Horsetooth Reservoir Wildfire Water Quality Monitoring Recovery Plan

City of Fort Collins Utilities – May 10, 2021

Purpose

This plan summarizes water quality monitoring, analyses and reporting that the Water Quality Services Division and Northern Water will conduct on the Hansen Supply Inlet Canal and Horsetooth Reservoir during the recovery phase of the East Troublesome and Cameron Peak Wildfires. For the purposes of this plan, the recovery phases for these fires are defined as the periods after the wildfires were considered fully contained, which was November 30 and December 2, respectively. This document is intended to be iterative and will be updated as necessary during recovery.

Objectives

- Collect real-time water quality surveillance and weekly and monthly water quality grab samples from the Hansen Supply Canal near the inlet to Horsetooth Reservoir;
- Continue to monitor short-and-long term water quality trends in the City's Horsetooth Reservoir drinking water supply using data from the Horsetooth Reservoir Water Quality Monitoring Program;
- Continue to monitor Horsetooth Reservoir for algal blooms, taste and odor compounds and cyanotoxins;
- Conduct a special study to determine whether smoke-related compounds are present in the City's Poudre and Horsetooth Reservoir Source Water supplies and finished water; and
- Address future Horsetooth Reservoir water quality concerns, as necessary, using water quality scenario modelling

Key Water Quality Parameters of Concern

Table 1. Table showing key post-fire water quality parameters of interest for water treatment processes.

Parameter(s)	Purpose of Sampling
Field Parameters	Temperature, pH, conductivity, dissolved oxygen and turbidity are basic measures used to characterize overall water quality and will be useful when tracking the water quality impacts of storm events as well as recovery. Turbidity and pH are important parameters for water treatment; turbidity is expected to increase due to post fire runoff and increases in algal growth.
Nutrients	We expect to see an increase in external and internal nutrient loading to Horsetooth Reservoir following the wildfires.

	Monitoring the concentrations and loads of nutrients (nitrate, ammonia and orthophosphate) entering Horsetooth Reservoir from the Hansen Inlet Canal and concentration in Horsetooth Reservoir will be important.
Algae Taste and odor compounds Chlorophyll-a Cyanotoxins	The frequency and magnitude of blue-green algal blooms in Horsetooth Reservoir may increase following these wildfires, leading to a higher risk for taste and odor compounds and cyanotoxins. There will also be a greater risk of blue-green algal blooms in the C-BT system upstream of Horsetooth and monitoring for these compounds in the Hansen Inlet Canal will be important.
TOC	TOC concentrations will be expected to increase as organic materials are from the burned forest and washed into Poudre River drainages. TOC is an important constituent for water treatment due to concerns over DBP formation
Smoke-related compounds*	Smoke odor in finished water is a concern for Utilities' customers. The Watershed Program is leading a regional cost-share collaborative study to determine whether a suite of five smoke-related compounds are present in our Poudre and Horsetooth Reservoir Source Water Supplies, and if so, whether these compounds are removed during water treatment. Samples will be collected on Horsetooth at Soldier Canyon, the Poudre River at PNF and the Water Treatment Facility's SS#2.

*****1,2-BPCA (benzene dicarboxylic acid, also known as phthalic acid, which is also a contaminant from plastic pollution); 1,2,4-BPCA (benzene polycarboxylic acid); 1,2,3-BPCA (benzene polycarboxylic acid); 1,3-5-BPCA (benzene polycarboxylic acid); and 3,5-PCA (pyridine carboxylic acid)

Hansen Supply Canal Water Quality Monitoring

Water Quality Laboratory staff have collected and analyzed water quality samples approximately from the Hansen Feeder Canal (C50) Inlet (**Figure 1**) since 1997. Water Quality Lab staff will continue to collect water quality samples weekly, bi-weekly, monthly or tri-annually, depending on the constituent. Grab samples will be collected from the canal using a swing sampler.

Weekly Water Quality Parameters:

- Temperature, coliforms, fecal strep, heterotrophic plate count

Bi-Weekly Parameters:

- TOC, chlorophyll-a, nitrate, nitrite, F, alkalinity, pH, conductivity, turbidity, hardness, o-Phos, NH3, color, dissolved Ca, Cu, Fe, Mg, Mn

Monthly Parameters:

- Cl, SO4, TDS, Langelier, silica, TKN, total Phosphorous, VOC's, dissolved Na, K, total recoverable Al, Cu, Fe, Pb, Mn

Tri-annual Parameters:

- *total recoverable Sb, AS, Ba, Be, Cd, Ca, Cr, Mg, Mo, Ni, K, Se, Ag, Na, Tl, Zn*

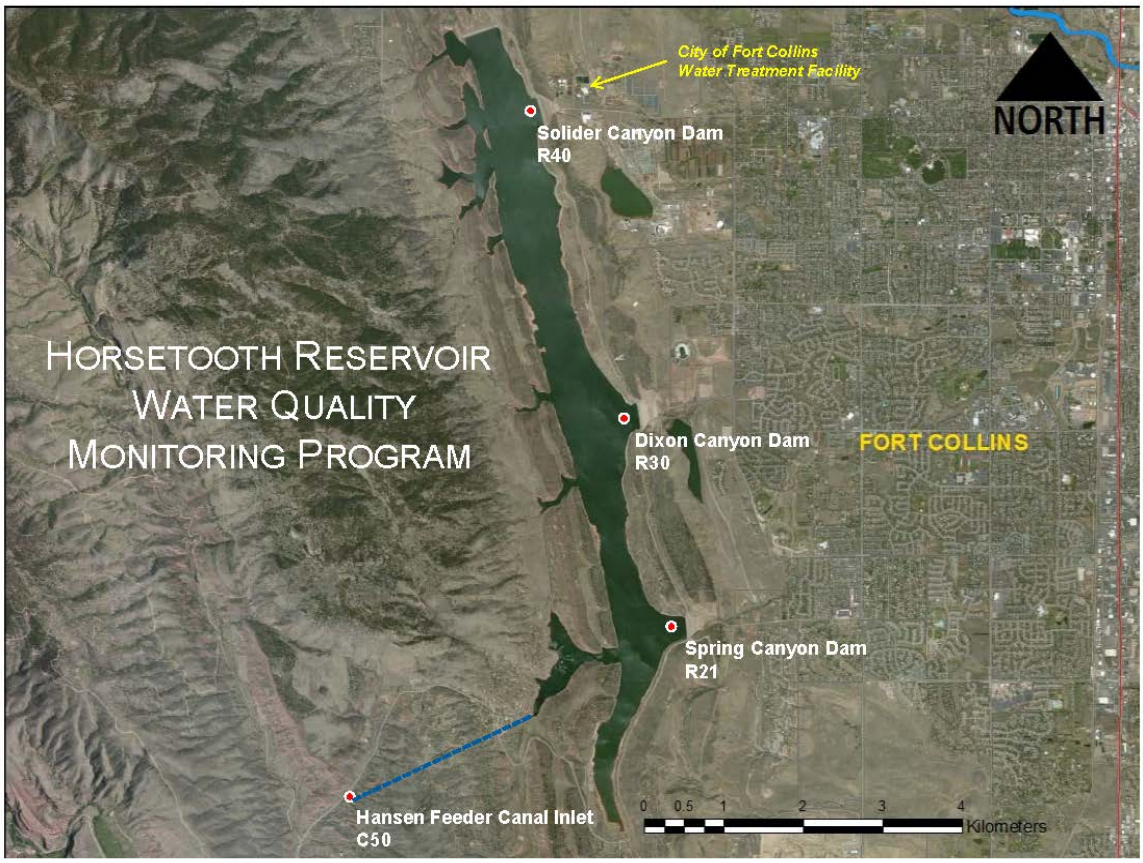

Figure 1. Map showing study sites for the Horsetooth Reservoir Water Quality Program and the Hansen Canal Inlet.

Water quality grab samples will be collected and immediately transported to the Water Quality Lab on ice by Watershed Program staff. Samples will be processed, preserved, and/or filtered by the Water Quality Lab and analyzed within each parameter's respective holding time. Results will be stored in the WQL Laboratory Information Management System (LIMS) database. Water samples will be analyzed for the parameters identified below, with the exception of field parameters.

Water quality samples will be analyzed at the City of Fort Collins' Water Quality Laboratory. The Water Quality Lab utilizes an established quality assurance plan that is applied to all samples received and implements analytical QA/QC by measuring laboratory blanks, duplicates, replicates and spiked samples.

Water quality data will be reviewed by the Quality Assurance Coordinator to ensure data are free of sample contamination, analytical, and/or data entry errors. Data are considered provisional prior to data validation by the Quality Assurance and Quality Control Program Coordinator.

Northern Water will also be collecting discrete water quality samples from the Hansen Feeder Inlet Canal monthly in January (LF) and March (SF); and twice per month during April (SF,SF), May (LF,SF), June (LF,SF) and July (LF,SF). Sample frequency will return to once per month in September (LF), October (S1) and November (SF). A table summarizing Northern Water's analytical suites is included in Appendix A.

Hansen Supply Canal and Horsetooth Reservoir Data Analyses and Reporting

Watershed Program, Water Quality Laboratory and Process Control staff will continue to provide monthly water quality updates to water treatment staff for parameters of interest; including taste and odor compounds, cyanotoxin screenings and monthly (seasonal) water quality summaries for data collected on Horsetooth Reservoir at Soldier Canyon Dam. Northern Water and/or Watershed staff will also summarize water quality trends using data collected by Northern at select Hansen Supply Canal sites either quarterly or twice annually.

Water Quality Surveillance

Northern Water installed a water quality sonde at the Hansen Feeder Canal (C50) Inlet (Figure 1) in 2020 to monitor water quality in real-time. The water quality sonde collects water temperature, pH, conductivity, dissolved oxygen and turbidity data in real-time just prior to the water entering Horsetooth Reservoir. Data from this and other real-time sondes managed by Northern Water are available here:

https://data.northernwater.org/applications/public.html?publicuser=Public#waterdata/stationoverview.

These data will be used by Water Quality Services and Water Treatment staff to monitor changes in water quality. The sonde will be installed when the canal is flowing and ice-free and maintained seasonally by Northern Water staff seasonally.

Horsetooth Reservoir Water Quality Monitoring Program

Fort Collins Utilities and Northern Water formed the collaborative Horsetooth Reservoir Water Quality Monitoring Program in 2015. Study locations include Spring Canyon (HT-SPR (R21)), Dixon Canyon (HT-DIX (R30)) and Soldier Canyon (HT-SOL (R40)). All three of these locations have long term datasets and are well positioned to detect water quality changes to Horsetooth Reservoir water quality from the Cameron Peak and East Troublesome Wildfires. Samples will continue to be collected from the surface and/or bottom of the reservoir monthly by Northern Water between in January and April through November. The specific water quality parameters and sampling frequencies are (surface and/or bottom of reservoir) for each sampling event are outlined in the 2021 Horsetooth Reservoir Water Quality Monitoring Plan and in Appendix A. Data collected and analyzed by Northern will be summarized in long term trend reports every 2-3 years.

Water Quality Parameters

- Field parameters: temperature, pH, conductivity, dissolved oxygen, turbidity, secchi depth

- Major ions
- Metals (total and dissolved)
- Alkalinity, TOC and TSS
- Nutrients
- Phytoplankton and zooplankton
- Geosmin and 2-MIB
- Cyanotoxins
- VOCs

Geosmin and 2-MIB, cyanotoxin and VOCs water samples will be collected by Northern Water field staff and immediately transported to the Water Treatment Facility for analyses. Samples will be processed, preserved, and/or filtered by the laboratory staff and analyzed within the parameter's respective holding time by the City of Fort Collins' Water Quality Laboratory or Water Treatment Facility Process Control Lab. Both labs utilize an established quality assurance plan that is applied to all samples received and implement analytical QA/QC by measuring laboratory blanks, duplicates, replicates and spiked samples. Results will be stored in the WQL Laboratory Information Management System (LIMS) database. All other water quality samples will be analyzed by Northern Water or contract labs.

Cyanotoxin and Cyanobacteria Monitoring and Action Plan

The Cyanotoxin and Cyanobacteria Monitoring and Action Plan outlines a phased method to assess water quality indicators that can inform decisions about when to monitor cyanotoxins in raw and finished water.

Early Warning Monitoring (Phase I)

Indicators are an important and inexpensive early warning tool for identifying when harmful algal blooms may be of concern to source water supplies. Visual inspections of reservoir condition are conducted weekly beginning in July. Weather data are additional information that are considered when evaluating for conditions that may lead to harmful algal blooms. Routine water quality monitoring is a more time intensive, but valuable pro-active approach to monitor for early warning harmful algal bloom indicators. Finally, routine phytoplankton monitoring can provide information about seasonal dynamics of phytoplankton abundance and diversity; however, identification and quantification of phytoplankton are timely.

Cyanotoxins Monitoring (Phase II)

In addition to early warning monitoring, weekly cyanotoxins monitoring (presence/absence tests) will be conducted from August through November on the Poudre and Horsetooth raw water supplies. If cyanotoxins are detected during weekly monitoring then the Cyanotoxins Action Plan (Phase III) will be implemented (see below). If cyanotoxins are not detected, then the algal bloom will be sampled weekly until the algal bloom subsides. In the event that cyanotoxins are detected in the algal bloom, staff will assess the risk of cyanotoxins entering the water treatment process, increase monitoring efforts, and identify best management practices for mitigating the algal bloom.

Cyanotoxins Action Plan (Phase III)

In the event cyanotoxins are detected in the raw water supply in Phase II, additional steps are necessary to *quantify* and *identify* the cyanotoxins. A grab sample will be collected from the raw water supply that tested positive for cyanotoxins and finished water within 24 hours of detection and sent to the Colorado Department of Public Health and Environment (CDPHE) Laboratory for analysis. Samples will be collected, preserved, and handled in accordance with the method established by the laboratory performing the analysis. Cyanotoxins concentrations in exceedance of the EPA's health advisory levels (Table 1) will require immediate changes in water treatment operations to proactively mitigate cyanotoxins from entering the finished water supply (see Phase IV, Operations & Communications Action Plan). Increased frequency in monitoring of raw and treated water will also be necessary to track cyanotoxins concentrations until results are below health advisory levels. Weekly sampling of raw and treated water will be implemented when raw water cyanotoxins concentrations are less than 5 µg/L. If raw water cyanotoxins concentrations are greater than 5 µg/L then sampling of raw and treated water will be implemented three times per week until cyanotoxins are less than 5 µg/L, which would result in sample frequency being reduced to once per week until cyanotoxins are no longer detected in raw water. In addition, the City of Fort Collins Utilities will communicate with the various stakeholders about bloom mitigation strategies.

Operations & Communications Action Plan (Phase IV)

If cyanotoxins are detected in finished water, additional samples will be collected within 24 hours of detection to confirm which cyanotoxins are present in the finished water and the concentration. Additional treatment and/or management strategies will be implemented to further mitigate cyanotoxins to concentrations below health advisory levels. American Water Works Association's Cyanotoxins Resource Community webpage provides utilities with valuable tools to determine best management strategies for the removal of cyanotoxins in drinking water. Strategies for treating and managing cyanotoxins when detected in raw and/or treated water are summarized in the Cyanotoxin and Cyanobacteria Monitoring and Action Plan.

Fort Collins Water Treatment Facility - Geosmin and 2-MIB Monitoring Plan

Monitoring Sites:

Horsetooth @ Tap
Poudre River @ Tap
Combined Filter Effluent
Trains
Sample Station #2

Monitoring Schedules and Action Levels

Geosmin and 2-MIB samples will be collected by Water Quality Laboratory staff according to the schedules outlined in **Table 1**. Routine monitoring will only occur at the following three study sites: Horsetooth @ Tap, Poudre River @ Tap and Combined Filter Effluent. Routine monitoring will occur on Mondays for both study periods. During August and September, routine samples should be collected every other week, whereas routine samples should be collected every week during October through March.

Monitoring schedules for each routine site and compound are independent of one another and should be adjusted on a site-by-site basis as necessary. Routine monitoring at a site should continue when the concentrations of geosmin and 2-MIB are below the action levels in **Table 2**. Monitoring at a routine site should be increased according to the schedule in **Table 1** when a compound exceeds its action level; the Trains and Sample Station #2 should also be sampled at the increased frequency. Once concentrations of an elevated compound fall below the action level, routine monitoring at the routine site should resume and sampling at the Trains and Sample Station #2 should be discontinued.

Table 1. Monitoring Schedules

Period	Routine Monitoring	Increased Monitoring
August-September	1 sample every other week (M)	1 sample every week (M)
October-March	1 sample every week (M)	2 samples every week (M,TH)

[1] M = Monday, TH = Thursday

Table 2. Action Levels

Compound	Action Level
Geosmin	4 ng/L
2-MIB	10 ng/L

Water Quality Laboratory staff should email geosmin and 2-MIB analytical results, scheduling updates and any other relevant information to the following staff: Jill Oropeza, Mark Kempton, Ken Morrison, Gregg Stonecipher, Jeff Monson, Tyler Wells, Kathleen Ganzer, Charlie Beasley, Sheri Lafferty, Ann Biegelsen, Joel Nolte, Steve Stefko, Richard Thorp and Jared Heath.

Horsetooth Reservoir Water Quality Modelling

In 2013, Hydros Consulting developed a two-dimensional hydrodynamic and water quality model for Horsetooth Reservoir. The model can be used to predict reservoir water temperature, dissolved oxygen, TOC, nutrients and chlorophyll-a. The study also examined reservoir water quality changes under a variety of reservoir management scenarios, combining residence time, TOC and nutrients as model inputs. The model could be useful for predicting future water quality changes in the reservoir following the Cameron Peak and East Troublesome Wildfires. It is currently unclear how management of the C-BT system will change during the recovery phase of the East Troublesome Wildfire, including Horsetooth Reservoir inflows and residence times; however, model inputs can be adjusted for a variety of hydrologic scenarios. There is also significant uncertainty regarding the fate and transport of TOC, nutrients and other wildfire related pollutants within the C-BT system post-fire, and how pollutant concentrations and loads entering Horsetooth Reservoir will be impacted is currently unknown. The Watershed Program and Northern Water staff intend to monitor discrete and continuous water quality data collected in the Hansen Feeder Canal and Horsetooth Reservoir during 2021 and re-evaluate the potential for modelling future reservoir water quality in 2022.

Smoke-Related Wildfire Compounds Special Study

Watershed staff recently helped lead the development of a smoke-related wildfire compounds special study as part of the Compounds of Emerging Concern Collaborative Water Quality

Monitoring Program. The purpose of the study is to: 1) develop improved analytical methods for the compounds listed below, including lower detection limits; 2) determine concentrations of these compounds at sites at locations throughout the east slope C-BT system and other source water sites of interest; and 3) to determine whether these compounds, if present in source water, are removed during water treatment at the FCWTF, Greeley's Boyd and Bellvue WTFs and the Town of Estes' WTF.

Compounds include:

- 1,2-BPCA (benzene dicarboxylic acid, also known as phthalic acid, which is also a contaminant from plastic pollution)
- 1,2,4-BPCA (benzene polycarboxylic acid)
- 1,2,3-BPCA (benzene polycarboxylic acid)
- 1,3-5-BPCA (benzene polycarboxylic acid)
- 3,5-PCA (pyridine carboxylic acid).

Watershed staff will be collecting raw water samples at the PNF and from Sample Station #2 at the FCWTF. Northern Water will also be collecting surface and bottom samples from Horsetooth Reservoir at Soldier Canyon Dam and at the Hansen Supply Inlet Canal as part of this study (see East Troublesome Horsetooth Reservoir Water Quality Monitoring Plan). Samples were initially collected in November of 2020 and additional samples will be collected in February, and April through October in 2021. Watershed staff will pair results from this study with data from odor profiles conducted at the FCWTF which may provide information on the relationship between smoke-related compounds and odors in finished water. A summary report will be completed at the conclusion of the study.

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Appendix A

2021 Northern Water Analytical Suites

2021 ANALYTICAL COSTS PER CONSTITUENTS SUITE								
	Flowing Sites			Reservoir Sites				
General Field Parameters	**L1**	**S1**	**LF**	**RL**	**RS**	**RF**	**RL^{S}**	**RS^{S}**
Temperature	X	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X
secchi depth				X	X	X	X	X
Major Ions (plus carbon and misc)								
Calcium	X		X	X	X		X	X
Magnesium	X		X	X	X		X	X
Potassium	X		X	X			X	
Sodium	X		X	X			X	
Chloride	X		X	X			X	
Sulfate	X		X	X			X	
Dissolved Organic Carbon			X	X			X	
Total Organic Carbon	X	X	X	X	X	X	X	X
Total Alkalinity	X		X	X			X	
Total Suspended Solids	X	X	X	X	X	X	X	X
Total Dissolved Solids								
Metals								
Arsenic, total	X		X	X			X	
Boron, total								
Cadmium, total	X		X	X			X	
Chromium, total	X		X	X			X	
Iron, total	X		X	X			X	
Lead, total	X		X	X			X	
Manganese, total								
Molybdenum, total	X		X	X			X	
Nickel, total	X		X	X			X	
Copper, dis	X		X	X	X		X	X
Iron, dis	X		X	X	X		X	X
Manganese, dis	X		X	X	X		X	X
Arsenic, dis	X		X	X			X	
Cadmium, dis	X		X	X			X	
Chromium, dis	X		X	X			X	
Lead, dis	X		X	X			X	
Nickel, dis	X		X	X			X	
Selenium, dis	X		X	X			X	
Silver, dis	X		X	X			X	
Zinc, dis	X		X	X			X	
Nutrients								
TKN	X	X	X	X	X	X	X	X
NH3 as N	X	X	X	X	X	X	X	X
NO3+NO2	X	X	X	X	X	X	X	X
Ortho P	X	X	X	X	X	X	X	X
P Total	X	X	X	X	X	X	X	X
chlorophyll a				X	X	X	X	X
phytoplankton				X	X	X		
zooplankton				X	X	X		

Appendix B

Horsetooth Reservoir Water Quality Monitoring Program Sampling Schedule and Field Parameters

Sampling Schedule

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HT-SPR	RL			RSF	RSF	RLF	RSF	RSF	RSF	RLF	RSF	
HT-DIX	RL^S			RSF^S	RSF^S	RLF^S	RSF^S	RSF^S	RSF^S	RLF^S	RSF^S	
HT-SOL	RL			RSF	RSF	RLF	RSF	RSF	RSF	RLF	RSF	

	RL	RL^S	RS	RLF	RSF	RLF^S	RSF^S
Temperature	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X
secchi depth	X	X	X	X	X	X	X
Major Ions, Carbon and Misc (1 meter and 1 meter above bottom)							
Calcium	X	X	X	X	X	X	X
Magnesium	X	X	X	X	X	X	X
Potassium	X	X		X		X	
Sodium	X	X		X		X	
Chloride	X	X		X		X	
Sulfate	X	X		X		X	
Dissolved Organic Carbon	X	X		X	X	X	
Total Organic Carbon	X	X	X	X	X	X	X
Dissolved Inorganic Carbon				X	X		
Total Inorganic Carbon				X	X		
Total Alkalinity	X	X		X		X	
Total Suspended Solids	X	X	X	X	X	X	X
Metals (1 meter and 1 meter above bottom)							
Arsenic, total	X	X		X		X	
Cadmium, total	X	X		X		X	
Chromium, total	X	X		X		X	
Iron, total	X	X		X		X	
Lead, total	X	X		X		X	
Molybdenum, total	X	X		X		X	
Nickel, total	X	X		X		X	
Copper, dis	X	X	X	X	X	X	X
Iron, dis	X	X	X	X	X	X	X
Manganese, dis	X	X	X	X	X	X	X
Arsenic, dis	X	X		X		X	
Cadmium, dis	X	X		X		X	
Chromium, dis	X	X		X		X	
Lead, dis	X	X		X		X	
Nickel, dis	X	X		X		X	
Selenium, dis	X	X		X		X	
Silver, dis	X	X		X		X	
Zinc, dis	X	X		X		X	
Nutrients (1 meter and 1 meter above bottom)							
TKN	X	X	X	X	X	X	X
NH3 as N	X	X	X	X	X	X	X
NO3+NO2	X	X	X	X	X	X	X
Ortho P	X	X	X	X	X	X	X
P Total	X	X	X	X	X	X	X
chlorophyll a	X	X	X	X	X	X	X
Phyto and Zooplankton							
phytoplankton	X		X	X	X		
zooplankton	X		X	X	X		

Additional samples will be collected for and delivered to Fort Collins as follows:

Geosmin
Locations: HT-SPR, HT-SOL
Depth: Top (1m), Bottom, Metalimnion
Months: Jun-Nov (Sampling season extended this year due to East Troublesome Fire and anticipated impacts on WQ in the C-BT system.)

VOCs
Locations: HT-SPR, HT-SOL
Depth: Top (1m)
Months: Apr - Nov

Cyanotoxins
Locations: HT-SPR, HT-SOL
Depth: Top (1m)
Months: Aug - Nov