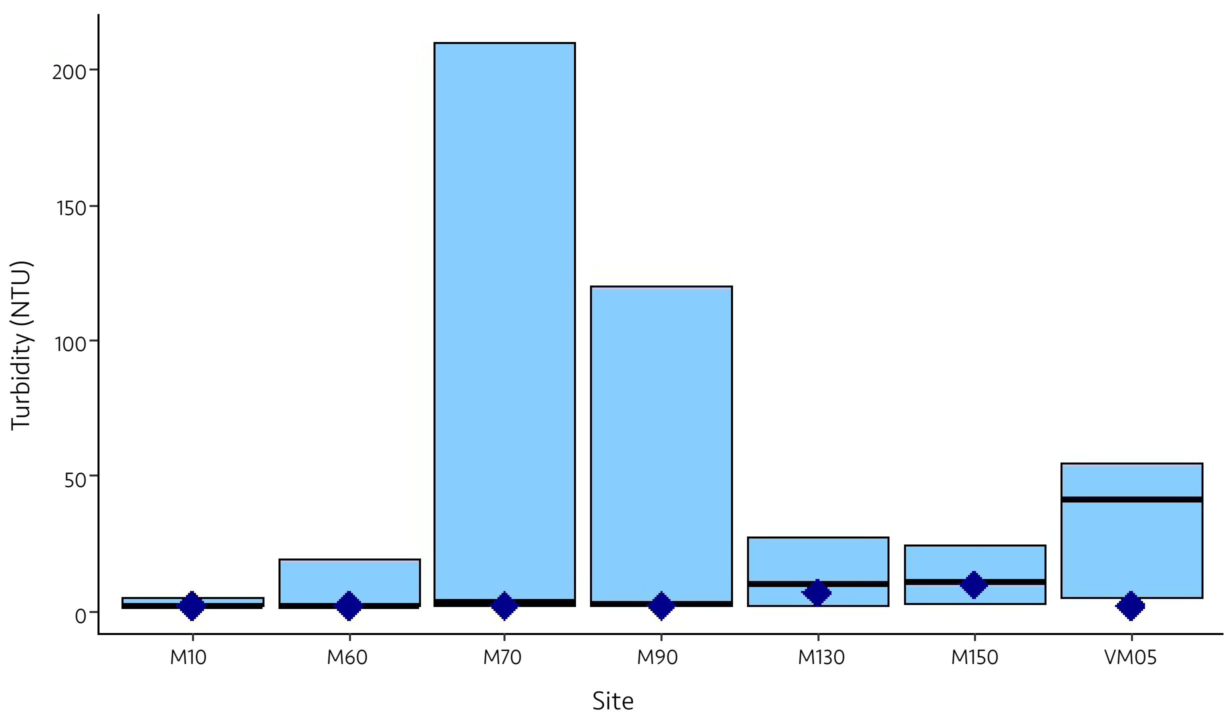
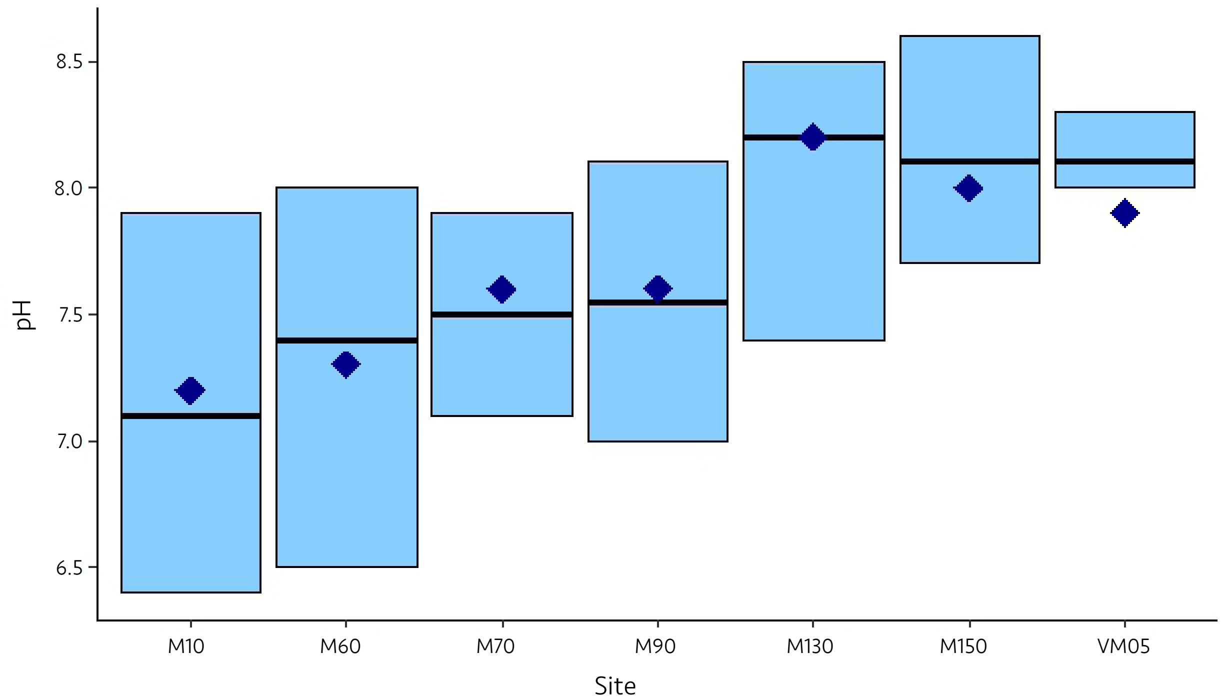
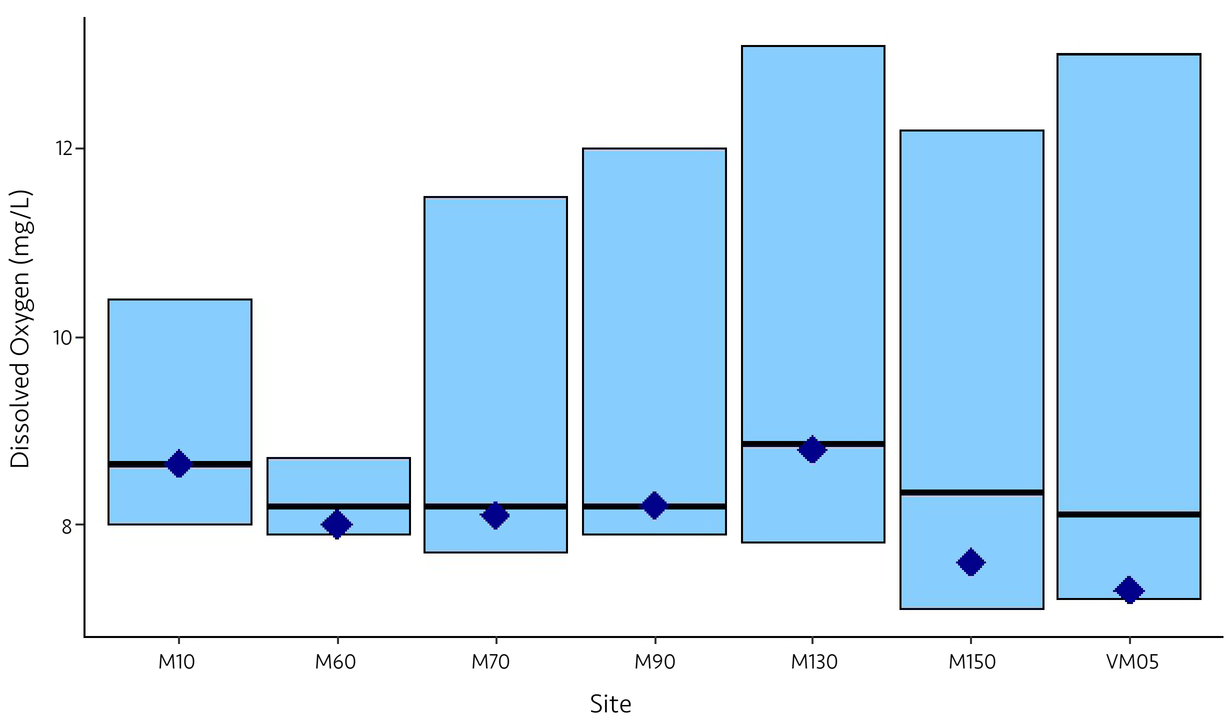


Figure 4. Blue diamonds represent the median summer 2019 value for each site. The black line represents the median value for the previous five-year summertime period (2014-2018). The blue box represents the range of values documented in spring at the corresponding sampling location from 2014-2018.





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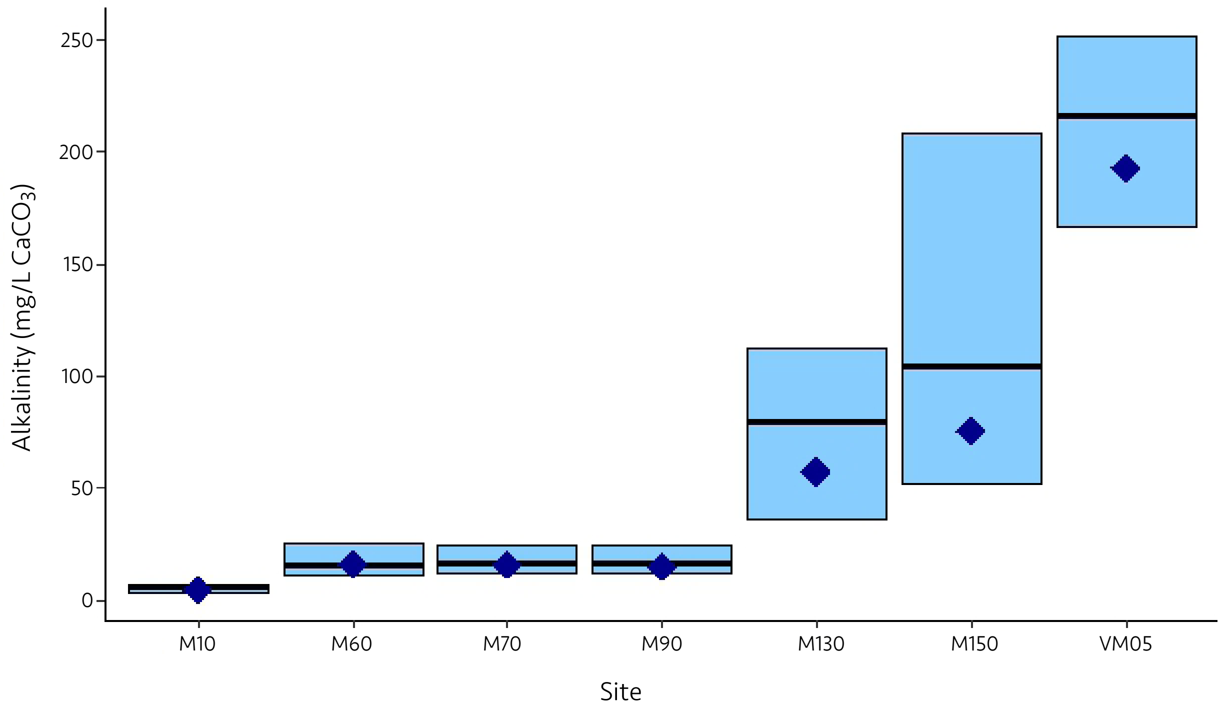

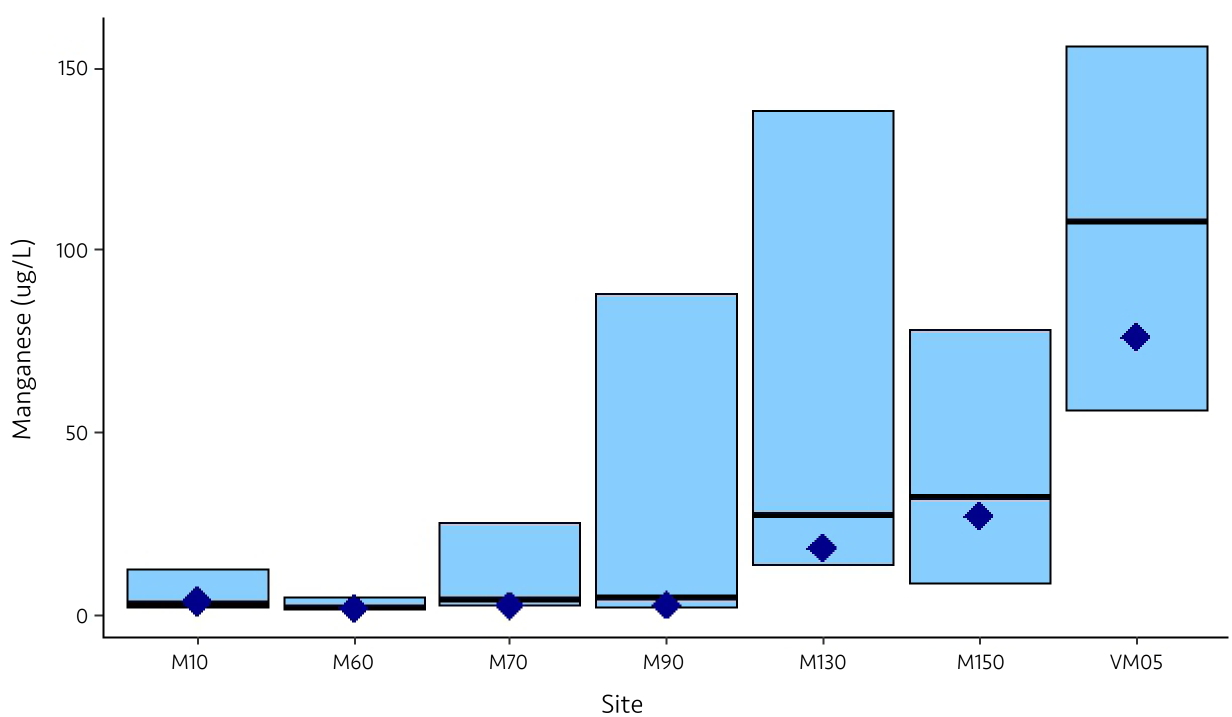

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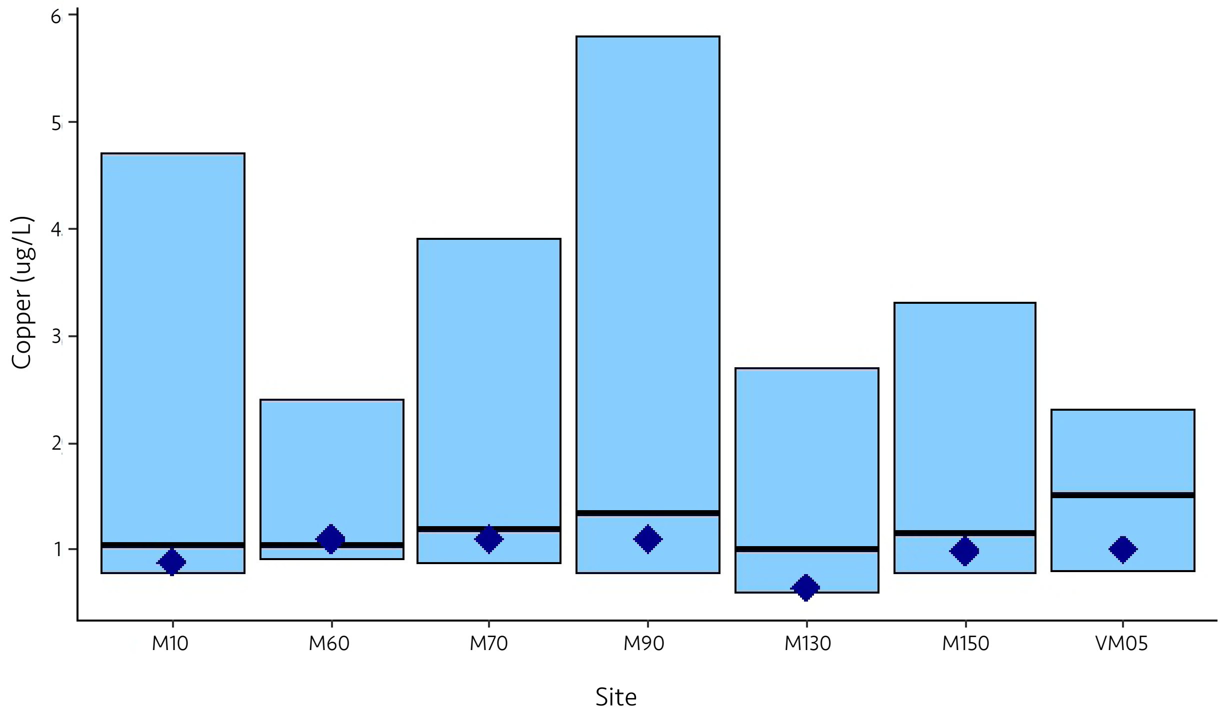

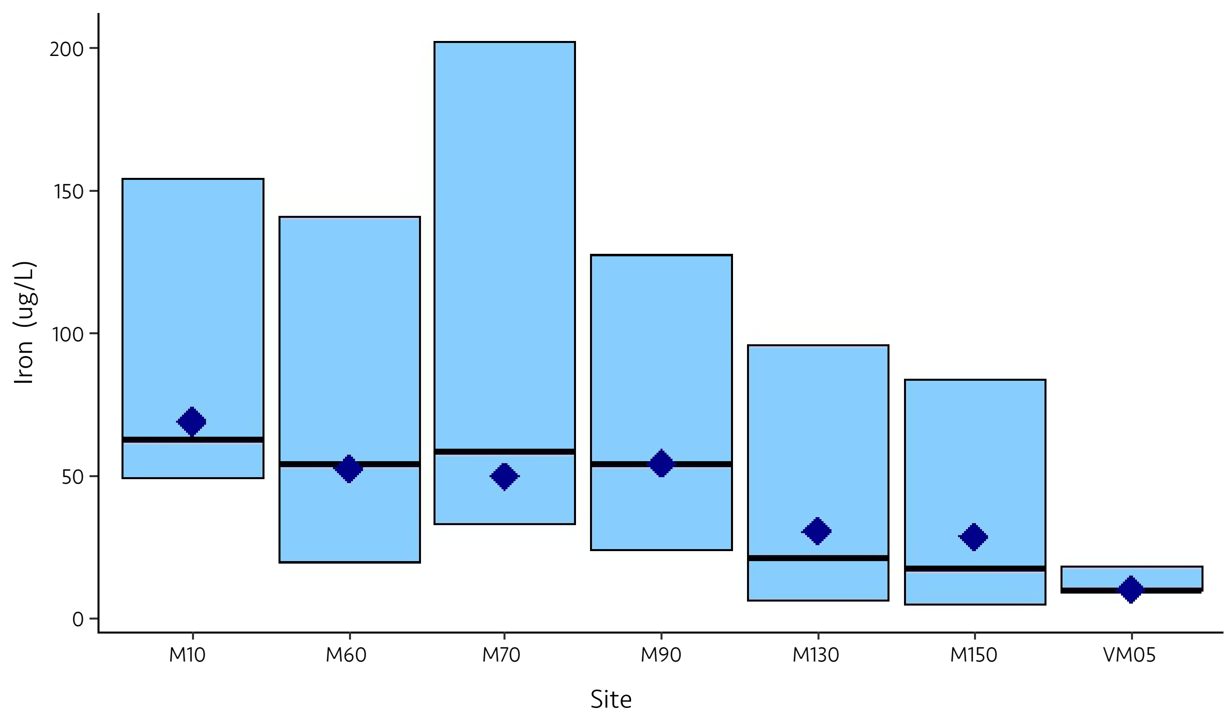

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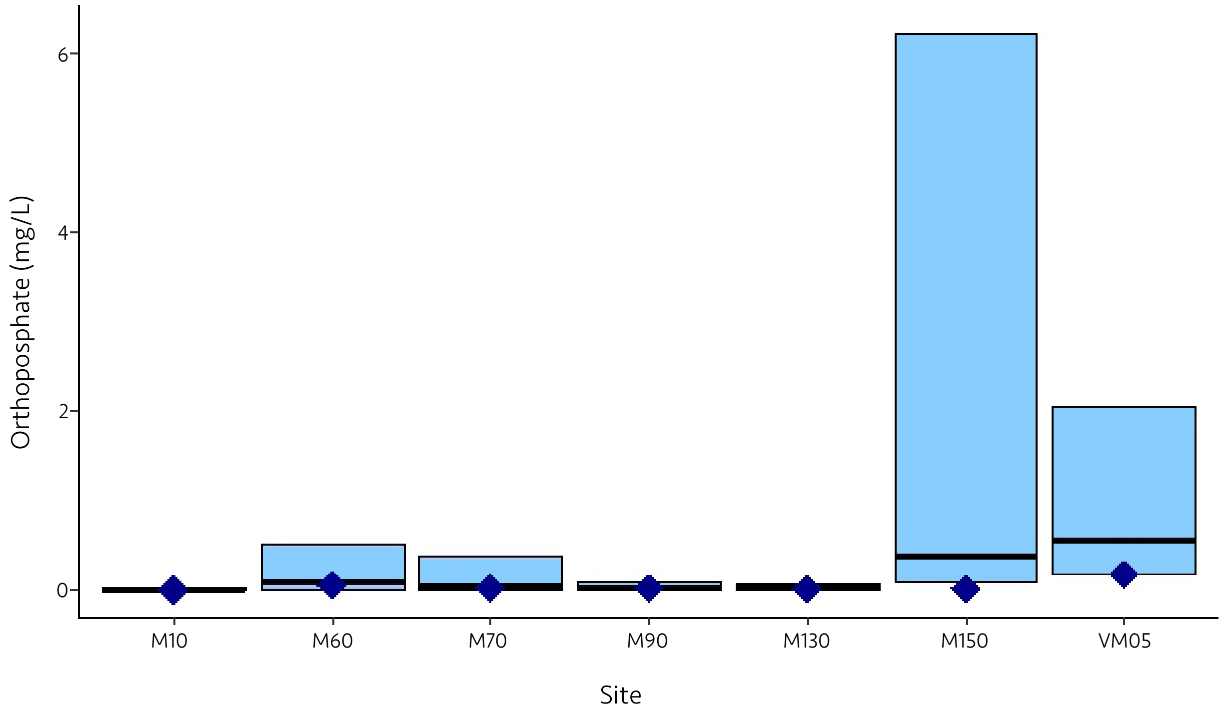

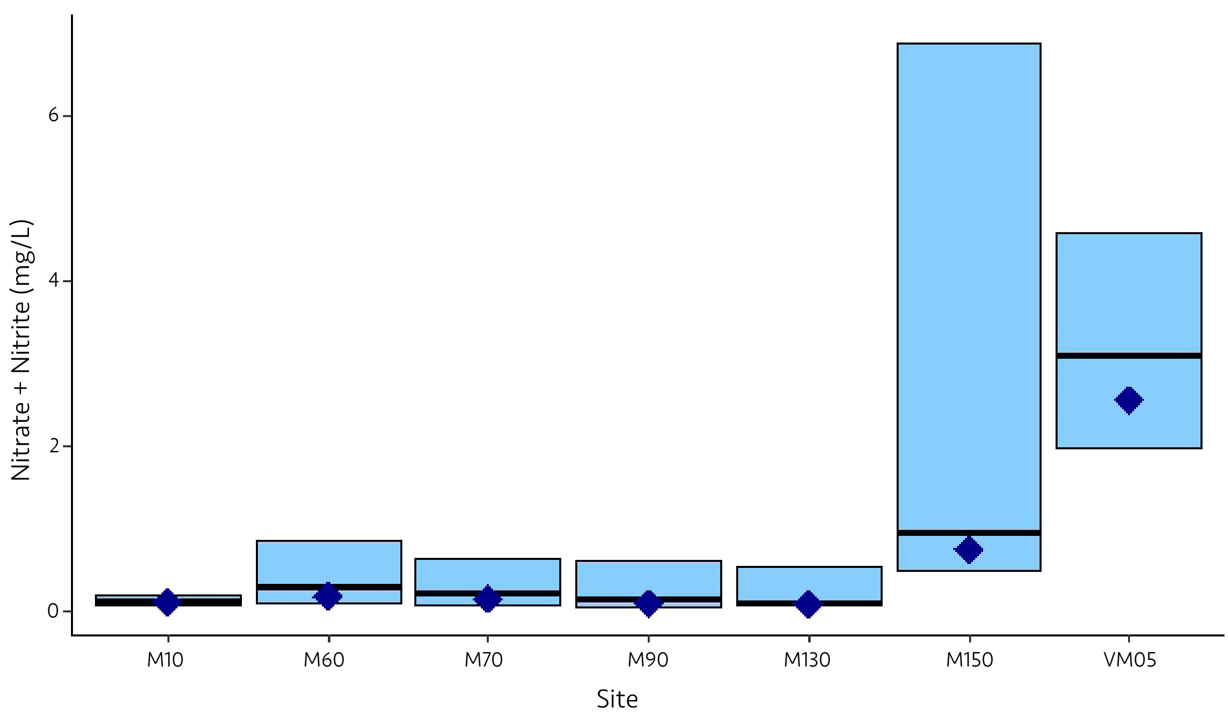

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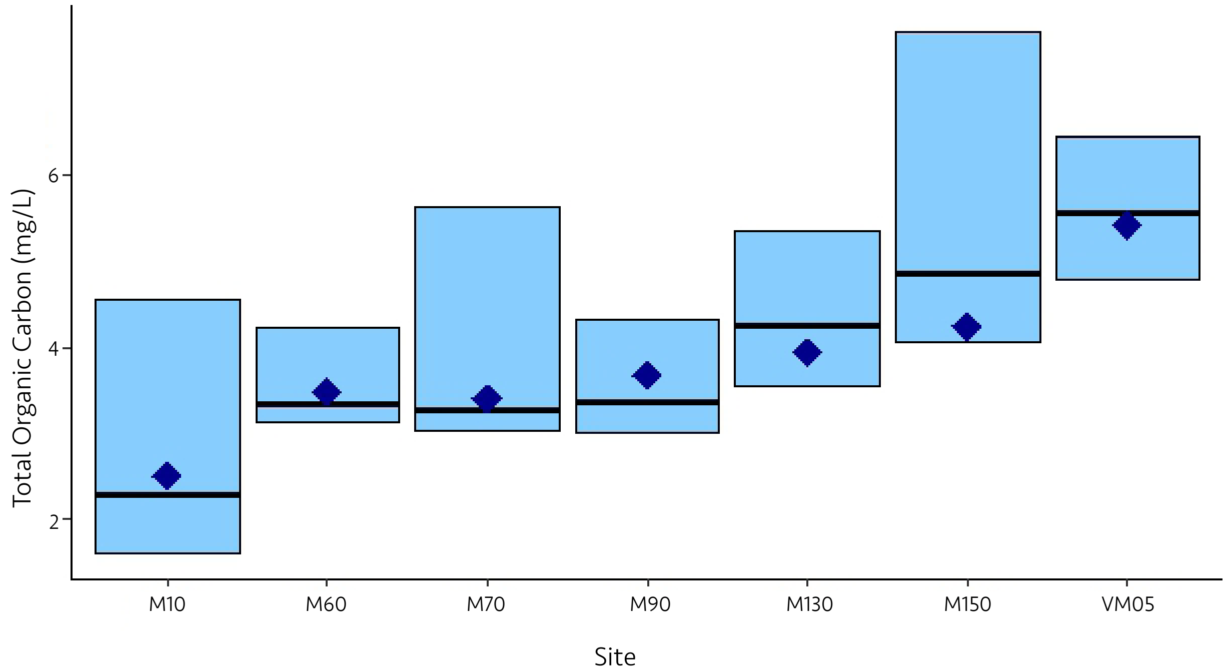

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