SUMMER RUNOFF GENERATION IN FOOTHILL CATCHMENTS OF THE COLORADO FRONT RANGE

by

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The final copy of this thesis has been examined by the signatories, and we find that both the content and the form met acceptable presentation standards of scholarly work in the above mentioned discipline

ABSTRACT

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Thesis directed by Associate Professor Holly R. Barnard

Climatic shifts, disturbances and land-use change have the potential to alter hydrologic flowpaths, water quality and water supply to downstream communities. Identifying the hydrological processes responsible for the transport of water to streams is important for understanding current and future hydrologic regimes, but our knowledge of these processes in foothill ecoregions of mountainous areas is limited. Prior research investigating streamflow generation processes in the Colorado Front Range has largely focused on high-elevation catchments and less is known about how lower elevation catchments in the western US respond to summer storms and how flowpaths sourcing streamflow change seasonally. Using hydrograph separations and concentration-runoff relationships, we inferred flowpaths to streams from April to August 2018 in three small (< 10 km^2) foothill catchments, and one larger catchment (63.2 km^2) extending from the foothill to the subalpine in the Colorado Front Range. We selected catchments with varying land-use and disturbances, such as historical mining, to investigate the relationship between these characteristics and hydrologic flowpaths. In general, constituent concentrations increased as seasonal runoff decreased in the three foothill catchments, reflecting a transition from shallow subsurface flowpaths to deeper subsurface flowpaths. Elevated SO_4^{2-} and Cl^- concentrations during low flow periods at two of our catchments suggests discharge from historical mines and anthropogenic activities such as the application of road salt during winter, or near-stream septic systems, has altered local stream and groundwater chemistry. During storm

events, mine discharge contributions to the larger catchment increased and will likely further degrade water quality with climatic shifts in the future. Streamflow during storm responses in the foothill catchment with impervious surfaces was sourced from faster, surficial flowpaths compared to its more natural neighboring catchment, highlighting the influence of land-use on runoff generation. Results from this study provide a framework for understanding how hydrologic regimes in foothill catchments operate and how they may function in the future with human development, precipitation shifts and disturbances.

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Summer Runoff Generation in Foothill Catchments of the Colorado Front Range

1. Introduction

Understanding the paths by which water flows through a landscape (hydrologic flowpaths) is critical for the provisioning of fresh water for human use (Barnett et al., 2005; Berghuijs et al., 2014), maintaining ecosystem stability and functionality (Bunn and Arthington, 2002) and better predicting how disturbances such as fire or drought may impact both water quantity and water quality (Mirus et al., 2017; Murphy et al., 2018). This is especially important in water-limited regions where societal and environmental function depends on seasonal inputs, such as snowmelt, or interannual precipitation variability, such as monsoonal rain inputs in the southwest USA (Barnett et al., 2005; IPCC, 2014; Postel, 2000; Sheppard et al., 2002). Within semi-arid, mountainous regions, intermittent streams in foothill and montane ecoregions are understudied compared to perennial, snowmelt-dominated waterways in higher elevations regions (Cowie et al., 2017; Datry et al., 2014; Leigh et al., 2016). Intermittent and ephemeral streams in lower elevation regions have been recognized as important vehicles for energy, water, material, and biota, as well as maintaining ecosystem health (Acuña et al., 2014; Buttle et al., 2012). Insight into hydrologic functioning in these areas holds important implications for improving our understanding of disturbance hydrology (Mirus et al., 2017), human-impacted environments (Leigh et al., 2016; Theobald and Romme, 2007) and climate-driven hydrologic changes (Blöschl et al., 2019; Clow, 2010; Kampf and Lefsky, 2016).

Past studies have shown that anthropogenic greenhouse gas emissions have altered spatiotemporal aspects of hydrology in the western US, and predicted future climatic changes will further alter the hydrologic cycle (Barnett et al., 2008, 2005; Clow, 2010; IPCC, 2014). Mountainous areas are predicted to experience accelerated atmospheric warming (Pepin et al., 2015; Rangwala and Miller, 2012), the elevation of the rain-snow transition point is predicted to increase (Abatzoglou, 2011; Knowles et al., 2006) and the intensity of rain events is expected to increase by ~7% per degree (◦C) warming (Prein et al., 2017). Consequently, climatic shifts will affect the timing, magnitude and duration of active hydrologic flowpaths and stream generation processes in mountainous areas (Diffenbaugh et al., 2005; Hinckley et al., 2014; Kampf and Lefsky, 2016). For example, as the rain-to-snow ratio increases (Knowles et al., 2006), rain events will contribute proportionally more to annual stream discharge. Additionally, recent work has shown the dominant source of annual peak discharge in the Colorado Front Range is shifting from snowmelt to rainfall (Kampf and Lefsky, 2016), highlighting the need to improve our understanding of how water is delivered to mountainous streams during summer rain events.

In addition to climate change impacts, anthropogenic activities can alter hydrologic processes in the western US. The foothill and montane ecoregions in the western US typically overlap with the wildland-urban interface (WUI) - the intersection of human development and private and public wildlands (Theobald and Romme, 2007). In this region, human development can alter hydrologic flowpaths and runoff behaviors by replacing vegetated areas with impermeable surfaces, leading to decreased infiltration capacity, and increased surface runoff volumes and peak runoff during precipitation events (Bernhardt and Palmer, 2007; Gremillion et al., 2000; Pickett et al., 2011; Shuster et al., 2005; Theobald and Romme, 2007). The WUI extent is expected to double in land area by 2030, largely in the intermountain West, holding future implications for water quality (Theobald and Romme, 2007). In some areas of the western US, foothill and montane ecoregions were subject to intensive mining in the 19th and 20th centuries, and these historical mines have potential to alter stream chemistry and can degrade downstream water quality (Coulthard and Macklin, 2003; Nordstrom, 2011; Rösner, 1998; Singer et al., 2008). Humans were the main ignitors of wildfires in the US from 1992 – 2017, and consequently, expansion of the WUI will likely increase wildfire frequency in the future (Balch et al., 2017). Fires can have substantial economic consequences (Lynch, 2004), and impact stream generation processes, as well as water quality, supplies and treatment (Ice et al., 2004; Mast et al., 2016; Murphy et al., 2018; Writer and Murphy, 2012). Extensive erosion and vegetation removal from wildfire has been shown to compound mine discharge impacts on water quality and substantial overlap exists between historical mining and fire-prone regions in the western US (Murphy et al., 2015). The combination of these climatic, land-use and disturbance regimes is likely to have consequences for future water quality and resources, increasing the need to improve our understanding of streamflow generation processes in these susceptible mountainous regions.

Streamflow generation processes vary both spatially and temporally, and fundamentally alter the geochemical properties of water (Bergstrom et al., 2016; Hinton et al., 1998; Johnson et al., 2006; Klaus and McDonnell, 2013; McGlynn et al., 1999; Rose et al., 2018). Complex topography and limited knowledge of subsurface hydrogeology impedes our understanding of and ability to trace flowpaths in mountainous areas (Cowie et al., 2017; Liu et al., 2004). Additionally, studies frequently require resource-intensive field efforts in remote locations, further contributing to a limited understanding of hydrologic flowpaths in mountainous regions. Investigating the relationship between constituent concentration (C) and runoff (R) and load export can provide insights into the magnitude and timing of hydrologic flowpaths contributing to streamflow across a range of flow regimes and temporal scales (Chorover et al., 2017; Evans and Davies, 1998; Godsey et al., 2009; Johnson et al., 1969; Murphy et al., 2018; Musolff et al., 2015; Rose et al., 2018; Stallard and Murphy, 2014). During low-flow conditions, lithogenic constituents associated with bedrock-weathering and deeper subsurface flowpaths (e.g., SiO_2,

Ca^{2+}, Mg^{2+}, Na^+ and K^+) typically become enriched in the stream, whereas bioactive constituents associated with shallow subsurface flowpaths (e.g., dissolved organic carbon [DOC]) typically become diluted (Chorover et al., 2017; Evans and Davies, 1998; Godsey et al., 2009; Rose et al., 2018). In turn, the spatiotemporal aspects of hydrologic flowpaths contributing to the stream can be inferred from stream chemistry. Additionally, utilizing C/R relationships to estimate constituent loads can reveal source contributions and hydrologic flowpath dynamics and elucidate catchment-scale hydrologic processes in response to disturbances and land-use (Dalzell et al., 2007; Mast et al., 2016; Murphy et al., 2018). For example, Murphy et al. (2015) showed Mn^+ and NO_3^- loads increased downstream of the burned area after the 2010 Fourmile Canyon Fire in the Colorado Front Range and attributed it to infiltration-excess overland flow from the burned area during storms. A recent study in Vermont found the sources, timing and magnitude of DOC and NO_3^- loads in streamwater were significantly linked to different land-use practices (i.e., agriculture, urban and forested) (Vaughan et al., 2017). Constituent loads and C/R relationships thus provide a framework for interpreting streamflow generation processes and behavior in different land-use settings.

C/R relationships can provide valuable insight into variability of hydrologic flowpaths especially when combined with other analysis such as hydrograph separation. Hydrograph separation using a simple end-member mixing approach is one of the most common methods for gaining fundamental insight into spatiotemporal aspects of streamflow generation processes. Using this approach, processes that generate storm runoff can be investigated by separating streamflow into proportions of event (e.g., precipitation) and pre-event (e.g., groundwater or water stored in the catchment before an event) water contributing to runoff (Birch et al., 2016; Buttle, 1994; Hooper and Shoemaker, 1986; Klaus and McDonnell, 2013; Sklash et al., 1979).

Hydrologic flowpaths can be complex and vary in space in time and using hydrograph separations in combination with hydrometric and geochemical datasets can help yield insight into runoff generation processes.

Understanding how hydrologic flowpaths change across different time scales (e.g., hours to days in response to storm events to months during seasonal climate shifts) across foothill and montane catchments can improve our ability to predict how land-use, disturbances, and climatic changes will affect water resources beyond the snowpack-dominated high-elevation area in mountainous regions. Here, we take a multi-catchment comparison approach to understand how mountainous, semi-arid catchments function in the Front Range of Colorado, as inferred by hydrology and stream chemistry. Our approach examines catchments with and without anthropogenic impacts such as mining and low-density housing, as well as catchments that vary in the proportion of precipitation inputs (i.e., snow versus rain). Specifically, we address the following research questions:

1. How do hydrologic flowpaths in lower elevation catchments of the Colorado Front Range change from early to late summer?

2. What are the dominant flowpaths in these catchments during summer storm events?

3. How do flowpaths differ among catchments with different land-use and how might they respond to future climatic changes and disturbances?

2. Study Area

We conducted our study in the Boulder Creek Watershed (BCW, 1,160 km^2) located in the Colorado Front Range, east of the Continental Divide (Fig. 1). The BCW spans an elevation gradient from 1,480 m (4,860 ft) to 4,120 m (13,200 ft) and can be divided into five major climatic zones/ecoregions: plains, foothill, montane, subalpine, and alpine (Murphy, 2006). Excluding the plains ecoregion, the foothill and montane ecoregions make up 58% of the BCW and the subalpine and alpine regions make up 42%. To address our research questions, we selected three catchments located in the foothill and lower montane ecoregions of the BCW, Keystone Gulch, Hawkin Gulch and Lost Gulch, as well as Fourmile Creek, which extends from the foothill to the subalpine (Table 1). The underlying geology of BCW is heterogeneous; however, across our field sites the geology is relatively similar. Our catchments are underlain by Precambrian-aged, metamorphic and granitic bedrock, predominately gneiss and schist (Murphy, 2006). In the subalpine regions of Fourmile Creek, there are also minimal Tertiary volcanics and Quaternary alluvium deposits. In the BCW, precipitation predominantly falls in the subalpine and alpine regions as snow in the winter. In the montane region of the BCW, annual precipitation is approximately 50% snow and 50% rain/mixed precipitation, while in the foothill region of the BCW, annual precipitation is approximately 39% rain, 33% snow and 28% mixed (Cowie, 2010). Barker Dam in Nederland, Colorado, approximately 20 km^2 upstream from our field area, regulates Boulder Creek runoff annually and spring snowmelt typically exceeds the reservoir spillway in May or early June. Annual snowmelt produces high flows in the Boulder Creek in the spring and early summer, and summer convective storms typically produce short-lived, high flows.

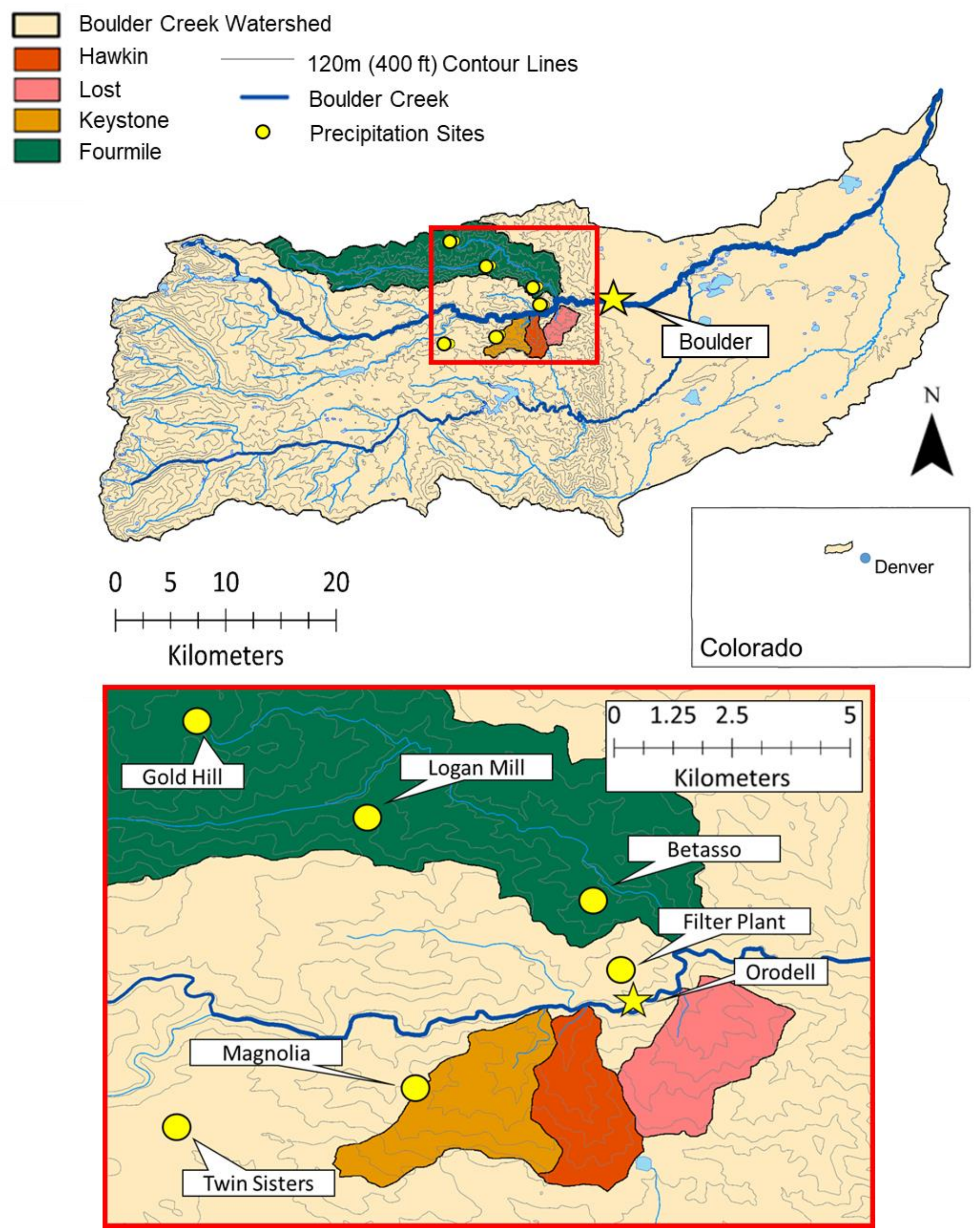

Figure 1. Map of the Boulder Creek Watershed showing locations of each study catchment, locations of the Urban Drainage and Flood Control District precipitation sites, the National Atmospheric Deposition Precipitation site at Betasso (Site ID: CO84, http://nadp.slh.wisc.edu/siteOps/ppt/default.aspx) and the Orodell stream-gauging station.

Keystone Gulch (5.3 km^2), Hawkin Gulch (3.6 km^2) and Lost Gulch (4.5 km^2) (collectively referred to as ‘foothill catchments’ hereafter) are small, north-flowing catchments with steep topography (ranging from an average slope of 38.4% at Keystone Gulch to 44.6% at Hawkin Gulch) and are nearly entirely (94% to 98.7%) forested (Table 1). Exposed rock outcrops are common in these foothill catchments. Hawkin Gulch and upper portions of Keystone Gulch are Boulder County-designated environmental conservation areas (Boulder County, 2013: https://www.bouldercounty.org/property-and-land/land-use/planning/boulder-county-comprehensive-plan/). Vegetation patterns largely depend on slope aspect and water availability (Kaufmann et al., 2006). South- and west-facing slopes with more sun exposure are dominated by ponderosa pine (*Pinus ponderosa*) with interspersed Rocky Mountain Juniper (*Juniperus scopulorum*). North- and east-facing slopes are typically dominated by more shade-tolerant Rocky Mountain Douglas-fir (*Psuedotsuga menziesii var. glauca*) and Colorado Blue Spruce (*Picea pungens*) with few aspen (*Populus tremuloides*) (Kaufmann et al., 2006). Keystone Gulch has considerable anthropogenic impacts compared to Hawkin Gulch and Lost Gulch, including low-density housing and a low-intensity trafficked paved road that extends the entire elevation range of the catchment. In addition, there are at least 38 historical hard-rock mines in Keystone Gulch, which operated in the late 19th century and early 20th century (Murphy, 2006).

Fourmile Creek (63.2 km^2) is a large perennial tributary of Boulder Creek ranging in elevation from 1746 m (foothill ecoregion) at the confluence with Boulder Creek to 3515 m at its headwaters (subalpine ecoregion). On average, the catchment is less steep (mean basin slope = 36.8%) than the foothill catchments in this study (Table 1). Mean annual precipitation is approximately 500-600 mm; however, annual precipitation increases in higher elevations in the headwaters (up to 1000 mm). Anthropogenic features of the Fourmile Creek catchment includes roads, businesses and houses, and similar to Keystone Gulch, mining activity occurred in the Fourmile Creek watershed in the late 19th and early 20th century. As a result, there is a complex of historic mines that impact Fourmile Creek water quality (Murphy, 2006; Writer and Murphy, 2012). In the fall of 2010, the Fourmile Canyon fire burned 23 percent of the watershed (pre-fire forested area: 79%, current forested area: 65.9%) and significantly altered hydrologic flowpaths and constituent transport (Ebel et al., 2012; McCleskey et al., 2012; Murphy et al., 2018, 2015; Writer and Murphy, 2012). Vegetation in the foothill and montane regions of Fourmile Creek is similar to that of the three foothill catchments. In the subalpine regions of the catchment, the forest is composed of Engelmann spruce (*Picea engelmannii*), sub-alpine fir (*Abies lasiocarpa*), limber pine (*Pinus flexilis*) and lodgepole pine (*Pinus contorta*), with some aspen (*Populus tremuloides*) (Cowie, 2010; Kaufmann et al., 2006).

Table 1. Site characteristics of each catchment in the study.

Catchment	**Area (km^2)**	**Avg. Elevation (m)**	**Min. Elevation (m)**	**Max. Elevation (m)**	**Avg. Basin Slope**	**% Forest Cover**	**Presence of Historical Mines**
Lost Gulch	4.5	2061	1768	2371	41.3	94.0	N
Hawkin Gulch	3.6	2158	1817	2457	44.6	98.7	N
Keystone Gulch	5.3	2240	1838	2633	38.4	96.2	Y
Fourmile Creek	63.2	2435	1746	3515	36.8	65.9	Y

3. Data Collection and Methods

3.1. Precipitation Data and Sampling

Local incremental rainfall data (1.0 mm tipping bucket) were obtained from Urban Drainage and Flood Control District (UDFCD; https://udfcd.onerain.com/home.php). The UDFCD Magnolia site was primarily used to estimate rainfall in the foothill catchments, and the UDFCD Betasso and Logan Mill sites were used for Fourmile Creek (Fig. 1). Daily precipitation totals and maximum 30-min precipitation intensities (I_{30}) were calculated at all sites.

Precipitation samples were collected for oxygen stable isotopes of water, $\delta^{18}O$, and electrical conductivity (EC) with a sequential precipitation sampler (Brooks et al., 2010; Kennedy et al., 1979) installed in an open canopy site at the Betasso Preserve National Atmospheric Deposition Program (NADP) site (Site ID: CO84, http://nadp.slh.wisc.edu/siteOps/ppt/default.aspx, 40.01°N, 105.34°W, 1934 m) (Fig. 1). Due to the high degree of spatial and temporal variability in summer convective storms occurring in the Colorado Front Range, we also used long-term precipitation isotope data collected from the SkyWatch observatory at the University of Colorado in Boulder, CO (http://skywatch.colorado.edu/index.htmL, 40.01 N, 105.25 W, 1660 m, approximately 9 km east of Betasso) to characterize isotopic variability of precipitation. Since 2009, monthly precipitation samples for stable isotopes of water analysis were collected from SkyWatch using a precipitation sampler with mineral oil to prevent evaporation according to sampling procedures by the Global Network of Isotopes in Precipitation at the International Atomic Energy Agency (Vienna, Austria, https://nucleus.iaea.org/Pages/GNIPR.aspx). Precipitation isotope samples collected at Betasso were compared to the long-term monthly precipitation isotope samples collected at SkyWatch.

3.2. Stream Discharge and Electrical Conductivity

We calculated a stage-discharge relationship for Keystone Gulch and Hawkin Gulch (Fig. A1 & Table A1). Stream stage was recorded every five min using a lab-calibrated, submerged pressure transducer (model- CS451) and a CR1000 data logger (Campbell Scientific, Inc., Logan, UT, USA). Discharge was measured weekly when stage was high enough using a flow meter (AquaCalc Pro, JBS Instruments, Columbus, OH, USA). We did not install a pressure transducer at Lost Gulch because of resource constraints. Fourmile Creek discharge data (5-min interval) were retrieved from the Fourmile Creek at Orodell, CO, U.S. Geological Survey (USGS) stream-gauging station (06727500; http://waterdata.usgs.gov/nwis; operates April – September) approximately 100 m upstream of its confluence with Boulder Creek. Boulder Creek discharge data (15 min interval) were retrieved from the Orodell stream-gauging station (Station name: Boulder Creek near Orodell (BOCOROCO, https://www.dwr.state.co.us/SurfaceWater/data/detail_graph.aspx?ID=BOCOCROCO&MTYPE=DISCHRG) located downstream of Keystone and Hawkin Gulch and upstream of Lost Gulch and the confluence of Fourmile and Boulder Creek (Fig. 1). At all catchments, runoff (mm/hr) was calculated by dividing stream discharge by drainage area.

At the foothill catchments and Boulder Creek, EC measurements (μS/cm) were recorded every 5 min with a lab-calibrated HOBO conductivity logger (model-U24-001, Onset Computer Corporation, Bourne, MA). To account for instrument data drift, we calibrated EC data to weekly EC measurements collected with a hand-held EC meter (model-2052, Amber Science Inc., Eugene, Oregon) that was lab-calibrated with lab-grade EC standards bi-monthly. An instrument malfunction at Fourmile Creek resulted in the loss of EC data from that catchment. All instruments were removed from all sites on October 1st, 2018.

3.3. Water Sampling

Stream samples were collected as grab samples on a weekly basis at all sites across the season from April 18th to August 1st (Table 2). We refer to 'seasonal' changes throughout this paper to reflect this period of April 18th to August 1st. Additional grab samples were collected before and after (within 24 hr) storm events. During storm events, samples were collected more frequently using automatic samplers (model-6712, Teledyne ISCO, Lincoln, NE, USA). Due to resource constraints, we did not install an automatic sampler at Lost Gulch. Automatic samplers were programmed to collect samples on a 15-min interval or 30-min interval, depending on storm forecast. At Keystone and Hawkin Gulch, stage-exceedance threshold values were programmed to a Campbell Scientific CR1000 data logger connected to the automatic sampler to initiate sampling during storm events. Threshold values were programmed based on current stage, previous stage behavior and future storm forecast. At Boulder Creek and Fourmile Creek, automatic samplers were triggered using an actuator situated above the water surface. As stage fluctuated, the height of the actuator was adjusted to 5-7 cm above the water surface each week. During some storm events, runoff response was not large enough to trigger the automatic samplers.

All samples were collected in 1-L Teflon® bottles previously washed in a 10 percent hydrochloric acid solution and rinsed three times with high-purity deionized (DI) water. Grab sample bottles were rinsed three times with streamwater before collecting a sample. Within 24 hrs of sample collection, samples were filtered using a 0.45 μm (47-mm) membrane filter (Pall Laboratory, VWR International LLC, Radnor, PA, USA) and the filtered water was parsed into separate bottles (rinsed three times with filtered sample water), tailored for preservation requirements according to specific constituent analysis. Samples for $\delta^{18}O$ were collected unfiltered with no headspace in 20 mL borosilicate glass bottles with a poly-seal cone liner cap wrapped in parafilm to prevent evaporation and isotopic fractionation. Samples for anions were collected in 20-mL HDPE bottles. Samples for dissolved organic carbon (DOC) were collected in 40-mL amber-colored borosilicate glass bottles (previously heated to 500°C for 4 hr). Samples for inductively coupled plasma optical emission spectrometry analysis were collected in 125-mL HDPE bottles pre-washed in an acid solution and the pH was lowered using a 1 percent (volume per volume) concentrated trace-metal grade HNO_3. All samples were stored in the dark and refrigerated at 4°C until analysis. For quality assurance, we ran a sample duplicate and blank (using DI water) approximately every 10 samples. For more information on sample preservation techniques, refer to McCleskey et al. (2012).

Table 2. Summary of water samples collected at each catchment.

Site	Grab Samples	Storm Samples	Total Samples	Date Flow Ended
Lost Gulch	20	0	20	7/4/2018
Hawkin Gulch	20	11	31	7/24/2018
Keystone Gulch	18	26	44	7/12/2018
Fourmile Creek	30	17	47	Perennial
Boulder Creek	25	2	27	Perennial

3.4. Laboratory Analysis

All stream water samples were analyzed for major cations and anions, DOC, $\delta^{18}O$, trace metals, and EC. Precipitation samples were analyzed for $\delta^{18}O$ and EC. For all analysis except for $\delta^{18}O$, precision was evaluated using average percent error between sample and sample duplicates and accuracy was evaluated using average percent error between standard value and known standard value. For $\delta^{18}O$, precision was evaluated using the absolute difference between sample and sample duplicates and accuracy was evaluated using absolute difference between standard value and known standard value.

Major cations and trace metals were determined using inductively coupled plasma optical emission spectrometry (ICP–OES, PerkinElmer 7300 DV) analysis at the USGS in Boulder, CO, with an accuracy of 1% and precision of 6%. Major anions were determined using ion chromatography system (model Dionex DX 600, Thermo Fisher Scientific, Waltham, MA, USA), with an accuracy of 9% +/- 2% standard deviation (SD) and precision of 6% +/- 4% SD. $\delta^{18}O$ were analyzed using wavelength-scanned cavity ringdown spectroscopy with a L2120-i Isotopic Liquid Water Analyzer (Picarro Incorporated, Santa Clara, CA, USA), with a mean accuracy of 0.09 ‰ +/- 0.08 SD and a mean precision of 0.06 ‰ +/- 0.01 SD. $\delta^{18}O$ values are expressed as a δ (per mil) in ratio to the Vienna Standard Mean Ocean Water. $\delta^{18}O$ is expressed as :

$$\delta^{18}O = \frac{(18_O/16_O)_{sample} - (18_O/16_O)_{VSMOW}}{(18_O/16_O)_{VSMOW}} \; X \; 1000 \qquad \textit{(Equation 1)}$$

DOC concentrations were determined using wet oxidation method with an Oceanography International Model 700 TOC Analyzer at the USGS Analytical Trace Elements Chemistry Laboratory in Boulder, CO, with an accuracy of 0.02 % and precision of 0.03 %.

3.5. Concentration-Runoff Relationships

To investigate how hydrologic flowpaths change from early to late summer, we developed linear regressions between concentration-runoff (C/R) at each site. For each site, C/R relationships were calculated using all samples (i.e., grab and storm samples). We examined a suite of constituents for each site: DOC, EC, SO_4^{2-}, Ca^{2+}, Na^+, Cl^-, Mg^{2+}, and K^+. At all sites C/R relationships demonstrated a near-linear relationship between log(C) and log(R) similar to findings by Godsey et al. (2009). At each site, a linear regression was calculated:

$$log(C) = a + b*(log(R)) \qquad \textit{(Equation 2)}$$

where *a* is the slope intercept, *b* is the slope, *R* is runoff (mm/hr) and *C* is a predicted constituent concentration expressed in mg/l. A negative slope ($b < 0$) indicates constituent enrichment, decreasing concentration with increased discharge, while a positive slope ($b > 0$) indicates dilution, increasing concentration with increased discharge (Godsey et al., 2009; Murphy et al., 2018; Musolff et al., 2015; Rose et al., 2018). A slope of zero indicates that constituents supplied are in proportion to the volume of water supplied, representing chemostasis (Godsey et al., 2009).

Linear regressions were performed to evaluate the relationship between hydrograph parameters (i.e., peak runoff, peak new water) to precipitation parameters over multiple storm events. All data analysis, including linear regression analysis, were run in the “R” statistical package (R Development Core Team, 2018).

3.6. Constituent Loading and Yields

We calculated constituent loadings to investigate controls on constituent export dynamics and impacts of land-use and disturbances on our catchments. Using C/R linear regressions, we interpolated 5-min interval constituent loads and summed them. At all sites with discharge data, we calculated total constituent loads (kg) and constituent loading per unit area (kg/ha) from May 17th, the earliest date when all four sites have discharge data, to July 12th when flow stopped at Keystone Gulch.

3.7. Hydrograph Separations

To help identify dominant hydrologic flowpaths during storm events, we used a simple one tracer, two end-member mixing model to perform hydrograph separations in Keystone Gulch and Hawkin Gulch. We separated storm hydrographs into new and old water contributions using EC as a tracer, except for the storm at Keystone Gulch on May 22nd we used $\delta^{18}O$ as a tracer because using EC as a tracer violated an assumption in the hydrograph separation. For a two end-member system, the hydrograph separation is calculated as:

$$\text{New Water Fraction} = \frac{(\text{Tracer}_{\text{mix}} - \text{Tracer}_{\text{baseflow}})}{(\text{Tracer}_{\text{event}} - \text{Tracer}_{\text{baseflow}})} \qquad (\textit{Equation 3})$$

$$\text{Baseflow Fraction} = (1 - \text{New Water Fraction}) \qquad (\textit{Equation 4})$$

where baseflow (pre-event water) and event water (precipitation) are end-members and EC or $\delta^{18}O$ is a tracer. Several conditions and assumptions must be met to perform the two end-member hydrograph separation: 1. Only two components are contributing to stormflow during the event (baseflow and event water); 2. Tracer values of each component are significantly different and remain constant during the event, or changes are known; and 3. Streamwater is completely mixed and there is no evaporation or exchange with the atmosphere.

At Fourmile Creek, two end-member mixing models did not meet the assumptions of the hydrograph separation (Fig. A2). Instead, we used a two tracer, three end-member mixing using new water, old water and mine discharge as end-members, and EC and $\delta^{18}O$ as tracers. For tracer parameterization of mine discharge in Fourmile Creek, we used EC and $\delta^{18}O$ chemistry data from mine discharge samples collected in Fourmile Creek in 2012 (Beganskas, 2012). For a three-end-member system, the hydrograph separation is calculated as:

$$f_1 = \frac{(C_t^1 - C_3^1)(C_2^2 - C_3^2) - (C_2^1 - C_3^1)(C_t^2 - C_3^2)}{(C_1^1 - C_3^1)(C_2^2 - C_3^2) - (C_2^1 - C_3^1))(C_1^2 - C_3^2)} \qquad (\textit{Equation 5})$$

$$f_2 = \frac{(C_t^1 - C_3^1)(C_1^1 - C_3^1)}{(C_2^1 - C_3^1)(C_2^1 - C_3^1)} * f_1 \qquad (\textit{Equation 6})$$

$$f_3 = 1 - f_1 - f_2 \qquad (\textit{Equation 7})$$

where *f* is the discharge fraction of a component (e.g., new water, old water or mine discharge), C is the tracer concentration ($\delta^{18}O$ and EC) and the subscripts and superscripts correspond to the respective component number and tracer number, respectively. For a three end-member mixing model, the assumptions and conditions associated with the two end-member mixing model must be met.

Due to instrument malfunctions and subsequent limited samples collected during storm events using our sequential precipitation sampler, we also used precipitation $\delta^{18}O$ samples collected at the SkyWatch precipitation observatory as the new (event) water isotopic tracer values to use in hydrograph separations. To test if SkyWatch samples well-represented precipitation $\delta^{18}O$ at our sites, we plotted the $\delta^{18}O$ precipitation values from our Betasso sampler against SkyWatch $\delta^{18}O$ values and compared them to the SD of monthly SkyWatch samples (Fig. 2). The $\delta^{18}O$ precipitation samples collected at Betasso samples plotted within the monthly range of SkyWatch $\delta^{18}O$ samples and were all within one SD of the monthly SkyWatch sample mean, except one sample on April 21st which was within two standard deviations of the SkyWatch monthly mean (Fig. 2).

Using the SkyWatch data, we calculated three different hydrograph separations for each storm using maximum, minimum and average SkyWatch $\delta^{18}O$ values (Fig. 2). When using maximum $\delta^{18}O$ precipitation values from SkyWatch, $\delta^{18}O$ tracer values did not meet the assumptions of the hydrograph separations during four out of the eleven hydrograph separations (i.e., calculated component contribution to streamflow > 100% or < 0%). The percent difference between new water contribution calculations when using maximum monthly isotope values versus average monthly isotope values was 32 %, while the percent difference between using minimum monthly isotope values and average monthly isotope values was 82 %. These large differences between hydrograph separations highlight annual variability in the SkyWatch isotope data. In our final hydrograph separation analysis for Fourmile Creek, we exclusively used average $\delta^{18}O$ values from SkyWatch. For the hydrograph separation on May 22nd at Keystone Gulch, we used $\delta^{18}O$ as a tracer because using EC violated an assumption of the two end-member mixing model.

EC was used as a tracer for hydrograph separations at Keystone and Hawkin Gulch because we had much higher EC sample resolution (5 min) compared to isotope samples (3-6 samples per storm event). The average EC value from all precipitation samples collected at Betasso (18.2 +/- 1.3 µS/cm standard error) was used as the precipitation EC tracer value for all hydrograph separations. Because we didn't have precipitation EC values from each individual storm, three different hydrograph separations for each storm event were calculated using different EC tracer values (15.6 µS/cm and 20.8 µS/cm, 2 standard deviations away from the average EC of precipitation; 18.2 µS/cm) for the event component to investigate if 18.2 µS/cm is a representative precipitation EC tracer value. Using 15.6 µS/cm and 20.8 µS/cm as the event EC tracer value minimally changed the results of component contributions (< 2 %) and we exclusively used 18.2 μS/cm as the tracer value for event water in our final hydrograph separation analysis at Keystone Gulch and Hawkin Gulch.

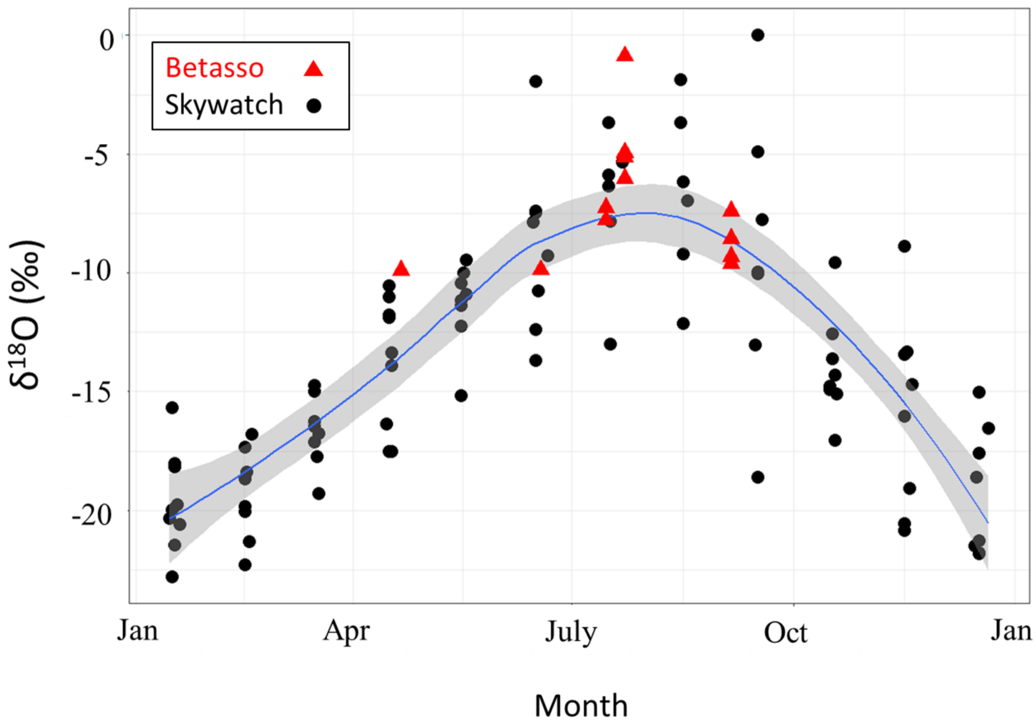

Figure 2. Precipitation $\delta^{18}O$ samples from Betasso (red triangles) and SkyWatch (black circles)(http://skywatch.colorado.edu/index.htmL). SkyWatch samples have been collected monthly since 2009. Betasso samples are from the 2018 field campaign.

4. Results

4.1. Precipitation

During the 2018 water year (October 2017-September 2018), 57% of annual precipitation fell from April through July at the NADP Betasso site near our field catchments, with the highest monthly precipitation totals occurring in May (129 mm) and June (60 mm) (Fig. 3). In May and June, relatively large storms were frequent, with ten storms having >10 mm of total precipitation and with the two largest events on June 18th (approximately 27 mm) and May 2nd (approximately

24 mm). UDFCD precipitation sites recorded large spatial variation in rainfall during summer convective storms (Table 3). The largest storm occurred on June 18th, when all UDFCD gages in the study area recorded daily precipitation totals greater than 20 mm, except two sites within the Fourmile Creek catchment (Logan Mill and Gold Hill) which recorded only 3-4 mm (Table 3).

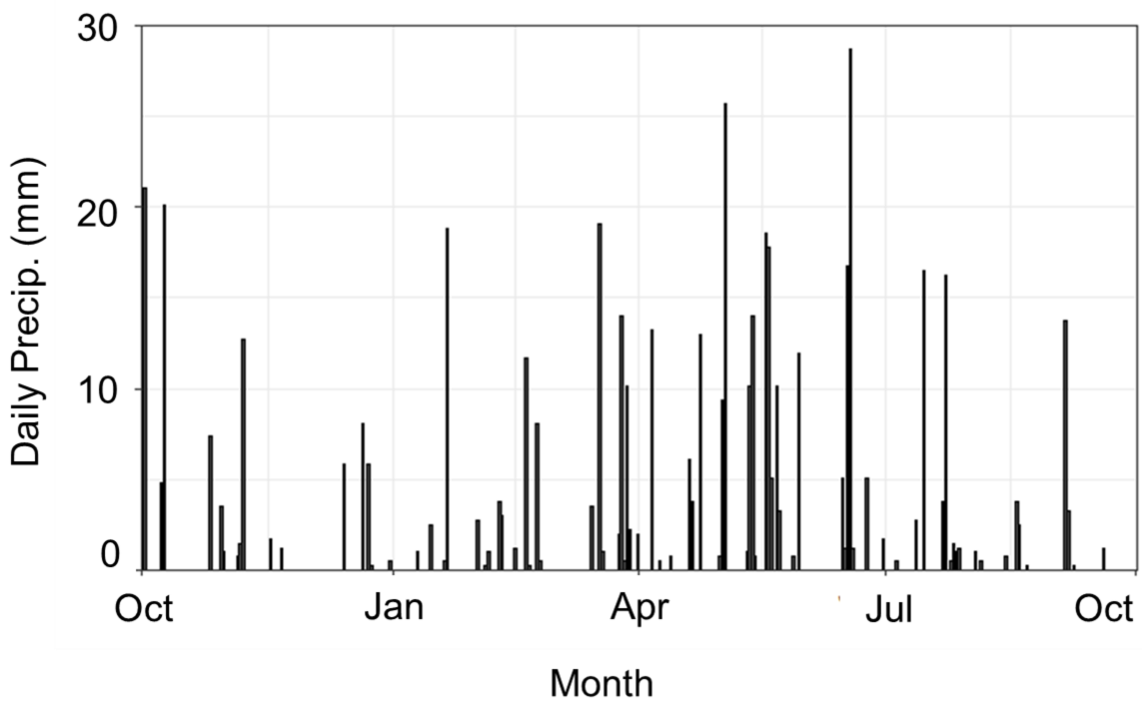

Figure 3. Daily precipitation values from October 1st, 2017 to October 1st, 2018 at the National Atmospheric Depositional Program Betasso Site (NADP; site ID: CO84, 40.01°N, 105.34°W, 1934 m http://nadp.slh.wisc.edu/siteOps/ppt/default.aspx).

Table 3. Daily precipitation values (mm) and maximum 30 min precipitation intensity (I_{30}) (mm/hr) recorded at local UDFCD precipitation sites (see Fig. 1 for locations) during storms.

	Twin Sisters		**Magnolia**		**Filter Plant**		**Betasso**		**Logan Mill**		**Gold Hill**	
Date	**Daily mm**	**I_{30} mm/hr**	**Daily mm**	**I_{30} mm/hr**	**Daily mm**	**I_{30} mm/hr**	**Daily mm**	**I_{30} mm/hr**	**Daily mm**	**I_{30} mm/hr**	**Daily mm**	**I_{30} mm/hr**
5/18/2018	0	0	5	8	8	16	38	66	3	6	0	0
5/22/2018	2	4	3	6	6	12	9	18	5	8	1	2
6/17/2018	18	6	21	6	15	6	16	6	15	6	16	8
6/18/2018	22	34	24	38	30	50	21	30	4	2	3	2
6/19/2018	1	2	0	0	2	4	1	2	13	24	4	6
7/15/2018	6	6	9	12	17	24	12	14	6	3	7	6

4.2. Runoff

Within the foothill catchments, runoff varied by several orders of magnitude during the study period, with an overall trend of decreasing runoff from mid-May to August. Runoff at Keystone, Hawkin and Lost Gulch was similar throughout the measurement period, and was lower than runoff in Fourmile and Boulder Creeks (Fig. 4). Diel runoff fluctuations were observed at all sites. Keystone, Hawkin and Lost Gulch were intermittent with flow ceasing on July 12th, July 24th and July 4th, respectively.

At all sites, runoff increased in response to summer storms. Runoff peaks were usually lower in the foothill catchments than in Fourmile Creek (Fig. 4). During the runoff measurement period at all sites, peak runoff occurred in response to rain events. The largest storm of the season on June 18th caused runoff to peak at Keystone Gulch and Hawkin Gulch at 0.08 mm/hr and 0.03 mm/hr, respectively (Fig. 4). Peak runoff at Fourmile Creek (0.14 mm/hr) occurred in response to the early season storm on May 18th. Runoff at one or more of the foothill catchments surpassed runoff at Fourmile Creek during response to storms on May 4th, June 18th and July 15th.

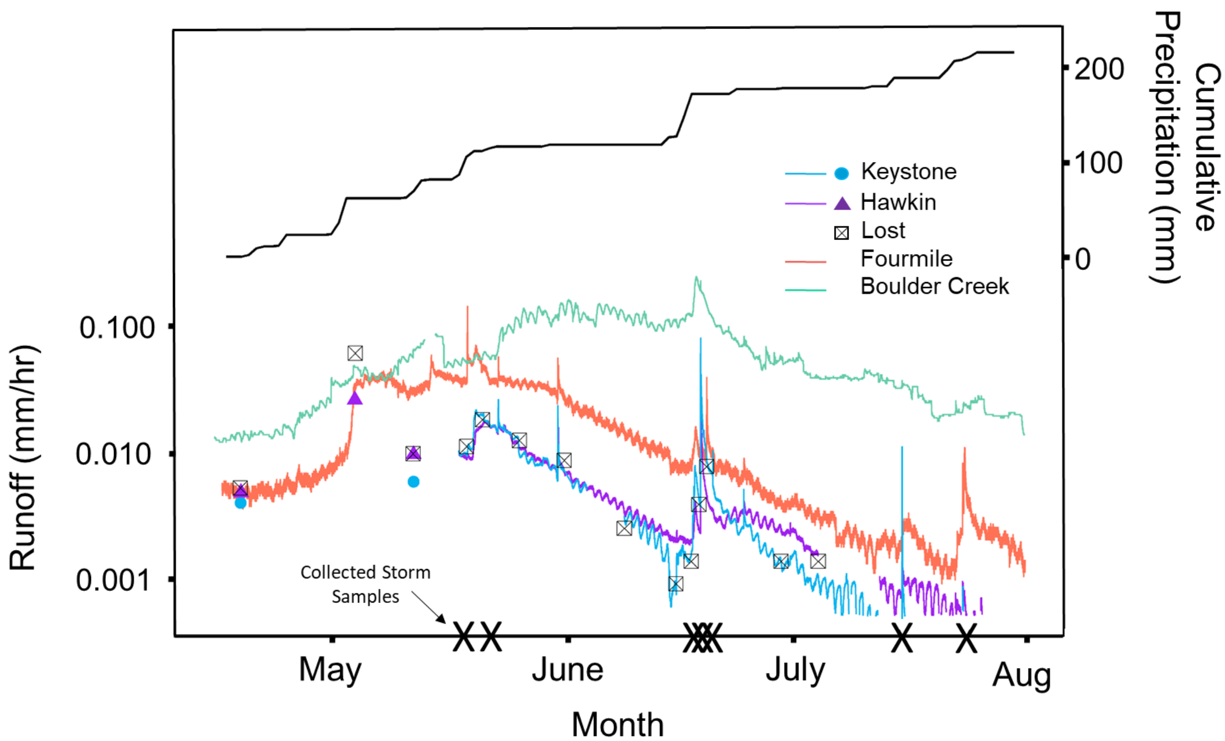

Figure 4. Runoff (mm/hr) at Keystone Gulch, Hawkin Gulch, Lost Gulch, Fourmile Creek and Boulder Creek from April 18th to July 31st. Cumulative precipitation data (mm) is from the UDFCD Magnolia precipitation site, the closest site to the headwaters of the foothill catchments (Fig. 1, https://udfcd.onerain.com/home.php). “X” along the x-axis marks points where we collected storm samples from at least one site. Note that we did not collect continuous stage/discharge data at Lost Gulch. Runoff values < 0.0005 (only observed in Keystone Gulch and Hawkin Gulch) are not plotted.

4.3 Seasonal Times Series of EC, Constituents and $\delta^{18}O$

4.3.1. Electrical Conductivity

We observed EC variability across the catchments seasonally and in response to storm events (Fig. 5). Throughout the summer, EC was similar in the three foothill catchments (126 - 403 μS/cm), and in general was inversely related to runoff, being lowest in mid-May and highest in July (Fig. 5). Fourmile Creek EC values were lower than the foothill catchments during the first half of the study (144 - 285 μS/cm). This period of low EC coincided with snowmelt recorded at a National Resource Conservation Service snow telemetry site (SNOTEL; available on the web: https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=663) near the headwaters of Fourmile Creek, in which snowmelt began approximately on May 4th and the site was snow-free by May 23rd. After the mid-June storms, Fourmile Creek EC increased from 187 μS/cm on June 15th to 305 μS/cm on July 4th, approaching values of the foothill catchments, and increased similarly to those catchments for the rest of the season (Fig. 5). EC values in Boulder Creek were much lower (42 - 154 us/cm) than in the foothill catchments and Fourmile Creek.

Typically, EC decreased in response to storm events, however, EC did not always respond to storms similarly at all sites. For example, EC always decreased in Hawkin Gulch during storms, but increased above pre-storm EC in Fourmile Creek. We also observed EC during storm runoff response increase above pre-storm EC levels at Keystone Gulch on May 22nd. However, EC decreased during all other storm responses at Keystone Gulch, similar to Hawkin Gulch.

4.3.2.Major Cations, Anions and Silica

We observed seasonal variations in lithogenic constituent concentrations, with the lowest concentrations during the high runoff period (May) and the highest concentrations in June and

July during low flow (Fig. 5 & 6). The range of constituent concentrations varied across the catchments. Among the foothill catchments, concentrations of Ca^{2+} were consistently the highest of the measured constituents, and ranged from 21.1 to 38.5 mg/l (Fig. 5). K^{+} concentrations were consistently the lowest, and ranged from < 1.0 to 3.4 mg/l at all sites. The foothill catchments had similar concentrations of SiO_2, Ca^{2+}, Mg^{2+}, and K^{+}, and were higher than Fourmile Creek until mid-June, when Fourmile Creek concentrations increased (Fig. 5 and 6). Of the foothill catchments, Keystone Gulch had higher concentrations of Cl^{-} and Na^{+} and had slightly higher SO_4^{2-} concentrations. Concentrations of Cl^{-} and Na^{+} at Fourmile Creek were more similar to Keystone Gulch than Hawkin or Lost Gulch. Some constituent concentrations in Fourmile Creek were comparable to or greater than concentrations observed in the foothill catchments, especially after mid-June, when concentrations of Na^{+}, Cl^{-}, SO_4^{2-} and K^{+} at Fourmile Creek increased above concentrations at Hawkin and Lost Gulch. For example, during the later summer, SO_4^{2-} concentrations at Fourmile Creek ranged from 18.3 mg/l on June 15th to 56.5 mg/l on July 24th and seasonal SO_4^{2-} concentrations at the foothill catchments ranged from 2.1 mg/l to 18.0 mg/l. At all sites, NO_3 concentrations were typically below detection limit (105 out of 158 samples were <0.01 mg/l) and ranged from <0.1 mg/l to 2.2 mg/l (Table A2). Out of the foothill catchments, NO_3 concentrations were lowest at Lost Gulch and were always below detection limits, except on July 4th (1.0 mg/l). NO_3 concentrations at Keystone and Hawkin Gulch were more frequently above detection limits, particularly during storms (Table A2). NO_3 concentrations at Fourmile Creek ranged from <0.01 mg/l to 0.38 mg/l and were lower than NO_3 concentrations at Keystone and Hawkin Gulch. In Boulder Creek, we observed minimal changes in constituent concentrations compared to the other sites and constituent concentrations were much lower than the other catchments.

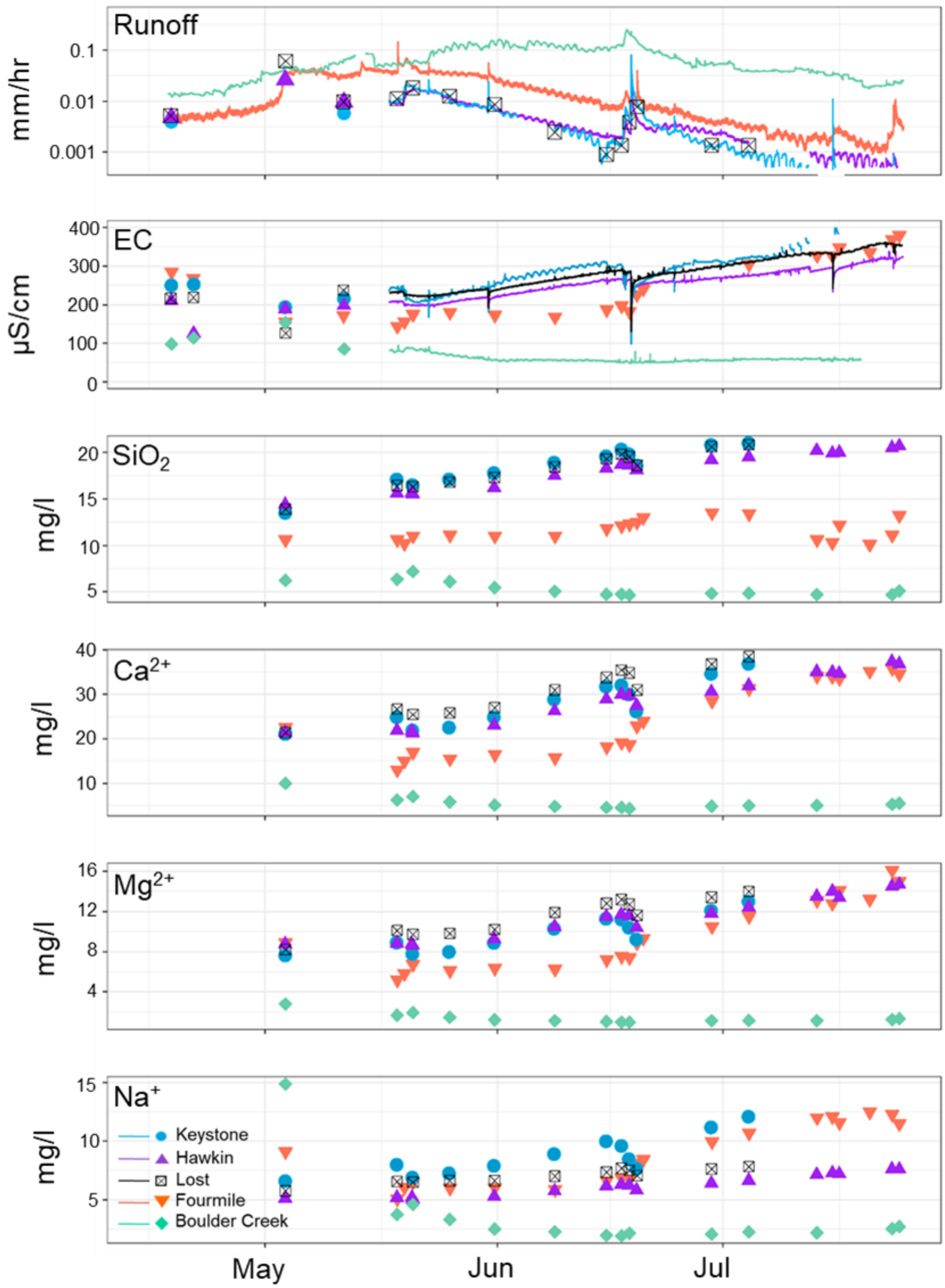

Figure 5. Times series of weekly grab samples from April 18th to August 1st of concentrations/values of runoff, EC, SiO_2, Ca^{2+}, Mg^{2+}, and Na^+ all sites. EC units are µS/cm and all constituents are in mg/l.

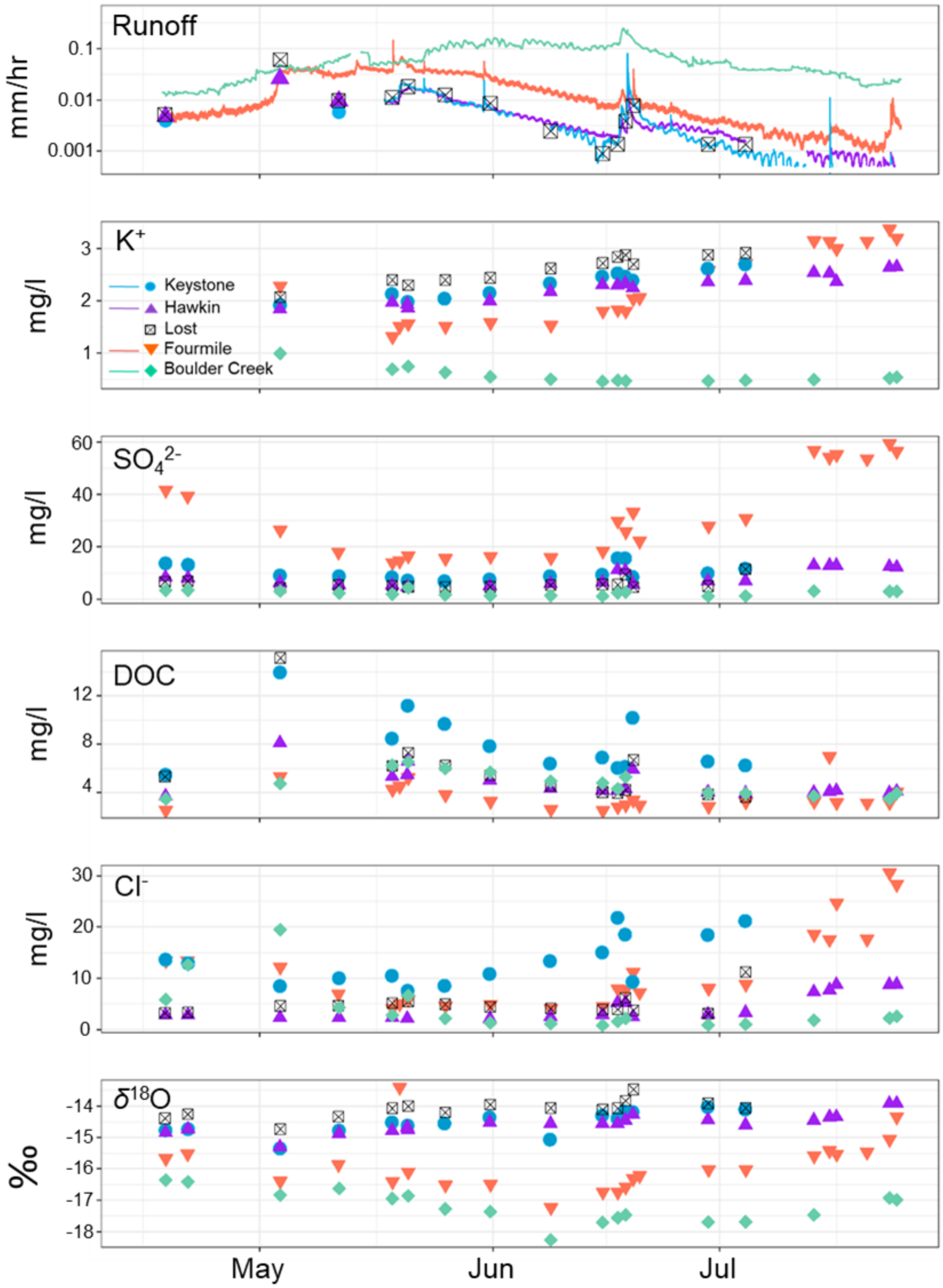

Figure 6. Times series of weekly grab samples from April 18th to August 1st of concentrations/values of runoff (mm/hr), K^+, Cl^-, SO_4^{2-}, DOC, and $\delta^{18}O$ at all sites. All constituent concentrations are in mg/l, except isotopes are in ‰.

4.3.3. Dissolved Organic Carbon

Of all the study sites, Keystone Gulch generally had the highest DOC concentrations (3.6-15.2 mg/l), while Fourmile Creek had the lowest concentrations (2.5-7.0 mg/l) (Fig. 6). Hawkin Gulch, Lost Gulch and Boulder Creek had similar concentrations throughout the season (2.7-8.1 mg/l), excluding the Lost Gulch sample on May 3rd in which DOC concentrations were 15.1 mg/l, the day after a storm event (Fig. 6). Seasonal variations in DOC were similar across all sites and DOC concentrations were highest in the high runoff period (early May to June). During the low runoff period (June to August), DOC concentrations generally remained constant at each catchment, hovering around 6.5 mg/l at Keystone Gulch and 3.5 mg/l at the other sites.

4.3.4. δ^{18}O

δ^{18}O values of Keystone, Hawkin and Lost Gulch were similar and typically higher (less negative) than δ^{18}O values of Fourmile Creek and Boulder Creek (Fig. 6). At the foothill catchments, δ^{18}O values ranged from -15.35 ‰ to -13.47 ‰ and slightly increased seasonally and δ^{18}O values of Fourmile Creek ranged from -17.23 ‰ to -13.40 ‰ (mean: -15.98 ‰ +/- 0.18 SE). At all sites, δ^{18}O values of storm samples increased (i.e., became less negative) with higher runoff during storm events (Table 2A).

4.3.5. Metals

At all sites, metal concentrations of As, Be, Cd, Co, Cr, Mo, P, Sb, Se and V were always or nearly always below detection limits (Table A2). At all sites, concentrations of Fe were low and ranged from <0.002 mg/l (below detection limit) to 0.07 mg/l. In the foothill catchments, Fe concentrations were highest at Keystone Gulch (mean concentration = 0.021 mg/l, n = 36) and lowest at Hawkin Gulch (mean concentration = 0.006 mg/l, n = 28). Concentrations of Zn were typically low and ranged from < 0.001 mg/l to 0.05 mg/l. Concentrations of Zn were very similar at the foothill catchments, Keystone (mean concentration = 0.007 mg/l, n = 36), Hawkin (mean concentration = 0.008 mg/l, n = 28), and Lost Gulch (mean concentration = 0.007 mg/l, n = 12).

4.4. Concentration-Runoff Relationships

Log (C) – Log (R) relationships were strong ($R^2 > 0.60$, $p < 0.05$) for SiO_2, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, and SO_4^{2-} in the foothill catchments and Fourmile Creek, except for Cl^- at Lost Gulch ($R^2 < 0.01$, $p = 0.96$) (Table 4). Runoff could not significantly explain variability in DOC concentrations at Keystone Gulch ($R^2 < 0.01$, $p = 0.69$), but could at all other catchments ($p < 0.01$). Relationships between Log (C) – Log (R) at Boulder Creek were weaker (all $R^2 < 0.60$) in comparison to the foothill catchments and Fourmile Creek.

Log (C) – Log (R) relationships exhibited different slope characteristics between constituents (Fig. 7 & Table 4). At all catchments, the relationship between EC, SiO_2, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, SO_4^{2-} and K^+ concentrations and runoff had negative slopes (except for Cl^- at Lost Gulch), indicating an inverse relationship between constituent concentration and runoff. Log (DOC) – Log (R) exhibited positive slopes at all catchments except at Keystone Gulch. The slope of Log (DOC) – Log (R) varied greatly across all catchments and ranged from 0.08 at Fourmile Creek to 0.29 at Lost Gulch. Slopes of EC, SiO_2, Ca^{2+}, Mg^{2+}, Na^+ and K^+ versus runoff were generally shallow (> -0.20) while the slopes of Cl^- and SO_4^{2-} versus runoff were steeper (< -0.20).

4.5. Constituent Loading

Despite higher constituent concentrations in the foothill catchments, total constituent export (kg) was at least an order of magnitude greater in Fourmile Creek and Boulder Creek than Keystone and Hawkin Gulch (Table 5 & 6), due to higher runoff. However, normalizing constituent loads to total drainage area resulted in constituent loads per area (kg/ha) within an order of magnitude across all catchments, except for SO_4^{2-} loads in Fourmile Creek. Total export for all constituents (kg/ha) was still higher in Fourmile Creek than the foothill catchments. Similar to concentration results, total constituent export of Ca^{2+} was generally the highest out of all the constituents, and ranged from 557 kg at Hawkin Gulch to 54,322 kg at Boulder Creek (Table 5). Total export of K^{+} was the lowest out of the constituents and ranged from 46 kg for Hawkin Gulch to 5679 kg for Boulder Creek. Keystone Gulch and Hawkin Gulch generally had similar constituent loads, except Cl^{-} export for Keystone Gulch was approximately four times higher (0.80 kg/h vs. 0.20 kg/h) than Cl^{-} export at Hawkin Gulch (Table 5).

Table 4. R^2, slope and p-values from Log(runoff) – Log(C) analysis of EC, SiO_2, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, SO_4^{2-}, DOC and K^+ for Keystone Gulch, Hawkin Gulch, Fourmile Creek, Lost Gulch and Boulder Creek.

R²									
	EC	**SiO_2**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**Cl^-**	**SO_4^{2-}**	**DOC**	**K^+**
Keystone Gulch	0.68	0.32	0.59	0.59	0.56	0.70	0.60	*< 0.01*	0.41
Hawkin Gulch	0.78	0.67	0.89	0.88	0.79	0.65	0.64	0.38	0.30
Lost Gulch	0.70	0.85	0.86	0.89	0.85	*< 0.01*	*0.18*	0.86	0.80
Fourmile Creek	0.82	0.31	0.80	0.83	0.78	0.68	0.84	0.17	0.55
Boulder Creek	0.16	*0.07*	0.28	0.17	*0.11*	0.21	0.59	0.40	0.22
Slope									
	EC	**SiO_2**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**Cl^-**	**SO_4^{2-}**	**DOC**	**K^+**
Keystone Gulch	-0.15	-0.14	-0.18	-0.18	-0.11	-0.27	-0.23	*0.02**	-0.11
Hawkin Gulch	-0.15	-0.11	-0.16	-0.15	-0.13	-0.33	-0.24	0.19	-0.05
Lost Gulch	-0.16	-0.04	-0.13	-0.12	-0.06	*0.00**	*-0.11**	0.29	-0.08
Fourmile Creek	-0.19	-0.05	-0.21	-0.24	-0.20	-0.37	-0.38	0.08	-0.15
Boulder Creek	-0.13	*0.04**	-0.10	-0.10	*-0.18**	-0.36	-0.34	0.15	-0.13
p-value									
	EC	**SiO_2**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**Cl^-**	**SO_4^{2-}**	**DOC**	**K^+**
Keystone Gulch	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	*0.69*	<0.01
Hawkin Gulch	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lost Gulch	<0.01	<0.01	<0.01	<0.01	<0.01	*0.96*	*0.07*	<0.01	<0.01
Fourmile Creek	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boulder Creek	0.02	*0.11*	<0.01	0.03	*0.06*	<0.01	<0.01	<0.01	0.01

* indicate $R^2 < 0.2$ and *italics* indicate p-value > 0.05

Table 5. Constituent loading (kg/ha) and total kg calculations for Keystone Gulch, Hawkin Gulch, Fourmile Creek and Boulder Creek. At all sites, loading calculations began on May 17th at 12:00 when stage data collection began at Keystone Gulch and Hawkin Gulch. Loading calculations stop when surface flow ceased at Keystone Gulch on July 12th at 18:35.

Total kg								
	SiO_2	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**Cl^-**	**SO_4^{2-}**	**DOC**	**K^+**
Keystone Gulch	426	687	251	288	424	248	*302**	85
Hawkin Gulch	355	557	222	120	73	153	154	46
Fourmile Creek	13979	26443	9833	9529	9560	25890	6299*	2981
Boulder Creek	*56481**	54322	*12900**	*28051**	21307	20525	54657	5679
kg/ha								
	SiO_2	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**Cl^-**	**SO_4^{2-}**	**DOC**	**K^+**
Keystone Gulch	0.80	1.29	0.47	0.54	0.80	0.47	*0.57**	0.16
Hawkin Gulch	1.00	1.56	0.62	0.34	0.20	0.43	0.43	0.13
Fourmile Creek	2.20	4.18	1.56	1.51	1.51	4.10	1.00*	0.47
Boulder Creek	*2.14**	2.06	*0.49**	*1.06**	0.81	0.78	2.07	0.22

* indicate $R^2 < 0.2$ and *italics* indicate p-value > 0.05

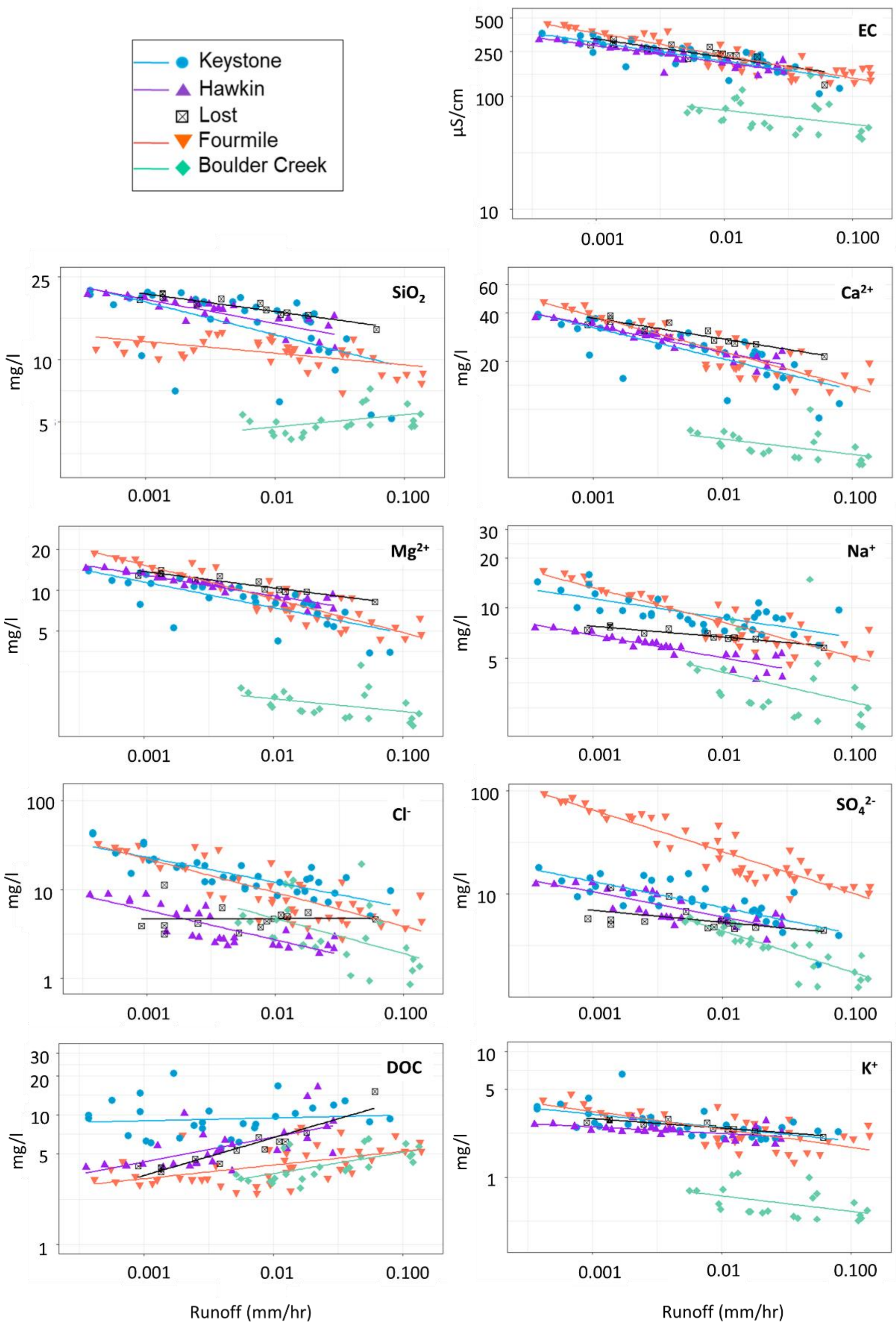

Figure 7. Log (C) – Log (R) for EC, SiO_2, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, SO_4^{2-}, DOC and K^+ at all catchments.

4.6. Hydrograph Separations

We collected storm samples from at least one catchment during seven storms (Table 6). At all catchments, peak runoff was more strongly related to maximum I_{30} ($p < 0.01$, $R^2 = 0.72$) than daily precipitation totals ($p = 0.01$, $R^2 = 0.40$) (using precipitation data from UDFCD Betasso and Magnolia sites). Maximum new water contribution during runoff response was weakly related to peak runoff ($p = 0.06$, $R^2 = 0.25$) and maximum I_{30} ($p = 0.08$, $R^2 = 0.20$), but not to daily precipitation ($p = 0.53$, $R^2 = 0.04$). During all storm events at Fourmile Creek, we observed EC increase (typically caused by increased concentrations of Ca^{2+} or Cl^-, but sometimes SO_4^{2}) with increased runoff. We also observed constituent enrichment with runoff response at Keystone Gulch on May 22nd (Fig. A3) and 7/15/18 (Fig. 9) and at Hawkin Gulch on June 18th (Fig. 8).

Table 6. Summary of all storms sampled at all sites with date, maximum 30 minute intensity, total precipitation, peak runoff, time to peak runoff, maximum new water and timing of maximum new water. All precipitation data is from the Magnolia UDFCD site, except where $^-$ is precipitation data from the Logan Mill site and * is from the Betasso site.

Site	Fourmile	Keystone	Fourmile	Keystone	Hawkin	Fourmile	Keystone	Hawkin	Fourmile	Keystone	Hawkin
Storm Date	5/18/2018	5/22/2018	6/17/2018			6/18/2018			6/19/2018	7/15/2018	
Max. I_{30} (mm/hr)	66*	6	6^-	6	6	30*	38	38	24^-	12	12
Total Precip. (mm)	38*	3	17^-	21	21	18*	24	24	12^-	9	9
Peak Runoff (mm/hr)	0.14	0.03	0.01	0.01	< 0.01	0.04	0.08	0.03	0.04	0.01	< 0.01
Time to Peak (min)	50	15	>180	>180	>180	35	30	45	5	10	65
Max. New Water (%)	48	48	16	21	5	26	70	46	33	63	22
Timing of Max. New Water	falling	peak	rising	peak	peak	falling	rising	falling	falling	peak	rising

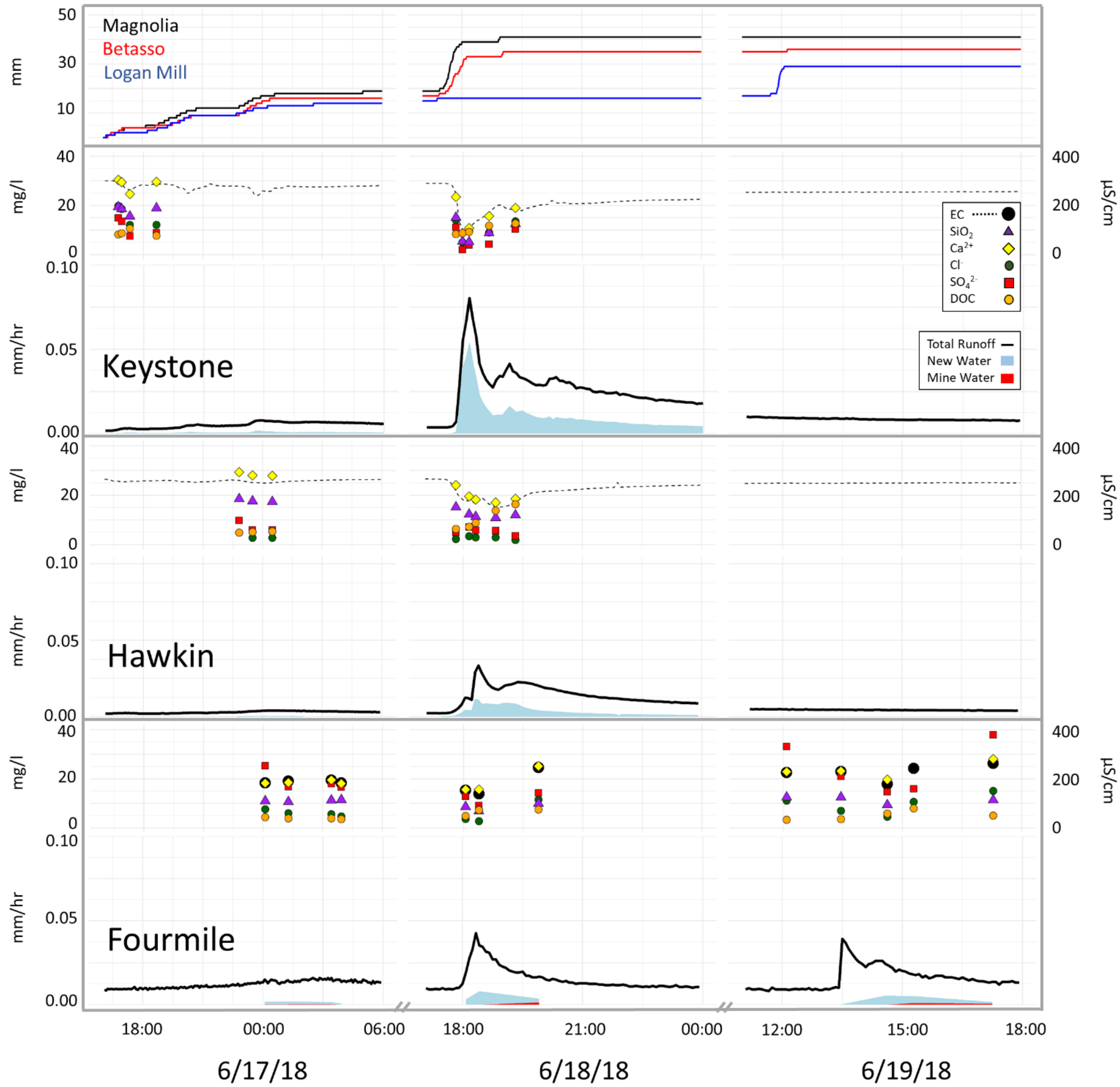

Figure 8. Precipitation, total runoff, new water fraction, mine discharge fraction (Fourmile Creek only), EC, and concentrations of SiO_2, Ca^{2+}, Cl^-, SO_4^{2-} and DOC on June 17th, June 18th, and June 19th at Keystone Gulch, Hawkin Gulch and Fourmile Creek. Precipitation data are from the UDFCD Magnolia, Betasso and Logan Mill precipitation sites.

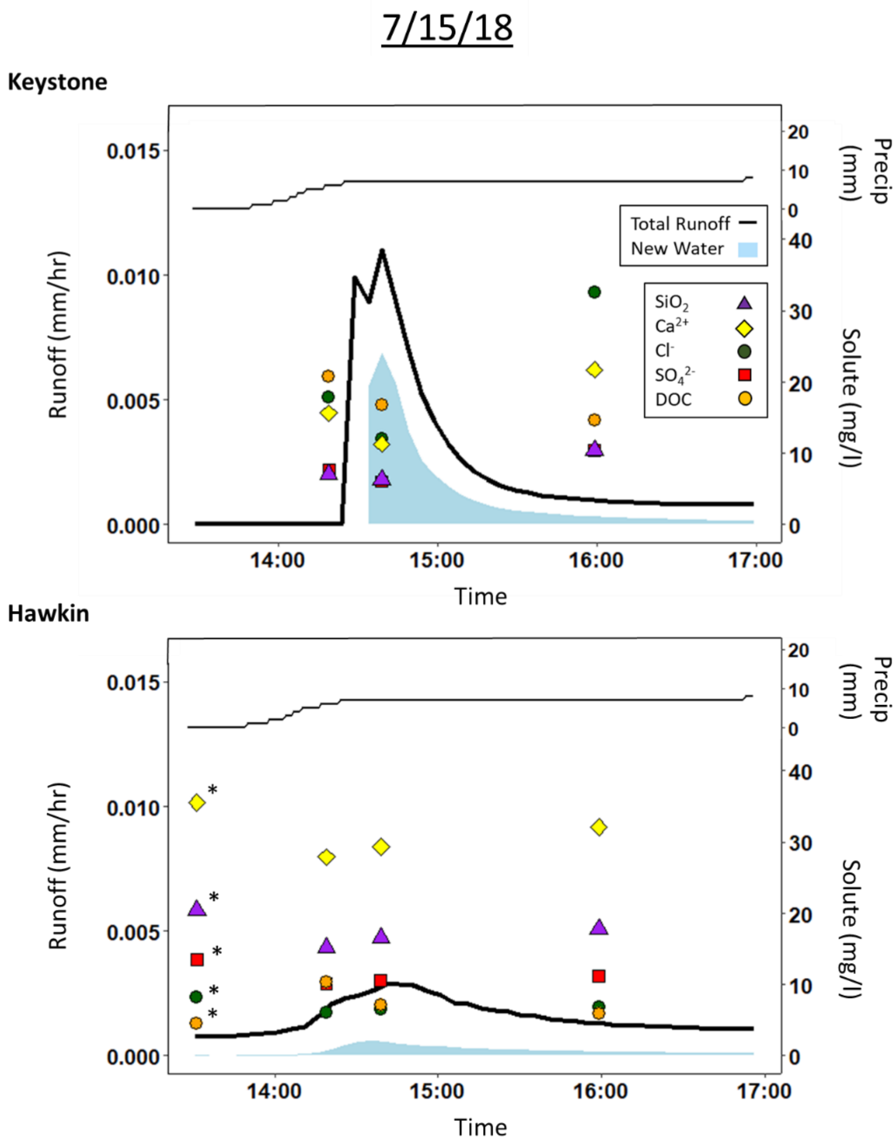

Figure 9. Total runoff, new water fraction, SiO_2, Ca^{2+}, Cl^-, SO_4^{2-} and DOC concentrations and precipitation on July 15th at Keystone and Hawkin Gulch. Precipitation data are from the UDFCD Magnolia precipitation site. Constituent concentrations with a * are from a water sample collected at 12:55 on June 15th.

4.6.1. Foothill Catchments

During three out of four storm events, Keystone Gulch exhibited a rapid runoff response to rainfall with a subsequent steep recession, while Hawkin Gulch exhibited a slower response to rainfall (Fig. 9). During the low-intensity storm event on June 17th (max. I_{30}: 6 mm/hr), Keystone Gulch and Hawkin Gulch both had very small runoff responses. During all storm responses (excluding the June 17th minor runoff response) at Keystone Gulch, runoff time-to-peak was short and ranged from 10 min on July 15th (Fig. 9) to 30 min on June 18th (Fig. 8), indicating water reached the stream via quick hydrologic flowpaths. Conversely, at Hawkin Gulch, runoff time-to-peak was always longer and ranged from 45 min on June 18th to 65 min on July 15th, suggesting water reaches Hawkin Gulch via flowpaths with longer transit times. During all storms, Keystone Gulch always had higher runoff peaks than Hawkin Gulch (Table 6). For example, during the largest storm of the season on June 18th, Keystone Gulch and Hawkin Gulch runoff peaked at 0.08 mm/hr and 0.03 mm/hr, respectively (Fig. 8).

Dividing streamflow into old (pre-event water) and new (event water) using EC-tracer based hydrograph separations revealed varied peak new water contributions to runoff during all storm responses at Keystone Gulch and Hawkin Gulch (Table 6). For the May 22nd storm hydrograph separation at Keystone Gulch, we used $\delta^{18}O$ as a tracer because using EC as a tracer violated an assumption of the mixing model (calculated component contributions were < 0). For all storm events, Hawkin Gulch runoff response to rainfall was dominated by old water contributions (new water contributions $< 50\%$). In contrast, at Keystone Gulch new water contributions peaked above 50% during three out of the four storm events and ranged from 21% on June 17th to 70% on June 18th (Fig. 8). The timing of peak new water sometimes differed between Keystone Gulch and Hawkin Gulch. At Keystone Gulch, peak new water contributions occurred at peak runoff, except on June 18th where peak new water contributions occurred on the rising limb, 10 min before peak runoff. At Hawkin Gulch, maximum new water also occurred on the rising limb on July 15th, but occurred on the falling limb during the largest storm of the season on June 18th.

We observed constituent dilution of SiO_2, Ca^{2+}, Cl^- and SO_4^{2-} at Hawkin and Keystone Gulch during storm events. Out of all the runoff responses at Keystone Gulch, we observed the largest change in constituent concentration on June 18th; in ten minutes (from 17:49 to 17:59) SiO_2 decreased from 15.1 to 5.4 mg/l, Ca^{2+} from 23.5 to 8.8 mg/l, Cl^- from 14.0 to 5.0 mg/l and SO_4^{2-} from 11.1 to 2.1 mg/l (Fig. 8). This large dilution coincided with the highest new water fraction (70%) observed at Keystone Gulch. During the runoff response on June 18th at Hawkin Gulch, constituent concentrations also decreased substantially: SiO_2 from 15.2 to 10.9 mg/l, Ca^{2+} from 24.1 to 17.1 mg/l, Cl^- from 2.3 to 1.9 mg/l and SO_4^{2-} from 5.0 to 3.5 mg/l. During this runoff response, the timing of maximum dilution occurred on the falling limb and coincided with the timing of peak new water. Concentrations of Cl^- and SO_4^{2-} at Hawkin Gulch increased above pre-storm concentrations on the rising limb, suggesting water enriched in Cl^- and SO_4^{2-} was contributing to streamflow on the rising limb of the hydrograph. We also observed constituent enrichment with increased runoff during the storm events on May 22nd and July 15th at Keystone Gulch (Fig. A3).

During the largest storm of the season on June 18th, concentrations of DOC at Keystone Gulch were lowest on the rising limb and peaked on the falling limb (12.7 mg/l), well after peak new water contributions of streamflow occurred (Fig. 8). During this storm, DOC concentrations at Hawkin Gulch were also highest (16.5 mg/l) on the falling limb but occurred more closely to the timing of peak new water contributions. Although DOC concentrations were higher at

Hawkin Gulch than at Keystone Gulch on June 18th, during the storm on July 15th, Keystone Gulch had much higher DOC concentrations (peak DOC concentrations: 20.7 mg/l vs. 10.2 mg/l). Notably, Keystone Gulch was completely dry before the storm occurred on July 15th, which may play a role in the contrasting DOC concentrations observed between Hawkin and Keystone Gulch.

4.6.2. Fourmile Creek

Runoff response at Fourmile Creek varied across storm events and peak runoff ranged from 0.01 mm/hr on June 17th to 0.14 mm/hr on May 18th during a spring storm event that occurred during initially high runoff from spring snowmelt (Table 6). Although runoff peaks on June 19th and June 18th were similar (0.042 mm/hr versus 0.039 mm/hr), the storm runoff response had different behaviors (Fig. 8). The extremely flashy behavior on June 18th coincided with high antecedent moisture conditions. Storm response at Fourmile Creek exhibited time-to-peak variability and ranged from 5 min on June 19th to 50 min on May 18th (excluding the very low intensity event with minor runoff response on June 17th; see Fig. 8).

Two-component hydrograph separations using EC as a tracer violated an assumption in the mixing model so we used a three-component hydrograph separation using new water, old water and mine discharge as components, and $\delta^{18}O$ and EC as tracers. Results from the three-component hydrograph separation showed old water consistently dominated streamflow at Fourmile Creek and mine discharge contributed to Fourmile Creek during all storm events. Peak mine discharge contributions ranged from 2% on June 17th to 9% on June 18th. During three out of the four storm events at Fourmile Creek, mine discharge peaked after peak runoff and occurred closely to the timing of peak new water. Across all storms, peak new water contributions ranged from 14% on June 17th to 48% on a May 18th. Excluding the very low intensity rain event on June 17th, peak new water fractions occurred on the falling limb during all runoff responses, in contrast to Keystone Gulch, where peak new water fraction occurred on the rising limb or peak runoff. The greatest new water contribution to streamflow occurred in response to heavy rainfall (maximum I_{30} = 66 mm/hr) on May 18th, but old water contributions still dominated streamflow (Fig. A3).

During all storm events, we observed constituent concentrations increase with increased runoff at Fourmile Creek. Constituent enrichment always occurred after peak runoff and close to the timing of peak mine discharge contributions to streamflow. For example, on May 18th, concentrations of Ca^{2+} and Cl^{-} during stormflow increased from 13.0 mg/l to 19.6 mg/l and 4.2 mg/l to 8.6 mg/l, respectively (Fig. A3). These peaks in constituent concentrations occurred simultaneously with maximum mine discharge contributions (8%), 10 min after peak runoff and peak new water contributions to streamflow. This constituent behavior was also observed on June 18th and June 19th in which Ca^{2+}, Cl^{-}, and SO_4^{2-} on June 19th only, spiked above pre-storm concentrations on the falling limb when new water fractions and mine discharge were contributing to streamflow. Across all storm events, concentrations of DOC were always highest on the falling limb of the hydrograph and lowest on the rising limb. DOC concentrations at Fourmile Creek were always lower and varied less than DOC concentrations at the foothill catchments. For example, on June 18th DOC concentrations at Fourmile Creek ranged from 4.9 mg/l to 7.5 mg/l while at Hawkin Gulch they ranged from 6.4 mg/l to 16.5 mg/l (Fig. 8).

5. Discussion

5.1. What does stream chemistry imply about streamflow generation processes in foothill catchments in the Colorado Front Range and how do hydrologic flowpaths change seasonally?

In foothill catchments in the Colorado Front Range, we observed lithogenic constituent enrichment and DOC depletion as runoff decreased throughout the season (Fig. 5, 6 & 7), consistent with findings from previous studies examining broad-scale solute behavior across a range of flow regimes (Clow and Drever, 1996; Evans and Davies, 1998; Godsey et al., 2009; Johnson et al., 1969; Musolff et al., 2015; Rose et al., 2018). Runoff can be divided into deep subsurface, shallow subsurface or surface flowpaths. Each flowpath contributing to the stream has constituent concentrations that depend on reaction rates, water transit duration, and constituents available along the path the water takes to reach the stream (Chorover et al., 2017; Godsey et al., 2009; Murphy et al., 2018; Stallard and Murphy, 2014). During low-flow conditions, constituents associated with deeper flowpaths (e.g., SiO_2, Ca^{2+}, Mg^{2+}, Na^+, and K^+) typically become enriched while bioactive constituents (e.g., DOC) become diluted (Chorover et al., 2017; Godsey et al., 2009; Murphy et al., 2018; Stallard and Murphy, 2014). Enrichment of lithogenic constituents across the season at the foothill catchments reflects a transition in dominant flowpath, where initial high runoff is primarily sourced from dilute, shallow subsurface contributions that progressively become disconnected from the stream, while deeper groundwater flowpaths remain hydrologically connected.

Seasonal DOC behavior supports our interpretation that flowpaths transition from shallow subsurface to deeper subsurface throughout the season. In snowmelt-dominated systems, DOC accumulates in the shallow subsurface and is flushed into the stream during snowmelt, producing high concentrations of DOC in streamwater during snowmelt conditions (Boyer et al., 1997; Burns et al., 2016; Hornberger et al., 1994). Excluding storm events, we observed peak DOC concentrations early in the season during high runoff, indicating runoff was generated via shallow subsurface flowpaths in the early summer. The transition from snowmelt sources in the early summer to deeper groundwater sources in the later summer and fall was also observed in Gordon Gulch, a small (2.6 km^2) montane catchment in the BCW (Cowie et al., 2017). Using end-member mixing analysis, Cowie et al. (2017) found streamflow was predominantly composed of snowmelt contributions in the early season, but shifted to primarily groundwater sources (and rain contributions) in the summer, similar to seasonal flowpath inferences made from seasonal stream chemistry at our catchments. Additionally, Burns et al. (2016) analyzed dissolved organic matter fluorescence and DOC concentrations in Gordon Gulch and showed shallow flowpaths through DOC-rich subsurface predominantly sourced the stream during snowmelt in April and May.

Seasonal stream chemistry and runoff in Fourmile Creek and the foothill catchments reflects differences in snowmelt influence on the timing of hydrologic and chemical behaviors. Fourmile Creek extends to the subalpine ecoregion of the BCW where snowpack development is larger and more extensive than in the foothill ecoregion, providing higher contributions of constituent-depleted snowmelt, prolonging constituent dilution of streamwater into the summer. Conversely, stream chemistry behavior at the foothill catchments reflects quickly waning snowmelt contributions while deeper constituent-enriched groundwater contributions remain hydrologically connected and compose a greater proportion of total streamflow. This interpretation is further supported by differences in the timing of snowmelt at precipitation sites in the BCW. At the Niwot Ridge SNOTEL site (available on the web: https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=663) and at Gordon Gulch, a montane catchment in the BCW (closer in elevation to the foothill ecoregion), the average date of complete snowpack melt from water years 2008 – 2017 was May 31st and April 28th, respectively (Anderson and Ragar, 2017). Additionally, a recent study in Fourmile Creek showed that as snowmelt contributions decrease seasonally, discharge from mines in Fourmile Creek likely play a larger role in controlling downstream chemistry (Murphy et al., 2018). Discharge from historical mines surrounding Fourmile Creek is highly concentrated in Ca^{2+}, Mg^{2+}, Na^{+} and SO_4^{2-} (McCleskey et al., 2012; Murphy et al., 2018) and these constituents are elevated in Fourmile Creek in mid-June and July, after spring snowmelt contributions decrease. Future research analyzing groundwater chemistry and isotopic variability across the elevational gradient of Fourmile Creek could shed light on the seasonal transition of hydrologic flowpaths and help determine the degree to which discharge from these mines affects long-term (i.e., seasonal) stream chemistry.

5.2. In the foothill catchments, what are the dominant flowpaths during summer storm events?

Comparing the timing and magnitude of peak new water fractions, hydrograph behavior and constituent behavior revealed that spatiotemporal flowpath dynamics at Keystone Gulch, Hawkin Gulch and Fourmile Creek often differed during storm events. Peak new water estimates at Hawkin Gulch, the undisturbed foothills catchment, were 5% to 46%, consistent with past studies where storm hydrographs are dominated by old water contributions (Brown et al., 1999; Buttle, 1994; Buttle and Peters, 1997; Genereux and Hooper, 2012; Gibson et al., 2005; Hooper and Shoemaker, 1986; Klaus and McDonnell, 2013; Sklash et al., 1979). Hawkin Gulch runoff was slower to rise and fall compared to Keystone Gulch (Fig. 9) and new water estimates were typically high or peaked on the falling limb, indicating that substantial volumes of new water were delivered to Hawkin Gulch after peak runoff. Combined with the observation that DOC concentrations and dilution of groundwater-derived constituents at Hawkin Gulch were highest on the falling limb, this suggests shallow subsurface flowpaths intersecting DOC-rich soils contribute to Hawkin Gulch runoff after peak runoff (Boyer et al., 1997; Hornberger et al., 1994; McDowell and Likens, 1988; McGlynn et al., 1999; Mills, 2016).

In contrast to hydrograph behavior at Hawkin Gulch and past studies where storm hydrographs are dominated by old water contributions (Brown et al., 1999; Buttle, 1994; Buttle and Peters, 1997; Genereux and Hooper, 2012; Gibson et al., 2005; Hooper and Shoemaker, 1986; Klaus and McDonnell, 2013; Sklash et al., 1979), Keystone Gulch had peak new water contributions frequently >50% that peaked at or near peak runoff, and coincided with low DOC and constituent concentrations. This observation suggests the rapid pulse of new water at Keystone Gulch is likely not delivered through shallow, macroporous lateral subsurface flowpaths (Klaus et al., 2013; McDonnell, 1990) or overland flowpaths across soils, both of which are typically rich in DOC (Gremillion et al., 2000; Pearce, 1990). Murphy and Stallard (2012) observed DOC concentrations decrease with high overland flowpath contributions during peak runoff and suggested large volumes of water delivered to streamflow via overland flow had limited contact with DOC-rich surfaces during peak runoff, resulting in lower DOC concentrations in high flows. However, this study was conducted in a tropical catchment in Puerto Rico, where annual precipitation (> 3000 mm/yr) and runoff are much higher than in the Colorado Front Range. New water contributions at Keystone Gulch are likely quickly delivered via surficial surfaces with low available DOC and constituent concentrations. Although overland flow across impervious surfaces has been shown to flush accumulated DOC on roads and pavement into streams during storm events (Aitkenhead-Peterson et al., 2009; Hook and Yeakley, 2005; Wise et al., 2019), these studies investigating DOC transport were in highly urbanized watersheds with traffic-intensive roads. Keystone Gulch has low-density, low-intensity trafficked roads and because DOC on roads is sourced from oil and grease and street litter (Barnes et al., 2002), it is possible that impervious surfaces in Keystone Gulch have low DOC concentrations and subsequently, flowpaths traveling along them would be dilute. Direct sampling and DOC analysis of road runoff could indicate if the large new water pulse observed at Keystone Gulch is from impervious surfaces. Another possible explanation for the large pulse of new water at Keystone Gulch is overland flow across several near-stream, rock outcrops upstream of our sampling point. At the Panola Mountain Research Watershed in Georgia, Burns et al. (2001) showed constituent-dilute water was sourced from upstream rock outcrops and dominated peak runoff during storm responses. During rainfall, flowpaths across rock outcrops quickly delivered high volumes of event (i.e., new) water to the stream (Burns et al., 2001). At Keystone Gulch, water sourced from flowpaths across rock outcrops may explain the rapid pulse of constituent-depleted water and timing of peak constituent dilution. However, with our current data set, the precise mechanism for the quick delivery of new water at Keystone Gulch cannot be definitively determined. The new water pulse is likely delivered by overland flow across DOC-poor roads, upstream rock outcrops or a combination of the two. Nonetheless, the large new water pulse that dominated peak runoff at Keystone Gulch was likely transported via short, near-surface flowpaths with low available DOC and constituent concentrations.

During the storms on May 22nd and July 15th at Keystone Gulch and June 18th at Hawkin Gulch, we observe concentrations of Ca^{2+}, Cl^{-}, and sometimes SO_4^{2-} slightly increase above pre-storm concentrations. We suggest this may be due to subsurface mixing with and flushing of atmospherically deposited and evapo-concentrated constituents in soil water. Previous studies have observed similar pulses of soluble salts in runoff typically during initial wetting of the area following dry periods (Anderson et al., 1997; Anderson and Dietrich, 2001; Liu et al., 2013; Mills, 2016; Newman et al., 1998; Stohlgren et al., 1991; Walling and Foster, 1975). Before the spikes of Cl^{-} and Ca^{2+} on June 18th and July 15th at Hawkin Gulch and Keystone Gulch, respectively, these catchments experienced prolonged dry periods before storms occurred (Fig.

4). For example, from June 20th to July 15th (24 days), less than 7 mm of precipitation fell. The flushing of accumulated constituents into Keystone and Hawkin Gulch during rain events supports our interpretations that shallow subsurface flowpaths primarily contribute to runoff response at Hawkin Gulch, but generally does not support our hypothesis that runoff response at Keystone Gulch is sourced by overland flow. Instead, the increase in constituent concentrations above pre-storm concentrations on the falling limb at Keystone Gulch more likely reflects subsurface flowpaths contributing to Keystone Gulch after peak runoff. Future work incorporating soil leachates and direct sampling of lateral flowpaths during storm events in the foothills ecoregions of the BCW would help determine if this flushing phenomena is a valid explanation.

During the storm on May 22nd, EC at Keystone Gulch rose above pre-storm EC levels. Thus, for the May 22nd hydrograph separation, we used $\delta^{18}O$ as a tracer because using EC as a tracer violated an assumption of the mixing model (calculated component contributions were < 0). Discharge from historic mines in the Keystone Gulch drainage area may play a role in this increase in EC with increased runoff, since historic mine discharge in the BCW has been shown to have high EC (McCleskey et al., 2012). However, we did not have samples of discharge from historic mines in Keystone Gulch and were unable to account for this.

New water contributions at Fourmile Creek were always < 50% total streamflow and consistently peaked after peak runoff, suggesting new water travels via flowpaths with long transit times, similar to flowpath inferences made at Hawkin Gulch. Peak DOC always occurred on the falling limb and closely coincided with peak new water fractions at Fourmile Creek, suggesting new water was arriving to the stream through flowpaths rich in DOC (Boyer et al., 1997; Hornberger et al., 1994). Although Fourmile Creek is a disturbed catchment (similar to

Keystone Gulch) with impervious surfaces, the observations that new water contributions are < 50% and do not coincide with peak runoff suggest that during the 2018 study, new water did not travel by overland flowpaths, as we inferred at Keystone Gulch. This contrasts what Murphy et al. (2015) observed during the first two years after the 2010 Fourmile Canyon Fire, in which they showed infiltration-excess overland flow contributed to the stream during storms. Our data suggests that seven years after the fire, new water arrives at Fourmile Creek via longer flowpaths with longer transit times.

While short time-to-peak can be attributed to overland flow, the short time-to-peak at Fourmile Creek on June 19th (5 min) more likely reflects the role of antecedent moisture conditions on runoff response (Fig. 8). Wet antecedent conditions in semi-arid catchments like Fourmile Creek have been linked to higher runoff rates and quick storm runoff response to rainfall (Castillo et al., 2003; Fitzjohn et al., 1998; Karnieli and Ben-Asher, 1993). Approximately 35 mm of precipitation fell within 48 hrs before the following storm runoff response at Fourmile Creek on June 19th, and high precipitation totals leading up to the storm event likely created wet antecedent conditions, explaining the rapid hydrograph behavior at Fourmile Creek on June 19th (Fig. 8).

During all four storm events, peak mine discharge contributions to Fourmile Creek occurred after peak runoff and closely coincided with peak new water contributions, suggesting mine discharge arrives to the stream via flowpaths with similar transit times to flowpaths sourcing new water. New water is likely delivered to Fourmile Creek via shallow subsurface flowpaths, similar to Hawkin Gulch, but also via flushing of mine workings. Previous studies have documented sulfide mineral oxidation products (e.g., SO_4^{2-}) and the accumulated efflorescent salts in subsurface mines can be subsequently flushed to the stream during rain events (Maest et al., 2004; Nordstrom, 2009, 2008, 1977; Younger and Blachere, 2003). Historic mines in Fourmile Creek have mine tailings that contain sulfide minerals (Lovering and Goddard, 1950) and the flushing of these minerals may be represented in our calculated increased contributions of mine discharge during storm events. However, most studies document a flush of mine-derived constituents to the stream on the rising limb of the hydrograph (Hart et al., 1982; Maest et al., 2004; Nordstrom, 2011, 2009), while we always observed peak mine discharge contributions on the falling limb at Fourmile Creek. The most dense area of historic mines in the Fourmile Creek drainage area is several kilometers upstream of our sampling site at the mouth of Fourmile Creek (Murphy, 2006), which may play a role in the delayed timing of mine discharge contributions in response to rainfall.

The flushing of mine discharge in Fourmile Creek during storm events may intensify in the future with predicted climatic changes. Predicted earlier snowmelt timing and prolonged dry summer periods (Stewart et al., 2005) will increase the accumulation and concentration of subsurface efflorescent salts, and residual groundwater may have higher constituent concentrations in historic mines (Nordstrom, 2009). Following dry periods, rainfall may flush this more concentrated mine discharge into receiving streams, degrading water quality. Additionally, high-intensity rain events are predicted in the future (Prein et al., 2017; Trenberth, 1999; Trenberth et al., 2003) and hold the potential to dissolve soluble salts more rapidly, producing a more pronounced spike of constituent concentrations into receiving waterways like Fourmile Creek (Nordstrom, 2009).

5.3. How do flowpaths differ among catchments with different land-use history in the Colorado Front Range?

Higher concentrations of Cl^- in the disturbed catchments (Keystone Gulch and Fourmile Creek) compared to the undisturbed catchments (Hawkin and Lost Gulch) are likely due to differences in land-use. Minimal Cl^- is present in Boulder Creek Granodiorite underlying Fourmile Creek and Keystone Gulch (Gable, 1980); however, we observed high concentrations of Cl^- in streamwater, up to 30.6 mg/l Cl^- in Fourmile Creek and 21.2 mg/l Cl^- in Keystone Gulch (Fig. 7). High Cl^- concentrations in streamwater have been linked to urban land-use (Stets et al., 2018) and the application of road salt may explain high Cl^- concentrations in Keystone Gulch and Fourmile Creek. Boulder County applies a mixture of sand and 5-10% rock salt [NaCl] (https://www.bouldercounty.org/transportation/road-maintenance/snow-removal) to main roads that mostly parallel Keystone Gulch and Fourmile Creek. Road salt has been shown to contaminate groundwater systems, slowly releasing Cl^- into streams via groundwater flowpaths (Kelly et al., 2008; Ledford et al., 2016; Perera et al., 2013; Sherwood, 1989). Low flow conditions at Keystone Gulch and Fourmile Creek were dominated by groundwater flowpaths and the timing of higher Cl^- concentrations during low flow in the later season supports the notion road salt may be altering stream chemistry.

Contributions from domestic sewage systems (e.g., septic) and/or mine discharge may also explain high Cl^- concentrations in Keystone Gulch and Cl^- and SO_4^{2-} concentrations in Fourmile Creek during low flow conditions. Previous studies have shown septic systems can elevate Cl^- concentrations in streamwater via contamination of near-stream subsurface waters (Kelly et al., 2008; Sherwood, 1989). Additionally, mine discharge from upstream historical mine complexes in Fourmile Creek and Keystone Gulch may have high concentrations of Cl^- since telluride ores historically mined in the BCW has complex mineralogy, include chloride minerals (Kelly and Goddard, 1969).

The observation that SO_4^{2-} concentrations are high in Fourmile Creek suggests that discharge from historical mines is altering stream chemistry. Mine discharge can lead to elevated

SO_4^{2-} in downstream waters due to the oxidation of pyrite (Nordstrom, 2011, 2009) and McCleskey et al. (2012) showed discharge from historical mines in Fourmile Creek contains elevated SO_4^{2-} concentrations (Murphy et al., 2015). If stream chemistry is altered from mine discharge during low flow condition, this holds implications for water quality during low water years in the future. It was beyond the scope of this study to collect samples of discharge from historical mines in Keystone Gulch but such samples would help determine the degree to which mine discharge affects stream chemistry in lower elevation catchments of the BCW.

5.4. Future Impacts on Foothill Catchments

If snow:rain ratios decrease in the future (Abatzoglou, 2011; Berghuijs et al., 2014; Knowles et al., 2006) and extreme precipitation events become more frequent (Prein et al., 2017; Trenberth, 1999), a current understanding of hydrologic flowpaths in foothill catchments is useful to predicting how these hydrologic systems will change. Dominant flowpaths sourcing new water during storms differ for Keystone and Hawkin Gulch and future precipitation shifts may alter foothill catchments differently, depending on land-use. In the disturbed catchment with impervious surfaces, Keystone Gulch, peak runoff is dominated by a quick pulse of new water that undergoes little infiltration before arriving to the stream. Therefore, more rain events in the future will increase the amount of runoff sourced by a rapid pulse of new water with little infiltration, which may hold implications for subsurface storage and the transportation of surficial pollutants into Keystone Gulch.

This study provides hydrogeochemical data in three catchments that are almost entirely forested (> 90%) and are located in the foothills and lower montane ecoregions within the wildland-urban interface, where fires are more frequent compared to their higher elevation counterparts in the Colorado Front Range (Balch et al., 2017; Theobald and Romme, 2007). If a fire occurs in our catchments, overland flowpaths and elevated constituent loads may impact downstream water quality and complicate water treatment. Depending on the severity and intensity of a future fire, we predict changes in hydrologic flowpaths and constituent export will occur in these foothill catchments (IPCC, 2014; Mast et al., 2016; McCleskey et al., 2012; Murphy et al., 2018; Writer and Murphy, 2012). In burned watersheds, reduced soil hydraulic properties and subsurface infiltration can led to overland flow (Ebel et al., 2016; Murphy et al., 2015; Neary et al., 2005) and at Keystone Gulch, contaminated sediment from prior mining activity has the potential to be exposed and remobilized after a fire, degrading downstream water quality (Mirus et al., 2017; Murphy et al., 2015). Additionally, DOC concentrations in streamflow can increase after a wildfire, complicating drinking water treatment (Bladon et al., 2014; Emelko et al., 2011; McCleskey et al., 2012; Writer and Murphy, 2012). For example, after the 2010 Fourmile Canyon fire, Writer and Murphy, (2012) observed stream water DOC concentrations increased from 1.5 mg/l to 17 mg/l during post-fire storms. Wildfires can oxidize sulfur in soil organic matter, increasing SO_4^{2} concentrations in surface soils, and Na, Cl and SO_4^{2-} can be leached from burnt plant litter (Khanna and Raison, 1986). As a result, post-fire constituent export can be elevated above pre-fire constituent export if ash is transported downstream through overland flowpaths (Smith et al., 2011). For example, in a pine-dominated foothills catchment in central Portugal, Na^+ , Cl^- and SO_4^{2-} loads in the burned section of a forest were 11, 19 and 4400 times higher, respectively, than the unburned section of the forest (Ferreira et al., 2005). A fire in our study area would alter hydraulic soil proprieties, hydrologic flowpaths and stream chemistry, which would have important implications for water quality, water supplies and water treatment in downstream communities. This study underlines the importance of considering anthropogenic development and disturbances in our current understanding of hydrologic and biogeochemical regimes as well as in our predictions of how these systems may change in the future.

6. Conclusion

The present study yields insight into hydrologic flowpath dynamics from spring to late summer in foothills catchments of the Colorado Front Range. Our results indicate that different components of land-use in the wildland-urban interface can alter stream chemistry and runoff generation, and that dominant flowpaths sourcing runoff response to storms in foothill catchments are likely altered by impervious surfaces from anthropogenic development. In the context of future development and surficial pollutant transport in the Colorado Front Range, our findings have implications for predicting future changes in stream chemistry and hydrology in this rapidly developing region. Additionally, results showed mine discharge contributions increased during storm events and a shift towards longer drier periods and more intense rain events could intensify mine discharge contributions to streamflow during storms. Given the high prevalence of historic mining sites in the region, future research incorporating more samples of mine discharge, particularly during storm events, could shed additional light on the degree to which historic mine discharge alters stream chemistry in similar lower elevation ecoregions. This research effort contributes to a broader understanding of current streamflow-generating processes in foothill catchments of the western US and provides a baseline from which future climatic variability and disturbances to such catchments may be assessed.

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Appendix

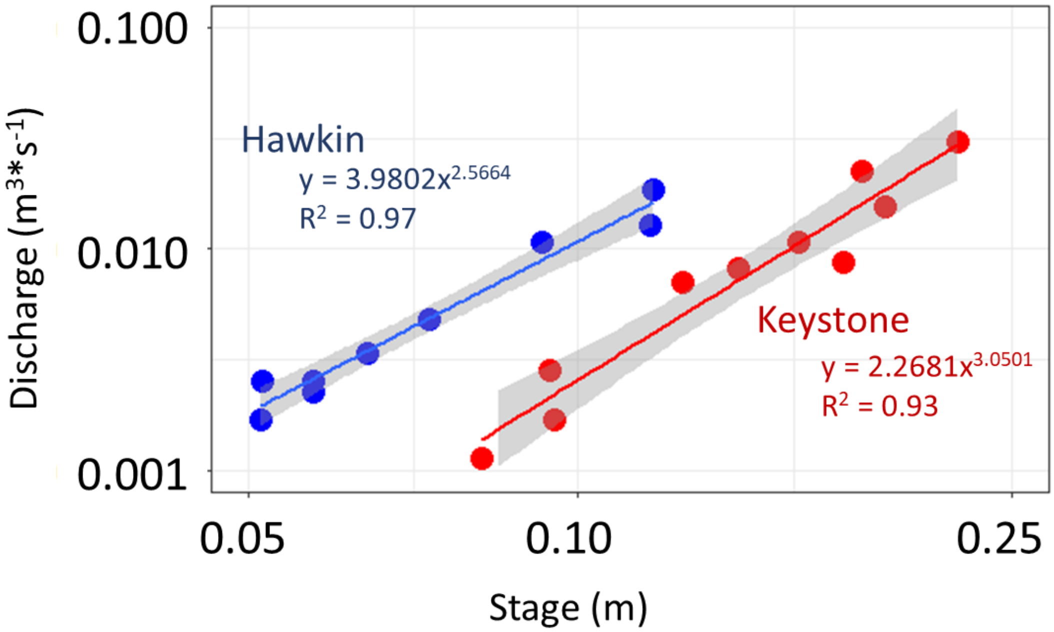

Figure A1. The stage-discharge relationship for Hawkin Gulch and Keystone Gulch. Grey shading represents the 95% confidence interval.

Table A1. Stage and discharge data used to create the stage-discharge relationships at Keystone and Hawkin Gulch.

Site	Date & Time	Stage (m)	Discharge (m^3s^{-1})
Keystone Gulch	5/18/2018 12:45	0.176	0.0088
Hawkin Gulch	5/18/2018 13:15	0.093	0.0026
Hawkin Gulch	5/20/2018 13:00	0.117	0.0033
Keystone Gulch	5/20/2018 14:35	0.223	0.0303
Hawkin Gulch	5/20/2018 15:55	0.117	0.0033
Keystone Gulch	5/25/2018 11:30	0.191	0.0156
Keystone Gulch	5/31/2018 10:35	0.160	0.0108
Keystone Gulch	6/8/2018 11:00	0.125	0.0071
Hawkin Gulch	6/8/2018 13:05	0.064	0.0018
Keystone Gulch	6/15/2018 9:35	0.082	0.0011
Hawkin Gulch	6/15/2018 10:50	0.052	0.0015
Keystone Gulch	6/17/2018 10:15	0.095	0.0017
Hawkin Gulch	6/17/2018 10:50	0.051	0.0015
Keystone Gulch	6/18/2018 9:55	0.141	0.0082
Hawkin Gulch	6/18/2018 11:05	0.057	0.0016
Keystone Gulch	6/19/2018 9:50	0.182	0.0224
Hawkin Gulch	6/19/2018 11:25	0.073	0.0021
Keystone Gulch	6/29/2018 9:20	0.094	0.0028
Hawkin Gulch	6/29/2018 10:20	0.057	0.0016
Hawkin Gulch	7/4/2018 10:00	0.046	0.0013

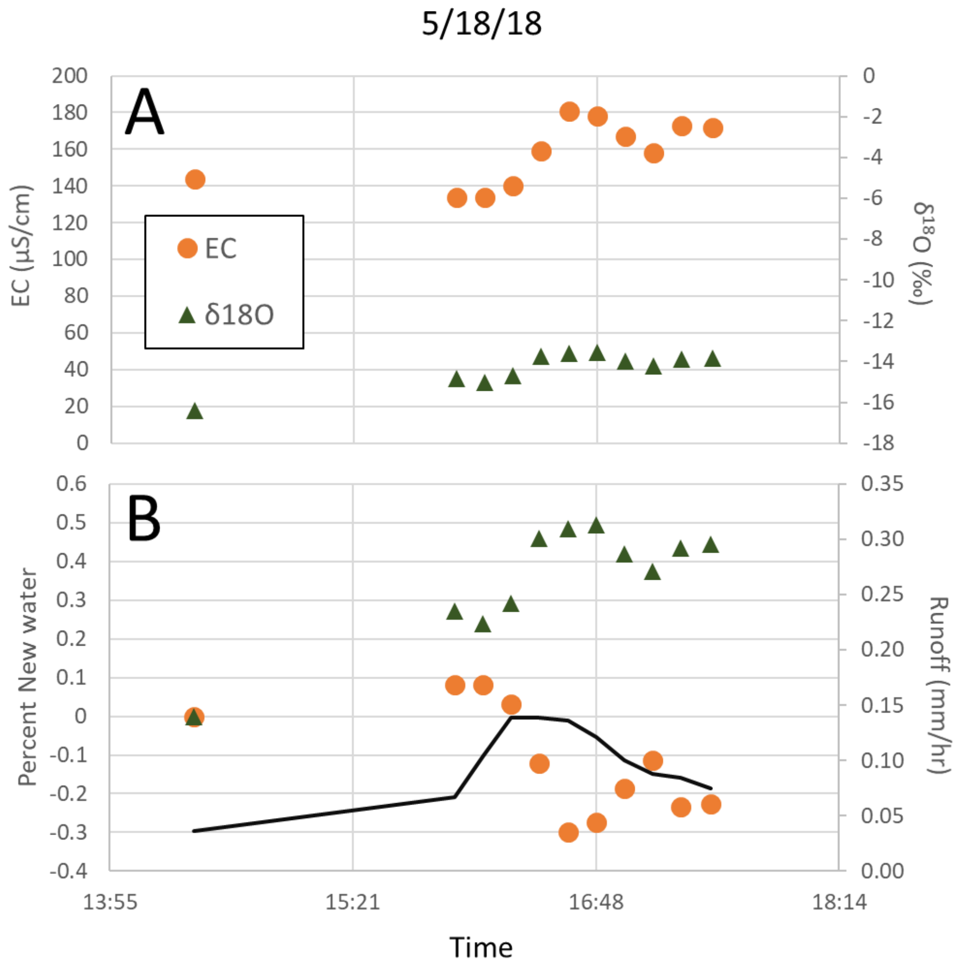

Figure A2. A: Fourmile Creek EC (green triangles) and isotopes values (orange circles) during the storm on May 18th. Note that EC increases during the storm event. B : Results from two-component hydrograph separations using two different tracers, EC (green triangles) and isotopes (orange circles) and runoff (black line). Note that using EC as a tracer yields negative new water contributions.

Table A2. All data collected for Boulder Creek, Fourmile Creek, Keystone Gulch, Hawkin Gulch and Lost Gulch. "- - " indicates samples were not analyzed or data was not retrieved

ID	Location	Date & Time MST	Discharge m^3/s	Runoff mm/hr	EC µS/cm	pH	Temp C°	DOC mg/l	SUVA L/mg-M
18BC004	Boulder Creek	4/18/2018 13:00	--	0.01	98	8.05	6.1	3.48	--
18BC008	Boulder Creek	4/21/2018 11:30	--	0.01	114	7.39	3.9	--	--
18BC013	Boulder Creek	5/3/2018 16:55	--	0.05	154	7.51	6.7	4.74	6.22
18BC018	Boulder Creek	5/11/2018 12:50	--	0.07	85	7.76	11.6	--	--
18BC024	Boulder Creek	5/18/2018 13:50	--	0.05	82	7.71	11.6	6.26	1.50
18BC036	Boulder Creek	5/20/2018 16:15	--	0.05	77	8.11	8.4	6.54	1.67
18BC041	Boulder Creek	5/25/2018 14:20	--	0.11	--	8.02	--	6.01	1.65
18BC053	Boulder Creek	5/31/2018 13:30	--	0.13	53	7.56	--	5.68	1.52
18BC060	Boulder Creek	6/8/2018 14:00	--	0.12	49	7.8	--	4.94	1.26
18BC067	Boulder Creek	6/15/2018 11:10	--	0.11	44	7.81	--	4.80	1.06
18BC074	Boulder Creek	6/17/2018 11:20	--	0.12	42	7.47	--	4.32	1.32
18BC081	Boulder Creek	6/18/2018 12:05	--	0.21	43	7.54	--	5.29	1.18
18BC121	Boulder Creek	6/29/2018 11:20	--	0.05	46	7.74	--	3.97	1.35
18BC128	Boulder Creek	7/4/2018 10:15	--	0.04	52	--	--	3.92	1.25
18BC135	Boulder Creek	7/13/2018 11:40	--	0.04	46	7.78	--	3.72	1.07
18BC161	Boulder Creek	7/23/2018 12:15	--	0.02	58	7.9	--	3.49	0.98
18BC167	Boulder Creek	7/24/2018 11:00	--	0.02	53	7.7	--	3.95	1.02
18BC177	Boulder Creek	8/3/2018 12:25	--	0.02	57	7.82	--	3.19	1.31
18BC183	Boulder Creek	8/10/2018 9:30	--	0.02	53	--	--	2.73	1.42
18BC189	Boulder Creek	8/17/2018 12:10	--	0.01	62	7.87	--	2.96	1.47
18BC195	Boulder Creek	8/24/2018 11:35	--	0.01	61	--	--	3.06	1.96
18BC201	Boulder Creek	8/30/2018 15:45	--	0.01	72	7.56	--	3.46	--
18BC212	Boulder Creek	9/5/2018 4:21	--	0.01	88	7.24	--	5.91	0.80
18BC213	Boulder Creek	9/5/2018 5:36	--	0.01	96	7.3	--	5.57	1.27
18BC207	Boulder Creek	9/5/2018 19:20	--	0.01	78	7.59	--	3.24	1.69
18BC216	Boulder Creek	9/20/2018 15:00	--	0.01	75	7.89	--	3.08	1.46
18BC222	Boulder Creek	9/28/2018 15:10	--	0.01	80	--	--	3.22	1.51
		Detection Limit	--	--	--	--	--	0.4	0.001

ID	Location	Date & Time MST	F mg/l	Cl mg/l	NO_2 mg/l	Br mg/l	NO_3 mg/l	PO_4 mg/l	SO_4 mg/l	Al mg/l	As mg/l
18BC004	Boulder Creek	4/18/2018 13:00	<0.02	5.88	<0.1	<0.1	<0.1	<0.2	3.50	--	--
18BC008	Boulder Creek	4/21/2018 11:30	<0.02	12.68	<0.1	<0.1	<0.1	<0.2	3.56	--	--
18BC013	Boulder Creek	5/3/2018 16:55	<0.02	19.52	<0.1	<0.1	<0.1	<0.2	3.21	0.005	<0.04
18BC018	Boulder Creek	5/11/2018 12:50	<0.02	4.31	<0.1	<0.1	<0.1	<0.2	2.46	--	--
18BC024	Boulder Creek	5/18/2018 13:50	<0.02	2.85	<0.1	<0.1	<0.1	<0.2	2.00	0.012	<0.04
18BC036	Boulder Creek	5/20/2018 16:15	0.11	6.64	<0.1	<0.1	0.15	<0.2	4.48	0.012	<0.04
18BC041	Boulder Creek	5/25/2018 14:20	<0.02	2.21	<0.1	<0.1	<0.1	<0.2	1.75	0.015	<0.04
18BC053	Boulder Creek	5/31/2018 13:30	<0.02	1.36	<0.1	<0.1	<0.1	<0.2	1.52	0.020	<0.04
18BC060	Boulder Creek	6/8/2018 14:00	<0.02	1.22	<0.1	<0.1	<0.1	<0.2	1.48	0.019	<0.04
18BC067	Boulder Creek	6/15/2018 11:10	<0.02	0.85	<0.1	<0.1	<0.1	<0.2	1.25	0.026	<0.04
18BC074	Boulder Creek	6/17/2018 11:20	0.08	1.65	<0.1	<0.1	0.23	<0.2	2.55	0.024	<0.04
18BC081	Boulder Creek	6/18/2018 12:05	0.08	2.18	<0.1	<0.1	0.23	<0.2	2.84	0.021	<0.04
18BC121	Boulder Creek	6/29/2018 11:20	<0.02	0.94	<0.1	<0.1	<0.1	<0.2	1.26	0.016	<0.04
18BC128	Boulder Creek	7/4/2018 10:15	<0.02	1.07	<0.1	<0.1	<0.1	<0.2	1.34	0.015	<0.04
18BC135	Boulder Creek	7/13/2018 11:40	0.09	1.87	<0.1	<0.1	0.19	<0.2	3.18	0.013	<0.04
18BC161	Boulder Creek	7/23/2018 12:15	0.10	2.25	<0.1	<0.1	0.21	<0.2	3.03	0.010	<0.04
18BC167	Boulder Creek	7/24/2018 11:00	0.10	2.61	<0.1	<0.1	0.30	<0.2	3.06	0.008	<0.04
18BC177	Boulder Creek	8/3/2018 12:25	0.10	2.38	<0.1	<0.1	0.18	<0.2	3.71	0.007	<0.04
18BC183	Boulder Creek	8/10/2018 9:30	0.09	2.30	<0.1	<0.1	0.18	<0.2	3.26	0.006	<0.04
18BC189	Boulder Creek	8/17/2018 12:10	0.12	2.81	<0.1	<0.1	<0.1	<0.2	4.17	0.005	<0.04
18BC195	Boulder Creek	8/24/2018 11:35	0.12	2.88	<0.1	<0.1	<0.1	<0.2	4.24	0.006	<0.04
18BC201	Boulder Creek	8/30/2018 15:45	0.14	4.25	<0.1	<0.1	0.10	<0.2	5.36	--	--
18BC212	Boulder Creek	9/5/2018 4:21	0.12	11.04	<0.1	<0.1	0.76	<0.2	4.96	0.003	<0.04
18BC213	Boulder Creek	9/5/2018 5:36	0.13	11.69	<0.1	<0.1	0.82	<0.2	5.30	<0.002	<0.04
18BC207	Boulder Creek	9/5/2018 19:20	0.13	4.61	<0.1	<0.1	0.15	<0.2	4.80	0.005	<0.04
18BC216	Boulder Creek	9/20/2018 15:00	0.13	4.37	<0.1	<0.1	<0.1	<0.2	5.41	0.005	<0.04
18BC222	Boulder Creek	9/28/2018 15:10	0.13	5.09	<0.1	<0.1	<0.1	0.21	5.91	0.004	<0.04
		Detection Limit	0.02	0.1	0.1	0.1	0.1	0.2	0.1	0.003	0.04

ID	Location	Date & Time MST	B mg/l	Ba mg/l	Be mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Cu mg/l	Fe mg/l
18BC004	Boulder Creek	4/18/2018 13:00	--	--	--	--	--	--	--	--	--
18BC008	Boulder Creek	4/21/2018 11:30	--	--	--	--	--	--	--	--	--
18BC013	Boulder Creek	5/3/2018 16:55	<0.007	0.027	<0.0002	10.0	<0.002	<0.003	<0.002	0.001	0.024
18BC018	Boulder Creek	5/11/2018 12:50	--	--	--	--	--	--	--	--	--
18BC024	Boulder Creek	5/18/2018 13:50	<0.007	0.017	<0.0002	6.3	<0.002	<0.003	<0.002	0.003	0.033
18BC036	Boulder Creek	5/20/2018 16:15	<0.007	0.018	<0.0002	7.1	<0.002	<0.003	<0.002	0.001	0.036
18BC041	Boulder Creek	5/25/2018 14:20	<0.007	0.016	<0.0002	5.8	<0.002	<0.003	<0.002	0.001	0.026
18BC053	Boulder Creek	5/31/2018 13:30	<0.007	0.014	<0.0002	5.1	<0.002	<0.003	<0.002	0.001	0.038
18BC060	Boulder Creek	6/8/2018 14:00	<0.007	0.013	<0.0002	4.8	<0.002	<0.003	<0.002	0.001	0.036
18BC067	Boulder Creek	6/15/2018 11:10	<0.007	0.013	<0.0002	4.6	<0.002	<0.003	<0.002	0.001	0.057
18BC074	Boulder Creek	6/17/2018 11:20	<0.007	0.012	<0.0002	4.6	<0.002	<0.003	<0.002	0.001	0.048
18BC081	Boulder Creek	6/18/2018 12:05	<0.007	0.011	<0.0002	4.3	<0.002	<0.003	<0.002	0.001	0.049
18BC121	Boulder Creek	6/29/2018 11:20	<0.007	0.013	<0.0002	4.9	<0.002	<0.003	<0.002	0.001	0.042
18BC128	Boulder Creek	7/4/2018 10:15	<0.007	0.013	<0.0002	5.0	<0.002	<0.003	<0.002	0.001	0.045
18BC135	Boulder Creek	7/13/2018 11:40	<0.007	0.013	<0.0002	5.0	<0.002	<0.003	<0.002	0.001	0.046
18BC161	Boulder Creek	7/23/2018 12:15	<0.007	0.014	<0.0002	5.3	<0.002	<0.003	<0.002	0.001	0.041
18BC167	Boulder Creek	7/24/2018 11:00	<0.007	0.014	<0.0002	5.5	<0.002	<0.003	<0.002	0.001	0.040
18BC177	Boulder Creek	8/3/2018 12:25	<0.007	0.014	<0.0002	5.5	<0.002	<0.003	<0.002	0.001	0.044
18BC183	Boulder Creek	8/10/2018 9:30	<0.007	0.014	<0.0002	5.6	<0.002	<0.003	<0.002	0.001	0.035
18BC189	Boulder Creek	8/17/2018 12:10	<0.007	0.015	<0.0002	5.9	<0.002	<0.003	<0.002	0.001	0.030
18BC195	Boulder Creek	8/24/2018 11:35	0.039	0.015	<0.0005	6.2	<0.002	<<0.003	<0.002	<0.001	0.032
18BC201	Boulder Creek	8/30/2018 15:45	--	--	--	--	--	--	--	--	--
18BC212	Boulder Creek	9/5/2018 4:21	<0.007	0.017	<0.0005	6.6	<0.002	<<0.003	<0.002	0.001	0.015
18BC213	Boulder Creek	9/5/2018 5:36	<0.007	0.018	<0.0005	7.0	<0.002	<<0.003	<0.002	0.001	0.010
18BC207	Boulder Creek	9/5/2018 19:20	<0.007	0.017	<0.0005	7.3	<0.002	<<0.003	<0.002	<0.001	0.025
18BC216	Boulder Creek	9/20/2018 15:00	<0.007	0.018	<0.0005	7.1	<0.002	<<0.003	<0.002	0.001	0.030
18BC222	Boulder Creek	9/28/2018 15:10	<0.007	0.019	<0.0005	7.5	<0.002	<<0.003	<0.002	0.001	0.021
		Detection Limit	0.007	0.001	0.0005	0.02	0.002	0.003	0.002	0.002	0.002

ID	Location	Date & Time MST	K mg/l	Li mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Na mg/l	Ni mg/l	P mg/l	Pb mg/l
18BC004	Boulder Creek	4/18/2018 13:00	--	--	--	--	--	--	--	--	--
18BC008	Boulder Creek	4/21/2018 11:30	--	--	--	--	--	--	--	--	--
18BC013	Boulder Creek	5/3/2018 16:55	0.99	<0.001	2.80	0.0020	<0.005	14.90	<0.003	<0.04	<0.02
18BC018	Boulder Creek	5/11/2018 12:50	--	--	--	--	--	--	--	--	--
18BC024	Boulder Creek	5/18/2018 13:50	0.69	<0.001	1.68	0.0020	<0.005	3.75	<0.003	<0.04	<0.02
18BC036	Boulder Creek	5/20/2018 16:15	0.74	<0.001	1.94	0.0020	<0.005	4.62	<0.003	<0.04	<0.02
18BC041	Boulder Creek	5/25/2018 14:20	0.63	<0.001	1.47	0.0030	<0.005	3.32	<0.003	<0.04	<0.02
18BC053	Boulder Creek	5/31/2018 13:30	0.54	<0.001	1.22	0.0030	<0.005	2.50	<0.003	<0.04	<0.02
18BC060	Boulder Creek	6/8/2018 14:00	0.50	<0.001	1.13	0.0020	<0.005	2.28	<0.003	<0.04	<0.02
18BC067	Boulder Creek	6/15/2018 11:10	0.45	<0.001	1.05	0.0020	<0.005	1.97	<0.003	<0.04	<0.02
18BC074	Boulder Creek	6/17/2018 11:20	0.47	<0.001	0.99	<0.001	<0.005	1.92	<0.003	<0.04	<0.02
18BC081	Boulder Creek	6/18/2018 12:05	0.46	<0.001	0.97	0.0020	<0.005	2.15	<0.003	<0.04	<0.02
18BC121	Boulder Creek	6/29/2018 11:20	0.46	<0.001	1.13	0.0020	<0.005	2.08	<0.003	<0.04	<0.02
18BC128	Boulder Creek	7/4/2018 10:15	0.47	<0.001	1.16	0.0020	<0.005	2.26	<0.003	<0.04	<0.02
18BC135	Boulder Creek	7/13/2018 11:40	0.49	<0.001	1.14	0.0020	<0.005	2.19	<0.003	<0.04	<0.02
18BC161	Boulder Creek	7/23/2018 12:15	0.52	<0.001	1.25	0.0030	<0.005	2.54	<0.003	<0.04	<0.02
18BC167	Boulder Creek	7/24/2018 11:00	0.54	<0.001	1.33	0.0035	<0.005	2.72	<0.003	<0.04	<0.02
18BC177	Boulder Creek	8/3/2018 12:25	0.53	<0.001	1.27	0.0020	<0.005	2.66	<0.003	<0.04	<0.02
18BC183	Boulder Creek	8/10/2018 9:30	0.53	<0.001	1.29	0.0020	<0.005	2.69	<0.003	<0.04	<0.02
18BC189	Boulder Creek	8/17/2018 12:10	0.56	<0.001	1.37	0.0030	<0.005	2.98	<0.003	<0.04	<0.02
18BC195	Boulder Creek	8/24/2018 11:35	0.62	<0.001	1.42	0.0028	<0.005	3.10	0.005	<0.04	<0.02
18BC201	Boulder Creek	8/30/2018 15:45	--	--	--	--	--	--	--	--	--
18BC212	Boulder Creek	9/5/2018 4:21	1.08	<0.001	1.60	0.0013	<0.005	7.50	0.005	<0.04	<0.02
18BC213	Boulder Creek	9/5/2018 5:36	1.04	<0.001	1.79	0.0007	<0.005	8.40	0.005	<0.04	<0.02
18BC207	Boulder Creek	9/5/2018 19:20	0.80	<0.001	1.62	0.0036	<0.005	4.30	0.005	<0.04	<0.02
18BC216	Boulder Creek	9/20/2018 15:00	0.78	<0.001	1.74	0.0033	<0.005	4.20	0.005	<0.04	<0.02
18BC222	Boulder Creek	9/28/2018 15:10	0.78	<0.001	1.90	0.0014	<0.005	4.60	0.005	<0.04	<0.02
		Detection Limit	0.04	0.001	0.002	0.001	0.005	0.07	0.003	0.04	0.02

ID	Location	Date & Time MST	Rb mg/l	Sb mg/l	Se mg/l	SiO2 mg/l	Sr mg/l	U mg/l	V mg/l	W mg/l	Zn mg/l
18BC004	Boulder Creek	4/18/2018 13:00	--	--	--	--	--	--	--	--	--
18BC008	Boulder Creek	4/21/2018 11:30	--	--	--	--	--	--	--	--	--
18BC013	Boulder Creek	5/3/2018 16:55	<0.002	<0.03	<0.04	6.25	0.083	<0.004	<0.001	<0.01	0.004
18BC018	Boulder Creek	5/11/2018 12:50	--	--	--	--	--	--	--	--	--
18BC024	Boulder Creek	5/18/2018 13:50	<0.002	<0.03	<0.04	6.38	0.054	<0.004	<0.001	<0.01	0.003
18BC036	Boulder Creek	5/20/2018 16:15	<0.002	<0.03	<0.04	7.20	0.060	<0.004	<0.001	<0.01	0.003
18BC041	Boulder Creek	5/25/2018 14:20	<0.002	<0.03	<0.04	6.12	0.048	<0.004	<0.001	<0.01	0.003
18BC053	Boulder Creek	5/31/2018 13:30	<0.002	<0.03	<0.04	5.47	0.041	<0.004	<0.001	<0.01	0.006
18BC060	Boulder Creek	6/8/2018 14:00	<0.002	<0.03	<0.04	5.08	0.039	<0.004	<0.001	<0.01	0.003
18BC067	Boulder Creek	6/15/2018 11:10	<0.002	<0.03	<0.04	4.76	0.036	<0.004	<0.001	<0.01	0.007
18BC074	Boulder Creek	6/17/2018 11:20	<0.002	<0.03	<0.04	4.77	0.036	<0.004	<0.001	<0.01	0.007
18BC081	Boulder Creek	6/18/2018 12:05	<0.002	<0.03	<0.04	4.67	0.035	<0.004	<0.001	<0.01	0.006
18BC121	Boulder Creek	6/29/2018 11:20	<0.002	<0.03	<0.04	4.85	0.039	<0.004	<0.001	<0.01	0.007
18BC128	Boulder Creek	7/4/2018 10:15	<0.002	<0.03	<0.04	4.87	0.041	<0.004	<0.001	<0.01	0.002
18BC135	Boulder Creek	7/13/2018 11:40	<0.002	<0.03	<0.04	4.74	0.041	<0.004	<0.001	<0.01	0.008
18BC161	Boulder Creek	7/23/2018 12:15	<0.002	<0.03	<0.04	4.72	0.044	0.007	<0.001	<0.01	0.002
18BC167	Boulder Creek	7/24/2018 11:00	<0.002	<0.03	<0.04	5.12	0.046	0.007	<0.001	<0.01	0.002
18BC177	Boulder Creek	8/3/2018 12:25	<0.002	<0.03	<0.04	4.45	0.047	0.007	<0.001	<0.01	0.003
18BC183	Boulder Creek	8/10/2018 9:30	<0.002	<0.03	<0.04	4.21	0.047	0.007	<0.001	<0.01	0.002
18BC189	Boulder Creek	8/17/2018 12:10	<0.002	<0.03	<0.04	4.31	0.051	0.007	<0.001	<0.01	0.002
18BC195	Boulder Creek	8/24/2018 11:35	<0.002	<0.03	<0.04	4.49	0.053	<0.004	<0.001	<0.01	0.002
18BC201	Boulder Creek	8/30/2018 15:45	--	--	--	--	--	--	--	--	--
18BC212	Boulder Creek	9/5/2018 4:21	<0.002	<0.03	<0.04	4.13	0.061	<0.004	<0.001	<0.01	0.003
18BC213	Boulder Creek	9/5/2018 5:36	<0.002	<0.03	<0.04	4.41	0.064	<0.004	<0.001	<0.01	0.003
18BC207	Boulder Creek	9/5/2018 19:20	<0.002	<0.03	<0.04	5.01	0.059	<0.004	<0.001	<0.01	0.015
18BC216	Boulder Creek	9/20/2018 15:00	<0.002	<0.03	<0.04	5.05	0.065	<0.004	<0.001	<0.01	0.004
18BC222	Boulder Creek	9/28/2018 15:10	<0.002	<0.03	<0.04	5.43	0.071	<0.004	<0.001	<0.01	0.006
		Detection Limit	0.002	0.03	0.04	0.03	0.001	0.004	0.001	0.01	0.001

ID	Location	Date & Time MST	$\delta^{18}O$ ‰	^{2}H ‰	Deuterium Excess
18BC004	Boulder Creek	4/18/2018 13:00	-16.35	-122.12	8.72
18BC008	Boulder Creek	4/21/2018 11:30	-16.41	-121.16	10.10
18BC013	Boulder Creek	5/3/2018 16:55	-16.83	-125.34	9.28
18BC018	Boulder Creek	5/11/2018 12:50	-16.62	-124.55	8.37
18BC024	Boulder Creek	5/18/2018 13:50	-16.94	-126.43	9.06
18BC036	Boulder Creek	5/20/2018 16:15	-16.85	-125.79	9.04
18BC041	Boulder Creek	5/25/2018 14:20	-17.27	-127.72	10.43
18BC053	Boulder Creek	5/31/2018 13:30	-17.36	-128.81	10.06
18BC060	Boulder Creek	6/8/2018 14:00	-18.26	-130.1	15.98
18BC067	Boulder Creek	6/15/2018 11:10	-17.7	-130.22	11.36
18BC074	Boulder Creek	6/17/2018 11:20	-17.55	-128.65	11.77
18BC081	Boulder Creek	6/18/2018 12:05	-17.46	-128.25	11.46
18BC121	Boulder Creek	6/29/2018 11:20	-17.69	-129.24	12.27
18BC128	Boulder Creek	7/4/2018 10:15	-17.68	-129.58	11.84
18BC135	Boulder Creek	7/13/2018 11:40	-17.46	-128.23	11.47
18BC161	Boulder Creek	7/23/2018 12:15	-16.92	-125.94	9.39
18BC167	Boulder Creek	7/24/2018 11:00	-16.98	-124.7	11.18
18BC177	Boulder Creek	8/3/2018 12:25	-16.84	-124.96	9.80
18BC183	Boulder Creek	8/10/2018 9:30	-16.73	-125.18	8.65
18BC189	Boulder Creek	8/17/2018 12:10	-17.16	-124.16	13.16
18BC195	Boulder Creek	8/24/2018 11:35	-16.8	-123.35	11.05
18BC201	Boulder Creek	8/30/2018 15:45	-16.28	-121.12	9.15
18BC212	Boulder Creek	9/5/2018 4:21	-14.96	-109.97	9.74
18BC213	Boulder Creek	9/5/2018 5:36	-15.51	-111.69	12.38
18BC207	Boulder Creek	9/5/2018 19:20	-16.51	-120.69	11.37
18BC216	Boulder Creek	9/20/2018 15:00	-16.15	-119.64	9.58
18BC222	Boulder Creek	9/28/2018 15:10	-16.19	-120.27	9.26
		Detection Limit	--	--	--

ID	Location	Date & Time MST	Discharge m^3/s	Runoff mm/hr	EC µS/cm	pH	Temp C°	DOC mg/l	SUVA L/mg-M
18BC005	Fourmile Creek	4/18/2018 13:15	0.092	0.01	285	8.2	9	2.52	--
18BC006	Fourmile Creek	4/21/2018 10:25	--	0.01	268	8.4	3.5	--	--
18BC011	Fourmile Creek	5/3/2018 17:45	0.592	0.03	155	7.36	7.3	5.32	1.67
18BC016	Fourmile Creek	5/11/2018 10:15	0.555	0.03	172	7.62	10.7	--	--
18BC022	Fourmile Creek	5/18/2018 14:25	0.643	0.04	144	8.02	12.5	4.25	6.76
18BC028	Fourmile Creek	5/18/2018 15:58	1.189	0.07	134	--	--	5.33	2.43
18BC029	Fourmile Creek	5/18/2018 16:08	1.841	0.10	134	--	--	5.24	1.90
18BC030	Fourmile Creek	5/18/2018 16:18	2.464	0.14	140	--	--	5.26	1.84
FCBC BTL 4 5/18/2018	Fourmile Creek	5/18/2018 16:28	2.464	0.14	159	--	--	--	--
18BC031	Fourmile Creek	5/18/2018 16:38	2.407	0.14	181	--	--	6.15	1.59
FCBC BTL 6 5/18/2018	Fourmile Creek	5/18/2018 16:48	2.152	0.12	178	--	--	--	--
FCBC BTL 7 5/18/2018	Fourmile Creek	5/18/2018 16:58	1.784	0.10	167	--	--	--	--
18BC032	Fourmile Creek	5/18/2018 17:08	1.557	0.09	158	--	--	6.93	1.66
FCBC BTL 9 5/18/2018	Fourmile Creek	5/18/2018 17:18	1.501	0.08	173	--	--	--	--
FCBC BTL 10 5/18/2018	Fourmile Creek	5/18/2018 17:29	1.331	0.08	172	--	--	--	--
18BC033	Fourmile Creek	5/19/2018 13:15	1.019	0.06	156	--	--	4.51	2.84
18BC034	Fourmile Creek	5/20/2018 17:00	0.813	0.05	175	7.85	--	5.23	1.47
18BC039	Fourmile Creek	5/25/2018 15:15	0.583	0.03	180	7.83	--	3.80	5.19
18BC051	Fourmile Creek	5/31/2018 14:45	0.467	0.03	173	7.92	--	3.26	4.00
18BC058	Fourmile Creek	6/8/2018 14:45	0.242	0.01	168	7.85	--	2.60	4.19
18BC065	Fourmile Creek	6/15/2018 12:20	0.132	0.01	187	7.84	--	2.49	4.10
18BC072	Fourmile Creek	6/17/2018 12:00	0.131	0.01	197	7.94	--	2.81	3.67
18BC089	Fourmile Creek	6/18/2018 0:06	0.216	0.01	184	--	--	4.45	4.49
18BC090	Fourmile Creek	6/18/2018 1:16	0.238	0.01	191	--	--	3.94	1.63
18BC091	Fourmile Creek	6/18/2018 3:26	0.253	0.01	195	--	--	3.95	1.55
18BC092	Fourmile Creek	6/18/2018 3:56	0.223	0.01	184	--	--	3.61	1.77
18BC079	Fourmile Creek	6/18/2018 13:10	0.169	0.01	182	--	--	2.97	4.40
18BC100	Fourmile Creek	6/18/2018 18:03	0.317	0.02	154	--	--	4.91	2.61
18BC101	Fourmile Creek	6/18/2018 18:23	0.592	0.03	139	--	--	7.38	1.05
18BC102	Fourmile Creek	6/18/2018 19:53	0.275	0.02	246	--	--	7.49	1.82
18BC085	Fourmile Creek	6/19/2018 12:05	0.163	0.01	226	--	--	3.37	3.87
18BC114	Fourmile Creek	6/19/2018 13:27	0.716	0.04	230	--	--	3.57	1.20
18BC115	Fourmile Creek	6/19/2018 14:37	0.385	0.02	179	--	--	5.86	0.87
18BC116	Fourmile Creek	6/19/2018 15:17	0.292	0.02	243	--	--	7.98	--
18BC117	Fourmile Creek	6/19/2018 17:17	0.223	0.01	263	--	--	5.08	2.48
18BC113	Fourmile Creek	6/20/2018 9:00	0.168	0.01	241	--	--	2.93	8.05
18BC119	Fourmile Creek	6/29/2018 12:10	0.070	0.00	--	8.18	--	2.84	3.14
18BC126	Fourmile Creek	7/4/2018 10:45	0.055	0.00	305	--	--	3.23	2.66
18BC133	Fourmile Creek	7/13/2018 12:00	--	0.00	328	8.19	--	3.25	2.23
18BC140	Fourmile Creek	7/15/2018 13:30	0.035	0.00	327	--	--	6.97	2.09
18BC143	Fourmile Creek	7/16/2018 12:25	--	0.00	348	--	--	3.16	1.74
18BC153	Fourmile Creek	7/20/2018 13:00	0.022	0.00	336	8.32	--	3.13	2.00
18BC159	Fourmile Creek	7/23/2018 12:55	0.042	0.00	369	8.5	--	3.16	2.13
18BC174	Fourmile Creek	7/23/2018 16:25	0.165	0.01	292	--	--	5.42	4.01
18BC165	Fourmile Creek	7/24/2018 11:25	0.064	0.00	380	8.14	--	4.04	1.92
18BC176	Fourmile Creek	8/3/2018 12:50	--	0.00	367	8.3	--	2.96	2.05
18BC182	Fourmile Creek	8/10/2018 9:40	0.016	0.00	381	8.15	--	2.90	1.96
18BC188	Fourmile Creek	8/17/2018 12:25	0.015	0.00	--	8.26	--	3.33	1.48
18BC194	Fourmile Creek	8/24/2018 11:45	0.011	0.00	418	8.33	--	3.03	1.63
18BC200	Fourmile Creek	8/30/2018 16:00	0.010	0.00	435	8.21	--	3.80	--
18BC206	Fourmile Creek	9/5/2018 19:35	0.012	0.00	410	8.06	--	4.35	1.35
18BC215	Fourmile Creek	9/20/2018 15:20	0.003	0.00	471	--	--	5.48	1.55
18BC221	Fourmile Creek	9/28/2018 15:25	0.007	0.00	440	--	--	3.18	1.43
		Detection Limit	--	--	--	--	--	0.4	0.001

ID	Location	Date & Time MST	F mg/l	Cl mg/l	NO_2 mg/l	Br mg/l	NO_3 mg/l	PO_4 mg/l	SO_4 mg/l	Al mg/l	As mg/l
18BC005	Fourmile Creek	4/18/2018 13:15	0.08	13.45	<0.1	<0.1	<0.1	<0.2	41.68	--	--
18BC006	Fourmile Creek	4/21/2018 10:25	0.07	13.43	<0.1	<0.1	<0.1	<0.2	39.32	--	--
18BC011	Fourmile Creek	5/3/2018 17:45	0.04	12.19	<0.1	<0.1	<0.1	<0.2	26.46	0.009	<0.04
18BC016	Fourmile Creek	5/11/2018 10:15	<0.02	6.94	<0.1	<0.1	<0.1	<0.2	17.97	--	--
18BC022	Fourmile Creek	5/18/2018 14:25	<0.02	4.16	<0.1	<0.1	<0.1	<0.2	14.02	0.007	<0.04
18BC028	Fourmile Creek	5/18/2018 15:58	<0.02	3.91	<0.1	<0.1	<0.1	<0.2	12.01	0.008	<0.04
18BC029	Fourmile Creek	5/18/2018 16:08	<0.02	3.68	<0.1	<0.1	<0.1	<0.2	11.78	0.007	<0.04
18BC030	Fourmile Creek	5/18/2018 16:18	<0.02	4.37	<0.1	<0.1	<0.1	<0.2	11.88	0.007	<0.04
FCBC BTL 4 5/18/2018	Fourmile Creek	5/18/2018 16:28	--	--	--	--	--	--	--	--	--
18BC031	Fourmile Creek	5/18/2018 16:38	0.03	8.63	<0.1	<0.1	0.29	<0.2	10.16	0.009	<0.04
FCBC BTL 6 5/18/2018	Fourmile Creek	5/18/2018 16:48	--	--	--	--	--	--	--	--	--
FCBC BTL 7 5/18/2018	Fourmile Creek	5/18/2018 16:58	--	--	--	--	--	--	--	--	--
18BC032	Fourmile Creek	5/18/2018 17:08	<0.02	5.66	<0.1	<0.1	0.17	<0.2	11.18	0.009	<0.04
FCBC BTL 9 5/18/2018	Fourmile Creek	5/18/2018 17:18	--	--	--	--	--	--	--	--	--
FCBC BTL 10 5/18/2018	Fourmile Creek	5/18/2018 17:29	--	--	--	--	--	--	--	--	--
18BC033	Fourmile Creek	5/19/2018 13:15	<0.02	5.06	<0.1	<0.1	<0.1	<0.2	14.67	0.008	<0.04
18BC034	Fourmile Creek	5/20/2018 17:00	<0.02	5.89	<0.1	<0.1	<0.1	<0.2	16.55	0.007	<0.04
18BC039	Fourmile Creek	5/25/2018 15:15	<0.02	4.62	<0.1	<0.1	<0.1	<0.2	15.63	0.009	<0.04
18BC051	Fourmile Creek	5/31/2018 14:45	<0.02	4.91	<0.1	<0.1	<0.1	<0.2	16.34	0.009	<0.04
18BC058	Fourmile Creek	6/8/2018 14:45	<0.02	4.14	<0.1	<0.1	<0.1	<0.2	15.89	0.007	<0.04
18BC065	Fourmile Creek	6/15/2018 12:20	0.03	4.50	<0.1	<0.1	<0.1	<0.2	18.37	0.008	<0.04
18BC072	Fourmile Creek	6/17/2018 12:00	0.19	7.95	<0.1	<0.1	<0.1	0.21	29.86	0.006	<0.04
18BC089	Fourmile Creek	6/18/2018 0:06	<0.02	7.69	<0.1	<0.1	<0.1	0.26	25.31	0.006	<0.04
18BC090	Fourmile Creek	6/18/2018 1:16	0.04	6.05	<0.1	<0.1	<0.1	<0.2	16.86	0.009	<0.04
18BC091	Fourmile Creek	6/18/2018 3:26	0.09	5.64	<0.1	<0.1	<0.1	<0.2	18.07	0.007	<0.04
18BC092	Fourmile Creek	6/18/2018 3:56	0.06	4.77	<0.1	<0.1	<0.1	<0.2	16.70	0.006	<0.04
18BC079	Fourmile Creek	6/18/2018 13:10	0.14	7.81	<0.1	<0.1	<0.1	0.31	25.86	0.007	<0.04
18BC100	Fourmile Creek	6/18/2018 18:03	<0.02	3.69	<0.1	<0.1	<0.1	<0.2	12.94	0.005	<0.04
18BC101	Fourmile Creek	6/18/2018 18:23	<0.02	2.80	<0.1	<0.1	<0.1	<0.2	9.09	0.008	<0.04
18BC102	Fourmile Creek	6/18/2018 19:53	0.07	11.57	<0.1	<0.1	<0.1	<0.2	14.29	0.008	<0.04
18BC085	Fourmile Creek	6/19/2018 12:05	0.19	11.18	<0.1	<0.1	<0.1	0.27	33.23	0.008	<0.04
18BC114	Fourmile Creek	6/19/2018 13:27	0.07	6.99	<0.1	<0.1	<0.1	<0.2	21.05	0.007	<0.04
18BC115	Fourmile Creek	6/19/2018 14:37	0.06	4.57	<0.1	<0.1	<0.1	<0.2	14.75	0.017	<0.04
18BC116	Fourmile Creek	6/19/2018 15:17	0.09	10.67	<0.1	<0.1	<0.1	<0.2	15.92	--	--
18BC117	Fourmile Creek	6/19/2018 17:17	0.23	15.14	<0.1	<0.1	0.14	0.20	37.90	0.009	<0.04
18BC113	Fourmile Creek	6/20/2018 9:00	0.05	7.24	<0.1	<0.1	<0.1	<0.2	22.29	0.009	<0.04
18BC119	Fourmile Creek	6/29/2018 12:10	0.07	8.05	<0.1	<0.1	<0.1	<0.2	27.94	0.009	<0.04
18BC126	Fourmile Creek	7/4/2018 10:45	0.39	8.85	<0.1	<0.1	<0.1	<0.2	30.84	0.009	<0.04
18BC133	Fourmile Creek	7/13/2018 12:00	0.27	18.60	<0.1	<0.1	<0.1	0.69	56.80	0.007	<0.04
18BC140	Fourmile Creek	7/15/2018 13:30	0.27	17.56	<0.1	<0.1	0.11	0.39	54.22	0.006	<0.04
18BC143	Fourmile Creek	7/16/2018 12:25	0.29	24.70	<0.1	<0.1	<0.1	<0.2	55.19	0.006	<0.04
18BC153	Fourmile Creek	7/20/2018 13:00	0.26	17.67	<0.1	<0.1	<0.1	0.55	53.60	0.006	<0.04
18BC159	Fourmile Creek	7/23/2018 12:55	0.27	30.63	<0.1	<0.1	0.25	<0.2	59.48	0.006	<0.04
18BC174	Fourmile Creek	7/23/2018 16:25	0.23	20.24	<0.1	<0.1	0.38	0.36	46.39	0.005	<0.04
18BC165	Fourmile Creek	7/24/2018 11:25	0.24	28.36	<0.1	<0.1	0.19	0.40	56.45	0.008	<0.04
18BC176	Fourmile Creek	8/3/2018 12:50	0.27	21.49	0.05	<0.1	2.83	<0.2	62.12	0.006	<0.04
18BC182	Fourmile Creek	8/10/2018 9:40	0.27	22.08	<0.1	<0.1	<0.1	0.57	64.30	0.006	<0.04
18BC188	Fourmile Creek	8/17/2018 12:25	0.31	31.70	<0.1	<0.1	<0.1	0.27	75.82	0.007	<0.04
18BC194	Fourmile Creek	8/24/2018 11:45	0.30	27.90	<0.1	<0.1	<0.1	0.21	79.03	0.009	<0.04
18BC200	Fourmile Creek	8/30/2018 16:00	0.31	29.93	<0.1	<0.1	<0.1	<0.2	78.43	--	--
18BC206	Fourmile Creek	9/5/2018 19:35	0.30	27.52	<0.1	<0.1	<0.1	<0.2	85.52	0.007	<0.04
18BC215	Fourmile Creek	9/20/2018 15:20	0.33	35.90	<0.1	<0.1	<0.1	0.46	87.37	0.009	<0.04
18BC221	Fourmile Creek	9/28/2018 15:25	0.30	33.28	<0.1	<0.1	<0.1	0.30	93.51	0.007	<0.04
		Detection Limit	0.02	0.1	0.1	0.1	0.1	0.2	0.1	0.003	0.04

ID	Location	Date & Time MST	B mg/l	Ba mg/l	Be mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Cu mg/l	Fe mg/l
18BC005	Fourmile Creek	4/18/2018 13:15	--	--	--	--	--	--	--	--	--
18BC006	Fourmile Creek	4/21/2018 10:25	--	--	--	--	--	--	--	--	--
18BC011	Fourmile Creek	5/3/2018 17:45	0.014	0.039	<0.0002	22.6	<0.002	<0.003	<0.002	0.002	0.007
18BC016	Fourmile Creek	5/11/2018 10:15	--	--	--	--	--	--	--	--	--
18BC022	Fourmile Creek	5/18/2018 14:25	0.008	0.025	<0.0002	13.0	<0.002	<0.003	<0.002	0.001	0.009
18BC028	Fourmile Creek	5/18/2018 15:58	0.010	0.022	<0.0002	12.9	<0.002	<0.003	<0.002	0.012	0.008
18BC029	Fourmile Creek	5/18/2018 16:08	0.010	0.026	<0.0002	13.5	<0.002	<0.003	<0.002	0.007	0.011
18BC030	Fourmile Creek	5/18/2018 16:18	0.010	0.030	<0.0002	15.1	<0.002	<0.003	<0.002	0.002	0.011
FCBC BTL 4 5/18/2018	Fourmile Creek	5/18/2018 16:28	--	--	--	--	--	--	--	--	--
18BC031	Fourmile Creek	5/18/2018 16:38	0.026	0.033	<0.0002	19.6	<0.002	<0.003	<0.002	0.003	0.004
FCBC BTL 6 5/18/2018	Fourmile Creek	5/18/2018 16:48	--	--	--	--	--	--	--	--	--
FCBC BTL 7 5/18/2018	Fourmile Creek	5/18/2018 16:58	--	--	--	--	--	--	--	--	--
18BC032	Fourmile Creek	5/18/2018 17:08	0.014	0.029	<0.0002	16.5	<0.002	<0.003	<0.002	0.004	0.011
FCBC BTL 9 5/18/2018	Fourmile Creek	5/18/2018 17:18	--	--	--	--	--	--	--	--	--
FCBC BTL 10 5/18/2018	Fourmile Creek	5/18/2018 17:29	--	--	--	--	--	--	--	--	--
18BC033	Fourmile Creek	5/19/2018 13:15	0.011	0.026	<0.0002	15.0	<0.002	<0.003	<0.002	0.002	0.009
18BC034	Fourmile Creek	5/20/2018 17:00	0.011	0.030	<0.0002	17.0	<0.002	<0.003	<0.002	0.001	0.010
18BC039	Fourmile Creek	5/25/2018 15:15	0.011	0.028	<0.0002	15.5	<0.002	<0.003	<0.002	0.002	0.008
18BC051	Fourmile Creek	5/31/2018 14:45	0.012	0.029	<0.0002	16.5	<0.002	<0.003	<0.002	0.001	0.003
18BC058	Fourmile Creek	6/8/2018 14:45	0.009	0.029	<0.0002	15.8	<0.002	<0.003	<0.002	0.001	0.006
18BC065	Fourmile Creek	6/15/2018 12:20	0.013	0.033	<0.0002	18.2	<0.002	<0.003	<0.002	0.002	0.007
18BC072	Fourmile Creek	6/17/2018 12:00	0.013	0.034	<0.0002	19.2	<0.002	<0.003	<0.002	0.001	0.009
18BC089	Fourmile Creek	6/18/2018 0:06	0.016	0.034	<0.0002	18.3	<0.002	<0.003	<0.002	0.003	0.009
18BC090	Fourmile Creek	6/18/2018 1:16	0.016	0.033	<0.0002	18.5	<0.002	<0.003	<0.002	0.002	0.007
18BC091	Fourmile Creek	6/18/2018 3:26	0.016	0.036	<0.0002	19.6	<0.002	<0.003	<0.002	0.024	0.006
18BC092	Fourmile Creek	6/18/2018 3:56	0.013	0.033	<0.0002	18.1	<0.002	<0.003	<0.002	0.002	0.006
18BC079	Fourmile Creek	6/18/2018 13:10	0.013	0.033	<0.0002	18.7	<0.002	<0.003	<0.002	0.002	0.010
18BC100	Fourmile Creek	6/18/2018 18:03	0.012	0.029	<0.0002	15.7	<0.002	<0.003	<0.002	0.002	0.007
18BC101	Fourmile Creek	6/18/2018 18:23	0.015	0.033	<0.0002	15.7	<0.002	<0.003	<0.002	0.002	0.013
18BC102	Fourmile Creek	6/18/2018 19:53	0.030	0.043	<0.0002	25.2	<0.002	<0.003	<0.002	0.002	0.004
18BC085	Fourmile Creek	6/19/2018 12:05	0.014	0.040	<0.0002	22.9	<0.002	<0.003	<0.002	0.002	0.011
18BC114	Fourmile Creek	6/19/2018 13:27	0.018	0.039	<0.0002	23.2	<0.002	<0.003	<0.002	0.001	0.003
18BC115	Fourmile Creek	6/19/2018 14:37	0.014	0.037	<0.0002	19.7	<0.002	<0.003	<0.002	0.002	0.004
18BC116	Fourmile Creek	6/19/2018 15:17	--	--	--	--	--	--	--	--	--
18BC117	Fourmile Creek	6/19/2018 17:17	0.031	0.042	<0.0002	28.1	<0.002	<0.003	<0.002	0.003	<0.002
18BC113	Fourmile Creek	6/20/2018 9:00	0.018	0.039	<0.0002	24.0	<0.002	<0.003	<0.002	0.002	0.004
18BC119	Fourmile Creek	6/29/2018 12:10	0.018	0.047	<0.0002	28.5	<0.002	<0.003	<0.002	0.001	0.010
18BC126	Fourmile Creek	7/4/2018 10:45	0.019	0.050	<0.0002	31.3	<0.002	<0.003	<0.002	0.001	0.015
18BC133	Fourmile Creek	7/13/2018 12:00	0.024	0.057	<0.0002	34.1	<0.002	<0.003	<0.002	0.001	0.027
18BC140	Fourmile Creek	7/15/2018 13:30	0.025	0.060	<0.0002	34.0	<0.002	<0.003	<0.002	0.001	0.033
18BC143	Fourmile Creek	7/16/2018 12:25	0.033	0.060	<0.0002	33.6	<0.002	<0.003	<0.002	0.001	0.018
18BC153	Fourmile Creek	7/20/2018 13:00	0.024	0.060	<0.0002	35.2	<0.002	<0.003	<0.002	0.001	0.022
18BC159	Fourmile Creek	7/23/2018 12:55	0.042	0.065	<0.0002	35.9	<0.002	<0.003	<0.002	0.001	0.007
18BC174	Fourmile Creek	7/23/2018 16:25	0.032	0.055	<0.0002	30.1	<0.002	<0.003	<0.002	0.002	0.007
18BC165	Fourmile Creek	7/24/2018 11:25	0.045	0.055	<0.0002	34.6	<0.002	<0.003	<0.002	0.002	0.004
18BC176	Fourmile Creek	8/3/2018 12:50	0.030	0.065	<0.0002	37.5	<0.002	<0.003	<0.002	0.001	0.015
18BC182	Fourmile Creek	8/10/2018 9:40	0.029	0.070	<0.0002	40.2	<0.002	<0.003	<0.002	0.001	0.020
18BC188	Fourmile Creek	8/17/2018 12:25	0.036	0.071	<0.0002	45.1	<0.002	<0.003	<0.002	0.001	<0.002
18BC194	Fourmile Creek	8/24/2018 11:45	0.031	0.073	<0.0005	44.4	<0.002	<<0.003	<0.002	0.005	0.013
18BC200	Fourmile Creek	8/30/2018 16:00	--	--	--	--	--	--	--	--	--
18BC206	Fourmile Creek	9/5/2018 19:35	0.033	0.073	<0.0005	42.2	<0.002	<<0.003	<0.002	0.003	0.013
18BC215	Fourmile Creek	9/20/2018 15:20	0.037	0.080	<0.0005	46.5	<0.002	<<0.003	<0.002	0.001	0.021
18BC221	Fourmile Creek	9/28/2018 15:25	0.030	0.075	<0.0005	46.8	<0.002	<<0.003	<0.002	0.002	0.011
		Detection Limit	0.007	0.001	0.0005	0.02	0.002	0.003	0.002	0.002	0.002

ID	Location	Date & Time MST	K mg/l	Li mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Na mg/l	Ni mg/l	P mg/l	Pb mg/l
18BC005	Fourmile Creek	4/18/2018 13:15	--	--	--	--	--	--	--	--	--
18BC006	Fourmile Creek	4/21/2018 10:25	--	--	--	--	--	--	--	--	--
18BC011	Fourmile Creek	5/3/2018 17:45	2.28	0.004	8.88	0.0425	<0.005	9.12	<0.003	<0.04	<0.02
18BC016	Fourmile Creek	5/11/2018 10:15	--	--	--	--	--	--	--	--	--
18BC022	Fourmile Creek	5/18/2018 14:25	1.31	<0.001	5.19	0.0100	<0.005	5.08	<0.003	<0.04	<0.02
18BC028	Fourmile Creek	5/18/2018 15:58	1.95	0.002	4.34	0.0070	<0.005	5.22	<0.003	<0.04	<0.02
18BC029	Fourmile Creek	5/18/2018 16:08	2.01	<0.001	4.39	0.0050	<0.005	5.00	<0.003	<0.04	<0.02
18BC030	Fourmile Creek	5/18/2018 16:18	2.14	0.002	4.69	0.0550	<0.005	5.34	<0.003	<0.04	<0.02
FCBC BTL 4 5/18/2018	Fourmile Creek	5/18/2018 16:28	--	--	--	--	--	--	--	--	--
18BC031	Fourmile Creek	5/18/2018 16:38	2.59	0.013	6.18	0.0050	<0.005	7.45	<0.003	<0.04	<0.02
FCBC BTL 6 5/18/2018	Fourmile Creek	5/18/2018 16:48	--	--	--	--	--	--	--	--	--
FCBC BTL 7 5/18/2018	Fourmile Creek	5/18/2018 16:58	--	--	--	--	--	--	--	--	--
18BC032	Fourmile Creek	5/18/2018 17:08	2.12	0.005	5.32	0.0050	<0.005	6.08	<0.003	<0.04	<0.02
FCBC BTL 9 5/18/2018	Fourmile Creek	5/18/2018 17:18	--	--	--	--	--	--	--	--	--
FCBC BTL 10 5/18/2018	Fourmile Creek	5/18/2018 17:29	--	--	--	--	--	--	--	--	--
18BC033	Fourmile Creek	5/19/2018 13:15	1.51	0.002	5.81	0.0120	<0.005	6.06	<0.003	<0.04	<0.02
18BC034	Fourmile Creek	5/20/2018 17:00	1.56	0.002	6.74	0.0130	<0.005	6.55	<0.003	<0.04	<0.02
18BC039	Fourmile Creek	5/25/2018 15:15	1.51	0.002	6.12	0.0130	<0.005	6.00	<0.003	<0.04	<0.02
18BC051	Fourmile Creek	5/31/2018 14:45	1.58	0.002	6.36	0.0170	<0.005	6.03	<0.003	<0.04	<0.02
18BC058	Fourmile Creek	6/8/2018 14:45	1.53	0.002	6.26	0.0105	<0.005	5.88	<0.003	<0.04	<0.02
18BC065	Fourmile Creek	6/15/2018 12:20	1.80	0.002	7.20	0.0110	<0.005	6.63	<0.003	<0.04	<0.02
18BC072	Fourmile Creek	6/17/2018 12:00	1.83	0.003	7.53	0.0100	<0.005	6.86	<0.003	<0.04	<0.02
18BC089	Fourmile Creek	6/18/2018 0:06	2.25	0.003	7.25	0.0020	<0.005	6.59	<0.003	<0.04	<0.02
18BC090	Fourmile Creek	6/18/2018 1:16	2.04	0.005	7.17	0.0020	<0.005	6.61	<0.003	<0.04	<0.02
18BC091	Fourmile Creek	6/18/2018 3:26	2.06	0.005	7.72	<0.001	<0.005	6.92	<0.003	<0.04	<0.02
18BC092	Fourmile Creek	6/18/2018 3:56	1.93	0.004	7.25	<0.001	<0.005	6.49	<0.003	<0.04	<0.02
18BC079	Fourmile Creek	6/18/2018 13:10	1.80	0.003	7.41	0.0120	<0.005	6.76	<0.003	<0.04	<0.02
18BC100	Fourmile Creek	6/18/2018 18:03	2.67	0.003	5.52	<0.001	<0.005	5.42	<0.003	<0.04	<0.02
18BC101	Fourmile Creek	6/18/2018 18:23	2.89	0.002	4.87	<0.001	<0.005	4.61	0.004	<0.04	<0.02
18BC102	Fourmile Creek	6/18/2018 19:53	2.75	0.014	9.38	<0.001	<0.005	8.41	<0.003	<0.04	<0.02
18BC085	Fourmile Creek	6/19/2018 12:05	2.04	0.003	8.86	0.0205	<0.005	8.12	<0.003	<0.04	<0.02
18BC114	Fourmile Creek	6/19/2018 13:27	2.07	0.004	8.81	<0.001	<0.005	8.05	<0.003	<0.04	<0.02
18BC115	Fourmile Creek	6/19/2018 14:37	2.44	0.002	6.20	<0.001	<0.005	6.53	<0.003	<0.04	<0.02
18BC116	Fourmile Creek	6/19/2018 15:17	--	--	--	--	--	--	--	--	--
18BC117	Fourmile Creek	6/19/2018 17:17	3.07	0.011	10.30	<0.001	<0.005	9.89	<0.003	<0.04	<0.02
18BC113	Fourmile Creek	6/20/2018 9:00	2.06	0.004	9.32	0.0180	<0.005	8.43	<0.003	<0.04	<0.02
18BC119	Fourmile Creek	6/29/2018 12:10	2.58	0.004	10.50	0.0175	<0.005	9.96	<0.003	<0.04	<0.02
18BC126	Fourmile Creek	7/4/2018 10:45	2.72	0.006	11.50	0.0150	<0.005	10.70	<0.003	<0.04	<0.02
18BC133	Fourmile Creek	7/13/2018 12:00	3.15	0.010	13.10	0.0130	<0.005	12.00	<0.003	<0.04	<0.02
18BC140	Fourmile Creek	7/15/2018 13:30	3.14	0.007	12.80	0.0110	<0.005	12.10	<0.003	<0.04	<0.02
18BC143	Fourmile Creek	7/16/2018 12:25	3.00	0.032	14.10	0.0160	<0.005	11.60	<0.003	<0.04	<0.02
18BC153	Fourmile Creek	7/20/2018 13:00	3.14	0.010	13.20	0.0110	<0.005	12.50	<0.003	<0.04	<0.02
18BC159	Fourmile Creek	7/23/2018 12:55	3.38	0.039	16.10	0.0110	<0.005	12.30	<0.003	<0.04	<0.02
18BC174	Fourmile Creek	7/23/2018 16:25	3.66	0.019	11.80	0.0005	<0.005	10.60	<0.003	<0.04	<0.02
18BC165	Fourmile Creek	7/24/2018 11:25	3.20	0.040	15.00	0.0130	<0.005	11.50	<0.003	<0.04	<0.02
18BC176	Fourmile Creek	8/3/2018 12:50	3.25	0.012	14.70	0.0120	<0.005	12.90	<0.003	<0.04	<0.02
18BC182	Fourmile Creek	8/10/2018 9:40	3.44	0.010	15.70	0.0145	<0.005	14.20	<0.003	<0.04	<0.02
18BC188	Fourmile Creek	8/17/2018 12:25	3.86	0.018	17.00	0.0120	<0.005	15.70	<0.003	<0.04	<0.02
18BC194	Fourmile Creek	8/24/2018 11:45	3.76	0.013	17.40	0.0115	<0.005	16.30	0.005	<0.04	<0.02
18BC200	Fourmile Creek	8/30/2018 16:00	--	--	--	--	--	--	--	--	--
18BC206	Fourmile Creek	9/5/2018 19:35	4.59	0.013	16.90	0.0096	<0.005	15.20	0.005	<0.04	<0.02
18BC215	Fourmile Creek	9/20/2018 15:20	5.24	0.013	18.40	0.0166	<0.005	17.10	0.005	<0.04	<0.02
18BC221	Fourmile Creek	9/28/2018 15:25	4.10	0.011	18.80	0.0111	<0.005	16.90	0.005	<0.04	<0.02
		Detection Limit	0.04	0.001	0.002	0.001	0.005	0.07	0.003	0.04	0.02

ID	Location	Date & Time MST	Rb mg/l	Sb mg/l	Se mg/l	SiO2 mg/l	Sr mg/l	U mg/l	V mg/l	W mg/l	Zn mg/l
18BC005	Fourmile Creek	4/18/2018 13:15	--	--	--	--	--	--	--	--	--
18BC006	Fourmile Creek	4/21/2018 10:25	--	--	--	--	--	--	--	--	--
18BC011	Fourmile Creek	5/3/2018 17:45	<0.002	<0.03	<0.04	10.60	0.228	<0.004	<0.001	<0.01	0.010
18BC016	Fourmile Creek	5/11/2018 10:15	--	--	--	--	--	--	--	--	--
18BC022	Fourmile Creek	5/18/2018 14:25	<0.002	<0.03	<0.04	10.60	0.135	<0.004	<0.001	<0.01	0.007
18BC028	Fourmile Creek	5/18/2018 15:58	<0.002	<0.03	<0.04	8.41	0.119	<0.004	<0.001	<0.01	0.006
18BC029	Fourmile Creek	5/18/2018 16:08	<0.002	<0.03	<0.04	8.48	0.125	<0.004	<0.001	<0.01	0.006
18BC030	Fourmile Creek	5/18/2018 16:18	<0.002	<0.03	<0.04	8.60	0.137	<0.004	<0.001	<0.01	0.028
FCBC BTL 4 5/18/2018	Fourmile Creek	5/18/2018 16:28	--	--	--	--	--	--	--	--	--
18BC031	Fourmile Creek	5/18/2018 16:38	<0.002	<0.03	<0.04	7.66	0.147	<0.004	<0.001	<0.01	0.005
FCBC BTL 6 5/18/2018	Fourmile Creek	5/18/2018 16:48	--	--	--	--	--	--	--	--	--
FCBC BTL 7 5/18/2018	Fourmile Creek	5/18/2018 16:58	--	--	--	--	--	--	--	--	--
18BC032	Fourmile Creek	5/18/2018 17:08	<0.002	<0.03	<0.04	8.05	0.129	<0.004	<0.001	<0.01	0.005
FCBC BTL 9 5/18/2018	Fourmile Creek	5/18/2018 17:18	--	--	--	--	--	--	--	--	--
FCBC BTL 10 5/18/2018	Fourmile Creek	5/18/2018 17:29	--	--	--	--	--	--	--	--	--
18BC033	Fourmile Creek	5/19/2018 13:15	<0.002	<0.03	<0.04	10.20	0.145	<0.004	<0.001	<0.01	0.007
18BC034	Fourmile Creek	5/20/2018 17:00	<0.002	<0.03	<0.04	11.00	0.164	0.005	<0.001	<0.01	0.011
18BC039	Fourmile Creek	5/25/2018 15:15	<0.002	<0.03	<0.04	11.10	0.158	<0.004	<0.001	<0.01	0.007
18BC051	Fourmile Creek	5/31/2018 14:45	<0.002	<0.03	<0.04	11.00	0.162	<0.004	<0.001	<0.01	0.008
18BC058	Fourmile Creek	6/8/2018 14:45	<0.002	<0.03	<0.04	11.00	0.168	0.005	<0.001	<0.01	0.005
18BC065	Fourmile Creek	6/15/2018 12:20	<0.002	<0.03	<0.04	11.80	0.198	<0.004	<0.001	<0.01	0.010
18BC072	Fourmile Creek	6/17/2018 12:00	<0.002	<0.03	<0.04	12.10	0.207	<0.004	<0.001	<0.01	0.006
18BC089	Fourmile Creek	6/18/2018 0:06	<0.002	<0.03	<0.04	11.00	0.195	<0.004	<0.001	<0.01	0.006
18BC090	Fourmile Creek	6/18/2018 1:16	<0.002	<0.03	<0.04	10.70	0.191	<0.004	<0.001	<0.01	0.006
18BC091	Fourmile Creek	6/18/2018 3:26	<0.002	<0.03	<0.04	11.30	0.203	<0.004	<0.001	<0.01	0.007
18BC092	Fourmile Creek	6/18/2018 3:56	<0.002	<0.03	<0.04	11.50	0.192	<0.004	<0.001	<0.01	0.006
18BC079	Fourmile Creek	6/18/2018 13:10	<0.002	<0.03	<0.04	12.30	0.199	0.005	<0.001	<0.01	0.014
18BC100	Fourmile Creek	6/18/2018 18:03	<0.002	<0.03	<0.04	8.63	0.149	<0.004	<0.001	<0.01	0.005
18BC101	Fourmile Creek	6/18/2018 18:23	<0.002	<0.03	<0.04	6.91	0.129	<0.004	<0.001	<0.01	0.007
18BC102	Fourmile Creek	6/18/2018 19:53	<0.002	<0.03	<0.04	9.97	0.188	0.006	<0.001	<0.01	0.007
18BC085	Fourmile Creek	6/19/2018 12:05	<0.002	<0.03	<0.04	12.50	0.233	<0.004	<0.001	<0.01	0.007
18BC114	Fourmile Creek	6/19/2018 13:27	<0.002	<0.03	<0.04	12.50	0.230	0.007	<0.001	<0.01	0.006
18BC115	Fourmile Creek	6/19/2018 14:37	<0.002	<0.03	<0.04	9.41	0.164	<0.004	<0.001	<0.01	0.005
18BC116	Fourmile Creek	6/19/2018 15:17	--	--	--	--	--	--	--	--	--
18BC117	Fourmile Creek	6/19/2018 17:17	<0.002	<0.03	<0.04	11.40	0.248	<0.004	<0.001	<0.01	0.005
18BC113	Fourmile Creek	6/20/2018 9:00	<0.002	<0.03	<0.04	13.00	0.238	<0.004	<0.001	<0.01	0.025
18BC119	Fourmile Creek	6/29/2018 12:10	<0.002	<0.03	<0.04	13.50	0.293	<0.004	<0.001	<0.01	0.006
18BC126	Fourmile Creek	7/4/2018 10:45	0.003	<0.03	<0.04	13.40	0.320	0.005	<0.001	<0.01	0.006
18BC133	Fourmile Creek	7/13/2018 12:00	<0.002	<0.03	<0.04	10.60	0.354	0.007	<0.001	<0.01	0.005
18BC140	Fourmile Creek	7/15/2018 13:30	0.004	<0.03	<0.04	10.30	0.338	0.007	<0.001	<0.01	0.006
18BC143	Fourmile Creek	7/16/2018 12:25	0.003	<0.03	<0.04	12.20	0.337	0.007	<0.001	<0.01	0.006
18BC153	Fourmile Creek	7/20/2018 13:00	0.003	<0.03	<0.04	10.10	0.346	0.007	<0.001	<0.01	0.005
18BC159	Fourmile Creek	7/23/2018 12:55	0.004	<0.03	<0.04	11.10	0.374	0.007	<0.001	<0.01	0.006
18BC174	Fourmile Creek	7/23/2018 16:25	0.004	<0.03	<0.04	9.78	0.296	0.007	<0.001	<0.01	0.005
18BC165	Fourmile Creek	7/24/2018 11:25	<0.002	<0.03	<0.04	13.20	0.330	0.007	<0.001	<0.01	0.007
18BC176	Fourmile Creek	8/3/2018 12:50	0.003	<0.03	<0.04	11.80	0.380	0.007	<0.001	<0.01	0.006
18BC182	Fourmile Creek	8/10/2018 9:40	0.004	<0.03	<0.04	12.60	0.403	0.007	<0.001	<0.01	0.006
18BC188	Fourmile Creek	8/17/2018 12:25	0.004	<0.03	<0.04	12.00	0.443	0.007	<0.001	<0.01	0.006
18BC194	Fourmile Creek	8/24/2018 11:45	0.003	<0.03	<0.04	11.90	0.437	<0.004	<0.001	<0.01	0.006
18BC200	Fourmile Creek	8/30/2018 16:00	--	--	--	--	--	--	--	--	--
18BC206	Fourmile Creek	9/5/2018 19:35	0.004	<0.03	<0.04	10.80	0.428	0.008	<0.001	<0.01	0.008
18BC215	Fourmile Creek	9/20/2018 15:20	0.006	<0.03	<0.04	12.60	0.453	<0.004	<0.001	<0.01	0.007
18BC221	Fourmile Creek	9/28/2018 15:25	0.003	<0.03	<0.04	11.20	0.459	0.008	<0.001	<0.01	0.007
		Detection Limit	0.002	0.03	0.04	0.03	0.001	0.004	0.001	0.01	0.001

ID	Location	Date & Time MST	δ18O ‰	²H ‰	Deuterium Excess
18BC005	Fourmile Creek	4/18/2018 13:15	-15.67	-117.63	7.70
18BC006	Fourmile Creek	4/21/2018 10:25	-15.52	-116.43	7.71
18BC011	Fourmile Creek	5/3/2018 17:45	-16.39	-123.03	8.08
18BC016	Fourmile Creek	5/11/2018 10:15	-15.86	-118.72	8.15
18BC022	Fourmile Creek	5/18/2018 14:25	-16.4	-122.32	8.88
18BC028	Fourmile Creek	5/18/2018 15:58	-14.83	-108.35	10.29
18BC029	Fourmile Creek	5/18/2018 16:08	-15.02	-107.73	12.45
18BC030	Fourmile Creek	5/18/2018 16:18	-14.71	-107.29	10.42
FCBC BTL 4 5/18/2018	Fourmile Creek	5/18/2018 16:28	-13.74	-97.68	12.21
18BC031	Fourmile Creek	5/18/2018 16:38	-13.6	-95.62	13.17
FCBC BTL 6 5/18/2018	Fourmile Creek	5/18/2018 16:48	-13.54	-95.64	12.67
FCBC BTL 7 5/18/2018	Fourmile Creek	5/18/2018 16:58	-13.97	-99.04	12.72
18BC032	Fourmile Creek	5/18/2018 17:08	-14.23	-101.47	12.41
FCBC BTL 9 5/18/2018	Fourmile Creek	5/18/2018 17:18	-13.89	-100.54	10.61
FCBC BTL 10 5/18/2018	Fourmile Creek	5/18/2018 17:29	-13.83	-99.36	11.27
18BC033	Fourmile Creek	5/19/2018 13:15	-13.4	-95.2	11.99
18BC034	Fourmile Creek	5/20/2018 17:00	-16.1	-120.76	8.01
18BC039	Fourmile Creek	5/25/2018 15:15	-16.51	-122.05	10.06
18BC051	Fourmile Creek	5/31/2018 14:45	-16.49	-123.33	8.58
18BC058	Fourmile Creek	6/8/2018 14:45	-17.23	-123.67	14.20
18BC065	Fourmile Creek	6/15/2018 12:20	-16.74	-124.51	9.40
18BC072	Fourmile Creek	6/17/2018 12:00	-16.74	-123.01	10.92
18BC089	Fourmile Creek	6/18/2018 0:06	-15.92	-117.04	10.31
18BC090	Fourmile Creek	6/18/2018 1:16	-15.72	-116.91	8.86
18BC091	Fourmile Creek	6/18/2018 3:26	-16.02	-117.13	11.00
18BC092	Fourmile Creek	6/18/2018 3:56	-16.29	-120.17	10.16
18BC079	Fourmile Creek	6/18/2018 13:10	-16.58	-121.39	11.27
18BC100	Fourmile Creek	6/18/2018 18:03	-15.96	-113.42	14.29
18BC101	Fourmile Creek	6/18/2018 18:23	-15.03	-105.26	14.95
18BC102	Fourmile Creek	6/18/2018 19:53	-14.97	-106.87	12.91
18BC085	Fourmile Creek	6/19/2018 12:05	-16.31	-119.89	10.63
18BC114	Fourmile Creek	6/19/2018 13:27	-16.24	-119.89	10.05
18BC115	Fourmile Creek	6/19/2018 14:37	-15.17	-110.04	11.36
18BC116	Fourmile Creek	6/19/2018 15:17	-14.38	-100.37	14.66
18BC117	Fourmile Creek	6/19/2018 17:17	-15.45	-111.52	12.06
18BC113	Fourmile Creek	6/20/2018 9:00	-16.21	-120.42	9.28
18BC119	Fourmile Creek	6/29/2018 12:10	-16.02	-119.15	8.98
18BC126	Fourmile Creek	7/4/2018 10:45	-16.02	-119.61	8.52
18BC133	Fourmile Creek	7/13/2018 12:00	-15.58	-116.3	8.38
18BC140	Fourmile Creek	7/15/2018 13:30	-15.42	-116.07	7.26
18BC143	Fourmile Creek	7/16/2018 12:25	-15.53	-115.59	8.62
18BC153	Fourmile Creek	7/20/2018 13:00	-15.47	-115.65	8.15
18BC159	Fourmile Creek	7/23/2018 12:55	-15.06	-111.7	8.78
18BC174	Fourmile Creek	7/23/2018 16:25	-12.78	-93.88	8.38
18BC165	Fourmile Creek	7/24/2018 11:25	-14.34	-104.51	10.18
18BC176	Fourmile Creek	8/3/2018 12:50	-14.93	-111.26	8.18
18BC182	Fourmile Creek	8/10/2018 9:40	-14.72	-111.09	6.64
18BC188	Fourmile Creek	8/17/2018 12:25	-14.27	-108.85	5.34
18BC194	Fourmile Creek	8/24/2018 11:45	-14.9	-110.14	9.07
18BC200	Fourmile Creek	8/30/2018 16:00	-14.24	-107.92	5.97
18BC206	Fourmile Creek	9/5/2018 19:35	-14.2	-105.76	7.80
18BC215	Fourmile Creek	9/20/2018 15:20	-14.19	-107.86	5.67
18BC221	Fourmile Creek	9/28/2018 15:25	-14.12	-108.16	4.79
		Detection Limit	--	--	--

ID	Location	Date & Time MST	Discharge m^3/s	Runoff mm/hr	EC µS/cm	pH	Temp C°	DOC mg/l	SUVA L/mg-M
18BC002	Keystone Gulch	4/18/2018 11:30	0.003	0.00	250	8.29	3.9	5.48	--
18BC010	Keystone Gulch	4/21/2018 12:00	--	--	253	8.28	3.2	--	--
18BC015	Keystone Gulch	5/3/2018 15:40	--	--	194	8.06	6.5	13.96	1.07
18BC020	Keystone Gulch	5/11/2018 11:45	0.009	0.01	216	8.13	11.6	--	--
18BC026	Keystone Gulch	5/18/2018 12:45	0.009	0.01	238	7.8	12.9	8.49	0.95
18BC038	Keystone Gulch	5/20/2018 14:35	0.030	0.02	203	8.13	8.3	11.21	0.88
18BC045	Keystone Gulch	5/22/2018 18:59	0.039	0.03	164	--	--	--	--
18BC046	Keystone Gulch	5/22/2018 19:19	0.033	0.02	190	--	--	--	--
18BC047	Keystone Gulch	5/22/2018 19:29	0.029	0.02	232	--	--	--	--
18BC048	Keystone Gulch	5/22/2018 19:49	0.028	0.02	222	--	--	--	--
18BC049	Keystone Gulch	5/22/2018 20:09	0.027	0.02	225	--	--	--	--
18BC050	Keystone Gulch	5/22/2018 21:09	0.026	0.02	207	--	--	--	--
18BC043	Keystone Gulch	5/25/2018 11:30	0.016	0.01	211	8.18	12.1	9.68	0.89
18BC055	Keystone Gulch	5/31/2018 10:35	0.011	0.01	232	8.23	13.4	7.86	1.04
18BC062	Keystone Gulch	6/8/2018 11:00	0.007	0.00	267	8.18	12.8	6.39	1.07
18BC069	Keystone Gulch	6/15/2018 9:35	0.001	0.00	290	8.23	14.6	6.92	0.85
18BC076	Keystone Gulch	6/17/2018 10:15	0.002	0.00	287	8.09	--	6.05	0.93
18BC096	Keystone Gulch	6/17/2018 16:44	0.004	0.00	270	--	--	8.21	1.05
18BC097	Keystone Gulch	6/17/2018 16:54	0.004	0.00	263	--	--	8.73	1.43
18BC098	Keystone Gulch	6/17/2018 17:19	0.005	0.00	243	--	--	10.68	1.33
18BC099	Keystone Gulch	6/17/2018 18:39	0.004	0.00	268	--	--	7.78	2.51
18BC083	Keystone Gulch	6/18/2018 9:55	0.008	0.01	261	--	--	6.15	1.11
18BC108	Keystone Gulch	6/18/2018 17:49	0.011	0.01	222	--	--	8.39	3.69
18BC109	Keystone Gulch	6/18/2018 17:59	0.083	0.06	105	--	--	8.77	1.67
18BC110	Keystone Gulch	6/18/2018 18:09	0.120	0.08	118	--	--	9.29	1.63
18BC111	Keystone Gulch	6/18/2018 18:39	0.044	0.03	163	--	--	11.78	1.52
18BC112	Keystone Gulch	6/18/2018 19:19	0.054	0.04	183	--	--	12.73	1.71
18BC088	Keystone Gulch	6/19/2018 9:50	0.022	0.01	244	--	--	10.18	0.95
18BC123	Keystone Gulch	6/29/2018 9:20	0.003	0.00	311	8.26	--	6.59	0.94
18BC130	Keystone Gulch	7/4/2018 9:05	--	0.00	321	--	--	6.26	0.92
18BC138	Keystone Gulch	7/12/2018 15:44	0.001	0.00	359	--	--	9.88	0.76
18BC139	Keystone Gulch	7/12/2018 16:54	0.000	0.00	363	--	--	9.41	1.67
18BC149	Keystone Gulch	7/15/2018 14:19	0.002	0.00	183	--	--	20.72	0.42
18BC150	Keystone Gulch	7/15/2018 14:39	0.017	0.01	138	--	--	16.70	2.21
Key BTL 5 7/15/2018	Keystone Gulch	7/15/2018 14:59	0.006	0.00	193	--	--	--	--
18BC151	Keystone Gulch	7/15/2018 15:59	0.001	0.00	246	--	--	14.64	1.95
Key ISO BTL 5	Keystone Gulch	7/15/2018 17:10	0.001	0.00	300	--	--	--	--
Key ISO BTL 24	Keystone Gulch	7/15/2018 19:50	0.001	0.00	346	--	--	--	--
18BC145	Keystone Gulch	7/16/2018 11:00	--	--	384	--	--	7.29	0.71
18BC157	Keystone Gulch	7/20/2018 10:55	--	--	378	8.21	--	7.07	0.79
18BC163	Keystone Gulch	7/23/2018 11:30	--	--	381	8.33	--	7.18	0.76
18BC171	Keystone Gulch	7/23/2018 16:04	0.001	0.00	352	--	--	10.49	0.86
18BC172	Keystone Gulch	7/23/2018 16:44	0.000	0.00	335	--	--	9.95	1.67
18BC173	Keystone Gulch	7/23/2018 17:54	0.001	0.00	311	--	--	12.85	1.25
18BC169	Keystone Gulch	7/24/2018 10:20	--	--	386	8.22	--	6.88	0.74
18BC179	Keystone Gulch	8/3/2018 11:55	--	--	397	8.12	--	6.63	0.76
18BC185	Keystone Gulch	8/10/2018 9:00	--	--	422	8.02	--	6.63	0.67
18BC191	Keystone Gulch	8/17/2018 10:55	--	--	457	7.67	--	6.65	0.74
18BC197	Keystone Gulch	8/24/2018 11:15	--	--	488	7.74	--	6.56	0.80
18BC203	Keystone Gulch	8/30/2018 15:15	--	--	534	7.83	--	8.54	--
18BC209	Keystone Gulch	9/5/2018 18:35	--	--	540	7.55	--	16.62	0.23
18BC218	Keystone Gulch	9/20/2018 14:40	--	--	638	--	--	12.69	0.50
		Detection Limit	--	--	--	--	--	0.4	0.001

ID	Location	Date & Time MST	F mg/l	Cl mg/l	NO_2 mg/l	Br mg/l	NO_3 mg/l	PO_4 mg/l	SO_4 mg/l	Al mg/l	As mg/l
18BC002	Keystone Gulch	4/18/2018 11:30	0.23	13.70	<0.1	<0.1	<0.1	<0.2	13.77	--	--
18BC010	Keystone Gulch	4/21/2018 12:00	0.22	12.95	<0.1	<0.1	<0.1	<0.2	13.30	--	--
18BC015	Keystone Gulch	5/3/2018 15:40	0.19	8.50	<0.1	<0.1	<0.1	<0.2	9.18	0.012	<0.04
18BC020	Keystone Gulch	5/11/2018 11:45	0.21	10.06	<0.1	<0.1	<0.1	<0.2	8.87	--	--
18BC026	Keystone Gulch	5/18/2018 12:45	0.20	10.55	<0.1	<0.1	<0.1	<0.2	8.45	0.006	<0.04
18BC038	Keystone Gulch	5/20/2018 14:35	0.32	7.64	<0.1	<0.1	<0.1	<0.2	7.28	0.009	<0.04
18BC045	Keystone Gulch	5/22/2018 18:59	0.09	7.22	<0.1	<0.1	0.17	<0.2	5.17	0.007	<0.04
18BC046	Keystone Gulch	5/22/2018 19:19	0.12	11.97	<0.1	<0.1	0.30	<0.2	5.38	0.007	<0.04
18BC047	Keystone Gulch	5/22/2018 19:29	0.14	17.65	<0.1	<0.1	0.22	<0.2	6.29	0.006	<0.04
18BC048	Keystone Gulch	5/22/2018 19:49	0.15	13.44	<0.1	<0.1	<0.1	<0.2	6.73	0.007	<0.04
18BC049	Keystone Gulch	5/22/2018 20:09	0.16	12.86	<0.1	<0.1	<0.1	<0.2	6.92	0.008	<0.04
18BC050	Keystone Gulch	5/22/2018 21:09	0.18	9.42	<0.1	<0.1	<0.1	<0.2	6.74	0.007	<0.04
18BC043	Keystone Gulch	5/25/2018 11:30	0.17	8.57	<0.1	<0.1	<0.1	<0.2	7.02	0.008	<0.04
18BC055	Keystone Gulch	5/31/2018 10:35	0.20	10.86	<0.1	<0.1	<0.1	<0.2	7.67	0.008	<0.04
18BC062	Keystone Gulch	6/8/2018 11:00	0.19	13.38	<0.1	<0.1	<0.1	<0.2	8.90	0.006	<0.04
18BC069	Keystone Gulch	6/15/2018 9:35	0.18	15.07	<0.1	<0.1	<0.1	<0.2	9.41	0.007	<0.04
18BC076	Keystone Gulch	6/17/2018 10:15	0.40	21.83	<0.1	<0.1	<0.1	0.62	15.72	0.007	<0.04
18BC096	Keystone Gulch	6/17/2018 16:44	0.38	19.86	<0.1	<0.1	<0.1	0.49	14.95	0.008	<0.04
18BC097	Keystone Gulch	6/17/2018 16:54	0.35	18.62	<0.1	<0.1	<0.1	<0.2	13.58	0.007	<0.04
18BC098	Keystone Gulch	6/17/2018 17:19	0.15	12.09	<0.1	<0.1	<0.1	<0.2	7.61	0.007	<0.04
18BC099	Keystone Gulch	6/17/2018 18:39	0.17	12.16	<0.1	<0.1	<0.1	<0.2	8.93	0.006	<0.04
18BC083	Keystone Gulch	6/18/2018 9:55	0.38	18.59	<0.1	<0.1	<0.1	<0.2	15.72	0.007	<0.04
18BC108	Keystone Gulch	6/18/2018 17:49	0.30	14.07	<0.1	<0.1	<0.1	0.45	11.14	0.009	<0.04
18BC109	Keystone Gulch	6/18/2018 17:59	0.05	5.05	<0.1	<0.1	0.13	<0.2	2.07	0.008	<0.04
18BC110	Keystone Gulch	6/18/2018 18:09	0.20	9.72	<0.1	<0.1	1.44	<0.2	3.97	0.010	<0.04
18BC111	Keystone Gulch	6/18/2018 18:39	0.10	9.01	<0.1	<0.1	0.58	<0.2	4.23	0.006	<0.04
18BC112	Keystone Gulch	6/18/2018 19:19	0.29	13.56	<0.1	<0.1	0.50	<0.2	10.36	0.006	<0.04
18BC088	Keystone Gulch	6/19/2018 9:50	0.17	9.36	<0.1	<0.1	<0.1	<0.2	8.55	0.008	<0.04
18BC123	Keystone Gulch	6/29/2018 9:20	0.20	18.47	<0.1	<0.1	<0.1	<0.2	9.98	0.008	<0.04
18BC130	Keystone Gulch	7/4/2018 9:05	0.78	21.22	<0.1	<0.1	<0.1	<0.2	11.79	0.008	<0.04
18BC138	Keystone Gulch	7/12/2018 15:44	0.39	43.82	<0.1	<0.1	0.60	0.89	17.96	0.006	<0.04
18BC139	Keystone Gulch	7/12/2018 16:54	0.39	41.90	<0.1	<0.1	0.49	1.12	17.80	0.007	<0.04
18BC149	Keystone Gulch	7/15/2018 14:19	0.18	17.77	0.04	<0.1	2.22	0.26	7.69	0.012	<0.04
18BC150	Keystone Gulch	7/15/2018 14:39	0.27	11.99	0.05	<0.1	1.82	<0.2	6.01	0.008	<0.04
Key BTL 5 7/15/2018	Keystone Gulch	7/15/2018 14:59	--	--	--	--	--	--	--	--	--
18BC151	Keystone Gulch	7/15/2018 15:59	0.30	32.54	0.05	<0.1	2.21	0.39	10.39	0.007	<0.04
Key ISO BTL 5	Keystone Gulch	7/15/2018 17:10	--	--	--	--	--	--	--	--	--
Key ISO BTL 24	Keystone Gulch	7/15/2018 19:50	--	--	--	--	--	--	--	--	--
18BC145	Keystone Gulch	7/16/2018 11:00	0.39	46.03	<0.1	<0.1	0.61	0.82	17.54	0.008	<0.04
18BC157	Keystone Gulch	7/20/2018 10:55	0.40	37.93	<0.1	<0.1	<0.1	<0.2	16.29	0.007	<0.04
18BC163	Keystone Gulch	7/23/2018 11:30	0.41	37.70	<0.1	<0.1	<0.1	<0.2	16.07	0.007	<0.04
18BC171	Keystone Gulch	7/23/2018 16:04	0.35	33.84	<0.1	<0.1	0.32	<0.2	14.16	0.008	<0.04
18BC172	Keystone Gulch	7/23/2018 16:44	0.36	32.55	<0.1	<0.1	0.42	<0.2	14.77	0.007	<0.04
18BC173	Keystone Gulch	7/23/2018 17:54	0.35	25.85	<0.1	<0.1	0.36	<0.2	13.28	0.007	<0.04
18BC169	Keystone Gulch	7/24/2018 10:20	0.39	39.35	<0.1	<0.1	0.49	<0.2	15.99	0.007	<0.04
18BC179	Keystone Gulch	8/3/2018 11:55	0.39	39.45	<0.1	<0.1	<0.1	<0.2	16.14	0.008	<0.04
18BC185	Keystone Gulch	8/10/2018 9:00	0.42	46.56	<0.1	<0.1	<0.1	<0.2	16.04	0.007	<0.04
18BC191	Keystone Gulch	8/17/2018 10:55	0.48	55.93	<0.1	<0.1	<0.1	<0.2	17.96	0.008	<0.04
18BC197	Keystone Gulch	8/24/2018 11:15	0.48	62.80	<0.1	<0.1	<0.1	<0.2	20.08	0.008	<0.04
18BC203	Keystone Gulch	8/30/2018 15:15	0.49	75.14	<0.1	<0.1	<0.1	<0.2	21.85	--	--
18BC209	Keystone Gulch	9/5/2018 18:35	0.43	104.21	<0.1	<0.1	0.78	<0.2	28.44	0.011	<0.04
18BC218	Keystone Gulch	9/20/2018 14:40	0.58	122.07	<0.1	<0.1	<0.1	0.18	27.78	0.009	<0.04
		Detection Limit	0.02	0.1	0.1	0.1	0.1	0.2	0.1	0.003	0.04

ID	Location	Date & Time	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe
		MST	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
18BC002	Keystone Gulch	4/18/2018 11:30	--	--	--	--	--	--	--	--	--
18BC010	Keystone Gulch	4/21/2018 12:00	--	--	--	--	--	--	--	--	--
18BC015	Keystone Gulch	5/3/2018 15:40	0.011	0.023	<0.0002	21.1	<0.002	<0.003	<0.002	0.002	0.022
18BC020	Keystone Gulch	5/11/2018 11:45	--	--	--	--	--	--	--	--	--
18BC026	Keystone Gulch	5/18/2018 12:45	0.014	0.029	<0.0002	24.9	<0.002	<0.003	<0.002	0.001	0.005
18BC038	Keystone Gulch	5/20/2018 14:35	0.013	0.025	<0.0002	21.9	<0.002	<0.003	<0.002	0.001	0.013
18BC045	Keystone Gulch	5/22/2018 18:59	0.013	0.017	<0.0002	13.8	<0.002	<0.003	<0.002	0.002	0.006
18BC046	Keystone Gulch	5/22/2018 19:19	0.013	0.019	<0.0002	16.4	<0.002	<0.003	<0.002	0.002	0.004
18BC047	Keystone Gulch	5/22/2018 19:29	0.018	0.034	<0.0002	22.0	<0.002	<0.003	<0.002	0.002	0.006
18BC048	Keystone Gulch	5/22/2018 19:49	0.016	0.030	<0.0002	22.1	<0.002	<0.003	<0.002	0.002	0.006
18BC049	Keystone Gulch	5/22/2018 20:09	0.016	0.031	<0.0002	22.9	<0.002	<0.003	<0.002	0.002	0.006
18BC050	Keystone Gulch	5/22/2018 21:09	0.015	0.025	<0.0002	21.7	<0.002	<0.003	<0.002	0.003	0.008
18BC043	Keystone Gulch	5/25/2018 11:30	0.013	0.027	<0.0002	22.6	<0.002	<0.003	<0.002	0.002	0.007
18BC055	Keystone Gulch	5/31/2018 10:35	0.015	0.029	<0.0002	24.9	<0.002	<0.003	<0.002	0.001	0.007
18BC062	Keystone Gulch	6/8/2018 11:00	0.016	0.033	<0.0002	28.9	<0.002	<0.003	<0.002	0.001	0.008
18BC069	Keystone Gulch	6/15/2018 9:35	0.019	0.036	<0.0002	31.8	<0.002	<0.003	<0.002	0.001	0.016
18BC076	Keystone Gulch	6/17/2018 10:15	0.019	0.037	<0.0002	32.1	<0.002	<0.003	<0.002	0.001	0.016
18BC096	Keystone Gulch	6/17/2018 16:44	0.019	0.035	<0.0002	30.4	<0.002	<0.003	<0.002	0.001	0.018
18BC097	Keystone Gulch	6/17/2018 16:54	0.020	0.034	<0.0002	29.5	<0.002	<0.003	<0.002	0.001	0.019
18BC098	Keystone Gulch	6/17/2018 17:19	0.020	0.031	<0.0002	24.7	<0.002	<0.003	<0.002	0.002	0.024
18BC099	Keystone Gulch	6/17/2018 18:39	0.019	0.034	<0.0002	29.6	<0.002	<0.003	<0.002	0.002	0.015
18BC083	Keystone Gulch	6/18/2018 9:55	0.019	0.034	<0.0002	30.0	<0.002	<0.003	<0.002	0.001	0.010
18BC108	Keystone Gulch	6/18/2018 17:49	0.018	0.032	<0.0002	23.5	<0.002	<0.003	<0.002	0.002	0.035
18BC109	Keystone Gulch	6/18/2018 17:59	0.015	0.013	<0.0002	8.8	<0.002	<0.003	<0.002	0.002	0.014
18BC110	Keystone Gulch	6/18/2018 18:09	0.023	0.019	<0.0002	10.8	<0.002	<0.003	<0.002	0.002	0.013
18BC111	Keystone Gulch	6/18/2018 18:39	0.021	0.030	<0.0002	15.7	<0.002	<0.003	<0.002	0.003	0.011
18BC112	Keystone Gulch	6/18/2018 19:19	0.018	0.027	<0.0002	19.0	<0.002	<0.003	<0.002	0.002	0.017
18BC088	Keystone Gulch	6/19/2018 9:50	0.019	0.030	<0.0002	26.2	<0.002	<0.003	<0.002	0.002	0.016
18BC123	Keystone Gulch	6/29/2018 9:20	0.019	0.040	<0.0002	34.7	<0.002	<0.003	<0.002	0.006	0.020
18BC130	Keystone Gulch	7/4/2018 9:05	0.022	0.042	<0.0002	36.9	<0.002	<0.003	<0.002	0.001	0.024
18BC138	Keystone Gulch	7/12/2018 15:44	0.024	0.044	<0.0002	37.9	<0.002	<0.003	<0.002	0.002	0.042
18BC139	Keystone Gulch	7/12/2018 16:54	0.024	0.045	<0.0002	39.0	<0.002	<0.003	<0.002	0.001	0.033
18BC149	Keystone Gulch	7/15/2018 14:19	0.023	0.030	<0.0002	15.6	<0.002	<0.003	<0.002	0.005	0.028
18BC150	Keystone Gulch	7/15/2018 14:39	0.017	0.016	<0.0002	11.3	<0.002	<0.003	<0.002	0.003	0.017
Key BTL 5 7/15/2018	Keystone Gulch	7/15/2018 14:59	--	--	--	--	--	--	--	--	--
18BC151	Keystone Gulch	7/15/2018 15:59	0.021	0.032	<0.0002	21.7	<0.002	<0.003	<0.002	0.003	0.011
Key ISO BTL 5	Keystone Gulch	7/15/2018 17:10	--	--	--	--	--	--	--	--	--
Key ISO BTL 24	Keystone Gulch	7/15/2018 19:50	--	--	--	--	--	--	--	--	--
18BC145	Keystone Gulch	7/16/2018 11:00	0.022	0.048	<0.0002	39.0	<0.002	<0.003	<0.002	0.001	0.071
18BC157	Keystone Gulch	7/20/2018 10:55	0.021	0.048	<0.0002	41.2	<0.002	<0.003	<0.002	0.001	0.072
18BC163	Keystone Gulch	7/23/2018 11:30	0.021	0.048	<0.0002	41.6	<0.002	<0.003	<0.002	0.001	0.071
18BC171	Keystone Gulch	7/23/2018 16:04	0.024	0.043	<0.0002	36.9	<0.002	<0.003	<0.002	0.001	0.040
18BC172	Keystone Gulch	7/23/2018 16:44	0.023	0.043	<0.0002	37.8	<0.002	<0.003	<0.002	0.001	0.044
18BC173	Keystone Gulch	7/23/2018 17:54	0.023	0.039	<0.0002	33.7	<0.002	<0.003	<0.002	0.002	0.042
18BC169	Keystone Gulch	7/24/2018 10:20	0.023	0.049	<0.0002	42.2	<0.002	<0.003	<0.002	0.001	0.074
18BC179	Keystone Gulch	8/3/2018 11:55	0.024	0.050	<0.0002	43.2	<0.002	<0.003	<0.002	0.001	0.088
18BC185	Keystone Gulch	8/10/2018 9:00	0.022	0.050	<0.0002	47.6	<0.002	<0.003	<0.002	0.001	0.064
18BC191	Keystone Gulch	8/17/2018 10:55	0.021	0.053	<0.0002	50.2	<0.002	<0.003	<0.002	0.001	0.039
18BC197	Keystone Gulch	8/24/2018 11:15	0.022	0.056	<0.0005	52.4	<0.002	<<0.003	<0.002	0.001	0.041
18BC203	Keystone Gulch	8/30/2018 15:15	--	--	--	--	--	--	--	--	--
18BC209	Keystone Gulch	9/5/2018 18:35	0.022	0.066	<0.0005	53.3	<0.002	<<0.003	<0.002	0.002	0.166
18BC218	Keystone Gulch	9/20/2018 14:40	0.024	0.072	<0.0005	67.4	<0.002	<<0.003	<0.002	<0.001	0.123
		Detection Limit	0.007	0.001	0.0005	0.02	0.002	0.003	0.002	0.002	0.002

ID	Location	Date & Time MST	K mg/l	Li mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Na mg/l	Ni mg/l	P mg/l	Pb mg/l
18BC002	Keystone Gulch	4/18/2018 11:30	--	--	--	--	--	--	--	--	--
18BC010	Keystone Gulch	4/21/2018 12:00	--	--	--	--	--	--	--	--	--
18BC015	Keystone Gulch	5/3/2018 15:40	1.92	0.003	7.62	<0.001	<0.005	6.59	<0.003	<0.04	<0.02
18BC020	Keystone Gulch	5/11/2018 11:45	--	--	--	--	--	--	--	--	--
18BC026	Keystone Gulch	5/18/2018 12:45	2.13	0.003	8.92	<0.001	<0.005	8.01	<0.003	<0.04	<0.02
18BC038	Keystone Gulch	5/20/2018 14:35	1.98	0.003	7.78	<0.001	<0.005	6.89	<0.003	<0.04	<0.02
18BC045	Keystone Gulch	5/22/2018 18:59	2.04	0.002	5.56	0.0655	<0.005	8.74	<0.003	<0.04	<0.02
18BC046	Keystone Gulch	5/22/2018 19:19	2.00	0.002	6.68	0.0020	<0.005	9.45	<0.003	<0.04	<0.02
18BC047	Keystone Gulch	5/22/2018 19:29	2.41	0.003	8.01	0.0700	<0.005	10.70	<0.003	<0.04	<0.02
18BC048	Keystone Gulch	5/22/2018 19:49	2.19	0.003	8.09	<0.001	<0.005	9.31	<0.003	<0.04	<0.02
18BC049	Keystone Gulch	5/22/2018 20:09	2.18	0.003	8.27	<0.001	<0.005	8.78	<0.003	<0.04	<0.02
18BC050	Keystone Gulch	5/22/2018 21:09	2.07	0.003	7.83	<0.001	<0.005	7.39	<0.003	<0.04	<0.02
18BC043	Keystone Gulch	5/25/2018 11:30	2.04	0.003	7.98	<0.001	<0.005	7.27	<0.003	<0.04	<0.02
18BC055	Keystone Gulch	5/31/2018 10:35	2.15	0.003	8.88	<0.001	<0.005	7.91	<0.003	<0.04	<0.02
18BC062	Keystone Gulch	6/8/2018 11:00	2.34	0.004	10.30	0.0020	<0.005	8.90	<0.003	<0.04	<0.02
18BC069	Keystone Gulch	6/15/2018 9:35	2.47	0.004	11.30	0.0020	<0.005	10.00	<0.003	<0.04	<0.02
18BC076	Keystone Gulch	6/17/2018 10:15	2.53	0.004	11.20	0.0020	<0.005	9.61	<0.003	<0.04	<0.02
18BC096	Keystone Gulch	6/17/2018 16:44	2.90	0.004	10.60	<0.001	<0.005	8.96	<0.003	<0.04	<0.02
18BC097	Keystone Gulch	6/17/2018 16:54	2.97	0.004	10.50	<0.001	<0.005	9.03	<0.003	<0.04	<0.02
18BC098	Keystone Gulch	6/17/2018 17:19	2.67	0.004	8.76	<0.001	<0.005	11.30	<0.003	<0.04	<0.02
18BC099	Keystone Gulch	6/17/2018 18:39	2.67	0.004	10.60	0.0020	<0.005	9.19	<0.003	<0.04	<0.02
18BC083	Keystone Gulch	6/18/2018 9:55	2.47	0.004	10.40	0.0015	<0.005	8.48	<0.003	<0.04	<0.02
18BC108	Keystone Gulch	6/18/2018 17:49	3.33	0.003	8.14	<0.001	<0.005	7.25	<0.003	<0.04	<0.02
18BC109	Keystone Gulch	6/18/2018 17:59	2.31	<0.001	3.42	0.1320	<0.005	5.93	<0.003	<0.04	<0.02
18BC110	Keystone Gulch	6/18/2018 18:09	2.30	0.002	3.46	0.0780	<0.005	9.73	<0.003	<0.04	<0.02
18BC111	Keystone Gulch	6/18/2018 18:39	2.48	0.002	5.38	0.0060	<0.005	8.55	<0.003	0.05	<0.02
18BC112	Keystone Gulch	6/18/2018 19:19	2.72	0.003	6.88	0.0005	<0.005	6.89	<0.003	<0.04	<0.02
18BC088	Keystone Gulch	6/19/2018 9:50	2.39	0.004	9.21	0.0020	<0.005	7.65	<0.003	<0.04	<0.02
18BC123	Keystone Gulch	6/29/2018 9:20	2.62	0.004	12.10	0.0040	<0.005	11.20	<0.003	<0.04	<0.02
18BC130	Keystone Gulch	7/4/2018 9:05	2.70	0.004	13.00	0.0040	<0.005	12.10	<0.003	<0.04	<0.02
18BC138	Keystone Gulch	7/12/2018 15:44	3.61	0.005	13.90	<0.001	<0.005	14.40	<0.003	<0.04	<0.02
18BC139	Keystone Gulch	7/12/2018 16:54	3.48	0.005	14.20	0.0020	<0.005	14.30	<0.003	<0.04	<0.02
18BC149	Keystone Gulch	7/15/2018 14:19	6.54	0.003	5.28	0.0190	<0.005	9.60	<0.003	0.21	<0.02
18BC150	Keystone Gulch	7/15/2018 14:39	2.57	0.002	4.20	0.0040	<0.005	8.77	<0.003	0.09	<0.02
Key BTL 5 7/15/2018	Keystone Gulch	7/15/2018 14:59	--	--	--	--	--	--	--	--	--
18BC151	Keystone Gulch	7/15/2018 15:59	3.19	0.003	7.84	<0.001	<0.005	15.90	<0.003	<0.04	<0.02
Key ISO BTL 5	Keystone Gulch	7/15/2018 17:10	--	--	--	--	--	--	--	--	--
Key ISO BTL 24	Keystone Gulch	7/15/2018 19:50	--	--	--	--	--	--	--	--	--
18BC145	Keystone Gulch	7/16/2018 11:00	2.61	0.005	14.20	0.0270	<0.005	14.30	<0.003	<0.04	<0.02
18BC157	Keystone Gulch	7/20/2018 10:55	3.24	0.005	14.80	0.0150	<0.005	14.60	<0.003	<0.04	<0.02
18BC163	Keystone Gulch	7/23/2018 11:30	2.88	0.005	15.10	0.0135	<0.005	15.00	<0.003	<0.04	<0.02
18BC171	Keystone Gulch	7/23/2018 16:04	4.22	0.004	13.50	0.0050	<0.005	13.80	<0.003	<0.04	<0.02
18BC172	Keystone Gulch	7/23/2018 16:44	3.89	0.004	13.80	0.0060	<0.005	13.50	<0.003	<0.04	<0.02
18BC173	Keystone Gulch	7/23/2018 17:54	3.81	0.004	11.80	0.0030	<0.005	12.80	<0.003	0.05	<0.02
18BC169	Keystone Gulch	7/24/2018 10:20	2.81	0.005	15.30	0.0200	<0.005	15.50	<0.003	<0.04	<0.02
18BC179	Keystone Gulch	8/3/2018 11:55	2.73	0.005	15.70	0.0380	<0.005	15.40	<0.003	<0.04	<0.02
18BC185	Keystone Gulch	8/10/2018 9:00	2.92	0.005	16.90	0.0350	<0.005	19.10	<0.003	<0.04	<0.02
18BC191	Keystone Gulch	8/17/2018 10:55	2.92	0.005	17.60	0.0985	<0.005	20.20	<0.003	<0.04	<0.02
18BC197	Keystone Gulch	8/24/2018 11:15	2.88	0.004	19.50	0.0737	<0.005	20.10	0.005	<0.04	<0.02
18BC203	Keystone Gulch	8/30/2018 15:15	--	--	--	--	--	--	--	--	--
18BC209	Keystone Gulch	9/5/2018 18:35	3.49	0.004	20.00	0.1850	<0.005	27.60	0.005	<0.04	<0.02
18BC218	Keystone Gulch	9/20/2018 14:40	5.36	0.004	25.40	0.2590	<0.005	24.50	0.005	<0.04	<0.02
		Detection Limit	0.04	0.001	0.002	0.001	0.005	0.07	0.003	0.04	0.02

ID	Location	Date & Time MST	Rb mg/l	Sb mg/l	Se mg/l	SiO2 mg/l	Sr mg/l	U mg/l	V mg/l	W mg/l	Zn mg/l
18BC002	Keystone Gulch	4/18/2018 11:30	--	--	--	--	--	--	--	--	--
18BC010	Keystone Gulch	4/21/2018 12:00	--	--	--	--	--	--	--	--	--
18BC015	Keystone Gulch	5/3/2018 15:40	<0.002	<0.03	<0.04	13.50	0.139	<0.004	<0.001	<0.01	0.010
18BC020	Keystone Gulch	5/11/2018 11:45	--	--	--	--	--	--	--	--	--
18BC026	Keystone Gulch	5/18/2018 12:45	<0.002	<0.03	<0.04	17.10	0.164	<0.004	<0.001	<0.01	0.004
18BC038	Keystone Gulch	5/20/2018 14:35	<0.002	<0.03	<0.04	16.50	0.147	0.006	<0.001	<0.01	0.005
18BC045	Keystone Gulch	5/22/2018 18:59	<0.002	<0.03	<0.04	10.80	0.124	<0.004	<0.001	<0.01	0.008
18BC046	Keystone Gulch	5/22/2018 19:19	<0.002	<0.03	<0.04	11.10	0.127	<0.004	<0.001	<0.01	0.004
18BC047	Keystone Gulch	5/22/2018 19:29	<0.002	<0.03	<0.04	12.60	0.149	<0.004	<0.001	<0.01	0.007
18BC048	Keystone Gulch	5/22/2018 19:49	<0.002	<0.03	<0.04	15.10	0.150	<0.004	<0.001	<0.01	0.005
18BC049	Keystone Gulch	5/22/2018 20:09	<0.002	<0.03	<0.04	15.40	0.155	<0.004	<0.001	<0.01	0.014
18BC050	Keystone Gulch	5/22/2018 21:09	<0.002	<0.03	<0.04	16.10	0.147	<0.004	<0.001	<0.01	0.007
18BC043	Keystone Gulch	5/25/2018 11:30	<0.002	<0.03	<0.04	17.10	0.151	<0.004	<0.001	<0.01	0.006
18BC055	Keystone Gulch	5/31/2018 10:35	<0.002	<0.03	<0.04	17.80	0.167	<0.004	<0.001	<0.01	0.006
18BC062	Keystone Gulch	6/8/2018 11:00	<0.002	<0.03	<0.04	18.90	0.191	<0.004	<0.001	<0.01	0.007
18BC069	Keystone Gulch	6/15/2018 9:35	<0.002	<0.03	<0.04	19.60	0.210	0.005	<0.001	<0.01	0.014
18BC076	Keystone Gulch	6/17/2018 10:15	<0.002	<0.03	<0.04	20.30	0.212	0.006	<0.001	<0.01	0.005
18BC096	Keystone Gulch	6/17/2018 16:44	0.003	<0.03	<0.04	19.40	0.202	0.006	<0.001	<0.01	0.012
18BC097	Keystone Gulch	6/17/2018 16:54	<0.002	<0.03	<0.04	18.60	0.195	<0.004	<0.001	<0.01	0.012
18BC098	Keystone Gulch	6/17/2018 17:19	<0.002	<0.03	<0.04	15.60	0.166	<0.004	<0.001	<0.01	0.008
18BC099	Keystone Gulch	6/17/2018 18:39	<0.002	<0.03	<0.04	18.90	0.197	<0.004	<0.001	<0.01	0.006
18BC083	Keystone Gulch	6/18/2018 9:55	<0.002	<0.03	<0.04	19.80	0.201	<0.004	<0.001	<0.01	0.005
18BC108	Keystone Gulch	6/18/2018 17:49	<0.002	<0.03	<0.04	15.10	0.164	0.008	<0.001	<0.01	0.010
18BC109	Keystone Gulch	6/18/2018 17:59	<0.002	<0.03	<0.04	5.40	0.075	<0.004	<0.001	<0.01	0.006
18BC110	Keystone Gulch	6/18/2018 18:09	<0.002	<0.03	<0.04	5.18	0.074	<0.004	<0.001	<0.01	0.004
18BC111	Keystone Gulch	6/18/2018 18:39	<0.002	<0.03	<0.04	8.84	0.110	0.005	<0.001	<0.01	0.005
18BC112	Keystone Gulch	6/18/2018 19:19	<0.002	<0.03	<0.04	12.50	0.134	0.005	<0.001	<0.01	0.005
18BC088	Keystone Gulch	6/19/2018 9:50	<0.002	<0.03	<0.04	18.60	0.179	<0.004	<0.001	<0.01	0.005
18BC123	Keystone Gulch	6/29/2018 9:20	<0.002	<0.03	<0.04	20.80	0.228	0.007	<0.001	<0.01	0.007
18BC130	Keystone Gulch	7/4/2018 9:05	0.003	<0.03	<0.04	21.00	0.242	<0.004	<0.001	<0.01	0.006
18BC138	Keystone Gulch	7/12/2018 15:44	0.003	<0.03	<0.04	20.40	0.252	0.007	<0.001	<0.01	0.006
18BC139	Keystone Gulch	7/12/2018 16:54	0.003	<0.03	<0.04	21.40	0.258	0.007	<0.001	0.04	0.008
18BC149	Keystone Gulch	7/15/2018 14:19	0.004	<0.03	<0.04	7.02	0.110	0.007	<0.001	<0.01	0.013
18BC150	Keystone Gulch	7/15/2018 14:39	<0.002	<0.03	<0.04	6.22	0.089	0.007	<0.001	<0.01	0.004
Key BTL 5 7/15/2018	Keystone Gulch	7/15/2018 14:59	--	--	--	--	--	--	--	--	--
18BC151	Keystone Gulch	7/15/2018 15:59	<0.002	<0.03	<0.04	10.40	0.144	0.007	<0.001	<0.01	0.005
Key ISO BTL 5	Keystone Gulch	7/15/2018 17:10	--	--	--	--	--	--	--	--	--
Key ISO BTL 24	Keystone Gulch	7/15/2018 19:50	--	--	--	--	--	--	--	--	--
18BC145	Keystone Gulch	7/16/2018 11:00	<0.002	<0.03	<0.04	21.80	0.261	0.007	<0.001	<0.01	0.006
18BC157	Keystone Gulch	7/20/2018 10:55	0.003	<0.03	<0.04	21.40	0.271	0.007	<0.001	<0.01	0.006
18BC163	Keystone Gulch	7/23/2018 11:30	0.003	<0.03	<0.04	21.60	0.276	0.007	<0.001	<0.01	0.007
18BC171	Keystone Gulch	7/23/2018 16:04	0.003	<0.03	<0.04	19.90	0.248	0.007	<0.001	<0.01	0.006
18BC172	Keystone Gulch	7/23/2018 16:44	0.003	<0.03	<0.04	20.40	0.253	0.007	<0.001	<0.01	0.007
18BC173	Keystone Gulch	7/23/2018 17:54	0.003	<0.03	<0.04	18.30	0.217	0.007	<0.001	<0.01	0.006
18BC169	Keystone Gulch	7/24/2018 10:20	<0.002	<0.03	<0.04	21.70	0.282	0.007	<0.001	<0.01	0.009
18BC179	Keystone Gulch	8/3/2018 11:55	<0.002	<0.03	<0.04	21.60	0.287	0.007	<0.001	<0.01	0.007
18BC185	Keystone Gulch	8/10/2018 9:00	<0.002	<0.03	<0.04	23.30	0.314	0.007	<0.001	<0.01	0.006
18BC191	Keystone Gulch	8/17/2018 10:55	<0.002	<0.03	<0.04	23.00	0.334	0.007	<0.001	<0.01	0.007
18BC197	Keystone Gulch	8/24/2018 11:15	<0.002	<0.03	<0.04	22.10	0.349	0.005	<0.001	<0.01	0.006
18BC203	Keystone Gulch	8/30/2018 15:15	--	--	--	--	--	--	--	--	--
18BC209	Keystone Gulch	9/5/2018 18:35	0.003	<0.03	<0.04	18.10	0.384	0.008	<0.001	<0.01	0.014
18BC218	Keystone Gulch	9/20/2018 14:40	0.004	<0.03	<0.04	22.30	0.507	0.006	<0.001	<0.01	0.018
		Detection Limit	0.002	0.03	0.04	0.03	0.001	0.004	0.001	0.01	0.001

ID	Location	Date & Time MST	$\delta^{18}O$ ‰	^{2}H ‰	Deuterium Excess
18BC002	Keystone Gulch	4/18/2018 11:30	-14.76	-110.95	7.15
18BC010	Keystone Gulch	4/21/2018 12:00	-14.73	-109.34	8.54
18BC015	Keystone Gulch	5/3/2018 15:40	-15.35	-115.1	7.67
18BC020	Keystone Gulch	5/11/2018 11:45	-14.78	-109.37	8.88
18BC026	Keystone Gulch	5/18/2018 12:45	-14.52	-106.9	9.25
18BC038	Keystone Gulch	5/20/2018 14:35	-14.62	-108	8.94
18BC045	Keystone Gulch	5/22/2018 18:59	-12.71	-89.96	11.75
18BC046	Keystone Gulch	5/22/2018 19:19	-12.79	-90.82	11.53
18BC047	Keystone Gulch	5/22/2018 19:29	-13.1	-94.74	10.09
18BC048	Keystone Gulch	5/22/2018 19:49	-13.92	-101.22	10.13
18BC049	Keystone Gulch	5/22/2018 20:09	-13.99	-103.1	8.83
18BC050	Keystone Gulch	5/22/2018 21:09	-14.12	-104.73	8.26
18BC043	Keystone Gulch	5/25/2018 11:30	-14.55	-105.86	10.53
18BC055	Keystone Gulch	5/31/2018 10:35	-14.36	-106.64	8.26
18BC062	Keystone Gulch	6/8/2018 11:00	-15.06	-107.67	12.83
18BC069	Keystone Gulch	6/15/2018 9:35	-14.3	-107.09	7.29
18BC076	Keystone Gulch	6/17/2018 10:15	-14.39	-106.04	9.08
18BC096	Keystone Gulch	6/17/2018 16:44	-14.18	-103.25	10.22
18BC097	Keystone Gulch	6/17/2018 16:54	-13.81	-101.28	9.19
18BC098	Keystone Gulch	6/17/2018 17:19	-12.64	-92.62	8.49
18BC099	Keystone Gulch	6/17/2018 18:39	-13.95	-102.94	8.65
18BC083	Keystone Gulch	6/18/2018 9:55	-14.17	-103.7	9.69
18BC108	Keystone Gulch	6/18/2018 17:49	-14.34	-102.53	12.19
18BC109	Keystone Gulch	6/18/2018 17:59	-14.53	-99.1	17.14
18BC110	Keystone Gulch	6/18/2018 18:09	-13.77	-93.92	16.24
18BC111	Keystone Gulch	6/18/2018 18:39	-13.68	-92.92	16.55
18BC112	Keystone Gulch	6/18/2018 19:19	-13.62	-94.35	14.60
18BC088	Keystone Gulch	6/19/2018 9:50	-14.19	-102.62	10.91
18BC123	Keystone Gulch	6/29/2018 9:20	-14.03	-103.42	8.83
18BC130	Keystone Gulch	7/4/2018 9:05	-14.11	-103.51	9.41
18BC138	Keystone Gulch	7/12/2018 15:44	-12.68	-94.94	6.51
18BC139	Keystone Gulch	7/12/2018 16:54	-13.22	-97.46	8.32
18BC149	Keystone Gulch	7/15/2018 14:19	-9.66	-68.15	9.11
18BC150	Keystone Gulch	7/15/2018 14:39	-9.6	-66.26	10.53
Key BTL 5 7/15/2018	Keystone Gulch	7/15/2018 14:59	-9.31	-65.25	9.26
18BC151	Keystone Gulch	7/15/2018 15:59	-10.52	-74.28	9.90
Key ISO BTL 5	Keystone Gulch	7/15/2018 17:10	-11.97	-86.91	8.82
Key ISO BTL 24	Keystone Gulch	7/15/2018 19:50	-13.03	-94.46	9.81
18BC145	Keystone Gulch	7/16/2018 11:00	-13.9	-101.25	9.97
18BC157	Keystone Gulch	7/20/2018 10:55	-13.77	-101.06	9.14
18BC163	Keystone Gulch	7/23/2018 11:30	-13.62	-100.49	8.44
18BC171	Keystone Gulch	7/23/2018 16:04	-12.21	-90.48	7.22
18BC172	Keystone Gulch	7/23/2018 16:44	-12.63	-92.55	8.46
18BC173	Keystone Gulch	7/23/2018 17:54	-11.41	-82.29	8.97
18BC169	Keystone Gulch	7/24/2018 10:20	-13.44	-99.35	8.15
18BC179	Keystone Gulch	8/3/2018 11:55	-13.39	-99.34	7.81
18BC185	Keystone Gulch	8/10/2018 9:00	-13.3	-99.65	6.76
18BC191	Keystone Gulch	8/17/2018 10:55	-13.85	-100.97	9.85
18BC197	Keystone Gulch	8/24/2018 11:15	-13.8	-101.11	9.33
18BC203	Keystone Gulch	8/30/2018 15:15	-13.49	-100.23	7.67
18BC209	Keystone Gulch	9/5/2018 18:35	-11.63	-85.01	8.03
18BC218	Keystone Gulch	9/20/2018 14:40	-12.71	-93.69	7.96
		Detection Limit	--	--	--

ID	Location	Date & Time MST	Discharge m^3/s	Runoff mm/hr	EC µS/cm	pH	Temp C°	DOC mg/l	SUVA L/mg-M
18BC003	Hawkin Gulch	4/18/2018 12:30	0.005	0.00	211	8.32	3.7	3.71	--
18BC009	Hawkin Gulch	4/21/2018 11:40	--	--	126	8.21	3.3	--	--
18BC014	Hawkin Gulch	5/3/2018 16:10	0.026	0.03	189	7.84	--	8.11	1.09
18BC019	Hawkin Gulch	5/11/2018 12:05	0.010	0.01	198	8.14	10.8	--	--
18BC025	Hawkin Gulch	5/18/2018 13:15	0.011	0.01	209	7.67	11.6	5.31	2.38
18BC042	Hawkin Gulch	5/20/2018 13:00	0.013	0.01	189	8.27	--	5.47	2.31
18BC037	Hawkin Gulch	5/20/2018 15:55	0.018	0.02	188	8.07	--	6.60	2.03
18BC054	Hawkin Gulch	5/31/2018 12:40	0.029	0.03	209	8.14	--	5.02	2.41
18BC061	Hawkin Gulch	6/8/2018 13:05	0.003	0.00	161	8.09	12.7	4.34	2.57
18BC068	Hawkin Gulch	6/15/2018 10:50	0.003	0.00	248	8.03	--	4.20	2.51
18BC075	Hawkin Gulch	6/17/2018 10:50	0.002	0.00	265	8.04	--	4.15	2.46
18BC093	Hawkin Gulch	6/17/2018 22:49	0.003	0.00	250	--	--	4.87	1.15
18BC094	Hawkin Gulch	6/17/2018 23:29	0.004	0.00	238	--	--	5.15	1.46
18BC095	Hawkin Gulch	6/18/2018 0:29	0.004	0.00	239	--	--	5.36	1.50
18BC082	Hawkin Gulch	6/18/2018 11:05	0.003	0.00	252	--	--	4.31	2.84
18BC103	Hawkin Gulch	6/18/2018 17:49	0.004	0.00	213	--	--	6.34	1.94
18BC104	Hawkin Gulch	6/18/2018 18:09	0.012	0.01	177	--	--	7.27	1.36
18BC105	Hawkin Gulch	6/18/2018 18:19	0.029	0.03	164	--	--	8.91	1.33
18BC106	Hawkin Gulch	6/18/2018 18:49	0.018	0.02	153	--	--	13.78	1.14
18BC107	Hawkin Gulch	6/18/2018 19:19	0.022	0.02	168	--	--	16.45	1.62
18BC087	Hawkin Gulch	6/19/2018 11:25	0.005	0.00	243	--	--	5.91	1.80
18BC122	Hawkin Gulch	6/29/2018 10:20	0.002	0.00	270	8.09	--	4.03	2.21
18BC129	Hawkin Gulch	7/4/2018 10:00	0.001	0.00	273	--	--	3.93	2.13
18BC136	Hawkin Gulch	7/13/2018 11:30	--	0.00	293	7.98	--	4.01	1.79
18BC142	Hawkin Gulch	7/15/2018 12:55	--	0.00	301	--	--	4.08	1.06
18BC146	Hawkin Gulch	7/15/2018 14:19	--	0.00	248	--	--	10.24	1.17
18BC147	Hawkin Gulch	7/15/2018 14:39	--	0.00	250	--	--	7.03	2.18
18BC148	Hawkin Gulch	7/15/2018 15:59	--	0.00	268	--	--	5.80	1.94
18BC144	Hawkin Gulch	7/16/2018 11:30	--	0.00	303	--	--	4.16	1.06
18BC162	Hawkin Gulch	7/23/2018 11:55	--	0.00	320	8.1	--	3.96	1.83
18BC168	Hawkin Gulch	7/24/2018 10:45	--	0.00	320	7.91	--	4.10	1.89
18BC178	Hawkin Gulch	8/3/2018 12:10	--	--	336	7.92	--	4.01	1.58
18BC184	Hawkin Gulch	8/10/2018 9:20	--	--	382	7.7	--	3.63	1.40
18BC190	Hawkin Gulch	8/17/2018 11:50	--	--	363	7.68	--	--	--
18BC196	Hawkin Gulch	8/24/2018 11:25	--	--	--	8.48	--	4.22	1.17
18BC202	Hawkin Gulch	8/30/2018 0:00	--	--	347	8.23	--	4.95	--
18BC208	Hawkin Gulch	9/5/2018 18:50	--	--	342	7.91	--	4.78	1.42
18BC217	Hawkin Gulch	9/20/2018 14:50	--	--	366	7.9	--	3.39	1.53
		Detection Limit	--	--	--	--	--	0.4	0.001

ID	Location	Date & Time MST	F mg/l	Cl mg/l	NO_2 mg/l	Br mg/l	NO_3 mg/l	PO_4 mg/l	SO_4 mg/l	Al mg/l	As mg/l
18BC003	Hawkin Gulch	4/18/2018 12:30	0.17	2.87	<0.1	<0.1	<0.1	<0.2	8.52	--	--
18BC009	Hawkin Gulch	4/21/2018 11:40	0.16	2.89	<0.1	<0.1	<0.1	<0.2	8.16	--	--
18BC014	Hawkin Gulch	5/3/2018 16:10	0.15	2.35	<0.1	<0.1	<0.1	<0.2	6.35	0.008	<0.04
18BC019	Hawkin Gulch	5/11/2018 12:05	0.14	2.36	<0.1	<0.1	<0.1	<0.2	5.60	--	--
18BC025	Hawkin Gulch	5/18/2018 13:15	0.14	2.34	<0.1	<0.1	<0.1	<0.2	5.36	0.005	<0.04
18BC042	Hawkin Gulch	5/20/2018 13:00	0.14	2.18	<0.1	<0.1	<0.1	<0.2	4.75	0.005	<0.04
18BC037	Hawkin Gulch	5/20/2018 15:55	--	--	--	--	--	--	--	0.006	<0.04
18BC054	Hawkin Gulch	5/31/2018 12:40	0.13	2.17	<0.1	<0.1	<0.1	<0.2	5.09	0.006	<0.04
18BC061	Hawkin Gulch	6/8/2018 13:05	0.15	2.53	<0.1	<0.1	<0.1	<0.2	5.95	0.005	<0.04
18BC068	Hawkin Gulch	6/15/2018 10:50	0.15	2.91	<0.1	<0.1	<0.1	<0.2	6.51	0.007	<0.04
18BC075	Hawkin Gulch	6/17/2018 10:50	0.32	5.26	<0.1	<0.1	<0.1	0.73	11.24	0.007	<0.04
18BC093	Hawkin Gulch	6/17/2018 22:49	0.29	4.94	<0.1	<0.1	0.40	0.81	9.83	0.007	<0.04
18BC094	Hawkin Gulch	6/17/2018 23:29	0.13	2.82	<0.1	<0.1	<0.1	<0.2	5.96	0.006	<0.04
18BC095	Hawkin Gulch	6/18/2018 0:29	0.12	2.78	<0.1	<0.1	<0.1	<0.2	5.92	0.007	<0.04
18BC082	Hawkin Gulch	6/18/2018 11:05	0.32	5.29	<0.1	<0.1	0.35	0.67	10.93	0.005	<0.04
18BC103	Hawkin Gulch	6/18/2018 17:49	0.10	2.35	<0.1	<0.1	<0.1	<0.2	4.96	0.005	<0.04
18BC104	Hawkin Gulch	6/18/2018 18:09	0.23	3.45	<0.1	<0.1	0.44	0.41	7.17	0.007	<0.04
18BC105	Hawkin Gulch	6/18/2018 18:19	0.20	2.93	<0.1	<0.1	0.77	0.44	5.89	0.006	<0.04
18BC106	Hawkin Gulch	6/18/2018 18:49	0.20	2.96	<0.1	<0.1	1.21	<0.2	5.68	0.014	<0.04
18BC107	Hawkin Gulch	6/18/2018 19:19	0.09	1.91	<0.1	<0.1	0.80	--	3.60	0.013	<0.04
18BC087	Hawkin Gulch	6/19/2018 11:25	0.14	2.52	<0.1	<0.1	<0.1	<0.2	5.84	0.007	<0.04
18BC122	Hawkin Gulch	6/29/2018 10:20	0.16	3.01	<0.1	<0.1	<0.1	<0.2	7.02	0.007	<0.04
18BC129	Hawkin Gulch	7/4/2018 10:00	0.18	3.33	<0.1	<0.1	<0.1	<0.2	7.08	0.008	<0.04
18BC136	Hawkin Gulch	7/13/2018 11:30	0.32	7.34	<0.1	<0.1	<0.1	0.85	12.99	0.006	<0.04
18BC142	Hawkin Gulch	7/15/2018 12:55	0.33	7.73	<0.1	<0.1	0.30	<0.2	12.96	0.006	<0.04
18BC146	Hawkin Gulch	7/15/2018 14:19	0.27	6.07	0.04	<0.1	1.46	0.78	10.11	0.006	<0.04
18BC147	Hawkin Gulch	7/15/2018 14:39	0.28	6.47	0.04	<0.1	0.54	0.53	10.58	0.005	<0.04
18BC148	Hawkin Gulch	7/15/2018 15:59	0.29	6.80	<0.1	<0.1	0.55	0.85	11.15	0.006	<0.04
18BC144	Hawkin Gulch	7/16/2018 11:30	0.31	8.83	<0.1	<0.1	0.59	0.78	12.94	0.005	<0.04
18BC162	Hawkin Gulch	7/23/2018 11:55	0.30	8.78	<0.1	<0.1	0.41	<0.2	12.55	0.007	<0.04
18BC168	Hawkin Gulch	7/24/2018 10:45	0.32	8.86	<0.1	<0.1	0.47	<0.2	12.34	0.005	<0.04
18BC178	Hawkin Gulch	8/3/2018 12:10	0.29	9.59	<0.1	<0.1	0.48	0.92	12.92	0.009	<0.04
18BC184	Hawkin Gulch	8/10/2018 9:20	0.64	10.41	<0.1	<0.1	0.66	<0.2	13.64	0.006	<0.04
18BC190	Hawkin Gulch	8/17/2018 11:50	0.32	10.87	<0.1	<0.1	1.05	0.88	16.84	0.007	<0.04
18BC196	Hawkin Gulch	8/24/2018 11:25	0.31	11.20	<0.1	<0.1	0.68	<0.2	18.03	0.009	<0.04
18BC202	Hawkin Gulch	8/30/2018 0:00	0.33	10.81	<0.1	<0.1	1.85	0.80	19.11	--	--
18BC208	Hawkin Gulch	9/5/2018 18:50	0.33	9.96	<0.1	<0.1	4.97	0.81	18.78	0.007	<0.04
18BC217	Hawkin Gulch	9/20/2018 14:50	0.34	10.46	<0.1	<0.1	3.87	<0.2	20.29	0.010	<0.04
		Detection Limit	0.02	0.1	0.1	0.1	0.1	0.2	0.1	0.003	0.04

ID	Location	Date & Time MST	B mg/l	Ba mg/l	Be mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Cu mg/l	Fe mg/l
18BC003	Hawkin Gulch	4/18/2018 12:30	--	--	--	--	--	--	--	--	--
18BC009	Hawkin Gulch	4/21/2018 11:40	--	--	--	--	--	--	--	--	--
18BC014	Hawkin Gulch	5/3/2018 16:10	0.012	0.020	<0.0002	21.4	<0.002	<0.003	<0.002	0.002	0.007
18BC019	Hawkin Gulch	5/11/2018 12:05	--	--	--	--	--	--	--	--	--
18BC025	Hawkin Gulch	5/18/2018 13:15	0.014	0.021	<0.0002	21.9	<0.002	<0.003	<0.002	0.001	<0.002
18BC042	Hawkin Gulch	5/20/2018 13:00	0.014	0.022	<0.0002	21.8	<0.002	<0.003	<0.002	0.001	<0.002
18BC037	Hawkin Gulch	5/20/2018 15:55	0.013	0.020	<0.0002	21.3	<0.002	<0.003	<0.002	0.001	<0.002
18BC054	Hawkin Gulch	5/31/2018 12:40	0.013	0.023	<0.0002	23.1	<0.002	<0.003	<0.002	0.001	<0.002
18BC061	Hawkin Gulch	6/8/2018 13:05	0.017	0.027	<0.0002	26.3	<0.002	<0.003	<0.002	0.001	<0.002
18BC068	Hawkin Gulch	6/15/2018 10:50	0.017	0.030	<0.0002	28.9	<0.002	<0.003	<0.002	0.001	<0.002
18BC075	Hawkin Gulch	6/17/2018 10:50	0.017	0.030	<0.0002	30.0	<0.002	<0.003	<0.002	0.001	<0.002
18BC093	Hawkin Gulch	6/17/2018 22:49	0.019	0.030	<0.0002	29.4	<0.002	<0.003	<0.002	0.003	<0.002
18BC094	Hawkin Gulch	6/17/2018 23:29	0.017	0.029	<0.0002	28.1	<0.002	<0.003	<0.002	0.001	0.004
18BC095	Hawkin Gulch	6/18/2018 0:29	0.018	0.028	<0.0002	27.9	<0.002	<0.003	<0.002	0.001	<0.002
18BC082	Hawkin Gulch	6/18/2018 11:05	0.019	0.030	<0.0002	29.7	<0.002	<0.003	<0.002	0.001	<0.002
18BC103	Hawkin Gulch	6/18/2018 17:49	0.016	0.025	<0.0002	24.1	<0.002	<0.003	<0.002	0.002	<0.002
18BC104	Hawkin Gulch	6/18/2018 18:09	0.015	0.021	<0.0002	19.6	<0.002	<0.003	<0.002	0.001	0.004
18BC105	Hawkin Gulch	6/18/2018 18:19	0.016	0.020	<0.0002	18.3	<0.002	<0.003	<0.002	0.016	0.007
18BC106	Hawkin Gulch	6/18/2018 18:49	0.018	0.020	<0.0002	17.1	<0.002	<0.003	<0.002	0.002	0.019
18BC107	Hawkin Gulch	6/18/2018 19:19	0.021	0.021	<0.0002	18.6	<0.002	<0.003	<0.002	0.003	0.019
18BC087	Hawkin Gulch	6/19/2018 11:25	0.019	0.028	<0.0002	27.5	<0.002	<0.003	<0.002	0.001	0.003
18BC122	Hawkin Gulch	6/29/2018 10:20	0.018	0.030	<0.0002	30.6	<0.002	<0.003	<0.002	0.001	<0.002
18BC129	Hawkin Gulch	7/4/2018 10:00	0.018	0.031	<0.0002	32.0	<0.002	<0.003	<0.002	0.001	<0.002
18BC136	Hawkin Gulch	7/13/2018 11:30	0.017	0.035	<0.0002	35.1	<0.002	<0.003	<0.002	0.001	<0.002
18BC142	Hawkin Gulch	7/15/2018 12:55	0.018	0.036	<0.0002	35.0	<0.002	<0.003	<0.002	0.001	<0.002
18BC146	Hawkin Gulch	7/15/2018 14:19	0.020	0.030	<0.0002	27.9	<0.002	<0.003	<0.002	0.001	0.004
18BC147	Hawkin Gulch	7/15/2018 14:39	0.020	0.030	<0.0002	29.3	<0.002	<0.003	<0.002	0.001	0.004
18BC148	Hawkin Gulch	7/15/2018 15:59	0.018	0.032	<0.0002	32.1	<0.002	<0.003	<0.002	0.001	<0.002
18BC144	Hawkin Gulch	7/16/2018 11:30	0.020	0.035	<0.0002	34.7	<0.002	<0.003	<0.002	0.001	<0.002
18BC162	Hawkin Gulch	7/23/2018 11:55	0.020	0.039	<0.0002	37.4	<0.002	<0.003	<0.002	0.001	<0.002
18BC168	Hawkin Gulch	7/24/2018 10:45	0.021	0.039	<0.0002	36.9	<0.002	<0.003	<0.002	0.001	<0.002
18BC178	Hawkin Gulch	8/3/2018 12:10	0.019	0.043	<0.0002	39.8	<0.002	<0.003	<0.002	0.001	0.003
18BC184	Hawkin Gulch	8/10/2018 9:20	0.020	0.045	<0.0002	42.4	<0.002	<0.003	<0.002	0.001	<0.002
18BC190	Hawkin Gulch	8/17/2018 11:50	0.021	0.048	<0.0002	44.4	<0.002	<0.003	<0.002	0.001	<0.002
18BC196	Hawkin Gulch	8/24/2018 11:25	0.018	0.047	<0.0005	43.1	<0.002	<<0.003	<0.002	<0.001	<0.002
18BC202	Hawkin Gulch	8/30/2018 0:00	--	--	--	--	--	--	--	--	--
18BC208	Hawkin Gulch	9/5/2018 18:50	0.019	0.045	<0.0005	40.2	<0.002	<<0.003	<0.002	0.002	<0.002
18BC217	Hawkin Gulch	9/20/2018 14:50	0.018	0.056	<0.0005	48.4	<0.002	<<0.003	<0.002	0.001	<0.002
		Detection Limit	0.007	0.001	0.0005	0.02	0.002	0.003	0.002	0.002	0.002

ID	Location	Date & Time MST	K mg/l	Li mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Na mg/l	Ni mg/l	P mg/l	Pb mg/l
18BC003	Hawkin Gulch	4/18/2018 12:30	--	--	--	--	--	--	--	--	--
18BC009	Hawkin Gulch	4/21/2018 11:40	--	--	--	--	--	--	--	--	--
18BC014	Hawkin Gulch	5/3/2018 16:10	1.84	0.003	8.76	<0.001	<0.005	5.13	<0.003	<0.04	<0.02
18BC019	Hawkin Gulch	5/11/2018 12:05	--	--	--	--	--	--	--	--	--
18BC025	Hawkin Gulch	5/18/2018 13:15	1.97	0.003	8.83	<0.001	<0.005	5.20	<0.003	<0.04	<0.02
18BC042	Hawkin Gulch	5/20/2018 13:00	1.93	0.003	8.78	<0.001	<0.005	5.21	<0.003	<0.04	<0.02
18BC037	Hawkin Gulch	5/20/2018 15:55	1.86	0.003	8.62	<0.001	<0.005	5.04	<0.003	<0.04	<0.02
18BC054	Hawkin Gulch	5/31/2018 12:40	2.00	0.003	9.27	<0.001	<0.005	5.29	<0.003	<0.04	<0.02
18BC061	Hawkin Gulch	6/8/2018 13:05	2.18	0.004	10.50	<0.001	<0.005	5.76	<0.003	<0.04	<0.02
18BC068	Hawkin Gulch	6/15/2018 10:50	2.31	0.004	11.50	<0.001	<0.005	6.17	<0.003	<0.04	<0.02
18BC075	Hawkin Gulch	6/17/2018 10:50	2.30	0.004	11.70	<0.001	<0.005	6.30	<0.003	<0.04	<0.02
18BC093	Hawkin Gulch	6/17/2018 22:49	2.40	0.004	11.40	<0.001	<0.005	6.16	<0.003	<0.04	<0.02
18BC094	Hawkin Gulch	6/17/2018 23:29	2.37	0.004	11.10	<0.001	<0.005	5.86	<0.003	<0.04	<0.02
18BC095	Hawkin Gulch	6/18/2018 0:29	2.43	0.004	10.90	<0.001	<0.005	5.77	<0.003	<0.04	<0.02
18BC082	Hawkin Gulch	6/18/2018 11:05	2.33	0.004	11.60	<0.001	<0.005	6.24	<0.003	<0.04	<0.02
18BC103	Hawkin Gulch	6/18/2018 17:49	2.39	0.003	9.55	<0.001	<0.005	5.17	<0.003	<0.04	<0.02
18BC104	Hawkin Gulch	6/18/2018 18:09	2.13	0.003	7.88	<0.001	<0.005	4.20	<0.003	<0.04	<0.02
18BC105	Hawkin Gulch	6/18/2018 18:19	2.27	0.002	7.28	<0.001	<0.005	3.82	<0.003	<0.04	<0.02
18BC106	Hawkin Gulch	6/18/2018 18:49	2.52	0.003	6.89	<0.001	<0.005	3.71	<0.003	0.08	<0.02
18BC107	Hawkin Gulch	6/18/2018 19:19	2.81	0.003	7.61	<0.001	<0.005	4.04	<0.003	0.20	<0.02
18BC087	Hawkin Gulch	6/19/2018 11:25	2.25	0.004	10.40	<0.001	<0.005	5.84	<0.003	<0.04	<0.02
18BC122	Hawkin Gulch	6/29/2018 10:20	2.36	0.004	11.80	<0.001	<0.005	6.41	<0.003	<0.04	<0.02
18BC129	Hawkin Gulch	7/4/2018 10:00	2.39	0.004	12.40	<0.001	<0.005	6.65	<0.003	<0.04	<0.02
18BC136	Hawkin Gulch	7/13/2018 11:30	2.54	0.005	13.50	<0.001	<0.005	7.16	<0.003	<0.04	<0.02
18BC142	Hawkin Gulch	7/15/2018 12:55	2.53	0.005	14.00	<0.001	<0.005	7.29	<0.003	<0.04	<0.02
18BC146	Hawkin Gulch	7/15/2018 14:19	2.98	0.004	10.80	0.0020	<0.005	5.82	<0.003	<0.04	<0.02
18BC147	Hawkin Gulch	7/15/2018 14:39	2.50	0.005	11.40	0.0020	<0.005	6.13	<0.003	<0.04	<0.02
18BC148	Hawkin Gulch	7/15/2018 15:59	2.47	0.005	12.40	0.0020	<0.005	6.53	<0.003	<0.04	<0.02
18BC144	Hawkin Gulch	7/16/2018 11:30	2.37	0.005	13.40	<0.001	<0.005	7.22	<0.003	<0.04	<0.02
18BC162	Hawkin Gulch	7/23/2018 11:55	2.64	0.006	14.50	<0.001	<0.005	7.62	<0.003	<0.04	<0.02
18BC168	Hawkin Gulch	7/24/2018 10:45	2.65	0.006	14.70	<0.001	<0.005	7.61	<0.003	<0.04	<0.02
18BC178	Hawkin Gulch	8/3/2018 12:10	2.76	0.006	15.60	<0.001	<0.005	7.91	<0.003	<0.04	<0.02
18BC184	Hawkin Gulch	8/10/2018 9:20	2.85	0.006	16.60	<0.001	<0.005	8.19	<0.003	<0.04	<0.02
18BC190	Hawkin Gulch	8/17/2018 11:50	3.02	0.006	17.00	<0.001	<0.005	8.39	<0.003	<0.04	<0.02
18BC196	Hawkin Gulch	8/24/2018 11:25	2.85	0.006	17.40	0.0016	<0.005	8.20	0.005	<0.04	--
18BC202	Hawkin Gulch	8/30/2018 0:00	--	--	--	--	--	--	--	--	--
18BC208	Hawkin Gulch	9/5/2018 18:50	2.98	0.006	15.50	<0.001	<0.005	7.80	0.005	0.05	<0.02
18BC217	Hawkin Gulch	9/20/2018 14:50	3.57	0.007	19.20	0.0013	<0.005	8.20	0.005	<0.04	<0.02
		Detection Limit	0.04	0.001	0.002	0.001	0.005	0.07	0.003	0.04	0.02

ID	Location	Date & Time MST	Rb mg/l	Sb mg/l	Se mg/l	SiO2 mg/l	Sr mg/l	U mg/l	V mg/l	W mg/l	Zn mg/l
18BC003	Hawkin Gulch	4/18/2018 12:30	--	--	--	--	--	--	--	--	--
18BC009	Hawkin Gulch	4/21/2018 11:40	--	--	--	--	--	--	--	--	--
18BC014	Hawkin Gulch	5/3/2018 16:10	<0.002	<0.03	<0.04	14.40	0.135	0.005	<0.001	<0.01	0.005
18BC019	Hawkin Gulch	5/11/2018 12:05	--	--	--	--	--	--	--	--	--
18BC025	Hawkin Gulch	5/18/2018 13:15	<0.002	<0.03	<0.04	15.60	0.139	<0.004	<0.001	<0.01	0.007
18BC042	Hawkin Gulch	5/20/2018 13:00	<0.002	<0.03	<0.04	15.70	0.139	0.005	<0.001	<0.01	0.004
18BC037	Hawkin Gulch	5/20/2018 15:55	<0.002	<0.03	<0.04	15.50	0.135	0.005	<0.001	<0.01	0.005
18BC054	Hawkin Gulch	5/31/2018 12:40	<0.002	<0.03	<0.04	16.20	0.147	0.005	<0.001	<0.01	0.005
18BC061	Hawkin Gulch	6/8/2018 13:05	0.003	<0.03	<0.04	17.50	0.167	0.006	<0.001	<0.01	0.007
18BC068	Hawkin Gulch	6/15/2018 10:50	<0.002	<0.03	<0.04	18.30	0.182	0.005	<0.001	<0.01	0.047
18BC075	Hawkin Gulch	6/17/2018 10:50	<0.002	<0.03	<0.04	18.70	0.188	0.005	<0.001	<0.01	0.005
18BC093	Hawkin Gulch	6/17/2018 22:49	<0.002	<0.03	<0.04	18.50	0.185	0.005	<0.001	<0.01	0.007
18BC094	Hawkin Gulch	6/17/2018 23:29	<0.002	<0.03	<0.04	17.60	0.177	0.006	<0.001	<0.01	0.005
18BC095	Hawkin Gulch	6/18/2018 0:29	<0.002	<0.03	<0.04	17.40	0.175	<0.004	<0.001	<0.01	0.019
18BC082	Hawkin Gulch	6/18/2018 11:05	<0.002	<0.03	<0.04	18.60	0.187	0.005	<0.001	<0.01	0.006
18BC103	Hawkin Gulch	6/18/2018 17:49	<0.002	<0.03	<0.04	15.20	0.152	<0.004	<0.001	<0.01	0.006
18BC104	Hawkin Gulch	6/18/2018 18:09	<0.002	<0.03	<0.04	12.30	0.124	<0.004	<0.001	<0.01	0.005
18BC105	Hawkin Gulch	6/18/2018 18:19	<0.002	<0.03	<0.04	11.30	0.116	<0.004	<0.001	<0.01	0.004
18BC106	Hawkin Gulch	6/18/2018 18:49	<0.002	<0.03	<0.04	10.90	0.109	<0.004	<0.001	<0.01	0.012
18BC107	Hawkin Gulch	6/18/2018 19:19	<0.002	<0.03	<0.04	12.00	0.118	<0.004	<0.001	<0.01	0.015
18BC087	Hawkin Gulch	6/19/2018 11:25	0.003	<0.03	<0.04	18.10	0.175	0.006	<0.001	<0.01	0.006
18BC122	Hawkin Gulch	6/29/2018 10:20	<0.002	<0.03	<0.04	19.20	0.193	0.005	<0.001	<0.01	0.008
18BC129	Hawkin Gulch	7/4/2018 10:00	<0.002	<0.03	<0.04	19.50	0.201	<0.004	<0.001	<0.01	0.004
18BC136	Hawkin Gulch	7/13/2018 11:30	0.003	<0.03	<0.04	20.20	0.222	0.007	<0.001	<0.01	0.005
18BC142	Hawkin Gulch	7/15/2018 12:55	0.003	<0.03	<0.04	19.90	0.221	0.008	<0.001	<0.01	0.005
18BC146	Hawkin Gulch	7/15/2018 14:19	0.004	<0.03	<0.04	15.20	0.171	0.007	<0.001	<0.01	0.006
18BC147	Hawkin Gulch	7/15/2018 14:39	0.003	<0.03	<0.04	16.50	0.180	0.007	<0.001	<0.01	0.005
18BC148	Hawkin Gulch	7/15/2018 15:59	0.003	<0.03	<0.04	17.80	0.196	0.007	<0.001	<0.01	0.005
18BC144	Hawkin Gulch	7/16/2018 11:30	0.004	<0.03	<0.04	20.00	0.209	0.007	<0.001	<0.01	0.005
18BC162	Hawkin Gulch	7/23/2018 11:55	0.004	<0.03	<0.04	20.50	0.231	0.007	<0.001	<0.01	0.005
18BC168	Hawkin Gulch	7/24/2018 10:45	0.003	<0.03	<0.04	20.70	0.234	0.007	<0.001	<0.01	0.006
18BC178	Hawkin Gulch	8/3/2018 12:10	0.004	<0.03	<0.04	20.80	0.251	0.007	<0.001	<0.01	0.014
18BC184	Hawkin Gulch	8/10/2018 9:20	0.004	<0.03	<0.04	20.60	0.267	0.010	<0.001	<0.01	0.031
18BC190	Hawkin Gulch	8/17/2018 11:50	0.004	<0.03	<0.04	20.60	0.281	0.007	<0.001	<0.01	0.006
18BC196	Hawkin Gulch	8/24/2018 11:25	0.004	<0.03	<0.04	16.10	0.273	0.008	<0.001	<0.01	0.005
18BC202	Hawkin Gulch	8/30/2018 0:00	--	--	--	--	--	--	--	--	--
18BC208	Hawkin Gulch	9/5/2018 18:50	0.003	<0.03	<0.04	19.30	0.254	0.006	<0.001	0.01	0.008
18BC217	Hawkin Gulch	9/20/2018 14:50	0.003	<0.03	<0.04	19.40	0.305	0.007	<0.001	0.01	0.081
		Detection Limit	0.002	0.03	0.04	0.03	0.001	0.004	0.001	0.01	0.001

ID	Location	Date & Time MST	δ^{18}O ‰	^{2}H ‰	Deuterium Excess
18BC003	Hawkin Gulch	4/18/2018 12:30	-14.84	-110.14	8.55
18BC009	Hawkin Gulch	4/21/2018 11:40	-14.73	-109.13	8.75
18BC014	Hawkin Gulch	5/3/2018 16:10	-15.3	-113.58	8.84
18BC019	Hawkin Gulch	5/11/2018 12:05	-14.87	-110.74	8.23
18BC025	Hawkin Gulch	5/18/2018 13:15	-14.78	-109.03	9.23
18BC042	Hawkin Gulch	5/20/2018 13:00	-14.68	-108.7	8.76
18BC037	Hawkin Gulch	5/20/2018 15:55	-14.75	-108.63	9.39
18BC054	Hawkin Gulch	5/31/2018 12:40	-14.52	-107.78	8.35
18BC061	Hawkin Gulch	6/8/2018 13:05	-14.55	-108.05	8.32
18BC068	Hawkin Gulch	6/15/2018 10:50	-14.55	-107.87	8.53
18BC075	Hawkin Gulch	6/17/2018 10:50	-14.56	-107.19	9.31
18BC093	Hawkin Gulch	6/17/2018 22:49	-14.42	-105.04	10.29
18BC094	Hawkin Gulch	6/17/2018 23:29	-14.25	-104.11	9.85
18BC095	Hawkin Gulch	6/18/2018 0:29	-14.32	-104.04	10.49
18BC082	Hawkin Gulch	6/18/2018 11:05	-14.45	-104.5	11.09
18BC103	Hawkin Gulch	6/18/2018 17:49	-14.32	-104.8	9.79
18BC104	Hawkin Gulch	6/18/2018 18:09	-14.5	-101.93	14.06
18BC105	Hawkin Gulch	6/18/2018 18:19	-14.21	-100.9	12.79
18BC106	Hawkin Gulch	6/18/2018 18:49	-14.22	-100.01	13.75
18BC107	Hawkin Gulch	6/18/2018 19:19	-13.96	-99.62	12.05
18BC087	Hawkin Gulch	6/19/2018 11:25	-14.26	-104.63	9.47
18BC122	Hawkin Gulch	6/29/2018 10:20	-14.44	-105.68	9.80
18BC129	Hawkin Gulch	7/4/2018 10:00	-14.6	-106.43	10.39
18BC136	Hawkin Gulch	7/13/2018 11:30	-14.45	-106.02	9.59
18BC142	Hawkin Gulch	7/15/2018 12:55	-14.35	-105.66	9.16
18BC146	Hawkin Gulch	7/15/2018 14:19	-13.01	-93.22	10.85
18BC147	Hawkin Gulch	7/15/2018 14:39	-13.19	-95.84	9.67
18BC148	Hawkin Gulch	7/15/2018 15:59	-13.46	-99.01	8.70
18BC144	Hawkin Gulch	7/16/2018 11:30	-14.34	-105.11	9.63
18BC162	Hawkin Gulch	7/23/2018 11:55	-13.92	-103.2	8.19
18BC168	Hawkin Gulch	7/24/2018 10:45	-13.91	-103.3	7.99
18BC178	Hawkin Gulch	8/3/2018 12:10	-14.12	-103.88	9.06
18BC184	Hawkin Gulch	8/10/2018 9:20	-13.86	-103.33	7.55
18BC190	Hawkin Gulch	8/17/2018 11:50	-14.47	-105.55	10.17
18BC196	Hawkin Gulch	8/24/2018 11:25	-13.99	-103.73	8.18
18BC202	Hawkin Gulch	8/30/2018 0:00	-13.87	-103.3	7.63
18BC208	Hawkin Gulch	9/5/2018 18:50	-13.41	-98.1	9.20
18BC217	Hawkin Gulch	9/20/2018 14:50	-13.96	-104.57	7.14
		Detection Limit	--	--	--

ID	Location	Date & Time	Discharge	Runoff	EC	pH	Temp	DOC	SUVA
		MST	m^3/s	mm/hr	µS/cm		C°	mg/l	L/mg-M
18BC001	Lost Gulch	4/18/2018 10:30	0.018	0.01	216	7.75	4	5.32	--
18BC007	Lost Gulch	4/21/2018 10:55	--	--	219	7.75	4.1	--	--
18BC012	Lost Gulch	5/3/2018 17:40	0.076	0.06	126	7.99	6.6	15.15	1.95
18BC017	Lost Gulch	5/11/2018 10:30	0.012	0.01	238	8.04	11.3	--	--
18BC023	Lost Gulch	5/18/2018 14:00	0.014	0.01	232	7.92	11.6	6.20	1.06
18BC035	Lost Gulch	5/20/2018 16:50	0.023	0.02	225	7.95	--	7.31	1.13
18BC040	Lost Gulch	5/25/2018 14:40	0.016	0.01	230	8.05	--	6.24	0.96
18BC052	Lost Gulch	5/31/2018 14:00	0.011	0.01	241	8	--	5.43	0.91
18BC059	Lost Gulch	6/8/2018 14:15	0.003	0.00	264	7.95	--	4.55	0.92
18BC066	Lost Gulch	6/15/2018 11:30	0.001	0.00	287	7.8	--	4.03	1.03
18BC073	Lost Gulch	6/17/2018 11:45	0.002	0.00	290	7.85	--	3.94	1.07
18BC080	Lost Gulch	6/18/2018 12:35	0.005	0.00	289	--	--	4.21	1.08
18BC086	Lost Gulch	6/19/2018 13:20	0.010	0.01	275	--	--	6.70	0.77
18BC120	Lost Gulch	6/29/2018 11:40	0.002	0.00	300	7.73	--	3.83	1.11
18BC127	Lost Gulch	7/4/2018 10:20	0.002	0.00	320	--	--	3.64	1.13
18BC134	Lost Gulch	7/13/2018 10:40	--	--	333	7.46	--	1.86	2.47
18BC141	Lost Gulch	7/15/2018 13:10	--	--	325	--	--	3.68	1.44
18BC154	Lost Gulch	7/20/2018 12:40	--	--	352	7.52	--	3.16	1.54
18BC160	Lost Gulch	7/23/2018 12:35	--	--	356	7.57	--	3.27	1.39
18BC166	Lost Gulch	7/24/2018 11:05	--	--	353	7.68	--	3.57	1.52
		Detection Limit	--	--	--	--	--	0.4	0.001

ID	Location	Date & Time MST	F mg/l	Cl mg/l	NO_2 mg/l	Br mg/l	NO_3 mg/l	PO_4 mg/l	SO_4 mg/l	Al mg/l	As mg/l
18BC001	Lost Gulch	4/18/2018 10:30	0.09	3.26	<0.1	<0.1	<0.1	<0.2	6.77	--	--
18BC007	Lost Gulch	4/21/2018 10:55	0.09	3.34	<0.1	<0.1	<0.1	<0.2	6.88	--	--
18BC012	Lost Gulch	5/3/2018 17:40	0.10	4.60	<0.1	<0.1	<0.1	<0.2	4.45	0.012	<0.04
18BC017	Lost Gulch	5/11/2018 10:30	0.10	4.68	<0.1	<0.1	<0.1	<0.2	5.49	--	--
18BC023	Lost Gulch	5/18/2018 14:00	0.09	5.18	<0.1	<0.1	<0.1	<0.2	5.26	0.006	<0.04
18BC035	Lost Gulch	5/20/2018 16:50	0.09	5.52	<0.1	<0.1	<0.1	<0.2	4.77	0.007	<0.04
18BC040	Lost Gulch	5/25/2018 14:40	0.10	4.95	<0.1	<0.1	<0.1	<0.2	4.62	0.007	<0.04
18BC052	Lost Gulch	5/31/2018 14:00	0.09	4.41	<0.1	<0.1	<0.1	<0.2	4.82	0.007	<0.04
18BC059	Lost Gulch	6/8/2018 14:15	0.09	4.16	<0.1	<0.1	<0.1	<0.2	5.42	0.006	<0.04
18BC066	Lost Gulch	6/15/2018 11:30	0.08	3.89	<0.1	<0.1	<0.1	<0.2	5.76	0.005	<0.04
18BC073	Lost Gulch	6/17/2018 11:45	0.11	3.95	<0.1	<0.1	<0.1	<0.2	5.62	0.007	<0.04
18BC080	Lost Gulch	6/18/2018 12:35	0.26	6.26	<0.1	<0.1	<0.1	0.71	9.48	0.008	<0.04
18BC086	Lost Gulch	6/19/2018 13:20	0.10	3.76	<0.1	<0.1	<0.1	<0.2	4.66	0.007	<0.04
18BC120	Lost Gulch	6/29/2018 11:40	0.08	3.15	<0.1	<0.1	<0.1	<0.2	5.10	0.007	<0.04
18BC127	Lost Gulch	7/4/2018 10:20	0.25	11.26	<0.1	<0.1	1.04	1.12	11.52	0.007	<0.04
18BC134	Lost Gulch	7/13/2018 10:40	0.22	5.69	<0.1	<0.1	<0.1	1.55	9.74	0.007	<0.04
18BC141	Lost Gulch	7/15/2018 13:10	0.25	6.36	<0.1	<0.1	<0.1	<0.2	9.79	0.008	<0.04
18BC154	Lost Gulch	7/20/2018 12:40	0.23	6.03	<0.1	<0.1	<0.1	1.03	9.27	0.006	<0.04
18BC160	Lost Gulch	7/23/2018 12:35	0.22	5.89	<0.1	<0.1	<0.1	<0.2	9.35	0.006	<0.04
18BC166	Lost Gulch	7/24/2018 11:05	0.24	5.84	<0.1	<0.1	<0.1	<0.2	9.38	0.006	<0.04
		Detection Limit	0.02	0.1	0.1	0.1	0.1	0.2	0.1	0.003	0.04

ID	Location	Date & Time MST	B mg/l	Ba mg/l	Be mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Cu mg/l	Fe mg/l
18BC001	Lost Gulch	4/18/2018 10:30	--	--	--	--	--	--	--	--	--
18BC007	Lost Gulch	4/21/2018 10:55	--	--	--	--	--	--	--	--	--
18BC012	Lost Gulch	5/3/2018 17:40	0.013	0.026	<0.0002	21.4	<0.002	<0.003	<0.002	0.024	0.014
18BC017	Lost Gulch	5/11/2018 10:30	--	--	--	--	--	--	--	--	--
18BC023	Lost Gulch	5/18/2018 14:00	0.015	0.032	<0.0002	26.7	<0.002	<0.003	<0.002	0.001	<0.002
18BC035	Lost Gulch	5/20/2018 16:50	0.014	0.031	<0.0002	25.5	<0.002	<0.003	<0.002	0.001	<0.002
18BC040	Lost Gulch	5/25/2018 14:40	0.014	0.031	<0.0002	25.8	<0.002	<0.003	<0.002	0.001	<0.002
18BC052	Lost Gulch	5/31/2018 14:00	0.015	0.033	<0.0002	27.0	<0.002	<0.003	<0.002	0.001	<0.002
18BC059	Lost Gulch	6/8/2018 14:15	0.017	0.038	<0.0002	31.0	<0.002	<0.003	<0.002	0.001	<0.002
18BC066	Lost Gulch	6/15/2018 11:30	0.019	0.042	<0.0002	33.8	<0.002	<0.003	<0.002	0.021	<0.002
18BC073	Lost Gulch	6/17/2018 11:45	0.019	0.044	<0.0002	35.5	<0.002	<0.003	<0.002	0.002	<0.002
18BC080	Lost Gulch	6/18/2018 12:35	0.019	0.042	<0.0002	34.8	<0.002	<0.003	<0.002	0.002	<0.002
18BC086	Lost Gulch	6/19/2018 13:20	0.019	0.038	<0.0002	31.0	<0.002	<0.003	<0.002	0.002	<0.002
18BC120	Lost Gulch	6/29/2018 11:40	0.019	0.045	<0.0002	36.8	<0.002	<0.003	<0.002	0.019	<0.002
18BC127	Lost Gulch	7/4/2018 10:20	0.021	0.048	<0.0002	38.5	<0.002	<0.003	<0.002	0.001	<0.002
18BC134	Lost Gulch	7/13/2018 10:40	0.024	0.057	<0.0002	42.9	<0.002	<0.003	<0.002	0.001	<0.002
18BC141	Lost Gulch	7/15/2018 13:10	0.021	0.055	<0.0002	39.0	<0.002	<0.003	<0.002	0.010	<0.002
18BC154	Lost Gulch	7/20/2018 12:40	0.023	0.060	<0.0002	42.3	<0.002	<0.003	<0.002	0.001	<0.002
18BC160	Lost Gulch	7/23/2018 12:35	0.024	0.060	<0.0002	43.5	<0.002	<0.003	<0.002	0.001	<0.002
18BC166	Lost Gulch	7/24/2018 11:05	0.022	0.060	<0.0002	42.7	<0.002	<0.003	<0.002	0.001	<0.002
		Detection Limit	0.007	0.001	0.0005	0.02	0.002	0.003	0.002	0.002	0.002

ID	Location	Date & Time MST	K mg/l	Li mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Na mg/l	Ni mg/l	P mg/l	Pb mg/l
18BC001	Lost Gulch	4/18/2018 10:30	--	--	--	--	--	--	--	--	--
18BC007	Lost Gulch	4/21/2018 10:55	--	--	--	--	--	--	--	--	--
18BC012	Lost Gulch	5/3/2018 17:40	2.07	0.003	8.19	<0.001	<0.005	5.75	<0.003	<0.04	<0.02
18BC017	Lost Gulch	5/11/2018 10:30	--	--	--	--	--	--	--	--	--
18BC023	Lost Gulch	5/18/2018 14:00	2.40	0.004	10.10	<0.001	<0.005	6.56	<0.003	<0.04	<0.02
18BC035	Lost Gulch	5/20/2018 16:50	2.30	0.004	9.73	<0.001	<0.005	6.49	<0.003	<0.04	<0.02
18BC040	Lost Gulch	5/25/2018 14:40	2.40	0.004	9.81	<0.001	<0.005	6.64	<0.003	<0.04	<0.02
18BC052	Lost Gulch	5/31/2018 14:00	2.44	0.005	10.20	<0.001	<0.005	6.63	<0.003	<0.04	<0.02
18BC059	Lost Gulch	6/8/2018 14:15	2.62	0.005	11.90	<0.001	<0.005	7.03	<0.003	<0.04	<0.02
18BC066	Lost Gulch	6/15/2018 11:30	2.72	0.006	12.80	<0.001	<0.005	7.37	<0.003	<0.04	<0.02
18BC073	Lost Gulch	6/17/2018 11:45	2.84	0.006	13.20	<0.001	<0.005	7.69	<0.003	<0.04	<0.02
18BC080	Lost Gulch	6/18/2018 12:35	2.88	0.006	12.70	<0.001	<0.005	7.50	<0.003	<0.04	<0.02
18BC086	Lost Gulch	6/19/2018 13:20	2.70	0.005	11.60	<0.001	<0.005	7.05	<0.003	<0.04	<0.02
18BC120	Lost Gulch	6/29/2018 11:40	2.88	0.006	13.40	<0.001	<0.005	7.64	<0.003	<0.04	<0.02
18BC127	Lost Gulch	7/4/2018 10:20	2.92	0.006	14.00	<0.001	<0.005	7.83	<0.003	<0.04	<0.02
18BC134	Lost Gulch	7/13/2018 10:40	3.24	0.007	15.60	<0.001	<0.005	8.33	<0.003	<0.04	<0.02
18BC141	Lost Gulch	7/15/2018 13:10	2.88	0.006	15.00	<0.001	<0.005	8.22	<0.003	<0.04	<0.02
18BC154	Lost Gulch	7/20/2018 12:40	3.16	0.007	16.10	<0.001	<0.005	8.73	<0.003	<0.04	<0.02
18BC160	Lost Gulch	7/23/2018 12:35	3.14	0.007	16.60	<0.001	<0.005	8.65	<0.003	<0.04	<0.02
18BC166	Lost Gulch	7/24/2018 11:05	3.04	0.007	16.30	<0.001	<0.005	8.76	<0.003	<0.04	<0.02
		Detection Limit	0.04	0.001	0.002	0.001	0.005	0.07	0.003	0.04	0.02

ID	Location	Date & Time MST	Rb mg/l	Sb mg/l	Se mg/l	SiO2 mg/l	Sr mg/l	U mg/l	V mg/l	W mg/l	Zn mg/l
18BC001	Lost Gulch	4/18/2018 10:30	--	--	--	--	--	--	--	--	--
18BC007	Lost Gulch	4/21/2018 10:55	--	--	--	--	--	--	--	--	--
18BC012	Lost Gulch	5/3/2018 17:40	<0.002	<0.03	<0.04	13.90	0.126	0.006	<0.001	<0.01	0.005
18BC017	Lost Gulch	5/11/2018 10:30	--	--	--	--	--	--	--	--	--
18BC023	Lost Gulch	5/18/2018 14:00	<0.002	<0.03	<0.04	16.40	0.157	0.006	<0.001	<0.01	0.005
18BC035	Lost Gulch	5/20/2018 16:50	0.003	<0.03	<0.04	16.30	0.150	0.005	<0.001	<0.01	0.007
18BC040	Lost Gulch	5/25/2018 14:40	<0.002	<0.03	<0.04	16.80	0.153	<0.004	<0.001	<0.01	0.006
18BC052	Lost Gulch	5/31/2018 14:00	<0.002	<0.03	<0.04	17.30	0.160	0.006	<0.001	<0.01	0.004
18BC059	Lost Gulch	6/8/2018 14:15	0.003	<0.03	<0.04	18.40	0.183	0.007	<0.001	<0.01	0.005
18BC066	Lost Gulch	6/15/2018 11:30	0.004	<0.03	<0.04	19.30	0.200	0.008	<0.001	<0.01	0.010
18BC073	Lost Gulch	6/17/2018 11:45	0.003	<0.03	<0.04	19.80	0.207	0.008	<0.001	<0.01	0.007
18BC080	Lost Gulch	6/18/2018 12:35	0.004	<0.03	<0.04	19.50	0.204	0.008	<0.001	<0.01	0.014
18BC086	Lost Gulch	6/19/2018 13:20	0.004	<0.03	<0.04	18.60	0.183	0.008	<0.001	<0.01	0.005
18BC120	Lost Gulch	6/29/2018 11:40	0.003	<0.03	<0.04	20.60	0.215	0.007	<0.001	<0.01	0.027
18BC127	Lost Gulch	7/4/2018 10:20	0.004	<0.03	<0.04	20.80	0.228	0.005	<0.001	<0.01	0.006
18BC134	Lost Gulch	7/13/2018 10:40	0.005	<0.03	<0.04	21.80	0.256	0.006	<0.001	<0.01	0.008
18BC141	Lost Gulch	7/15/2018 13:10	0.005	<0.03	<0.04	19.40	0.226	0.008	<0.001	<0.01	0.007
18BC154	Lost Gulch	7/20/2018 12:40	0.005	<0.03	<0.04	21.20	0.249	0.010	<0.001	<0.01	0.006
18BC160	Lost Gulch	7/23/2018 12:35	0.005	<0.03	<0.04	20.80	0.255	0.010	<0.001	<0.01	0.006
18BC166	Lost Gulch	7/24/2018 11:05	0.005	<0.03	<0.04	20.70	0.249	0.012	<0.001	<0.01	0.006
		Detection Limit	0.002	0.03	0.04	0.03	0.001	0.004	0.001	0.01	0.001

ID	Location	Date & Time MST	$\delta^{18}O$ ‰	^{2}H ‰	Deuterium Excess
18BC001	Lost Gulch	4/18/2018 10:30	-14.39	-105.8	9.29
18BC007	Lost Gulch	4/21/2018 10:55	-14.26	-104.92	9.13
18BC012	Lost Gulch	5/3/2018 17:40	-14.73	-109.64	8.21
18BC017	Lost Gulch	5/11/2018 10:30	-14.34	-105.69	9.07
18BC023	Lost Gulch	5/18/2018 14:00	-14.07	-103.49	9.10
18BC035	Lost Gulch	5/20/2018 16:50	-14	-103.63	8.37
18BC040	Lost Gulch	5/25/2018 14:40	-14.2	-103.73	9.89
18BC052	Lost Gulch	5/31/2018 14:00	-13.95	-103.34	8.27
18BC059	Lost Gulch	6/8/2018 14:15	-14.06	-104.01	8.45
18BC066	Lost Gulch	6/15/2018 11:30	-14.11	-104.38	8.51
18BC073	Lost Gulch	6/17/2018 11:45	-14.07	-103.58	9.00
18BC080	Lost Gulch	6/18/2018 12:35	-13.83	-102.28	8.35
18BC086	Lost Gulch	6/19/2018 13:20	-13.47	-98.8	9.00
18BC120	Lost Gulch	6/29/2018 11:40	-13.91	-101.19	10.08
18BC127	Lost Gulch	7/4/2018 10:20	-14.06	-102.12	10.34
18BC134	Lost Gulch	7/13/2018 10:40	-14.03	-102.48	9.74
18BC141	Lost Gulch	7/15/2018 13:10	-13.75	-100.67	9.30
18BC154	Lost Gulch	7/20/2018 12:40	-13.54	-100.63	7.66
18BC160	Lost Gulch	7/23/2018 12:35	-13.66	-100.35	8.90
18BC166	Lost Gulch	7/24/2018 11:05	-13.68	-99.79	9.63
		Detection Limit	--	--	--

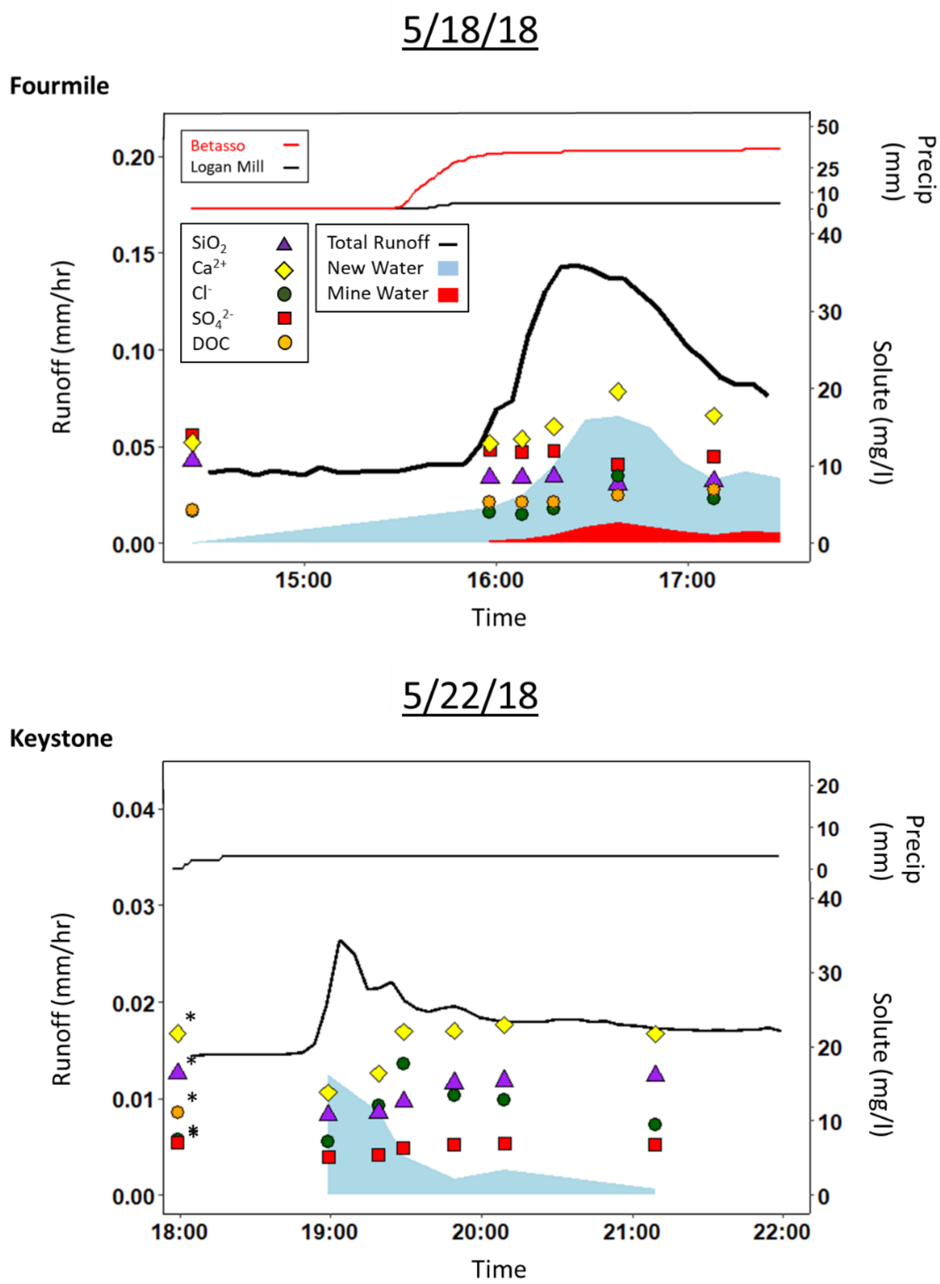

Figure A3. Total runoff (mm/hr), new water fraction, SiO_2, Ca^{2+}, Cl^-, SO_4^{2-} and DOC concentrations (mg/l) and precipitation on May 18th at Fourmile Creek and May 22nd at Keystone Gulch. Precipitation data for Fourmile Creek are from the UDFCD Betasso (maximum I_{30}: 66 mm) and Logan Mill (maximum I_{30}: 6 mm) sites. Precipitation data for Keystone Gulch are from the UDFCD Magnolia (maximum I_{30}: 6 mm) site and the pre-storm constituent concentrations with * are from a sample collected at 14:35 on May 20th.