SOURCE WATER MONITORING

The Upper Cache la Poudre (UCLP) Watershed Collaborative Monitoring Program was established in 2008 between the City of Fort Collins, the City of Greeley and Tri-Districts, to help meet present and future drinking water treatment goals.

Water quality monitoring of our raw, Cache la Poudre River drinking water supply is conducted from April through November. Monitoring sites are strategically located throughout the UCLP. Water quality data provide valuable information about the health of our source watershed and raw water supply.

The Fall 2015 Water Quality Update provides a seasonal summary of the UCLP Watershed by highlighting precipitation and streamflow conditions, as well as water quality during the months of October and November.

Results are reported for six key monitoring sites located throughout the Upper Cache la Poudre watershed, which capture water quality conditions above and below major tributaries and near water supply intake structures (Figure 1).

More information is available at *fcgov.com/source-water-monitoring*.

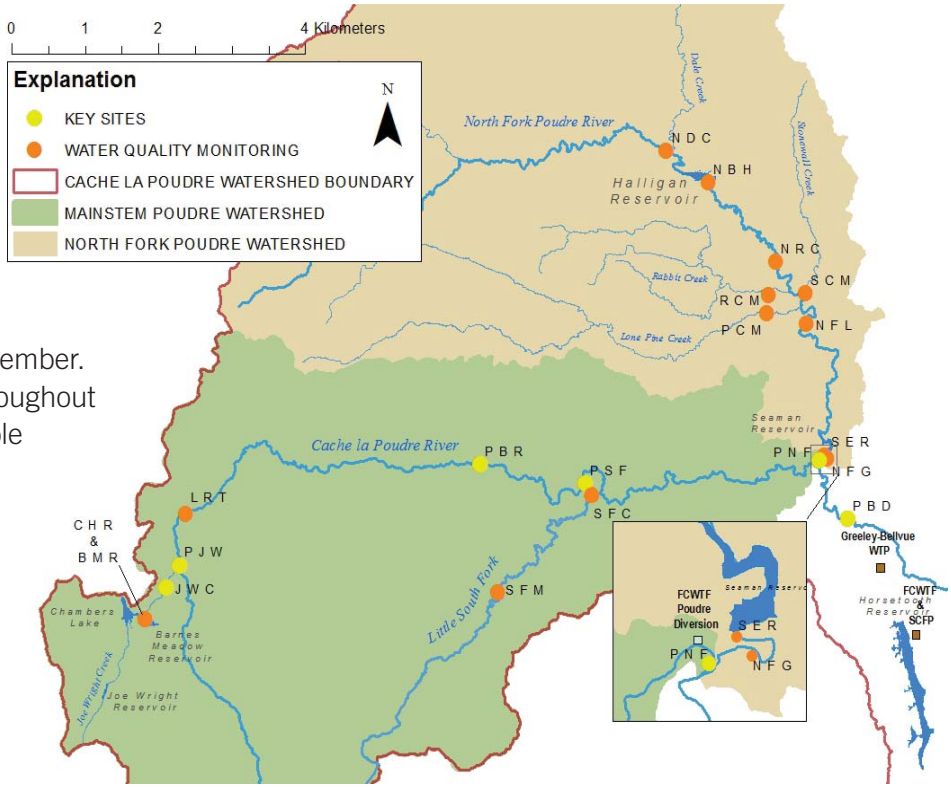


Figure 1 - Upper Cache la Poudre Collaborative Monitoring Program sampling locations

JWC - Joe Wright Creek above the confluence with the Poudre River
PJW - Poudre River above the confluence with Joe Wright Creek
PBR - Poudre River below the Town of Rustic
PSF - Poudre River below the confluence with the Little South Fork
PNF - Poudre River above the confluence with the North Fork at the City of Fort Collins' Intake
PBD - Poudre River below the confluence with the North Fork at the Bellvue Diversion

PRECIPITATION AND STREAMFLOW CONDITIONS

The UCLP watershed experienced normal precipitation during the first week of the 2016 water year (Oct. 1, 2015 – Sept. 30, 2016), but was followed by several weeks of dry weather. An early winter storm brought much needed water to the upper watershed in late October with steady precipitation through November. By December 1, cumulative precipitation totaled 7.1 inches, which was 88 percent of average (8.1 inches) (Figure 2a). Total monthly precipitation was near average in October and November (Figure 2b). As we transition into the winter season, the upper watershed acts as a natural storage reservoir during the snow accumulation season.

Streamflow in the UCLP watershed decreased to baseflow (low flow) conditions by early September and remained at or below the average streamflow through November (Figure 2c). Baseflow measured at the Canyon Mouth was higher than normal following the 2013 flood.

This pattern continued through 2015 before recently returning to normal. Average daily streamflow on November 30, 2015 was measured at 36.5 cubic feet per second (cfs), which was 70 percent of the historical average (52.6 cfs) and 15 percent of November 2014 flows (244 cfs).

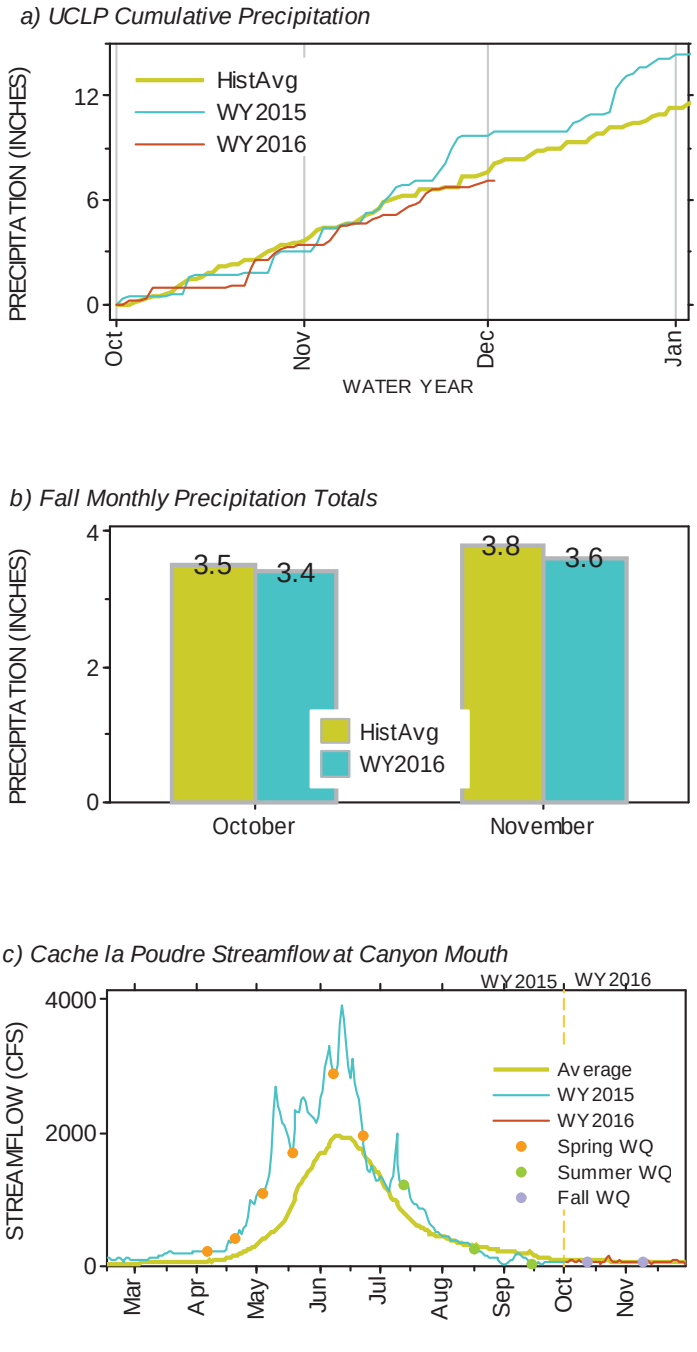


Figure 2 - Cumulative precipitation (a), fall monthly precipitation totals (b), and streamflow in the UCLP (c) during the 2016 water year. A water year is a common term used when evaluating precipitation and streamflow defining the 12-month period from October 1 through September 30.

WATER QUALITY INDICATORS

The Upper Cache la Poudre Collaborative Water Quality Monitoring Program tests for several key water quality indicators, including pH, conductivity, temperature and turbidity (Table 1). These key measurements provide a snapshot of water quality conditions, which are useful to identify trends or changes in water quality. Significant changes in water quality may provide an early warning of potential water pollution.

Table 1 - Water quality indicators measured as part of the Upper Cache la Poudre Collaborative Water Quality Monitoring Program.

Water Quality Indicator	Explanation
Temperature	Water temperature influences other water quality parameters and is a major driver of biological activity and algal growth in rivers, including certain phytoplankton species that produce the taste and odor compound, geosmin.
pH	pH is an important water quality parameter to monitor, as it influences the solubility and biological availability of chemical constituents, including nutrients and heavy metals. pH near 7 is considered neutral, with more acidic conditions occurring below 7 and more basic, or alkaline, conditions occurring above 7.
Conductivity	Conductivity is an index of dissolved ionic solids in water. Hardness is an index of the total calcium (Ca) and magnesium (Mg) in water.
Turbidity	Turbidity is monitored to track changes in water clarity. Clarity is influenced by the presence of algae and/or suspended solids introduced to surface waters through various land use activities, including runoff and erosion, urban storm water runoff and drainage from agricultural lands. For water treatment, turbidity is an important indicator of the amount of suspended material that is available to harbor pollutants, such as heavy metals, bacteria, pathogens, nutrients and organic matter.

Fall water quality monitoring captures water quality conditions during early baseflow conditions that begin in early fall and continue through winter. Baseflow conditions are not influenced by direct runoff during the fall and winter seasons, so streamflow experiences little change and results in stable and reliable water quality until snowmelt runoff begins in early April.

All water quality indicators were within the range of values observed over the long-term monitoring record during the 2015 fall monitoring season, with the exception of specific conductivity. Specific conductivity was the highest recorded over the long-term record at all monitoring locations, except PJW and PBD.

An increase in specific conductivity is an indicator of increased dissolved solids in source waters. Elevated concentrations in the major cations: calcium (Ca2+), potassium (K+), magnesium (Mg2+), and sodium (Na+), and major anions: sulfate (SO42-), nitrate (NO3-), ammonia (NH3), and ortho-phosphate (PO43-) were

Measuring water quality indicators at JWC on November 9 using a multiparameter water quality sonde

WATER QUALITY INDICATORS CONTINUED

observed following the 2012 wildfires and have continued through 2015. In addition, specific conductivity is highly variable throughout the year as a result of changing streamflow. Higher streamflows dilute dissolved ions in water and conversely, low streamflow conditions concentrate dissolved ions.

The combined effects of low baseflow conditions and wildfire impacts to water quality provide evidence for the increase in specific conductivity at monitoring locations situated within the burn area (PSF and PNF), but do not explain elevated specific conductivity at sites located outside of the burn area (JWC and PBR). It is speculated that low streamflow is the primary driver to change at these sites, but drought and flooding impacts may also be a reason for increased specific conductivity. This will be further investigated in the 2015 annual report.

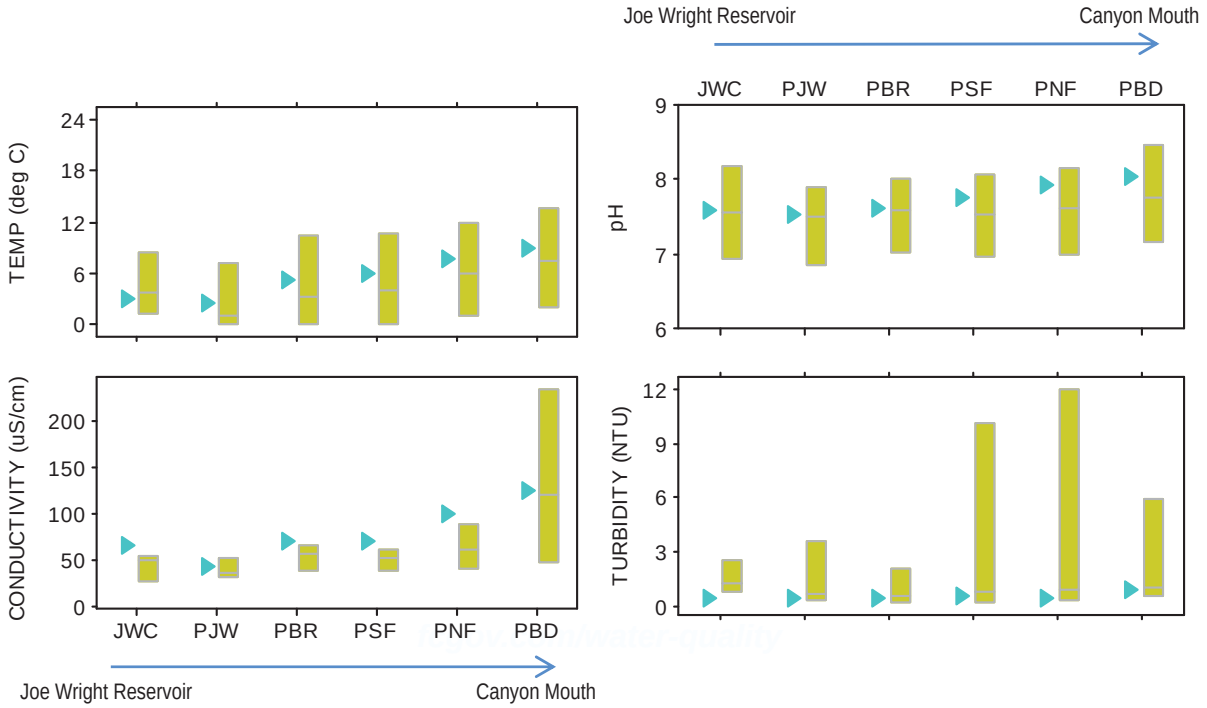
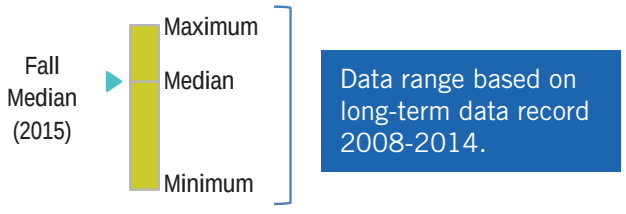


Figure 3 - Water quality indicator data collected at key monitoring sites during fall (October, November) 2015

Graphic Explanation



Specific conductivity was the highest recorded over the long-term record at all monitoring locations.

MICROORGANISMS

Coliforms are types of bacteria found naturally in plant and soil material. They can also be found in the digestive tract of animals, including humans.

Disease causing bacteria or pathogens can be introduced to the raw drinking water supply from fecal contamination. Although the water treatment process effectively eliminates pathogens, source watershed monitoring can provide indication of changes in the activity and location of pathogen sources over time.

Through the Upper Cache la Poudre Collaborative Monitoring Program, the raw Poudre River water supply is routinely tested for the presence of bacterial contamination. This is done by measuring the total amount of coliforms, an indicator organism for the presence of pathogenic bacteria.

In addition, *Escherichia coli (E. coli)* is measured and used as an indicator of human or animal fecal waste pollution, since the source of origin is more specific than total coliforms.

In fall 2015, *E. coli* and T. coli counts remained within the range of values seen in previous years, but were slightly higher than the long-term median (Figure 5a, 5b). T. coli counts at PBD were outside the long-term data record, but low counts of *E. coli* at PBD indicate that the majority of coliform bacteria are non-fecal bacteria, and pose low risk to the drinking water supply.

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T. coli organisms are naturally present in soil, and the higher than normal concentrations at PBD may be associated with relatively large amounts of sediment entering the river from burned areas in the watershed in recent years.

In 2015, there was one high intensity precipitation event over the burn scar that would have delivered large amounts of these bacteria into the Poudre River.

However, because non-fecal coliforms generally have a longer life-span than fecal coliforms, the elevated concentrations observed at fire-impacted sites may reflect concentrated abundance due to below average streamflows combined with previous sediment deliveries.

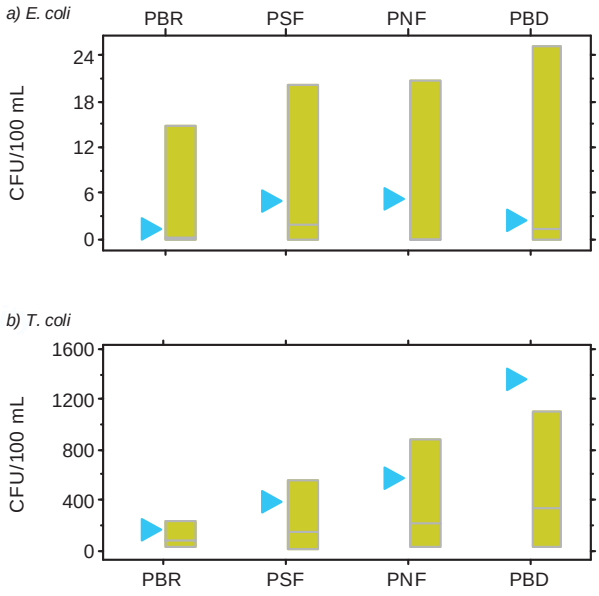

Figure 5 - E. coli (a) and (b) T. coli colony forming units (CFU) in the Poudre River during the 2015 fall season

TASTE AND ODOR COMPOUNDS

Geosmin and 2-methlyisoborneol (MIB) are naturally occurring organic compounds that impart an earthy odor to water. They can be detected by the most sensitive individuals at concentrations as low as 4 nanograms per liter (ng/L) or 4 parts per trillion (ppt). These compounds do not pose a public health risk, but their presence can negatively affect customer confidence in the quality of drinking water.

During the fall months in 2015, geosmin concentrations remained below detection at PBR. Concentrations continued to decrease at PNF in October and November, but remained below the taste and odor threshold of 4 mg/L. MIB was not detected (ND) at either site (Table 2). Geosmin monitoring will continue at PBR and PNF through the winter months, as this is the time of year when highest concentrations are typically observed.

Dr. Keith Elmund injects an extracted geosmin sample into a Gas Chromatography Mass Spectrometer to quantify geosmin concentrations at PBR and PNF. These data provide early warning of potential taste and odor issues in the UCLP drinking water supply.

Concentrations remained below the taste and odor threshold.

Table 2 - Poudre River geosmin concentrations (ppt) in the fall of 2015 at Poudre above the North Fork (PNF) and Poudre below Rustic (PBR) monitoring locations

Monitor Date	PBR		PNF	
	Geosmin (ppt)	MIB (ppt)	Geosmin (ppt)	MIB (ppt)
10/12/2015	<1	ND	1.62	ND
11/9/2015	<1	ND	1.13	ND

EMERGING CONTAMINANTS

Contaminants of emerging concern (CEC) and their presence in drinking water have recently received national attention. CEC are trace concentrations (at the ng/L or ppt level, or less) of the pharmaceuticals, personal care products (PCPs), endocrine disrupting chemicals (EDCs), and pesticides and herbicides.

In 2008, Northern Water initiated an emerging contaminant study to determine the presence of these compounds in waters of the CBT system. In 2009, the program was opened up as a regional collaboration, with two monitoring sites on the Upper Cache la Poudre, the Poudre River above the North Fork and the North Fork below Seaman Reservoir (PNF and NFG), being added to the study with funding provided by the City of Fort Collins and the City of Greeley.

In 2015, samples were collected once in February, June and August to assess seasonal influences of spring runoff, recreational activities, weed management activities and low streamflow conditions. Samples were analyzed for 140 PCPs/ pharmaceuticals, herbicides/pesticides and hormones, and only one compound, the herbicide 2.4-D, was detected at a concentration near the reporting limit of 5 ng/L. 2,4-D is a herbicide commonly used to control terrestrial and aquatic broadleaf weeds, and the presence of 2,4-D in the Poudre River is likely associated with weed management activities along Highway 14. At such low concentrations and rapid biodegradation rates in water, the detection of 2,4-D is considered a low risk to the Poudre drinking water supply.

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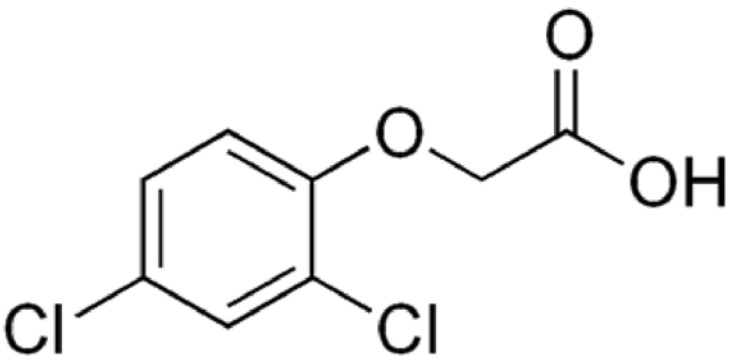

Molecular structure 2,4-D