Big Thompson River

2017–2018 Winter Monitoring Summary

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Background

During Highway 34 construction stakeholder meetings, which occurred monthly throughout 2017, several discussions related to water quality monitoring and construction activity occurred. In addition to permit-specific monitoring requirements, two primary monitoring gaps were identified by the Big Thompson Watershed Forum (BTWF) monitoring program manager and the City of Loveland representative. These two gaps were: 1) the collection of construction site-specific metals information and 2) monitoring during the winter months.

Dissolved metals can negatively affect aquatic life and drinking water quality. Although the BTWF collects information on dissolved metals from its standard sites once per month, it would be difficult to identify a source should an issue arise. The time between collection and receipt of results was more than one month; as such, these results would not provide information quickly enough to rectify the situation in a timely manner. The City of Loveland began collecting site-specific water samples for metals out of concern related to this gap.

The City of Loveland maintains a real-time data collection station at Narrows Park (40°24'53.72"N, 105°15'2.26"W) (Figure 1) from approximately mid-March through mid-November, depending on conditions. The data collection sonde is removed in mid-November because it is relatively expensive and can be damaged by ice during winter months. The BTWF's contract with the USGS for monthly sampling excludes December and January, due to cost and logistical constraints. Therefore, other than permit-required sampling, no external water quality monitoring efforts take place during these months. Even if monthly sampling were to occur during these months, short-lived water quality events may be missed in the absence of continuously collected real-time data. This lack of information was concerning to the BTWF, City of Loveland, and other stakeholders. The monitoring station upstream of the City of Loveland water intake provides information to help prepare for conditions that may require additional treatment or alternative water sources. For example, the City needs to shut off the intake if turbidity reaches 100 NTU or more, because treating high turbidity means much higher chemical costs and potential violations of water quality parameters for drinking water. The intake also needs to be shut down for high or low pH events or other events that could be harmful to aquatic life.

Figure 1. USGS and City of Loveland real-time data collection stations

A sub-group of stakeholders specifically tasked with evaluating monitoring efforts, including representatives from the BTWF, Colorado Department of Transportation (CDOT), Kiewit, Colorado Parks and Wildlife, the U.S. Forest Service, the USGS, Northern Water, and the City of Loveland met on June 14, 2017, and endorsed the idea of real-time winter monitoring for the winter of 2017–2018.

The USGS is uniquely qualified to complete this work. The organization has experience and expertise in collecting water quality information in winter conditions in similar systems in Colorado and elsewhere. In addition, the USGS has the distinct advantage of being able to rent the necessary equipment, an option not available to those outside the federal government. Thus, if costly equipment were to be damaged, new equipment would not need to be purchased but simply exchanged for functional equipment.

Request for funding for real-time winter monitoring was made by the BTWF and carried forward by Steven Humphrey (Project Manager, Muller Engineering) and Nick Schipanski (Environmental Project Manager, Colorado Department of Transportation) to the Federal Highway Administration, which is ultimately funding the Highway 34 construction work. On September 14, 2017, the Federal Highway Administration agreed to provide funds to establish and operate the real-time station through their Emergency Relief funding program. Administratively, the simplest way to fund the project was to amend the Kiewit contract to reflect the cost of the winter monitoring effort; the BTWF then subcontracted with USGS for the monitoring services. The total amount allocated to Kiewit (and subsequently to the BTWF and USGS) was $23,190 to install and operate the station from mid-November 2017 through mid-March 2018. Subsequently, USGS obtained additional matching funds in the amount of $6,957. The BTWF is holding these additional funds as a restricted asset to be used for winter monitoring in 2018–2019.

Site Selection

Prior to installing the sonde, USGS and BTWF staff made two site visits to examine the City of Loveland location and other potential sites. Considerations included the availability of sunlight for solar power to be used for the heat tape to prevent freezing, access to the main channel of the river, and depth. The most optimal location was determined to be the Jasper Road bridge, which is owned by Larimer County. BTWF staff contacted Larimer County to ask permission to install the equipment on the bridge

Figure 2. Greg Smith (left) and Dave Lorenz at the USGS real-time data station.

but was informed that the bridge was scheduled for demolition and reconstruction in winter. Therefore, the bridge site was abandoned as a potential winter monitoring site. USGS staff then contacted a landowner (Dave Lorenz) who owned riverfront property with electricity at a trailer pad approximately 100 meters downstream of the bridge (Figure 1). Lorenz agreed to host the station on his property and allow his electricity to be used when necessary. As a goodwill gesture, the BTWF paid the landowner $200 for electricity and the use of his land, although Lorenz stated that he would still host the station with no payment.

Data Collection

Real-time data collection included four water quality parameters: temperature, specific conductance, pH, and turbidity (measured every 15 minutes). Although these parameters are not all-inclusive, they are general enough to indicate potential issues that are directly or indirectly reflected by these parameters. In addition, the USGS website enabled subscription to "WaterAlert." This service sends an email or text to the user if any of the measured parameters are above user-defined limits. Data are available at https://waterdata.usgs.gov/co/nwis/current/?type=quality

Figure 3. The USGS real-time monitoring station

Loveland and USGS Real-time Data Collection Comparison

The USGS winter sonde (Figure 3) was installed on November 8, 2017, began collecting and transmitting data on November 15, 2017, and was removed on March 23, 2018. At this time, the City of Loveland sonde was also in operation, which enabled a comparison of the data collected from the two sondes at the same time. The City of Loveland sonde was removed from service on November 21, 2017. The sondes were located in the mainstem of the Big Thompson River.

Turbidity readings were similar between the Loveland and USGS sondes and the measurements tracked well (Figure 4). However, the USGS readings were generally higher than the Loveland readings. The Loveland station was located approximately 400 meters downstream of the USGS station and was in a slightly more 'off channel' portion of the river. While the difference in location may account for some small variations in measurements, the primary cause was likely the fact that the sonde initially deployed by the USGS lacked a wiper and, as a result, increased turbidity was measured. A sonde with a wiper was deployed by USGS on November 22, 2017. In addition, the Loveland sonde measured turbidity using white light, resulting in a measurement in units of NTU, and the USGS sonde measured turbidity using infrared light, resulting in a measurement in units of FNU. These two measurements are equivalent when measuring calibration standards of formazin; however, their values may differ in environmental samples. While the actual values between the two sondes may differ slightly, they are expected to increase and decrease in a similar fashion in response to increases and decreases in turbidity.

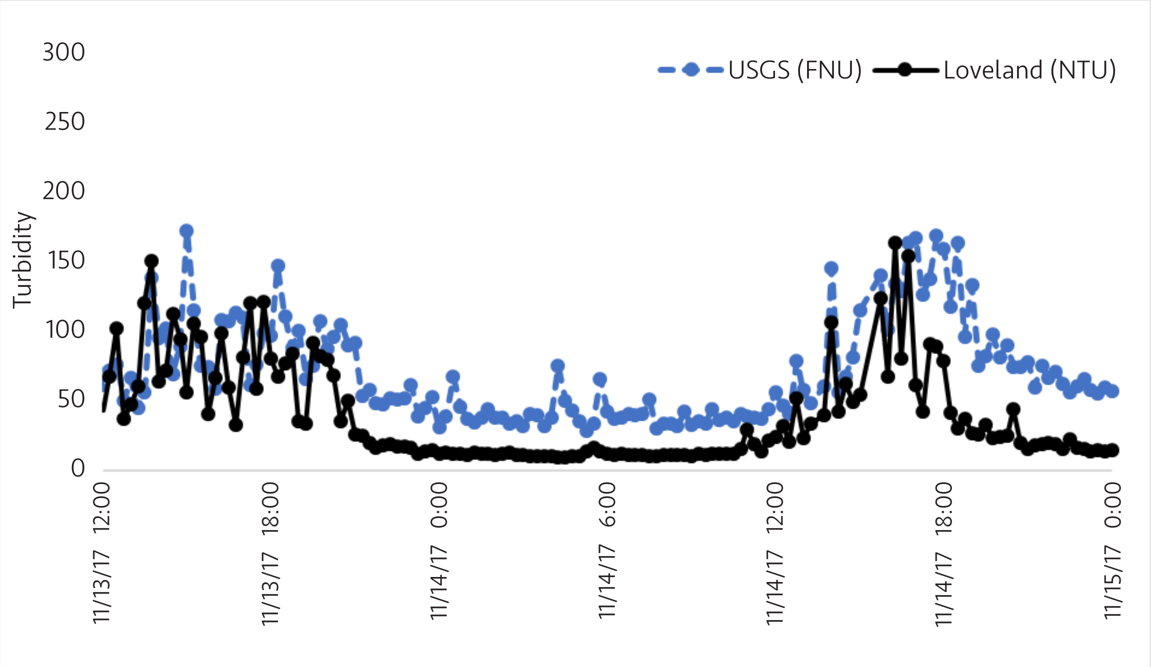

Figure 4. Comparable Loveland and USGS real-time water quality sonde turbidity data

Specific conductance readings were similar between the Loveland and USGS sondes; the measurements tracked almost perfectly, although the USGS sonde was consistently 4 uS/cm higher than the USGS sonde (Figure 5). While the actual values between the two sondes differ slightly, they are expected to increase and decrease in a similar fashion in response to increases and decreases in specific conductance. In addition, it is possible that the measures were more similar after the USGS exchanged its sonde on November 22, 2017.

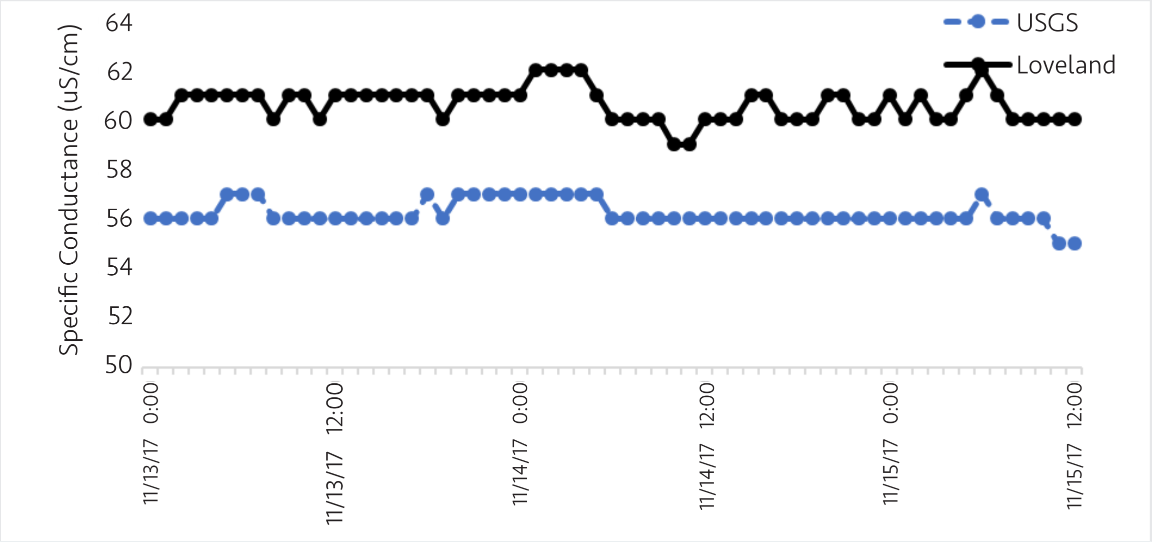

Figure 5. Comparable Loveland and USGS real-time water quality sonde specific conductance data

The pH readings were similar between the Loveland and USGS sondes and the measurements were highly correlated, although the USGS sonde was consistently 0.4 pH units lower than the Loveland sonde (Figure 6). The difference of 0.4 pH units is substantial given that pH is measured in log scale. However, the USGS sonde is expected to increase and decrease in a similar fashion in response to changes in specific conductance. In addition, it is possible that the measures were more similar after the USGS exchanged its sonde on November 22, 2017.

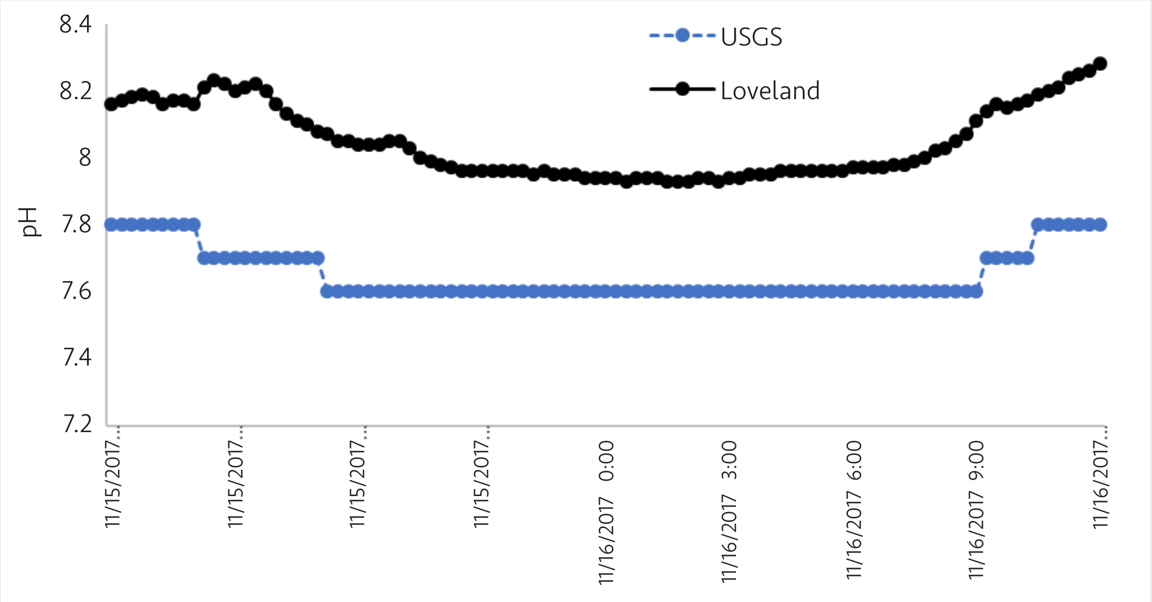

Figure 6. Comparable Loveland and USGS real-time water quality sonde pH data

The temperature readings were almost identical between the Loveland and USGS sondes, despite the spatial differences between the two stations (Figure 7).

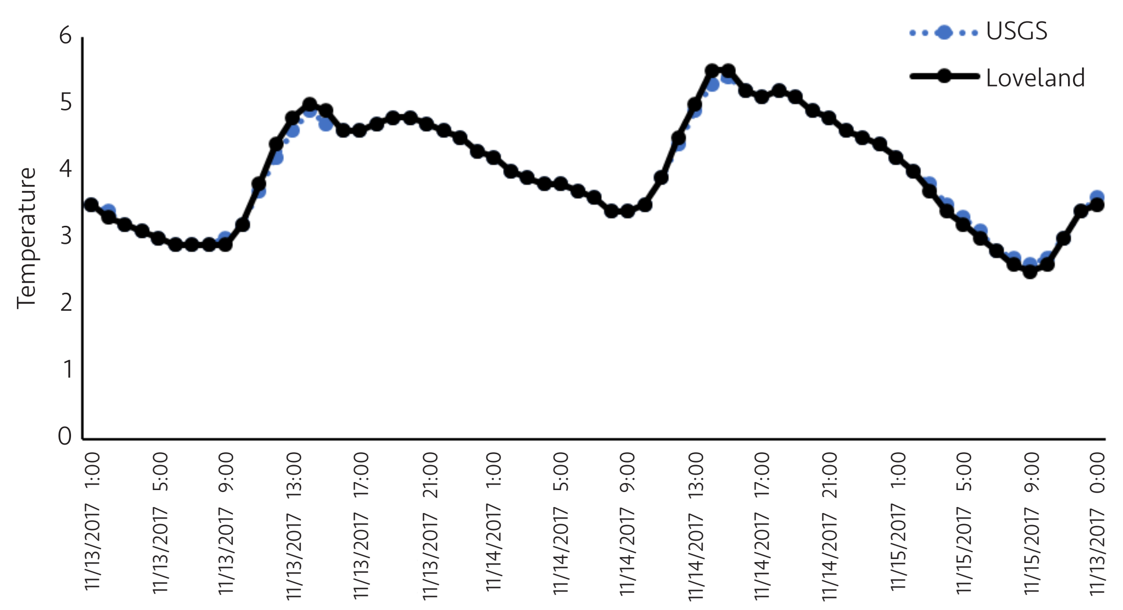

Figure 7. Comparable Loveland and USGS real-time water quality sonde temperature data

Winter Season Data Summary

The USGS sonde performed well in general and provided basic water quality information during the entire winter season of 2017–2018. Increased turbidity and sediment associated with construction activity was the primary water quality concern identified by the USGS sonde. The only operational issue occurred when turbidity was extremely high (2330 FNU at 2:30 on December 17, 2017), which caused fouling (Figure 8). Due to the real-time data availability, the high value was quickly noted by the BTWF, Loveland, and USGS staff. USGS staff visited the station on December 19, 2017, to clear the accumulated sediment.

Figure 8. Sonde fouled with sediment

The utility of measuring specific conductance and pH is that many different changes in water quality are reflected in these parameters. The City of Loveland collected additional monthly water quality samples near active construction sites to supplement BTWF baseline samples. Several samples revealed relatively high metal concentrations (particularly copper and aluminum), but there were no corresponding spikes in pH or specific conductance of a magnitude that would be of concern. However, there were significantly elevated turbidity measurements throughout the sampling period. Increased turbidity can be associated with increased dissolved metals. For example, increased dissolved organic carbon is positively associated with dissolved copper (Nason et al. 2012), and dissolved organic carbon is associated with increased turbidity (Cauwet and Mackenzie 1993). The increased dissolved metals observed in the samples collected by the City of Loveland appear to be associated with prolonged elevated turbidity rather than an acute event.

Turbidity was extremely high during the winter of 2017–2018 ranging from 2.9 to 120 FNU with an average of 84.5 FNU. Under normal conditions, average turbidity is in the range of 1–4 NTU (Jasby and Goldman 2003). These elevated values were almost certainly caused by construction activity based on the return to normal turbidity levels at the end of December when there was essentially no construction activity due to the Christmas holiday (Figure 9).

Elevated turbidity has negative impacts on municipal water treatment plants and aquatic communities. Turbidity levels are positively associated with total organic carbon (TOC) levels (LeChevallier et al. 1981). 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. Elevated turbidity can have direct negative effects on aquatic organisms, as well as 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 (Shaw and Richardson 2001). Growth of trout species, such as rainbow trout (*Oncorhynchus mykiss*), is negatively associated with increased turbidity (Al Shaw and Richardson 2001), and higher turbidity can lead to increased mortality of salmonids as well (Newcombe and Jensen 1996). Effects of elevated turbidity become more severe with longer exposure (Newcombe and Jensen 1996, Al Shaw and Richardson 2001).

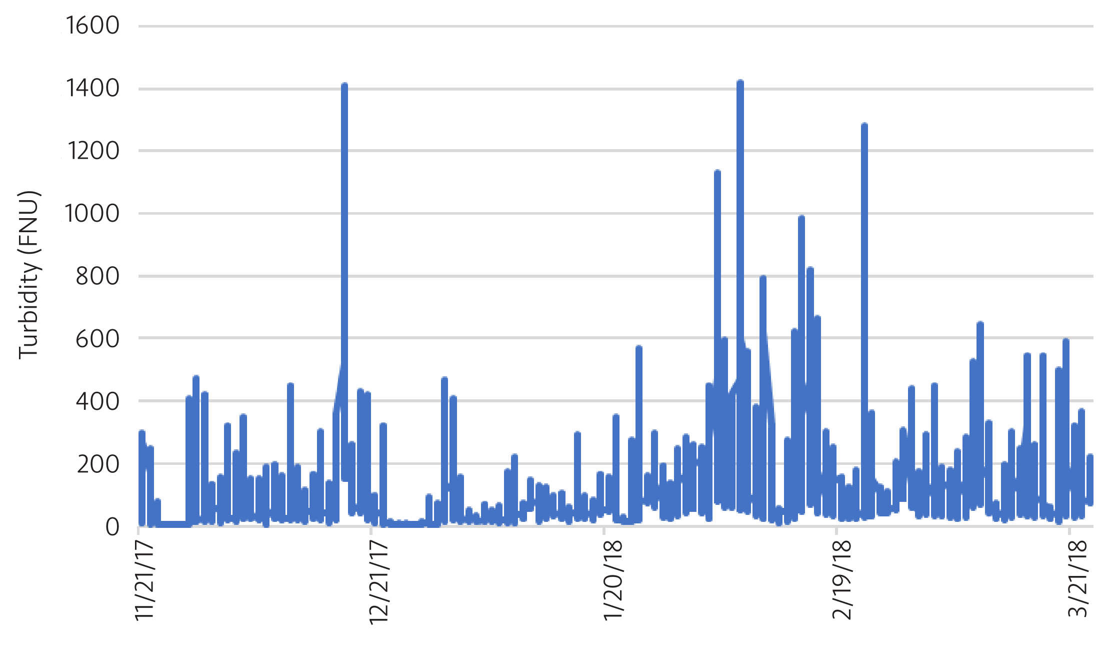

Figure 9. Turbidity measurements from the USGS real-time station

No unexpected or unusual temperature, specific conductance, or pH spikes occurred during the sampled time period (Figures 10, 11, and 12). These results suggest that, although the City of Loveland measured unacceptably high levels of some dissolved metals in association with construction activities, they were likely associated with increased turbidity levels rather than an acute event, as would be reflected in observable spikes in pH and/or specific conductance measures. However, increased turbidity and dissolved metals are likely to have had a significant negative effect on aquatic organism populations in the Big Thompson River.

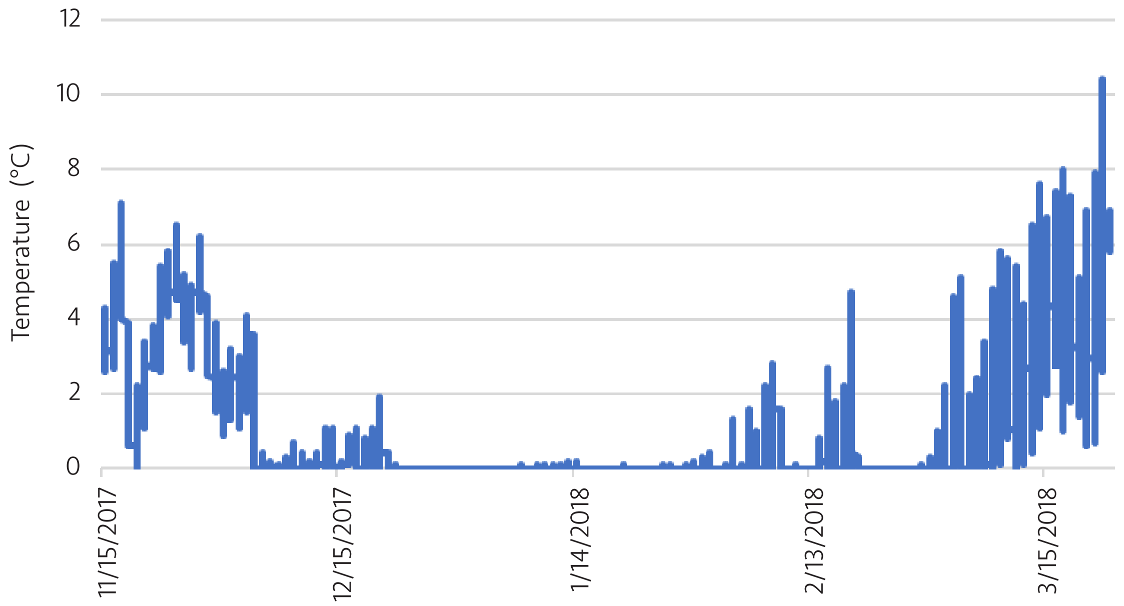

Figure 10. Temperature measurements from the USGS real-time station

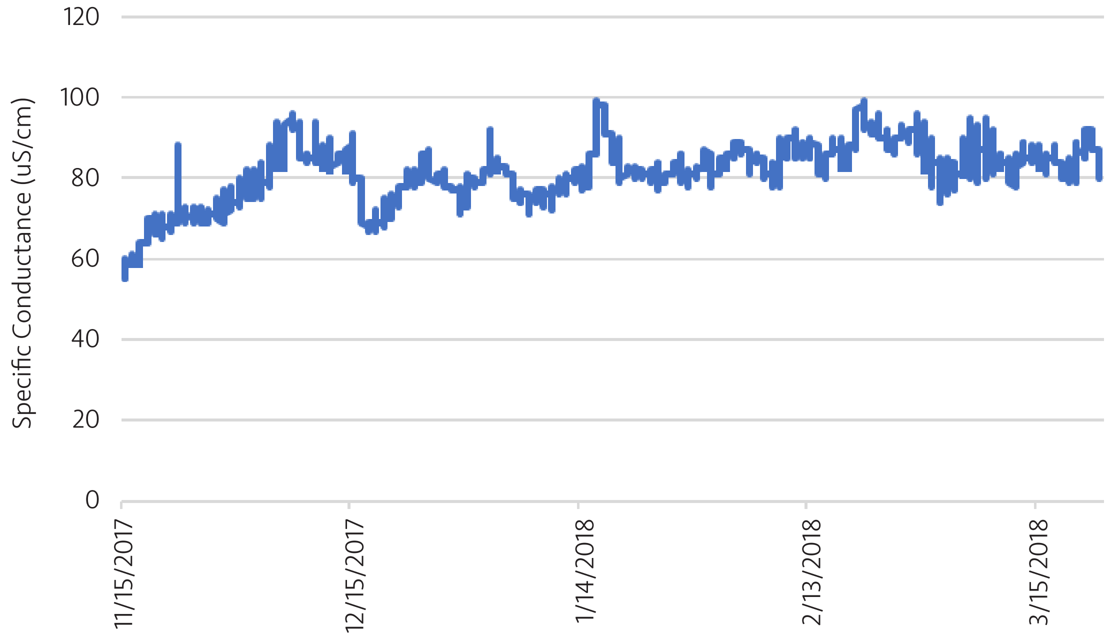

Figure 11. Specific conductance measurements from the USGS real-time station

Results and Discussion

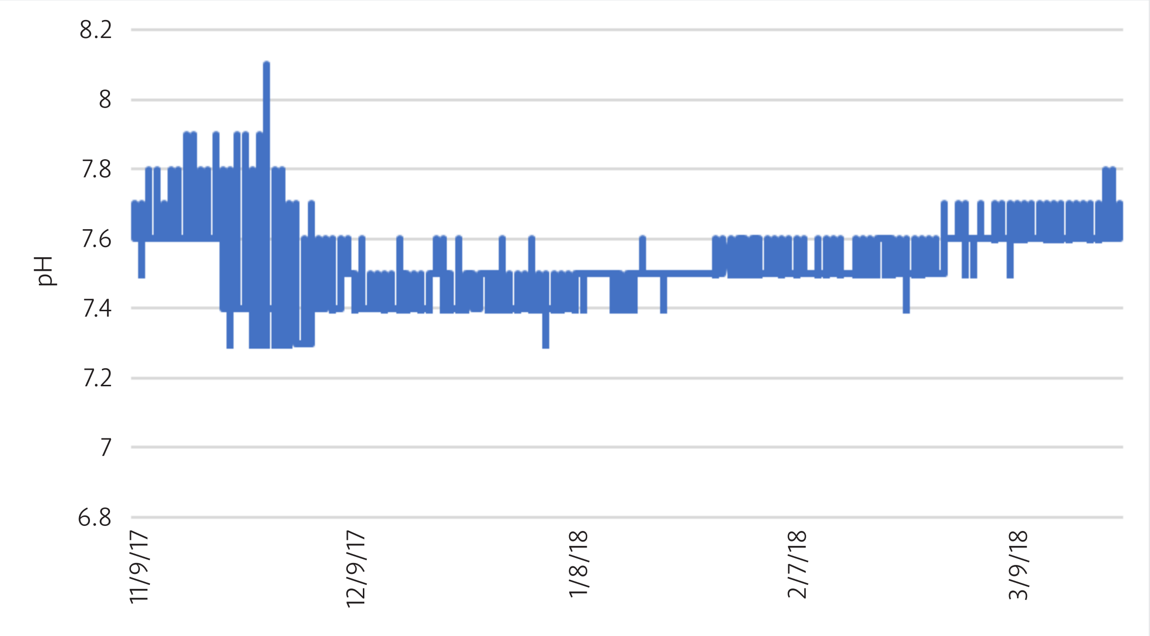

Figure 12. pH measurements from the USGS real-time station

Acknowledgements

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