2018 ANNUAL WATER QUALITY REPORT

The Keep it Clean Partnership

Final Report
December 2019

KEEP IT CLEAN PARTNERSHIP
Stormwater Protection
BOULDER • BOULDER COUNTY • LONGMONT
ERIE • LAFAYETTE • LOUISVILLE • SUPERIOR
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EXECUTIVE SUMMARY

In 2014 the Keep it Clean Partnership (KICP) developed a shared monitoring plan to improve coordination between multiple independent monitoring efforts being conducted by various parties in the watershed. The annual development of this report furthers the KICP's work on monitoring and improving water quality throughout the watershed and aligns with the goals of the 319 non-point source management plan developed by the KICP in 2015. Key findings from analysis of 2018 data include:

General water quality

- Water temperature, conductivity, total suspended solids, alkalinity, hardness, and pH values generally increased from upstream to downstream.
- Dissolved oxygen was low in Rock Creek and did not meet the stream standard.
- pH was relatively low on Boulder Creek above South Boulder Creek but was in attainment of the stream standard at all sites.
- Conductivity has generally increased in Boulder Creek over the last 5 years.

Nutrients

- Nitrogen and phosphorus increased from upstream to downstream, especially below major Wastewater Treatment Plants (WWTPs), where streams are not expected to meet future standards.
- Total nitrogen has decreased or remained the same over the last 5 years, while total phosphorus has increased at several monitoring sites.

Bacteria

- *E. coli* concentrations were generally highest a few miles downstream of the urban boundary and decreased gradually further downstream.
- *E. coli* concentrations were low until late spring, with increasing values throughout the summer and a rapid decrease in the mid-late fall.

Metals

- Total arsenic and dissolved selenium increased downstream, dissolved copper increased below the Boulder WWTP, and dissolved silver had no clear pattern.
- Dissolved copper was relatively low above the Boulder WWTP and increased downstream, but indicated attainment of all stream standards.
- Dissolved silver was similar between all Boulder Creek sites, but upstream sites with lower hardness did not indicate attainment of the stream standard.
- Total arsenic has generally decreased over the last 5 years in St. Vrain Creek and Boulder Creek.

Recommendations

- Further investigation of low dissolved oxygen values in Rock Creek.
- Further study and monitoring of long-term water quality trends.
- Consider an active role in rulemaking sessions for new nutrient standards.
- Focus bacteria efforts on source determination and mitigation.
- Consider monitoring dissolved fractions of metals to compare with standards.
- Further study of arsenic, silver, and selenium standards for appropriateness.
- Further review of monitoring, analysis, and statistical methods for future reports.

INTRODUCTION

Monitoring program overview

The Keep it Clean Partnership (KICP) coordinated monitoring program was initiated in 2014 in tandem with a 319 non-point source management plan (KICP and WWE 2015) for the Boulder St. Vrain Basin. The original objectives for this plan were to leverage data to target impaired stream reaches for improvement, identify changes in water quality, and evaluate the return on investment for capital improvements (WWE 2017). Over the last 5 years the KICP has continued to pursue these objectives and enhanced communication and integration of data with the public and other organizations.

Data for this report is collected by the cities of Boulder, Longmont, Louisville, and Lafayette, and the towns of Erie and Superior. Maps of regularly monitored sites are presented in Figures 1.1-3 and a summary of these sites is presented in Table 1.2. The 2018 annual data report includes data from the last 5 years (2014 – 2018) in accordance with the period of record considered by the Colorado Department of Public Health and Environment (CDPHE), with a focus on the most recent year of data.

Table 1.1 provides a summary of the analytes considered as part of the KICP monitoring program with units, minimum detection limits (MDL), and sampling frequency. MDLs provided here are the baseline agreed upon by the participating entities, and some analyses utilize more sensitive sampling methods with lower MDLs.

Analyte	Units	MDL	Frequency
Temperature	°C	-15 °C	Monthly
Hardness	mg/L	1 mg/L	Monthly
Alkalinity	mg/L	1 mg/L	Monthly
Conductivity	µS/cm	0.1 µS/cm	Monthly
Total suspended solids	mg/L	2 mg/L	Monthly
Dissolved oxygen	mg/L	0.1 mg/L	Monthly
pH	Standard units	1 S.U.	Monthly
Total nitrogen	mg/L	0.1 mg/L	Monthly
Total Kjedahl nitrogen	mg/L	0.1 mg/L	Monthly
Total inorganic nitrogen	mg/L	N/A	Monthly
Nitrites and nitrates	mg/L	0.02 mg/L	Monthly
Total ammonia	mg/L	0.05 mg/L	Monthly
Total phosphorus	mg/L	0.01 mg/L	Monthly
E. coli	MPN or CFU /100 mL	1 MPN or CFU /100 mL	Monthly
Total arsenic	µg/L	Varies	Monthly
Dissolved copper	µg/L	Varies	Monthly
Dissolved selenium	µg/L	Varies	Monthly
Benthic monitoring	N/A	N/A	Biannually

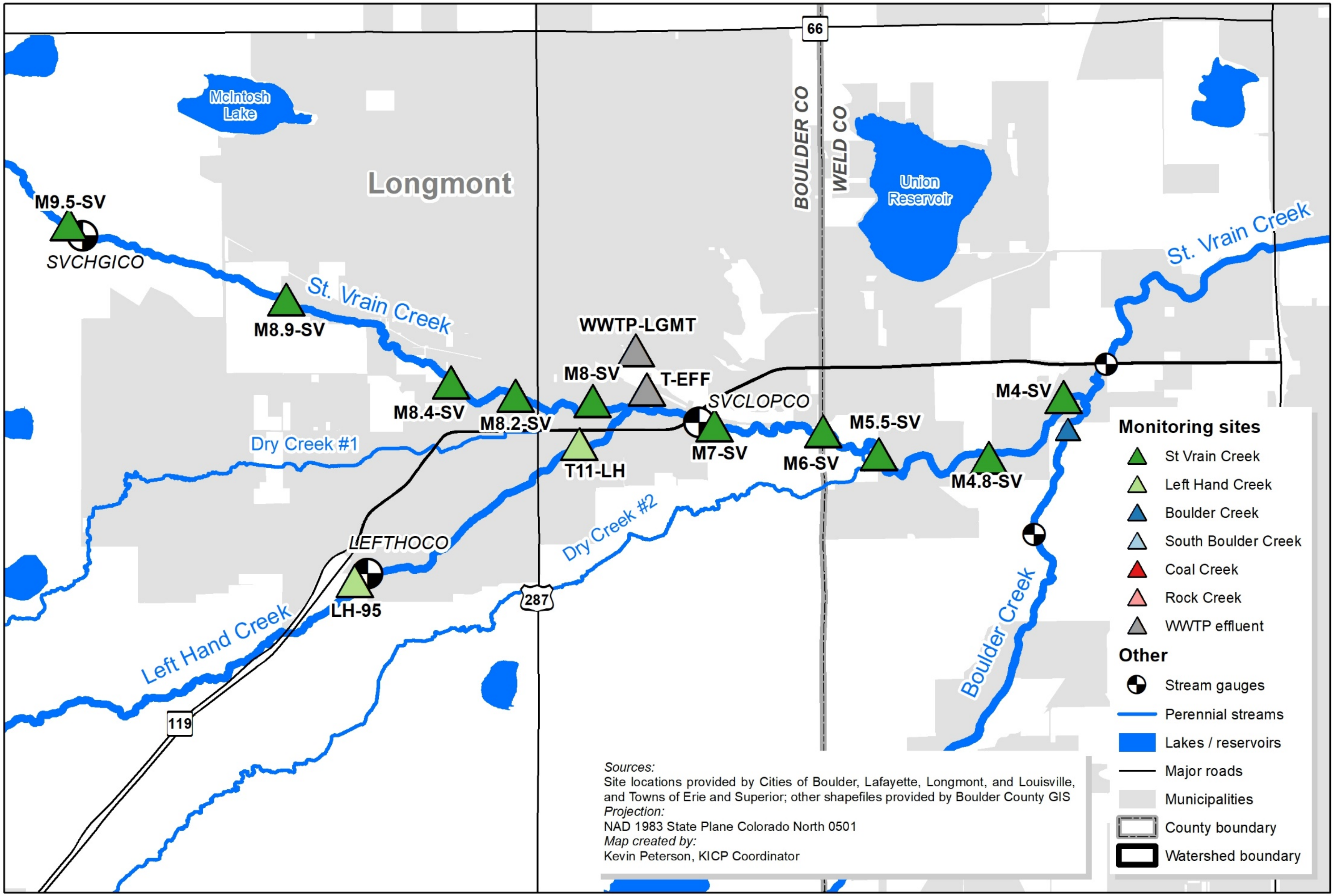
Table 1.1 Summary of KICP shared monitoring program analytes

Changes to this report

This is the first year that the KICP Annual Water Quality Report was directly developed by in-house staff rather than a consultant. In accordance with this transition numerous changes have been made to the format of this report to improve readability and focus on the most important observations. Benthic macroinvertebrate data continues to be collected by the entities participating in the KICP shared monitoring plan but was not included in this year's report as these observations had not yet been provided when this report was developed. A summary of benthic macroinvertebrate data may be included in a future version of this report or in subsequent years.

Future versions of this report will continue to be modified and expanded based on feedback received from stakeholders and the priorities of the Keep it Clean Partnership and its participating communities.

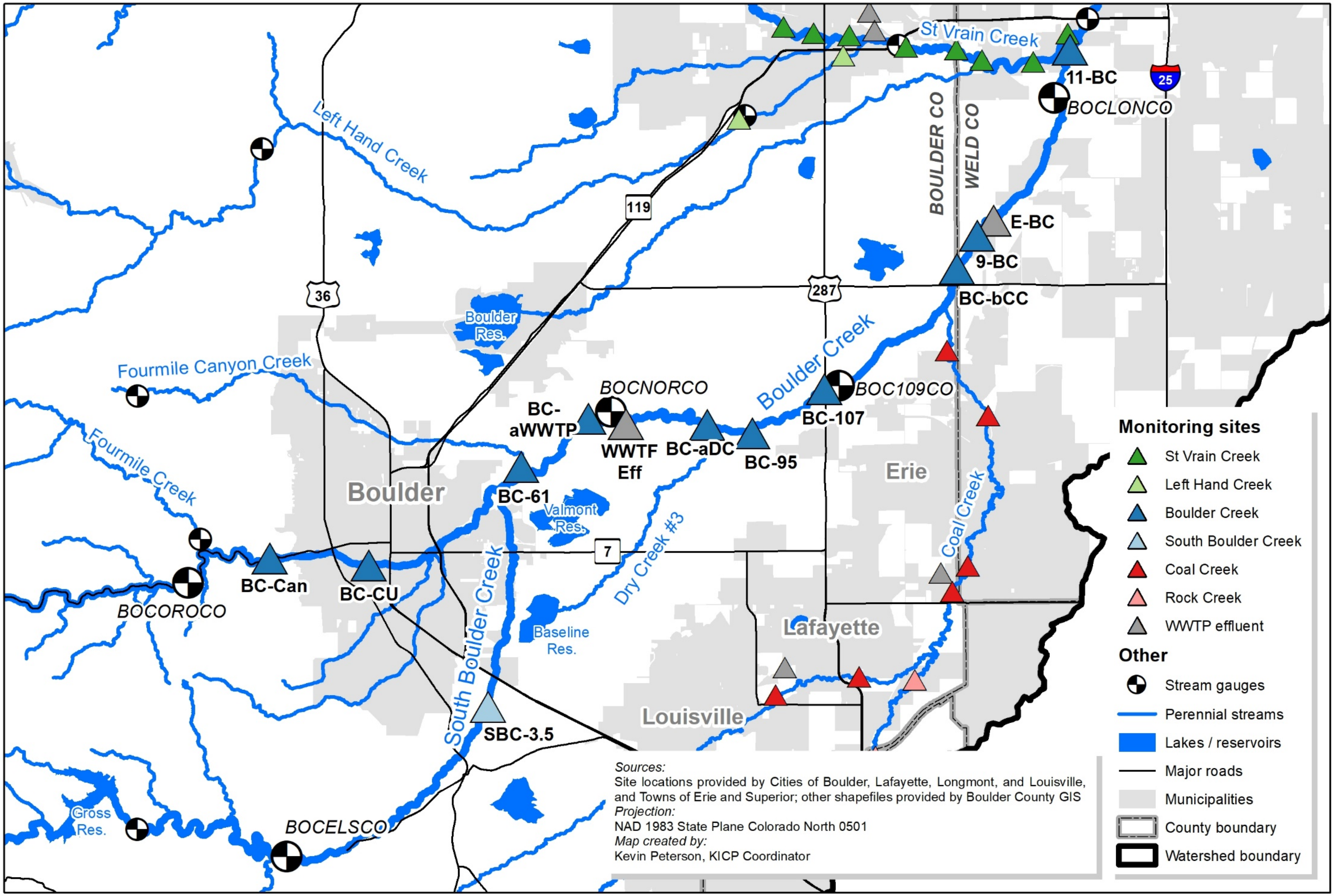
ST VRAIN CREEK MONITORING SITES



Note: several site locations adjusted slightly to enhance readability

Figure 1.1 2018 St Vrain Creek monitoring sites

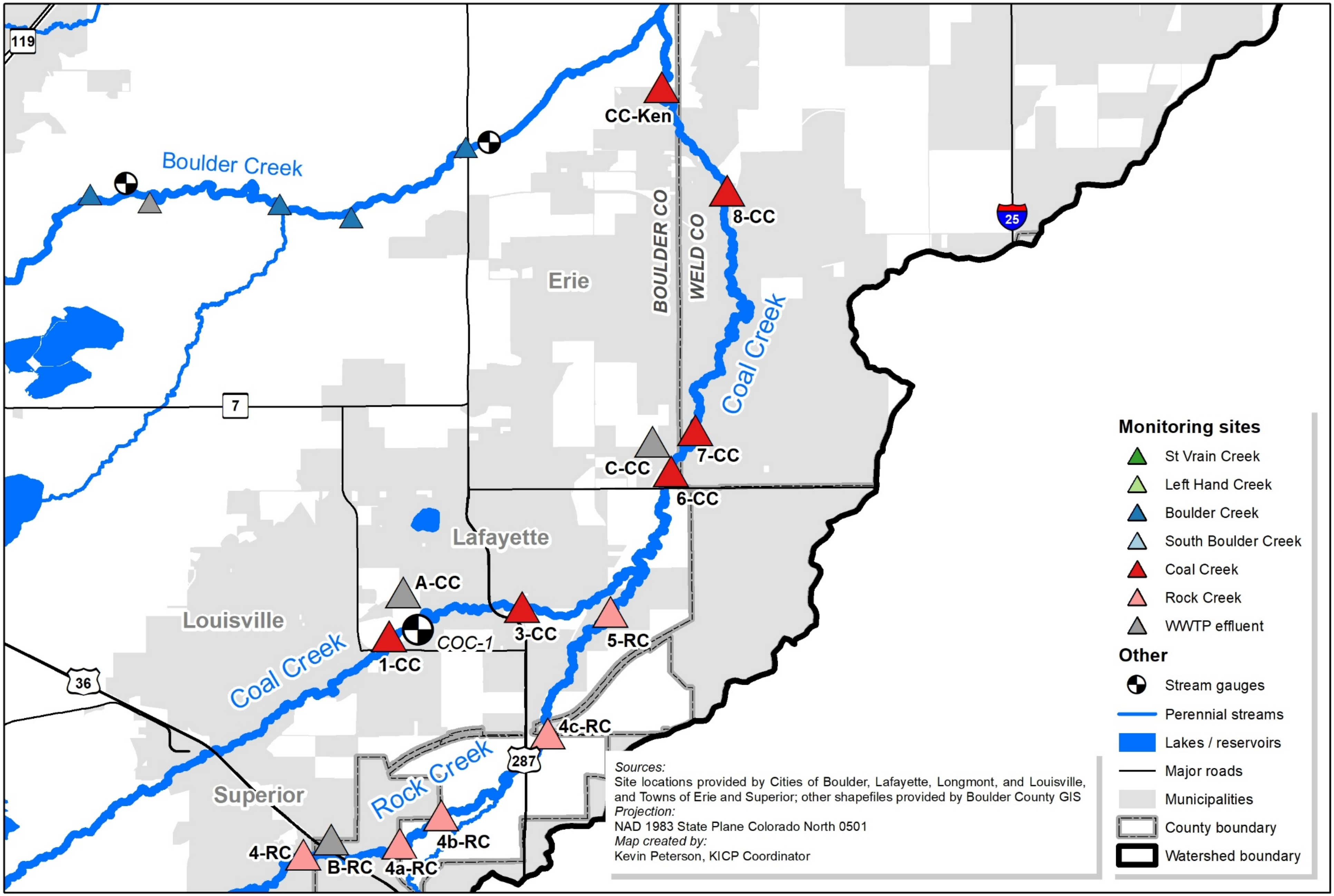
BOULDER CREEK MONITORING SITES



Note: several site locations adjusted slightly to enhance readability

Figure 1.2 2018 Boulder Creek monitoring sites

COAL CREEK MONITORING SITES



Note: several site locations adjusted slightly to enhance readability

Figure 1.3 2018 Coal Creek monitoring sites

Site	Description	Latitude	Longitude	Data provider	sStream Segment
M9.5-SV	St. Vrain Creek at North 75th St	40.1775	-105.1784	City of Longmont	COSPSV03
M8.9-SV	St. Vrain Creek at Golden Ponds	40.1693	-105.1442	City of Longmont	COSPSV03
M8.4-SV	St. Vrain Creek downstream of Boston Ave	40.1586	-105.1169	City of Longmont	COSPSV03
M8.2-SV	St. Vrain Creek at Pratt Parkway	40.1569	-105.1062	City of Longmont	COSPSV03
M8-SV	St. Vrain Creek upstream of the Longmont WWTP discharge	40.1553	-105.0878	City of Longmont	COSPSV03
LH-95	Left Hand Creek at 95th St	40.13391	-105.1318	City of Longmont	COSPSV05
T11-LH	Left Hand Creek at St. Vrain Creek	40.1551	-105.087	City of Longmont	COSPSV05
WWTP-LGMT	Discharge from Longmont WWTP	40.1574	-105.0862	City of Longmont	N/A
T-EFF	Ditch carrying combined WWTP effluent and roadside flow to St. Vrain Creek	40.1557	-105.0862	City of Longmont	N/A
M7-SV	St. Vrain Creek at CO-119	40.153	-105.0741	City of Longmont	COSPSV03
M6-SV	St. Vrain Creek at County Line Rd	40.1522	-105.0551	City of Longmont	COSPSV03
M5.5-SV	St. Vrain Creek at Peschel Rd	40.14944	-105.048	City of Longmont	COSPSV03
M4.8-SV	St. Vrain Creek below Spring Gulch #2	40.14889	-105.028	City of Longmont	COSPSV03
M4-SV	St. Vrain Creek upstream of the confluence with Boulder Creek	40.1582	-105.0108	City of Longmont	COSPSV03
BC-Can	Boulder Creek at the pool area at the Anderson Ditch head gate	40.01318	-105.3015	City of Boulder	COSPBO02b
BC-CU	Boulder Creek at the foot bridge connecting Folsom Field with the parking lot to the north	40.011112	-105.2661	City of Boulder	COSPBO02b
SBC-3.5	South Boulder Creek at McGinn Ditch Gate	39.97215	-105.2236	City of Boulder	COSPBO04b
BC-61	Boulder Creek just west of the 61st St bridge	40.03809	-105.2116	City of Boulder	COSPBO09
BC-aWWTP	Boulder Creek under bridge at 75th St upstream of the Boulder WWTP discharge	40.05152	-105.1786	City of Boulder	COSPBO09
WWTF Eff	Discharge from Boulder WWTP	40.05137	-105.1775	City of Boulder	N/A
BC-aDC	Boulder Creek upstream of Dry Creek	40.04948	-105.1449	City of Boulder	COSPBO09
BC-95	Boulder Creek downstream of the Lower Boulder Ditch headgate	40.04716	-105.1288	City of Boulder	COSPBO09
BC-107	Boulder Creek at the 107th St bridge	40.05922	-105.103	City of Boulder	COSPBO09
BC-bCC	Boulder Creek at the East County Line Rd bridge	40.09211	-105.0553	City of Boulder	COSPBO10
9-BC	Boulder Creek upstream of the North Erie WWTP discharge	40.1012	-105.048	Town of Erie	COSPBO10
E-BC	Discharge from the North Erie WWTP	40.1021	-105.0474	Town of Erie	N/A
11-BC	Boulder Creek at mouth near Longmont at USGS gage 06730500	40.1522	-105.0144	Town of Erie	COSPBO10
1-CC	Coal Creek upstream of the Louisville WWTP discharge	39.9761	-105.1164	City of Louisville	COSPBO07b
A-CC	Discharge from the Louisville WWTP	39.9801	-105.1221	City of Louisville	N/A
3-CC	Coal Creek upstream of the confluence with Rock Creek	39.9799	-105.0909	City of Lafayette	COSPBO07b
4-RC	Rock Creek upstream of the Superior WWTP discharge	39.93738	-105.1402	Town of Superior	COSPBO08
B-RC	Discharge from the Superior WWTP	39.9368	-105.1403	Town of Superior	N/A
4a-RC	Rock Creek at Brainard Dr	39.9392	-105.1186	Town of Superior	COSPBO08
4b-RC	Rock Creek at South 104th St	39.94409	-105.1093	Town of Superior	COSPBO08
4c-RC	Rock Creek at West Dillon Rd near Ruth Roberts Park	39.95806	-105.0853	Town of Superior	COSPBO08
5-RC	Rock Creek upstream of the confluence with Coal Creek	39.979	-105.0711	City of Lafayette	COSPBO08
6-CC	Coal Creek upstream of the Lafayette WWTP discharge	40.0032	-105.0574	City of Lafayette	COSPBO07b
7-CC	Coal Creek downstream of the Lafayette WWTP discharge	40.0103	-105.0519	City of Lafayette	COSPBO07b
C-CC	Discharge from the Lafayette WWTP	40.0038	-105.0579	City of Lafayette	N/A
8-CC	Coal Creek at Cheesman St	40.05157	-105.0444	City of Louisville	COSPBO07b
CC-Ken	Coal Creek at the Kenosha Rd bridge upstream of Boulder Creek	40.06949	-105.059	City of Boulder	COSPBO07b

Table 1.2 Summary of 2018 KICP shared monitoring program sites

PRECIPITATION & STREAM FLOW

Precipitation data

Precipitation data was summarized for two sites within the basin in line with previous analysis reports; Station US1COBO0352 in Longmont, CO (Lat. 40.1848, Long. -105.082) and Station USC00050848 in Boulder, CO (Lat. 39.9919, Long. -105.2667). Data was obtained from the National Oceanic and Atmospheric Administration National Centers for Environmental Information database (https://www.ncdc.noaa.gov/). Precipitation is highly variable throughout the watershed and these summaries should not be considered representative of precipitation throughout the entire basin.

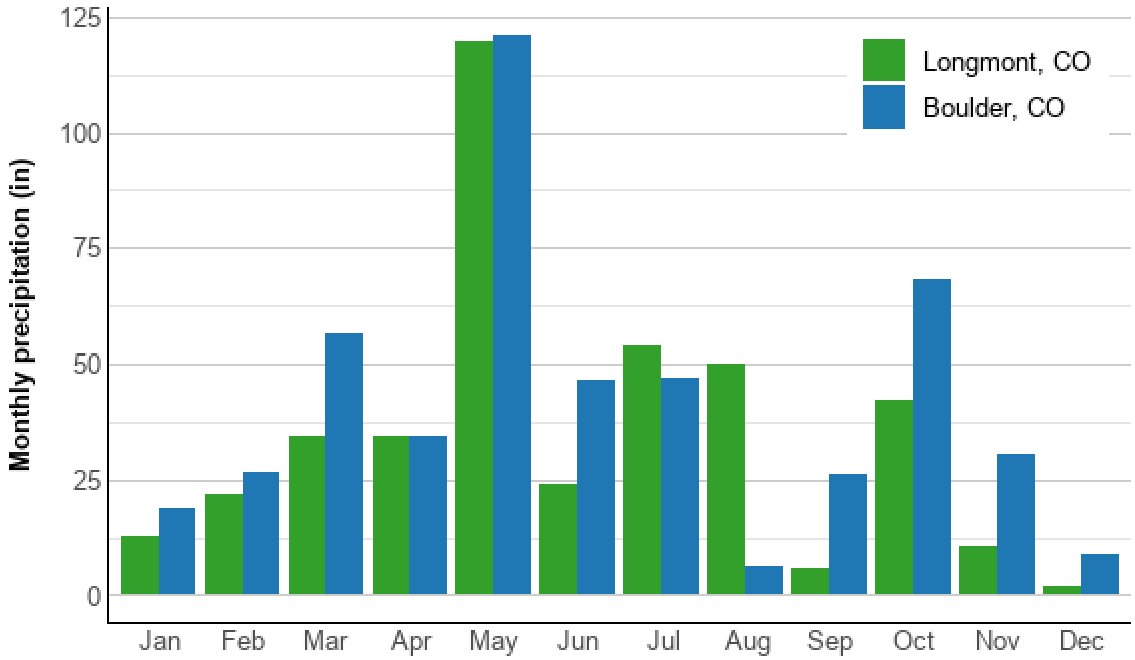


Figure 2.1 2018 monthly precipitation totals in Boulder and Longmont

Precipitation events that exceeded a total of 1 inch at either station were recorded in Table 2.1 and annotated in Figure 2.2 to compare the same events at each station. A single precipitation event was identified as a period with consecutive days of measured precipitation. There was a total of 3 precipitation events at the Longmont station and 8 events at the Boulder station that exceeded 1 inch total. Both sites received a significant precipitation event in early and mid-May and late July. Timing of precipitation events was very similar between the two monitoring sites, but magnitude varied considerably for individual events.

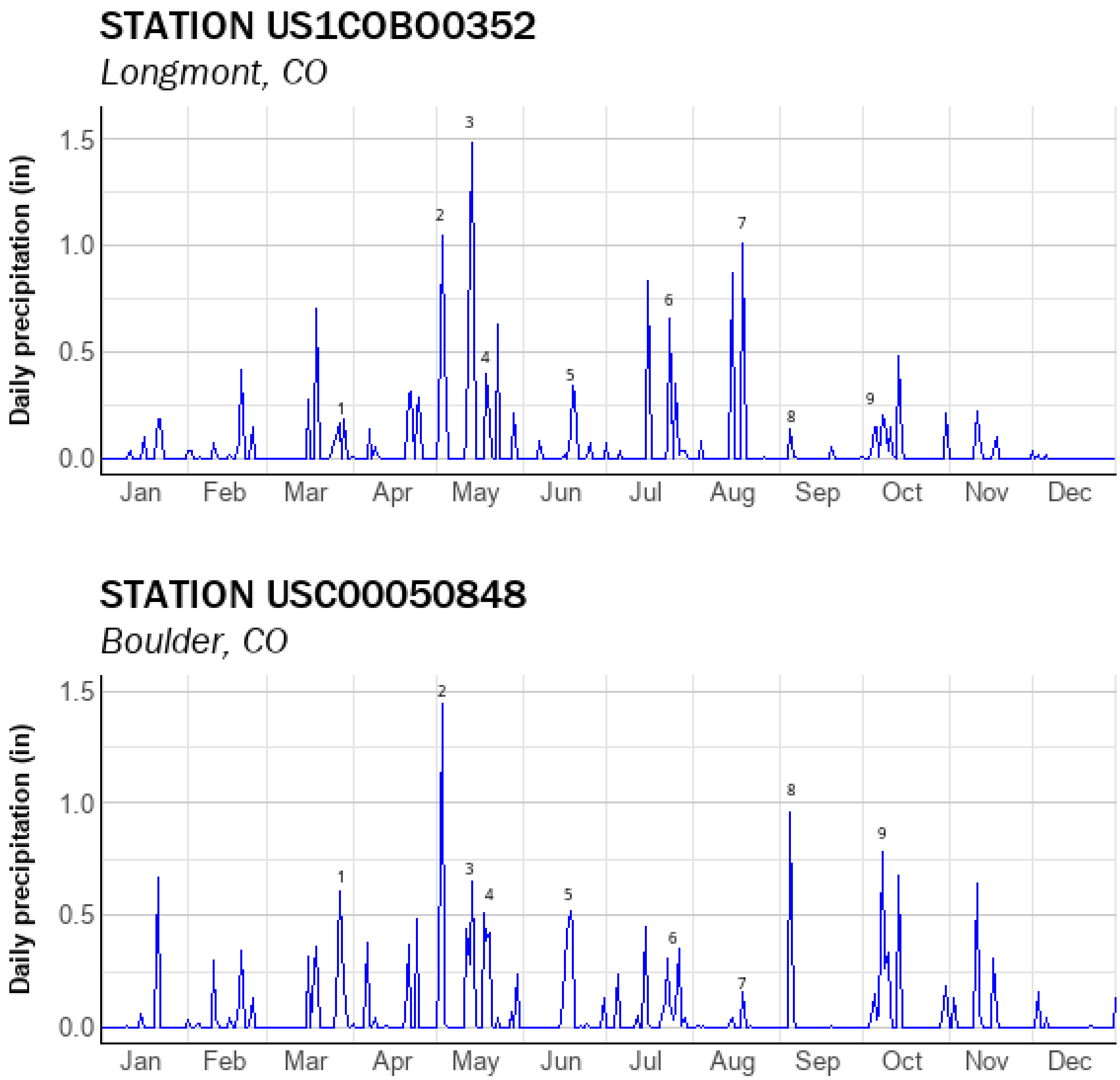


Figure 2.2 2018 daily precipitation at Boulder and Longmont gages

Event #	Event dates *Longmont, CO*	Total precipitation *Longmont, CO*	Event dates *Boulder, CO*	Total precipitation *Boulder, CO*
1	March 24-27, 29	0.37 in (9.44 mm)	March 26-30	1.30 in (33.0 mm)
2	May 2-4	1.71 in (43.5 mm)	May 2-4	1.70 in (43.2 mm)
3	May 12-14	1.57 in (39.9 mm)	May 12-15	1.38 in (35.1 mm)
4	May 19-21	0.59 in (15.1 mm)	May 18-21	1.33 in (33.9 mm)
5	June 16, 18-20	0.78 in (19.7 mm)	June 15-19	1.66 in (42.2 mm)
6	July 23-24, 26-30	1.19 in (29.8 mm)	July 21-29	1.09 in (27.6 mm)
7	August 19	1.07 in (25.7 mm)	August 19	0.16 in (4.1 mm)
8	September 5-7	0.17 in (4.2 mm)	September 5-6	1.01 in (25.7 mm)
9	October 4-12	0.91 in (23.2 mm)	October 4-11	1.72 in (43.8 mm)

Table 2.1 Major 2018 precipitation events at Boulder and Longmont gages

Stream flow data

Data was obtained from the Colorado Division of Water Resources (DWR) and U.S. Geological Survey (USGS). Table 2.2 provides a basic summary of 2018 flow conditions at each gage and Figures 2.3-2.11 depict 2018 hydrographs of each gaging station with reference medians. 2018 flows in St. Vrain Creek were low relative to the previous 4 years, while Boulder Creek and Coal Creek were more similar to the reference period. See Figures 1.1-1.3 for stream gage locations.

Stream gage	Location	Major peaks	2018 peak	2014 – 2017 median peak
SVCHGICO	St. Vrain Creek at Hygiene	May 28, Jun 18	228 cfs	664 cfs
LEFTHOCO	Left Hand Creek at Hover Rd	May 28, Jun 19	139 cfs	213 cfs
SVCLOPCO	St. Vrain Creek below Ken Pratt Blvd	May 28, Jun 19	260 cfs	782 cfs
BOCOROCO	Boulder Creek near Orodell	Jun 1, Jun 18	557 cfs	617 cfs
BOCELSCO	S Boulder Creek near Eldorado Springs	May 12, Jun 11	228 cfs	263 cfs
BOCNORCO	Boulder Creek at N 75th St	May 3, May 14, Jun 1, Jun 18	592 cfs	706 cfs
BOC109CO	Boulder Creek at 109th St	May 3, May 14, May 19, Jun 1, Jun 19	458 cfs	534 cfs
BOCLONCO	Boulder Creek at mouth	May 3, May 14, May 19, Jun 1, Jun 19	583 cfs	751 cfs
COC-1	Coal Creek near Louisville	Mar 19, Mar 28, Apr 21, Apr 24, May 3, May 14, May 18	46 cfs	33 cfs

Table 2.2 Summary of 2018 flow conditions at nearby gages

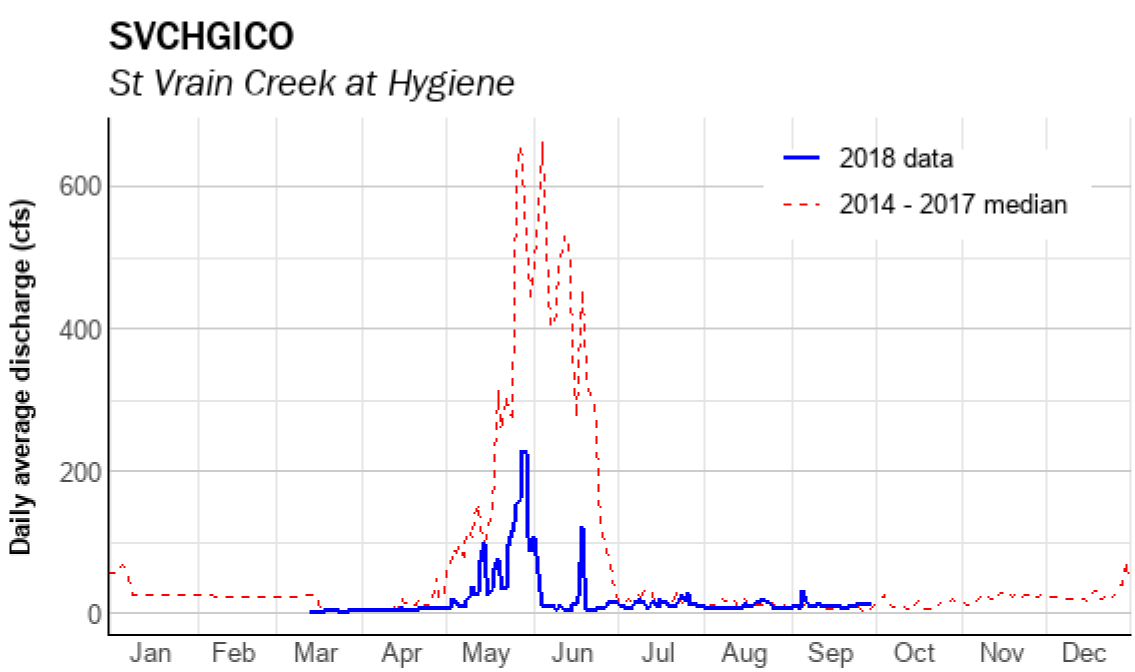


Figure 2.3 Stream flow at gage SVCHGICO

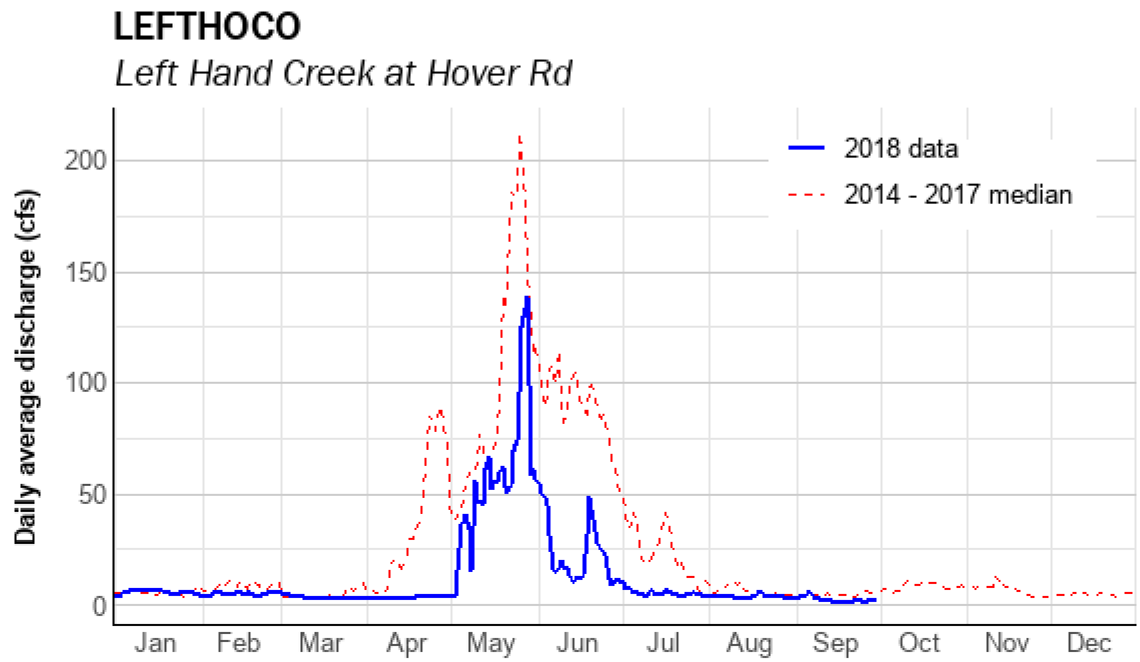


Figure 2.4 Stream flow at gage LEFTHOCO

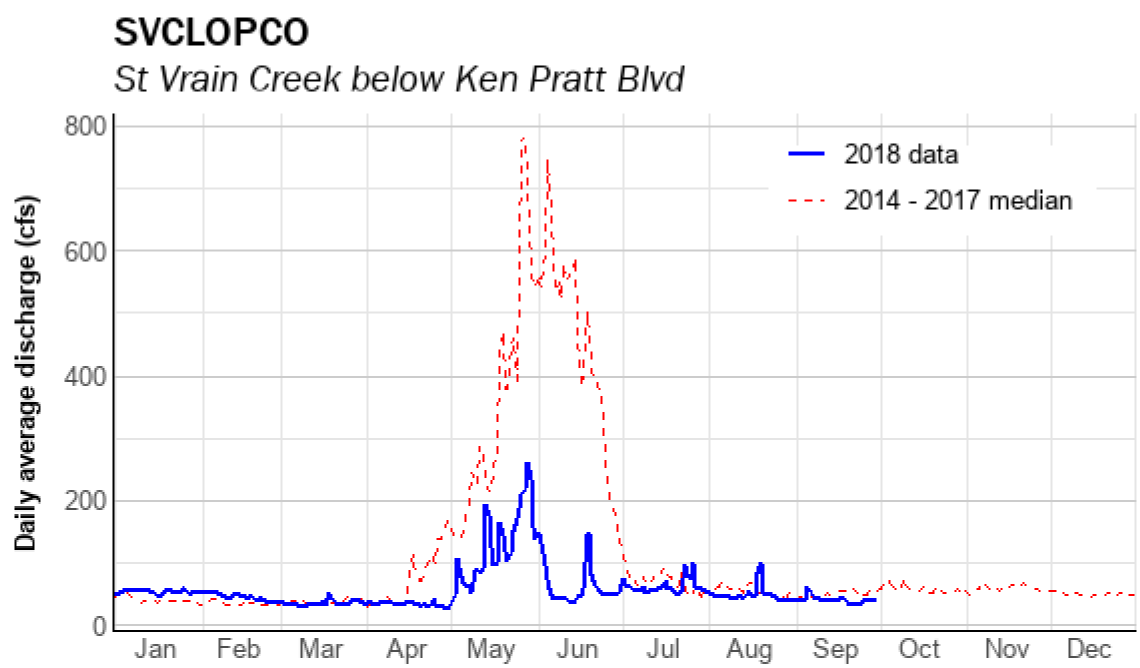


Figure 2.5 Stream flow at gage SVCLOPCO

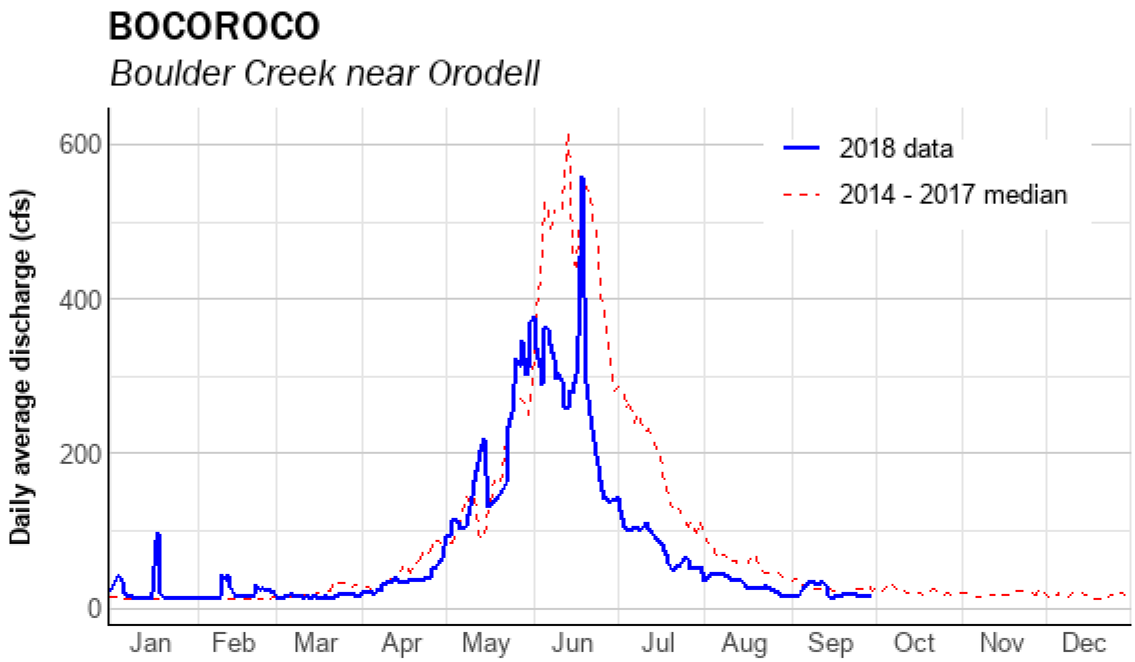


Figure 2.6 Stream flow at gage BOCOROCO

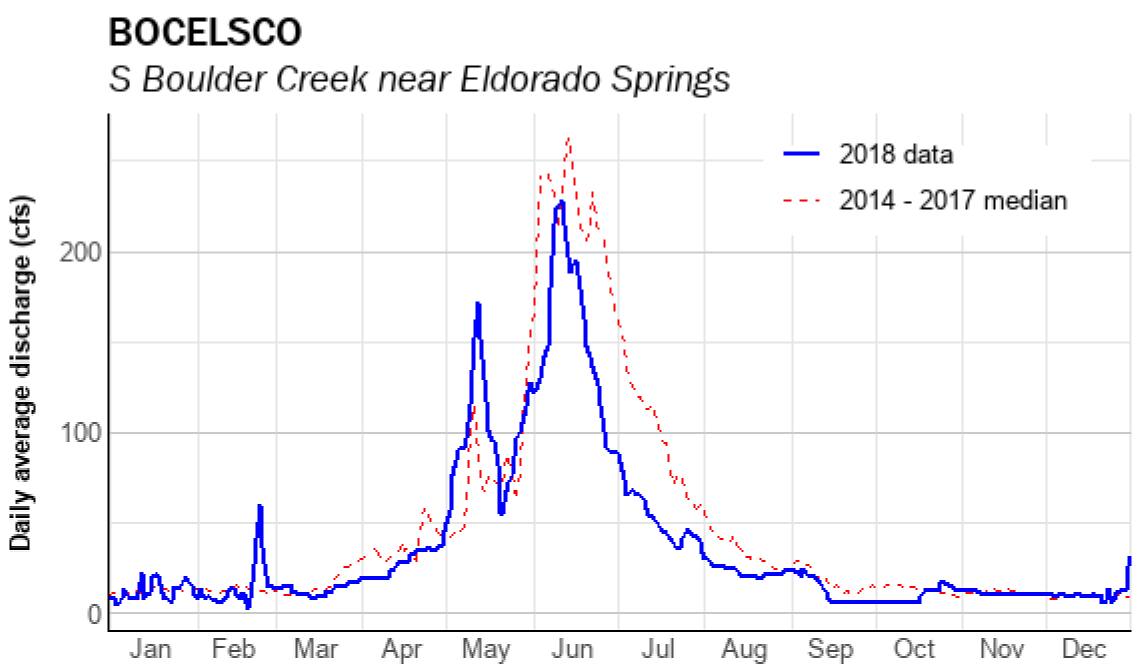


Figure 2.7 Stream flow at gage BOCELSCO

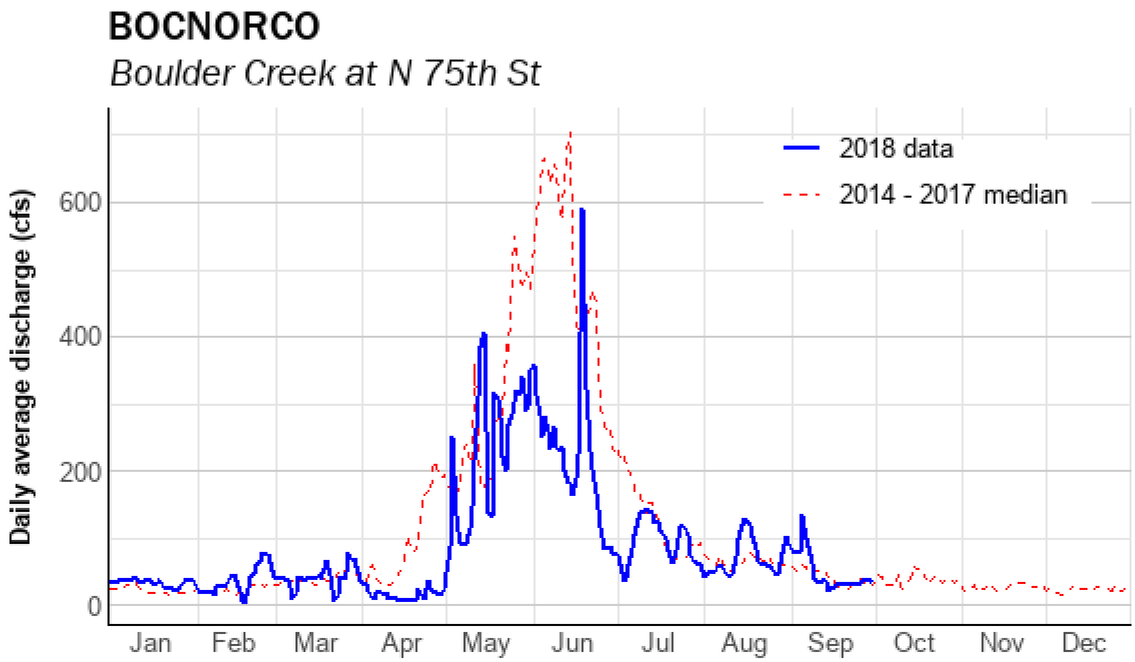


Figure 2.8 Stream flow at gage BOCNORCO

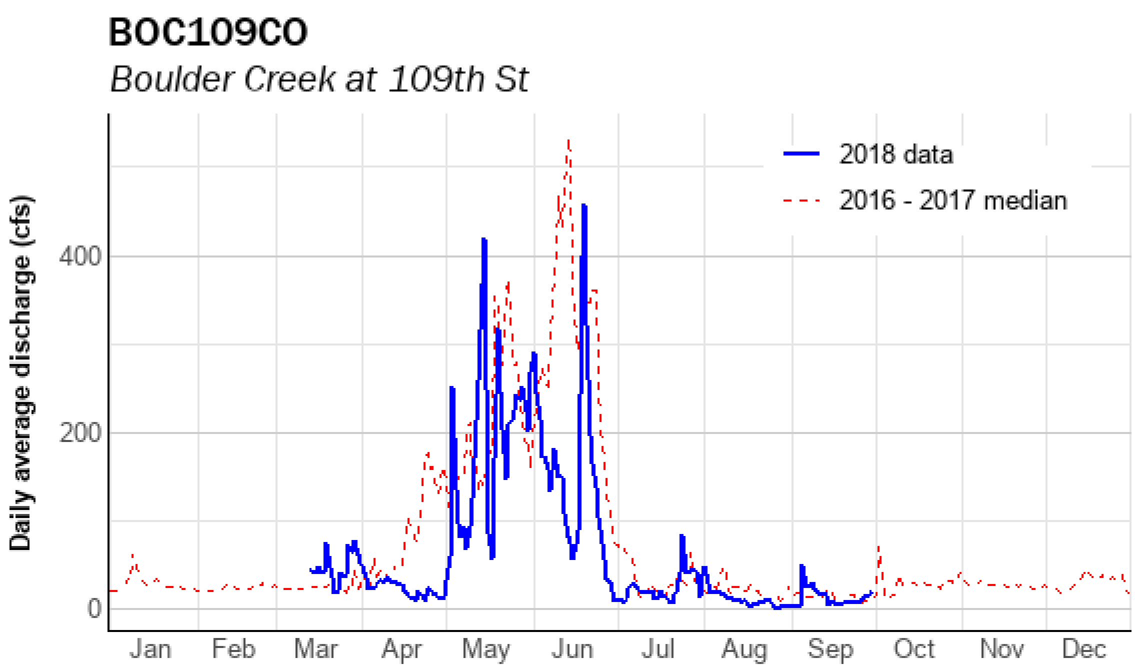


Figure 2.9 Stream flow at gage BOC109CO

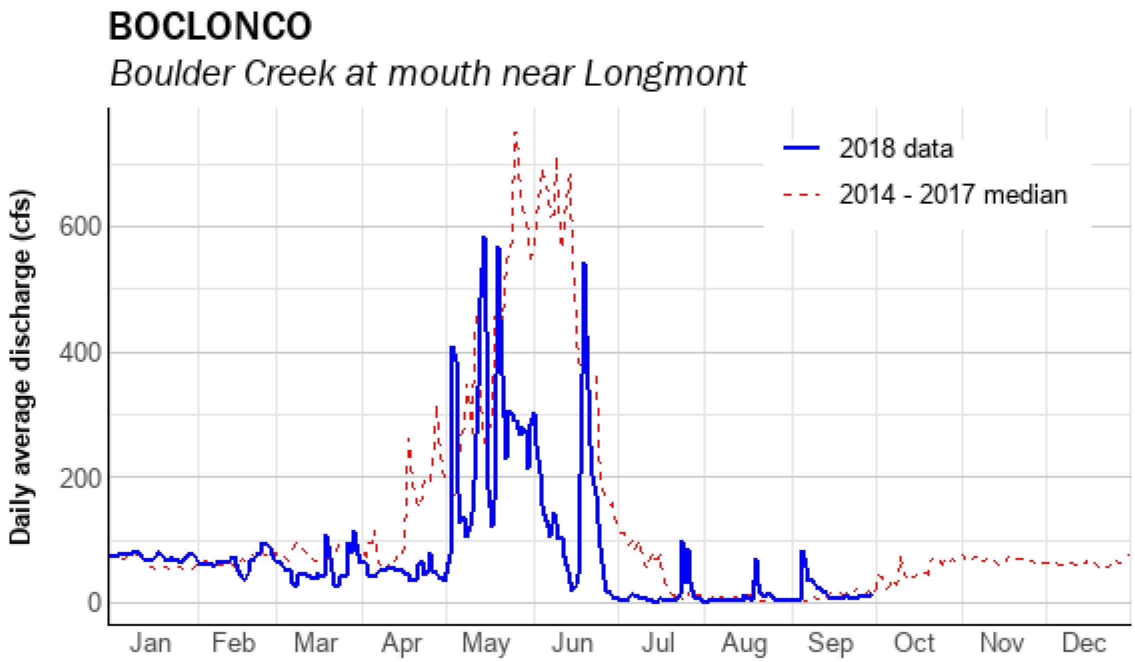


Figure 2.10 Stream flow at gage BOCLONCO

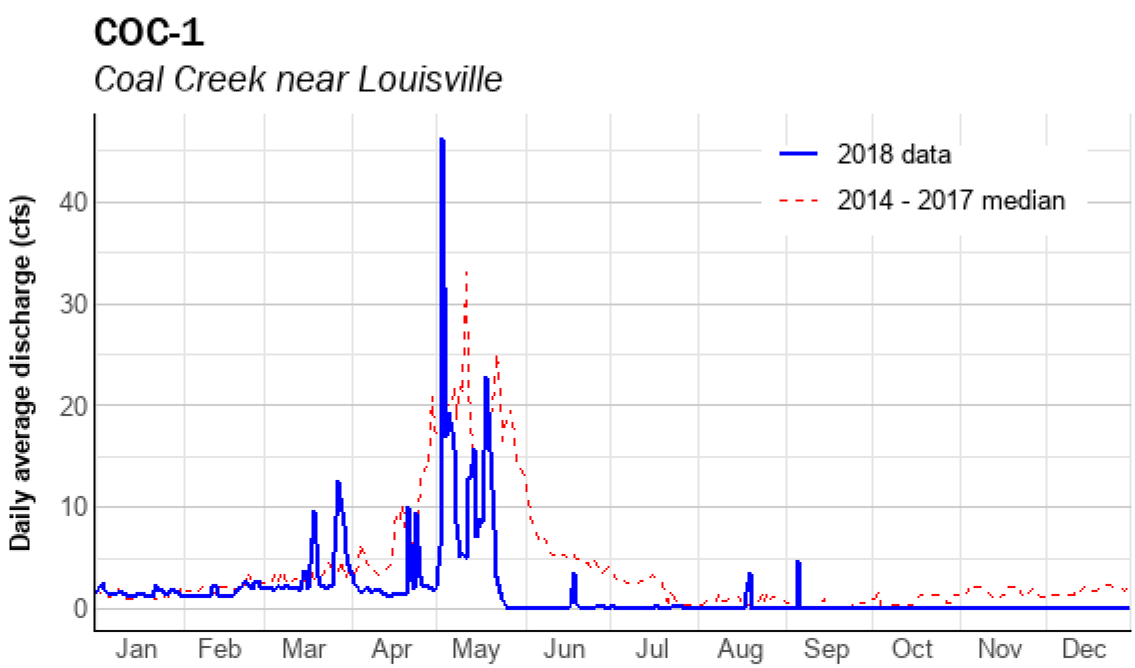


Figure 2.11 Stream flow at gage COC-1

STREAM STANDARDS

Standard assessment

Stream standards in Colorado are assessed according to the most recent regulations and listing methodology distributed by the Colorado Department of Public Health and Environment (CDPHE). A brief overview is presented of the current listing methodology used by the Water Quality Control Division to list streams for impairment (CDPHE 2019c).

Step 1: Evaluate the most recent five years of data at each sample site

For acute standards:
Impaired if more than 1 sample exceeds standard in a 3-year period

For pH, 15th percentile should not be less than lower end of standard and 85th percentile should not be greater than higher end of standard

For chronic standards:
Impaired if percentile value exceeds (< or >) standard

Percentile	Analytes
15th (<)	Dissolved oxygen
50th (>)	Total metals
85th (>)	Dissolved metals and all others

Step 2: Combine all sites in a stream segment and assess together

If segment exceeds standard or limited samples available:
Full stream segment may be listed

If some sites exceed standard, but entire segment does not:
Portion of segment may be listed

Step 3: Assess sample size for chronic standards (stream chemistry only)

If percentile value exceeds standard by more than 50%:

Sample size	List
1	No action
2 – 3	M&E list
4+	303(d) list

Otherwise:

Sample size	List
1	No action
2 – 9	M&E list
10+	303(d) list

Figure 3.1 Stream standard assessment method overview

Table 3.1 depicts the updated stream impairments in stream segments containing KICP monitoring sites according to the draft 2020 303(d) list provided by CDPHE (CDPHE 2019b). Proposed additions or removals are highlighted for emphasis. Since this is a draft document, it should be anticipated that some of these impairments may be modified prior to adoption.

Boulder Creek from 13th St to S Boulder Creek (COSPBO02B)			**BC-CU**
Affected use	Analyte	Category	Status
Recreational use	*E. coli*	TMDL	Retain
Water supply use	Arsenic (total)	303(d)	Retain
Aquatic life use	Silver (dissolved)	303(d)	New
Boulder Creek from N Boulder Creek to 13th St (COSPBO02B)			**BC-Can**
Affected use	Analyte	Category	Status
Water supply use	Arsenic (total)	303(d)	Retain
Aquatic life use	Silver (dissolved)	303(d)	New
Recreational use	*E. coli*	303(d)	New
S Boulder Creek from Community Ditch to S Boulder Rd (COSPBO04B)			**SBC-3.5**
Affected use	Analyte	Category	Status
Aquatic life	Copper (dissolved)	All attaining	Remove
Recreational use	*E. coli*	M&E list	New
Water supply use	Arsenic (total)	303(d)	Retain
Aquatic life use	Silver (dissolved)	303(d)	New
Coal Creek from Highway 36 to Rock Creek (COSPBO07B)			**1-CC, 3-CC**
Affected use	Analyte	Category	Status
Aquatic life use	Macroinvertebrates	M&E list	Retain
Recreational use	*E. coli*	303(d)	Retain
Coal Creek from Rock Creek to Boulder Creek (COSPBO07B)			**6-CC, 7-CC, 8-CC, CC-Ken**
Affected use	Analyte	Category	Status
Aquatic life use	Macroinvertebrates	M&E list	Retain
Recreational use	*E. coli*	303(d)	Retain
Aquatic life use	Selenium (dissolved)	303(d)	Retain
Water supply use	Manganese (dissolved)	303(d)	New
Rock Creek (COSPBO08)			**4-RC, 4a-RC, 4b-RC, 4c-RC, 5-RC**
Affected use	Analyte	Category	Status
Recreational use	*E. coli*	M&E list	Retain
Aquatic life use	Selenium (dissolved)	303(d)	Retain
Boulder Creek from S Boulder Creek to 107th St (COSPBO09)			**BC-61, BC-aWWTP, BC-aDC, BC-95, BC-107**
Affected use	Analyte	Category	Status
Aquatic life use	Ammonia	TMDL	Retain
Recreational use	*E. coli* (Jul – Oct)	303(d)	Retain
Water supply use	Arsenic (total)	303(d)	Retain
Boulder Creek from Coal Creek to St. Vrain Creek (COSPBO10)			**BC-bCC, 9-BC, 11-BC**
Affected use	Analyte	Category	Status
Aquatic life use	pH	All attaining	Remove
Aquatic life use	Ammonia	TMDL	Retain
Recreational use	*E. coli*	303(d)	Retain
Water supply use	Arsenic (total)	303(d)	Retain
St. Vrain Creek from Left Hand Creek to Boulder Creek (COSPSV03)			**M7-SV, M6-SV, M5.5-SV, M4.8-SV, M4-SV**
Affected use	Analyte	Category	Status
Aquatic life use	Ammonia	TMDL	Retain
Recreational use	*E. coli*	303(d)	Retain
St. Vrain Creek from Hygiene Rd to Left Hand Creek (COSPSV03)			**M9.5-SV, M8.9-SV, M8.4-SV, M8.2-SV, M8-SV**
Affected use	Analyte	Category	Status
Recreational use	*E. coli*	303(d)	Retain
Left Hand Creek from Boulder Feeder Canal to St. Vrain Creek (COSPSV05)			**LH-95, T11-LH**
Affected use	Analyte	Category	Status
Aquatic life use	Copper (dissolved)	303(d)	Retain
Water supply use	Manganese (dissolved)	303(d)	New

Table 3.1 Summary of local stream impairments from draft 2020 303(d) list

Temperature

Temperature standards are based on the time of year and the classification of streams into warm water and cold water tiers based on expected fish species. Table 3.2 depicts stream standards that apply to KICP monitoring sites. Continuous temperature data is typically used to compare to stream standards, but single samples can be used in place of daily maximum temperatures if needed. There are several exceptions for periods between seasons and extreme air temperatures.

Temperature tier	KICP monitoring sites	Applicable months	Max weekly average temperature (MWAT)	Daily maximum temperature (DM)
Cold Stream Tier II (CS-II)	BC-Can, BC-CU, SBC-3.5	Apr – Oct	18.3 °C	23.9 °C
		Nov – Mar	9.0 °C	13.0 °C
Warm Stream Tier I (WS-I)	All St. Vrain Creek and Left Hand Creek sites	Mar – Nov	24.2 °C	29.0 °C
		Dec – Feb	12.1 °C	14.5 °C
Warm Stream Tier II (WS-II)	All other sites	Mar – Nov	27.5 °C	28.6 °C
		Dec – Feb	13.8 °C	14.3 °C

Table 3.2 Local water temperature stream standards

Ammonia

Total ammonia standards are based on pH and water temperature and the aquatic life classification of the stream (warm water or cold water). Individual samples may not exceed the acute standard more than once in every 3 years, while the 85th percentile may not exceed the chronic standard as calculated by mean pH and temperature (Figure 2.3). If calculated for individual events, less than 15% of values may exceed the paired standard (CDPHE 2019a).

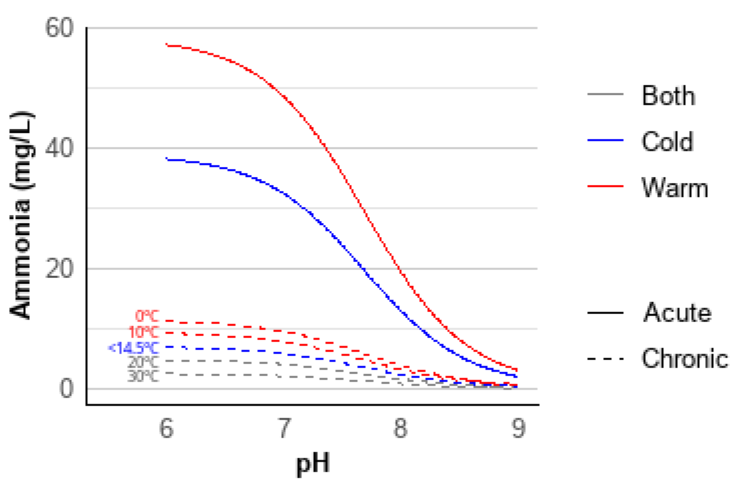


Figure 3.2 Graph of total ammonia standards based on pH, temperature, and aquatic life classification

Nutrients

Interim standards are in place for total phosphorus (TP), total nitrogen (TN), and chlorophyll-a. TP and chlorophyll standards only apply upstream of designated wastewater treatment facilities and TN standards have not yet been adopted. Where adopted, annual median values may not exceed the standard more than once in every 5 years (CDPHE 2019c). Table 3.3 provides a summary of current interim standards and Table 3.6 provides a schedule of adoption for future regulations.

Analyte	Cold water	Warm water
Total phosphorus (TP)	0.11 mg/L	0.17 mg/L
Total nitrogen (TN)	1.25 mg/L	2.01 mg/L
Chlorophyll-a	150 mg/m^2	

Table 3.3 Interim value nutrient standards

E. coli

E. coli standards are assessed by calculating the geometric mean for rolling 61-day intervals for the entire period of record, with each new sample starting a new window. This is a significant revision to the previous methods and existing impairments should be reassessed. The current method is generally more stringent, and it should be anticipated that additional segments may now be considered impaired. Placement on the M&E list or 303(d) list is dependent on the maximum number of samples in a window. For delisting, a minimum of 5 samples must be collected within one window and all windows must indicate attainment, including during the months originally exceeding the standard when placed on the M&E or 303(d) list (CDPHE 2019c).

Geometric mean exceeds standard by > 50%:

Sample size	List
1	No action
2 – 3	M&E list
4+	303(d) list

Otherwise:

Sample size	List
1	No action
2 – 4	M&E list
5+	303(d) list

Arsenic

Arsenic standards are based on the aquatic life and water supply classifications of a stream segment as summarized in Table 3.4. Individual samples may not exceed the acute standard for dissolved arsenic more than once in every 3 years, while the 85th percentile may not exceed the chronic standard for total arsenic. When a range of standards is listed, the first number is a health-based value that serves as a water quality target and the second number is the maximum contaminant level under the federal Safe Drinking Water Act. Water bodies are considered in attainment of this standard as long as the existing quality does not exceed the second number.

Aquatic life classification	Water supply classification	KICP monitoring sites	Acute dissolved arsenic standard	Chronic total arsenic standard
Cold 1 / Warm 1	Water Supply	All Boulder Creek and South Boulder Creek sites	340 µg/L	0.02 µg/L
Warm 2	Water Supply	All Left Hand Creek and Coal Creek sites	340 µg/L	0.02-10 µg/L
Warm 1	N/A	All St. Vrain Creek sites	340 µg/L	7.6 µg/L
Warm 2	N/A	Rock Creek	340 µg/L	100 µg/L

Table 3.4 Local total arsenic standards

Copper

Dissolved copper standards are based on hardness as depicted in Figure 3.3. Individual samples may not exceed the acute standard more than once in every 3 years, while the 85th percentile may not exceed the chronic standard as calculated by mean hardness. If calculated for individual events, less than 15% of values may exceed the paired standard (CDPHE 2019a).

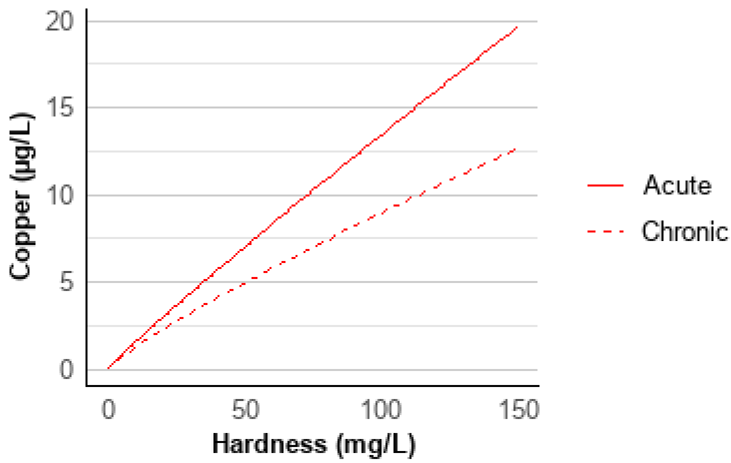


Figure 3.3 Graph of dissolved copper standards based on hardness

Silver

Dissolved silver standards are based on hardness and whether sensitive trout species are thought to be present as depicted in Figure 3.4. Individual samples may not exceed the acute standard more than once in every 3 years, while the 85th percentile may not exceed the chronic standard as calculated by mean hardness. If calculated for individual events, less than 15% of values may exceed the paired standard (CDPHE 2019a).

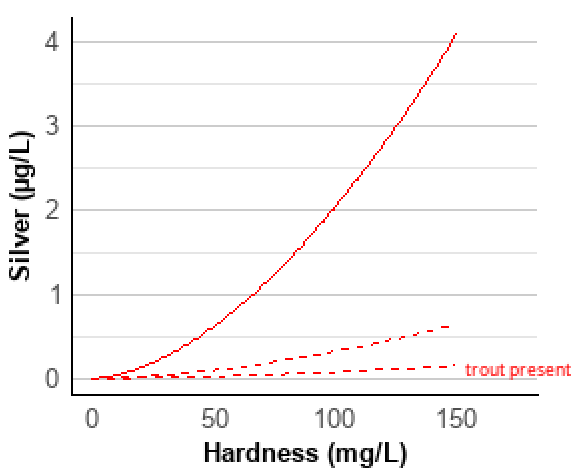


Figure 3.4 Graph of dissolved silver standards based on hardness

Manganese

Dissolved manganese standards are based on hardness as depicted in Figure 3.5. Individual samples may not exceed the acute standard more than once in every 3 years, while the 85th percentile may not exceed the chronic standard as calculated by mean hardness. If calculated for individual events, less than 15% of values may exceed the paired standard (CDPHE 2019a).

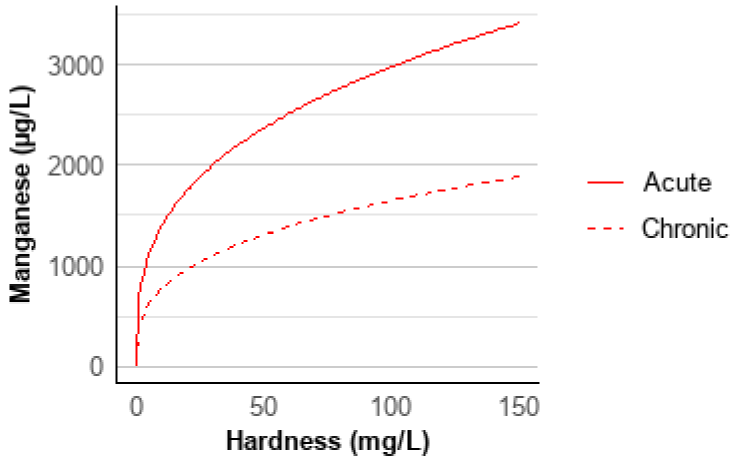


Figure 3.5 Graph of dissolved manganese standards based on hardness

Future regulations

In 2017 the Water Quality Control Division developed a 10 year plan to adopt new water quality standards through evidence development, stakeholder outreach, and rulemaking hearings (CDPHE 2018). A timeline of standard adoption statewide is provided in Table 3.6.

Year	Analytes	Status
2020	*Cadmium, arsenic*	*Draft*
2021	**Cadmium, arsenic, temperature**	**Adopt**
2022	**Chlorophyll-a**	**Adopt**
2023	*Ammonia*	*Draft*
2024	*Selenium*	*Draft*
2026	*Total nitrogen, total phosphorus*	*Draft*
2027	**Ammonia, selenium, total nitrogen, total phosphorus**	**Adopt**

Table 3.5 Upcoming regulations for Colorado streams

DATA ANALYSIS

Methods

Preprocessing steps
Samples designated as field duplicates were removed from analysis and considered solely for quality control, with accidental duplicates also being removed. Values below detection limit (flagged variously as ND, BDL, U, or <) were set to 0, except for *E. coli* values which were set to 1, based on the most recent assessment methodology used by the Colorado Department of Public Health and Environment (CDPHE 2019c). Values reported as estimates (flagged as J) were removed if a non-estimated value was also available for the same sample. Except for when evaluating five year trends (see method below), if multiple samples remained for the same date they were averaged together. Units were converted if necessary to align with shared monitoring procedures (see Table 1.1). A thorough analysis of outliers was not conducted for this report and outliers were not removed from analysis, but data providers were contacted to clarify and/or correct any values suspected for inaccuracy.

Upstream to downstream trends
Upstream to downstream trends plots include all sites along the mainstems of St. Vrain Creek, Boulder Creek, and Coal Creek. A GIS analysis was used to measure stream miles between each site and sites were plotted according to their distance from the furthest upstream site (M9.5-SV, BC-Can, or 1-CC). The median, or geometric mean for *E. coli*, of all 2018 samples was calculated and plotted against this distance.

Five year trends
Significant trends over the last five years were evaluated for each analyte at instream sites using a Seasonal Kendall test with a significance level of $p = 0.05$. A seasonal Sen's slope was calculated for significant trends to provide an estimated yearly rate of change. Seasons were defined as individual months and a single sample was used for each month and year combination. If more than one valid sample existed for a given month and year a random sample was taken of these values according to accepted practice for this method. Trends are plotted on maps for select analytes with the estimated rate of change annotated. In several cases minimum detection limits have changed during this five year period and are considered in case they have any effect on observed trends

Boxplots

Data for several analytes in the main report and all analytes in Appendix A are plotted as boxplots including the median value, 25th and 75th percentiles, and lower and upper outlier limits (Figure 4.1). Outliers are values that exceed the 75th percentile by greater than the interquartile range (75th – 25th percentile), or that are lower than the interquartile range subtracted from the 25th percentile. Where applicable, stream standards are also depicted with a solid red line for acute standards and a dashed red line for chronic standards.

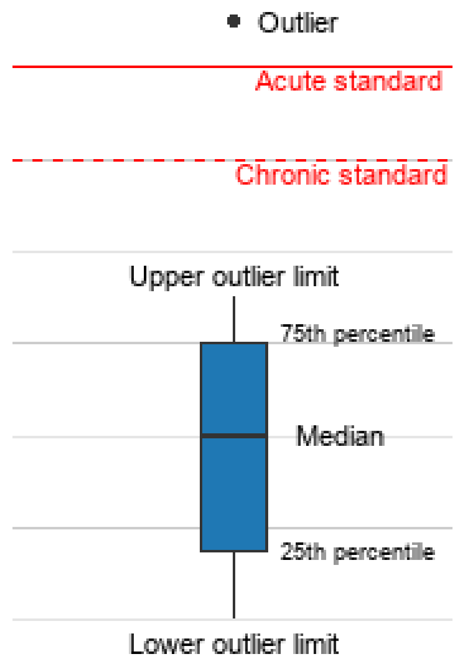


Figure 4.1 Boxplot features

General water quality

Water temperature, conductivity, total suspended solids, alkalinity, hardness, and pH generally increased from upstream to downstream (Figure 4.2). These trends were less evident in Coal Creek and tended to taper off or decrease further downstream. Values at site 8-CC were consistently low for several analytes and may need to be investigated further. pH in St. Vrain Creek dropped below the Longmont WWTP before increasing further downstream. Most of the collected temperature data is based on grab samples and results may be affected by sampling time or holding time.

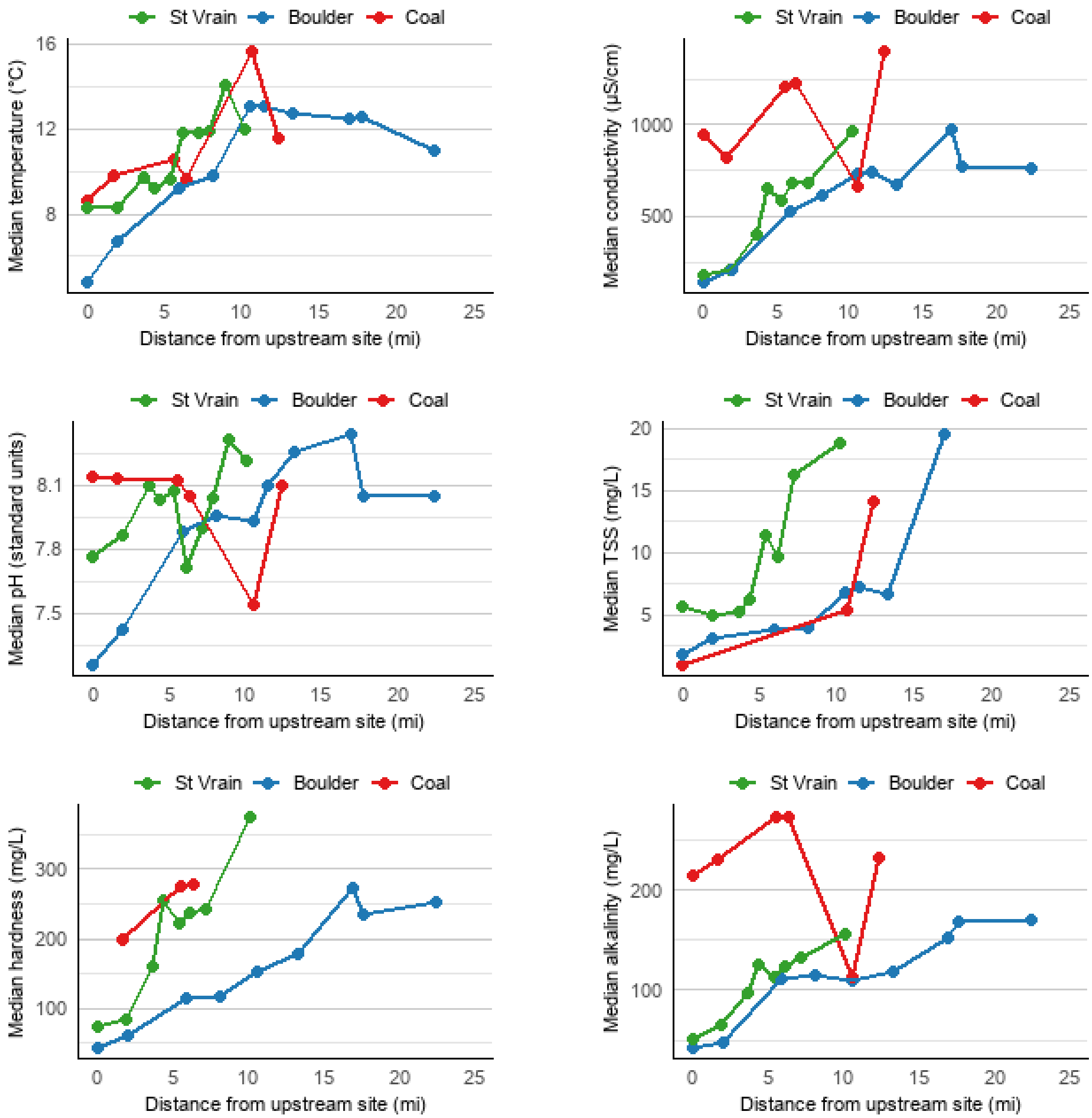


Figure 4.2 2018 median general water quality values by distance from upstream site

Dissolved oxygen was below the 5.0 mg/L stream standard in Rock Creek in 2018 for the first time in recent years (Figure 4.3). Further investigation is needed to determine the cause of these low values.

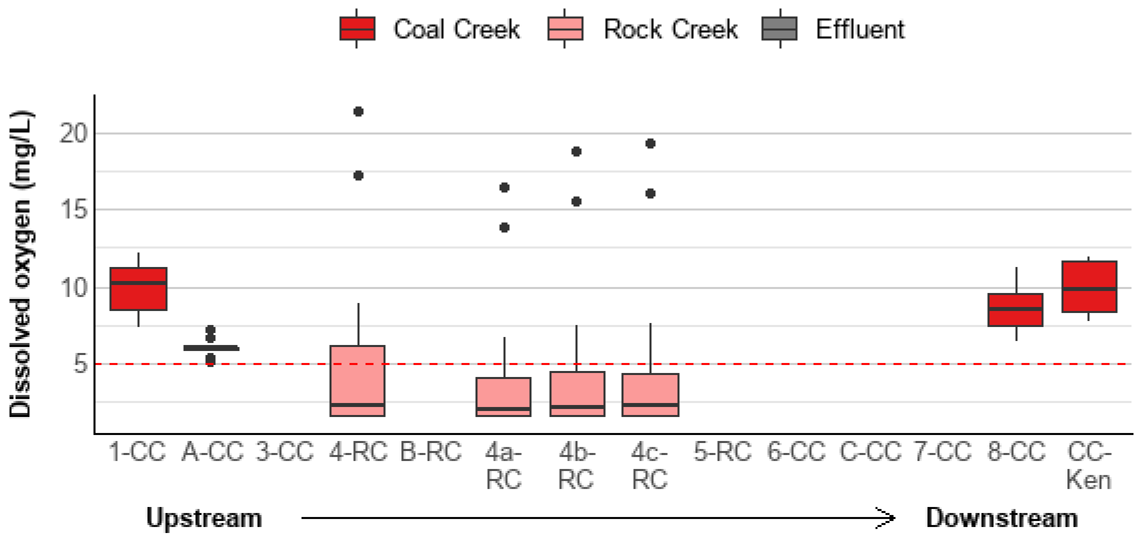


Figure 4.3 2018 dissolved oxygen in Coal Creek and Rock Creek

All monitoring sites met the pH stream standard (between 6.5 and 9.0), although upper Boulder Creek (BC-Can, BC-CU) had several values below 6.5 that may merit further study to see if this trend continues in future years. This data supports the removal of lower Boulder Creek from the 303(d) list for pH.

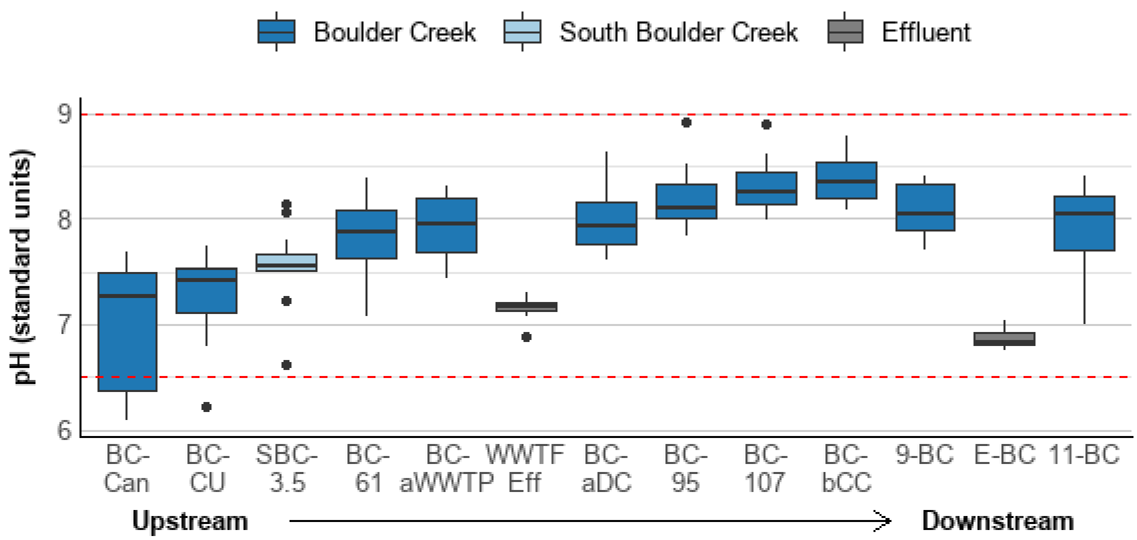
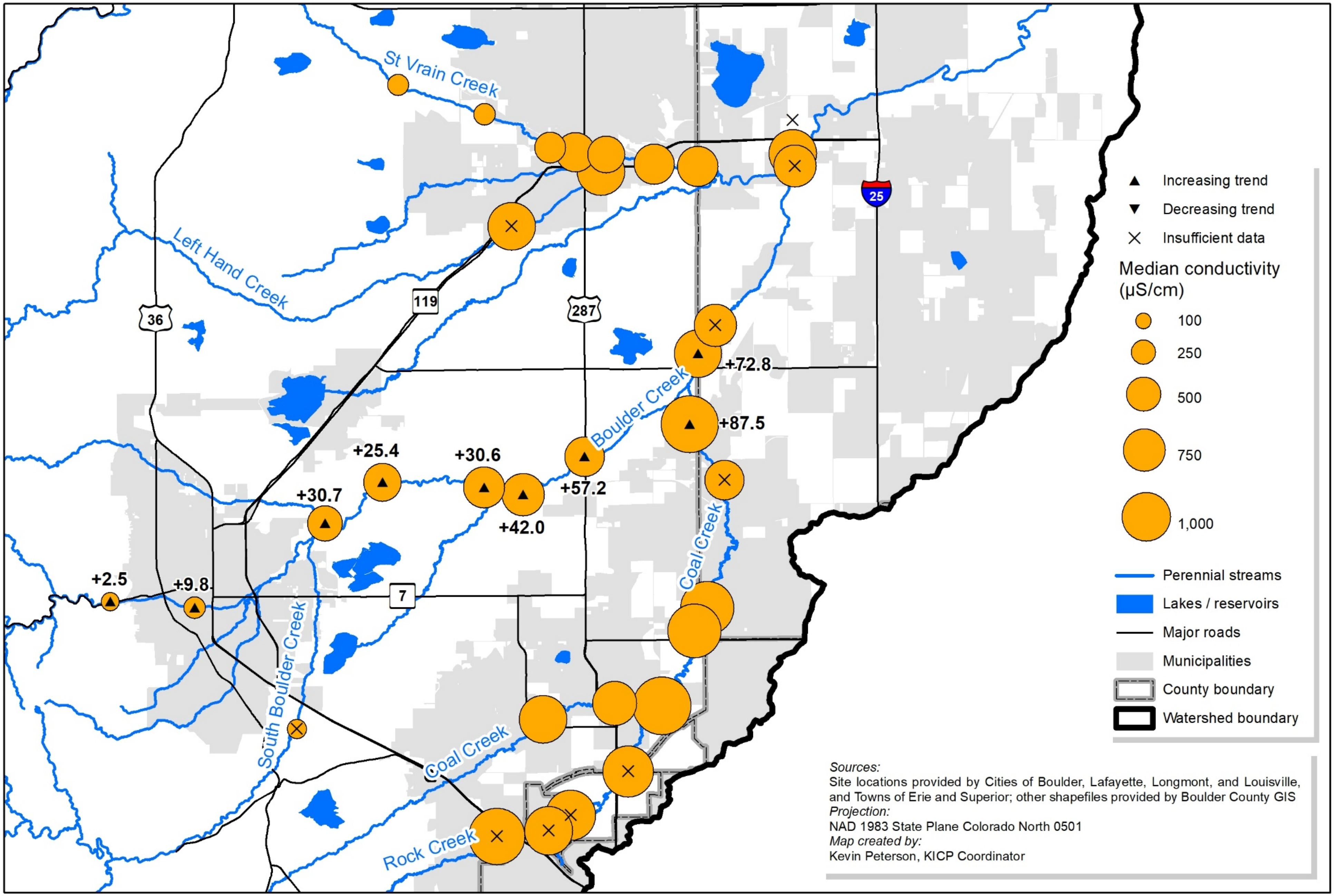


Figure 4.4 2018 pH in Boulder Creek

Conductivity has generally increased in Boulder Creek and at Coal Creek site CC-Ken over the last 5 years (Figure 4.5). Increases were largest downstream and ranged from an average increase of 2.5 to 72.8 µS/cm per year. pH increased slightly at several sites in Boulder Creek over the last 5 years at several sites but decreased at site BC-CU.

CONDUCTIVITY TRENDS



Note: several site locations adjusted slightly to enhance readability

Figure 4.5 2018 conductivity values and significant 5 year trends (average change in µS/cm per year)

Nutrients

Total nitrogen, total phosphorus, and nitrites/nitrates generally increased from upstream to downstream, increasing dramatically below WWTPs and tapering off or decreasing further downstream (Figure 4.6). Total ammonia increased downstream with a less clear trend and a large increase on Coal Creek downstream of Lafayette's WWTP with a subsequent decrease further downstream.

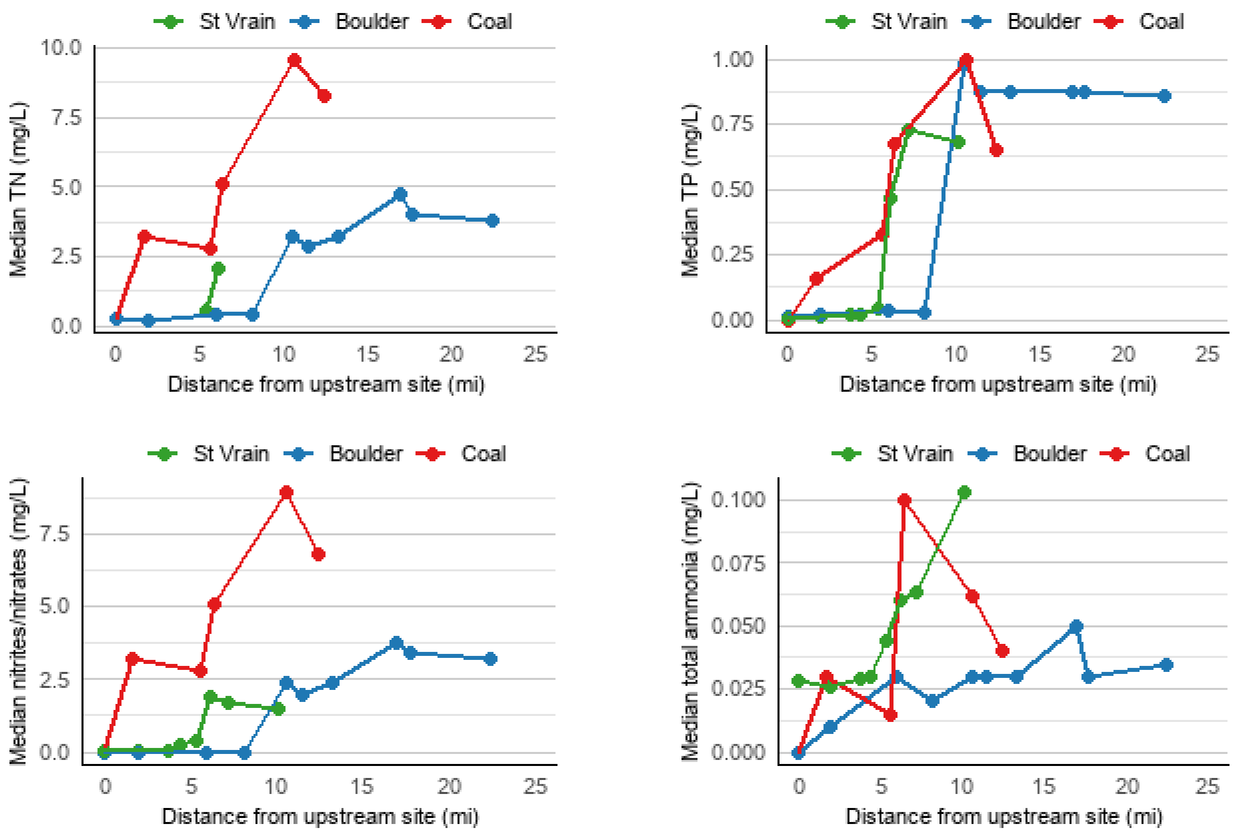
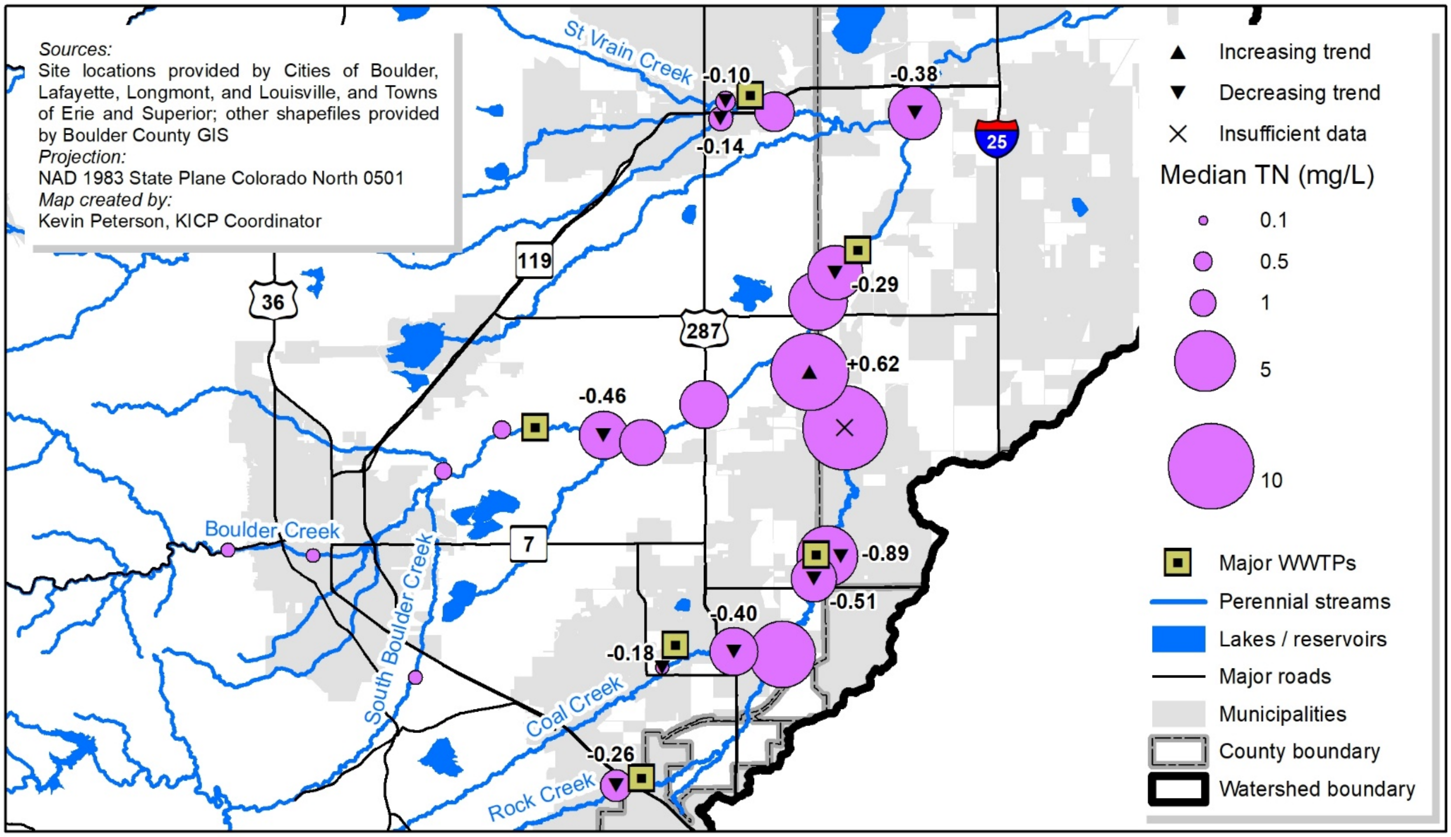


Figure 4.6 2018 median nutrient values by distance from upstream site

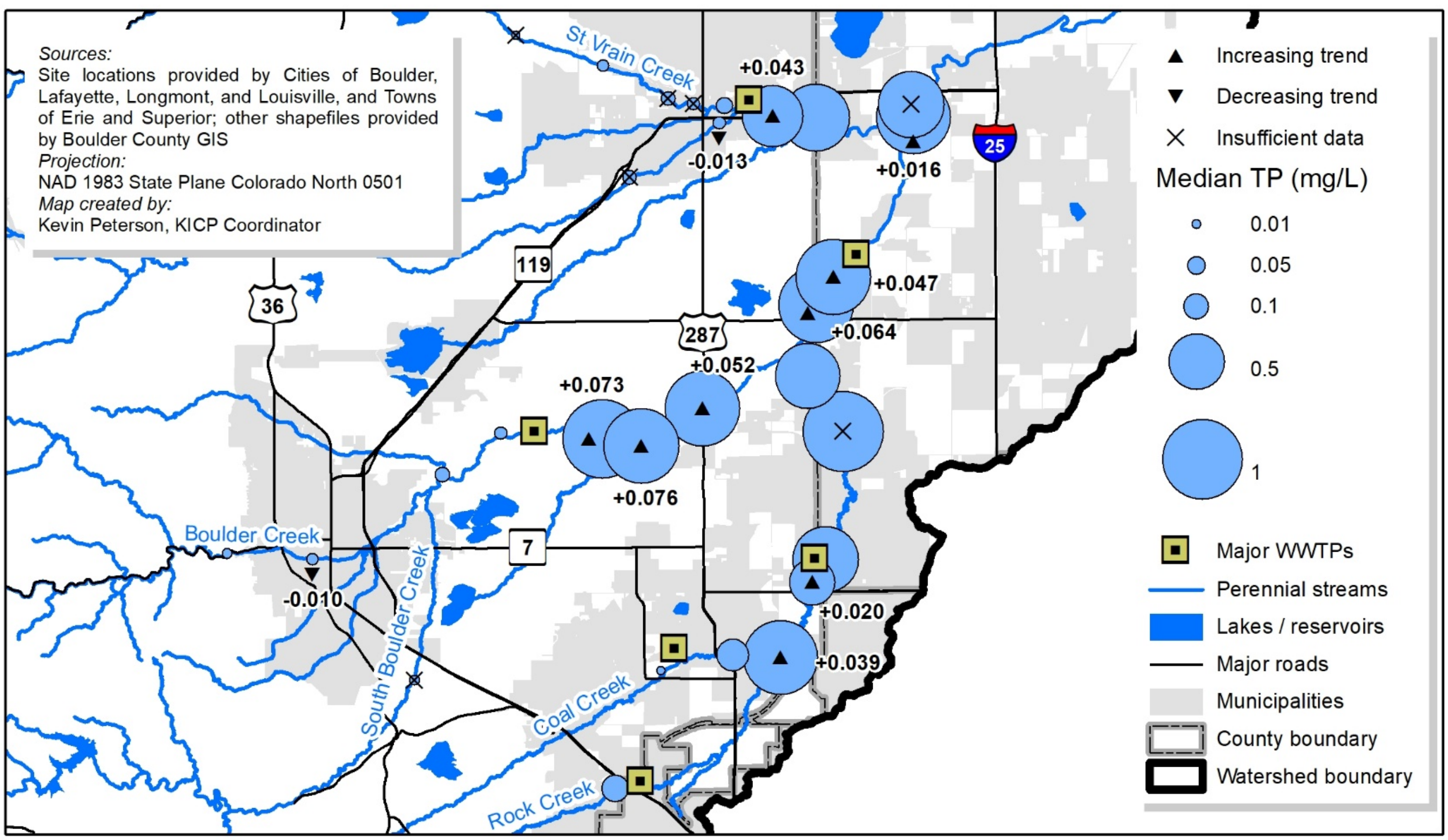
The interim stream standard currently applies only to sites 1-CC and 4-RC of the KICP monitoring sites, but all sites below major WWTPs would not meet the current interim standard if applied. See Figure 4.7 for locations of major WWTPs and page 18 for more details on nutrient standards.

Total nitrogen has generally decreased or remained the same over the last 5 years, while total phosphorus has generally increased (Figure 4.7). A few exceptions to this trend are site CC-Ken, where total nitrogen increased, and sites BC-CU and T11-LH, where total phosphorus decreased slightly.

TOTAL NITROGEN TRENDS



TOTAL PHOSPHORUS TRENDS



Note: several site locations adjusted slightly to enhance readability

Figure 4.7 2018 nitrogen and phosphorus values and significant 5 year trends (average change in mg/L per year)

Bacteria

As shown in Figure 4.8, during the recreation season (May – October) in St. Vrain Creek *E. coli* concentrations were elevated about 2 miles downstream and highest over 5 miles downstream from North 75th Street. During the same period, concentrations in Boulder Creek were highest about 6 miles downstream from the mouth of Boulder Canyon and were relatively low further downstream until the confluence with Coal Creek (~16 miles from the canyon mouth). *E. coli* concentrations in Coal Creek were highest about 2 miles downstream from Highway 42 and lowest at around 10 miles downstream. Similar trends were observed at lower concentrations during the non-recreation season (November – April). These trends are likely related to land use patterns, with highly urbanized areas contributing to greater bacteria concentrations.

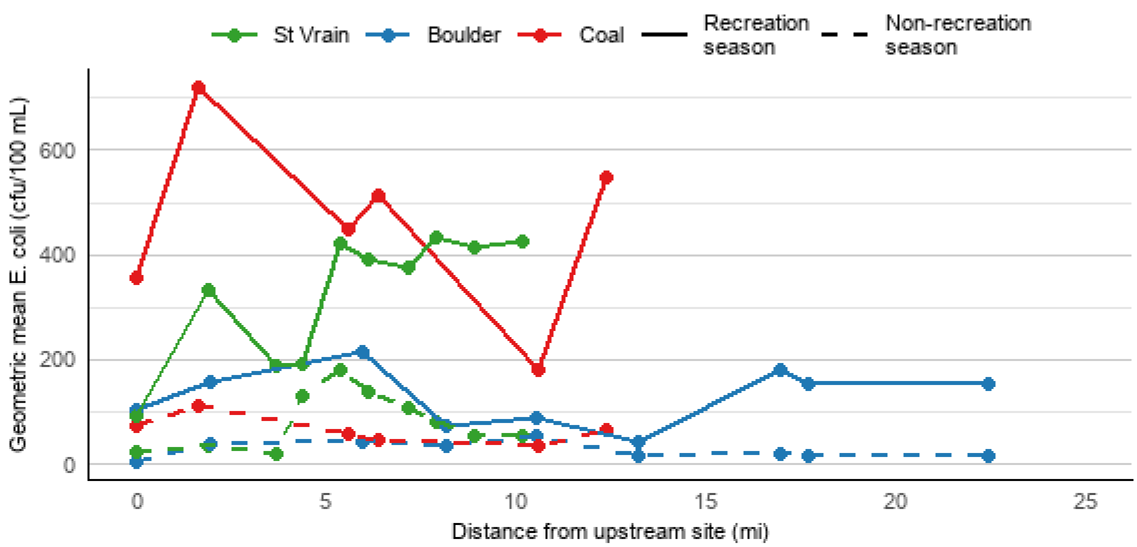


Figure 4.8 2018 geometric mean *E. coli* values by distance from upstream site

E. coli concentrations generally remained low in St. Vrain Creek, Boulder Creek, and Coal Creek from January through March/April and increased in the late spring. Timing varied between streams, but concentrations generally were elevated during the summer months and early fall before decreasing later in the year (Figure 4.9). Timing of peaks varied between sites but were generally earlier (June/July) in St. Vrain Creek, and later in Coal Creek (September) and Boulder Creek (October).

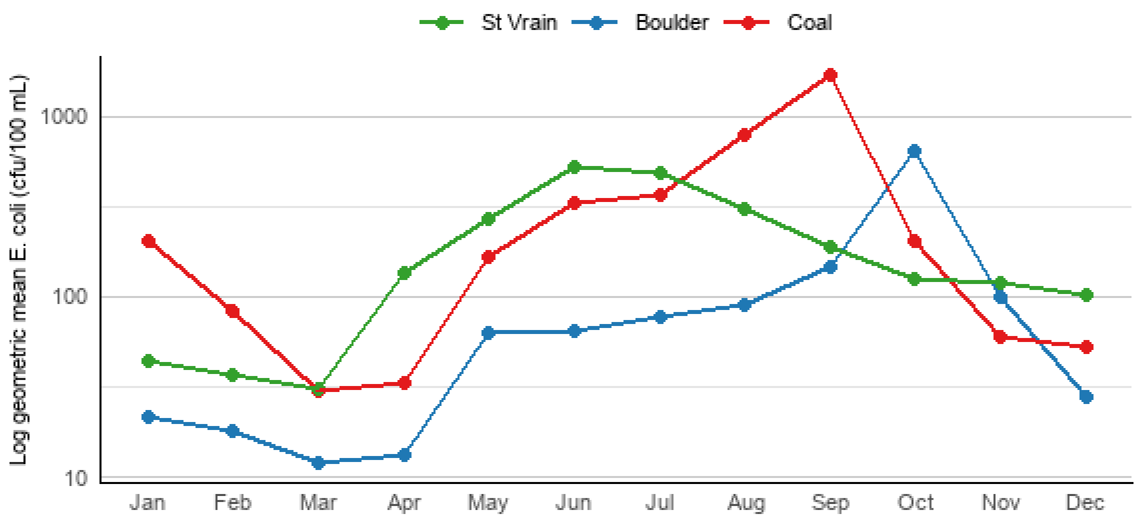
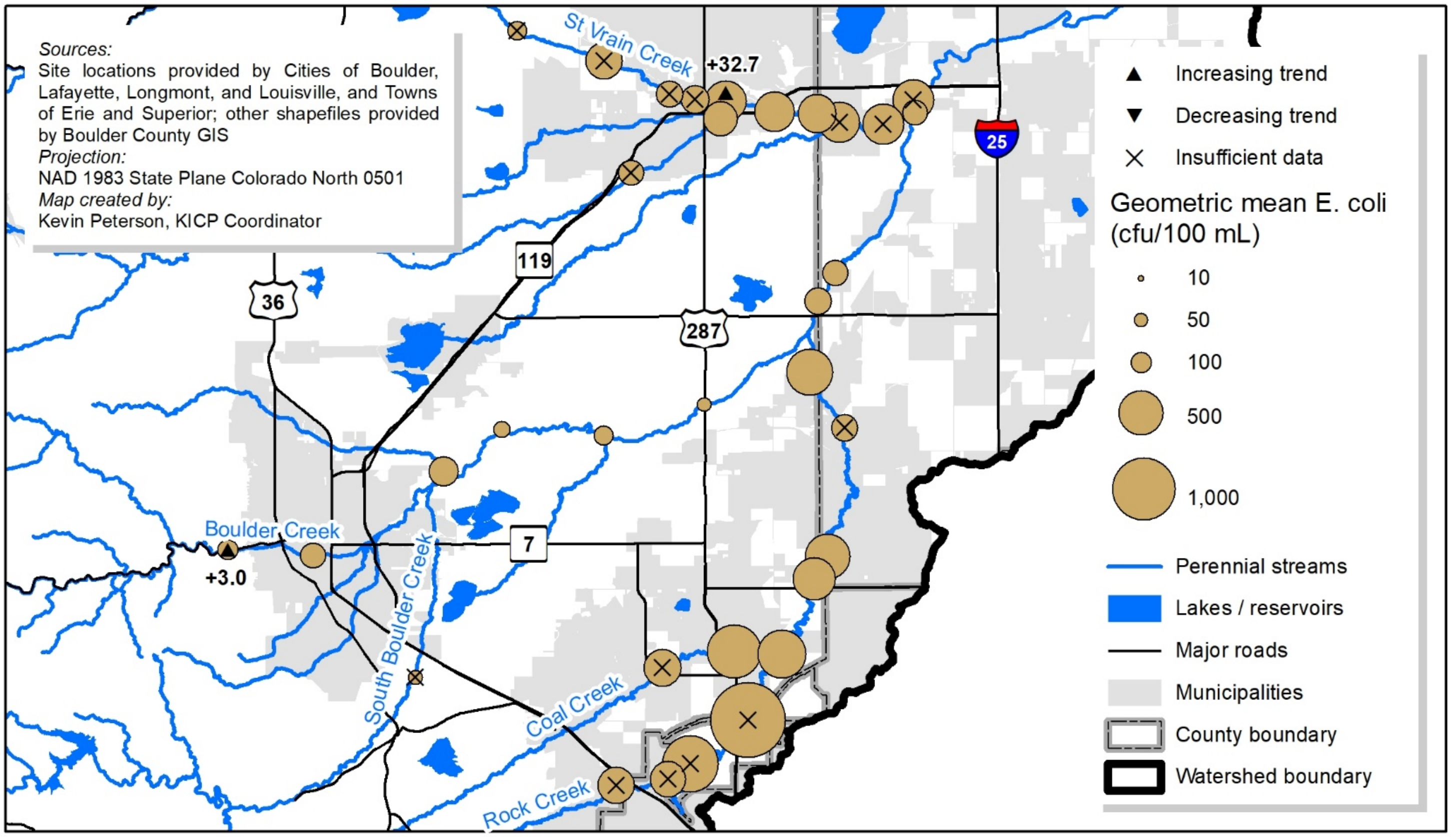


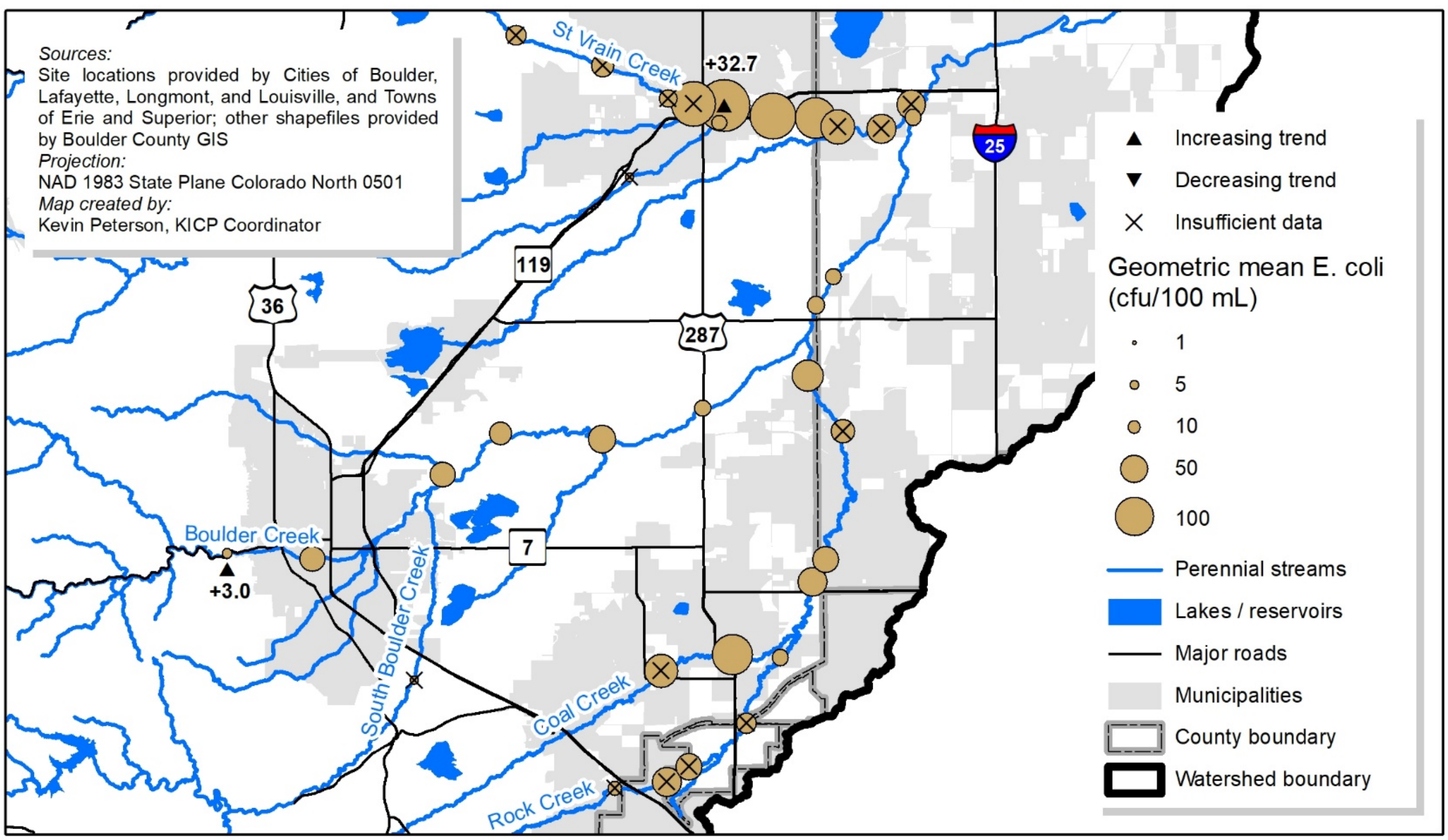
Figure 4.9 2018 log geometric mean *E. coli* values by month (all mainstem sites compiled)

Because *E. coli* concentrations are highly variable, further study is suggested into relationships with stream flow, sampling methods, time of day, and other variables that may affect observed values.

E. COLI TRENDS (RECREATION SEASON)



E. COLI TRENDS (NON-RECREATION SEASON)



Note: several site locations adjusted slightly to enhance readability

Figure 4.10 2018 *E. coli* values and significant 5 year trends (average change in cfu/100 mL per year)

Metals

Total arsenic and dissolved selenium generally increased downstream, dissolved copper had a large increase below the Boulder WWTP and subsequent decrease, and dissolved silver did not have a clear pattern (Figure 4.11). Dissolved copper and silver were only monitored in Boulder Creek and dissolved selenium was not monitored in St. Vrain Creek.

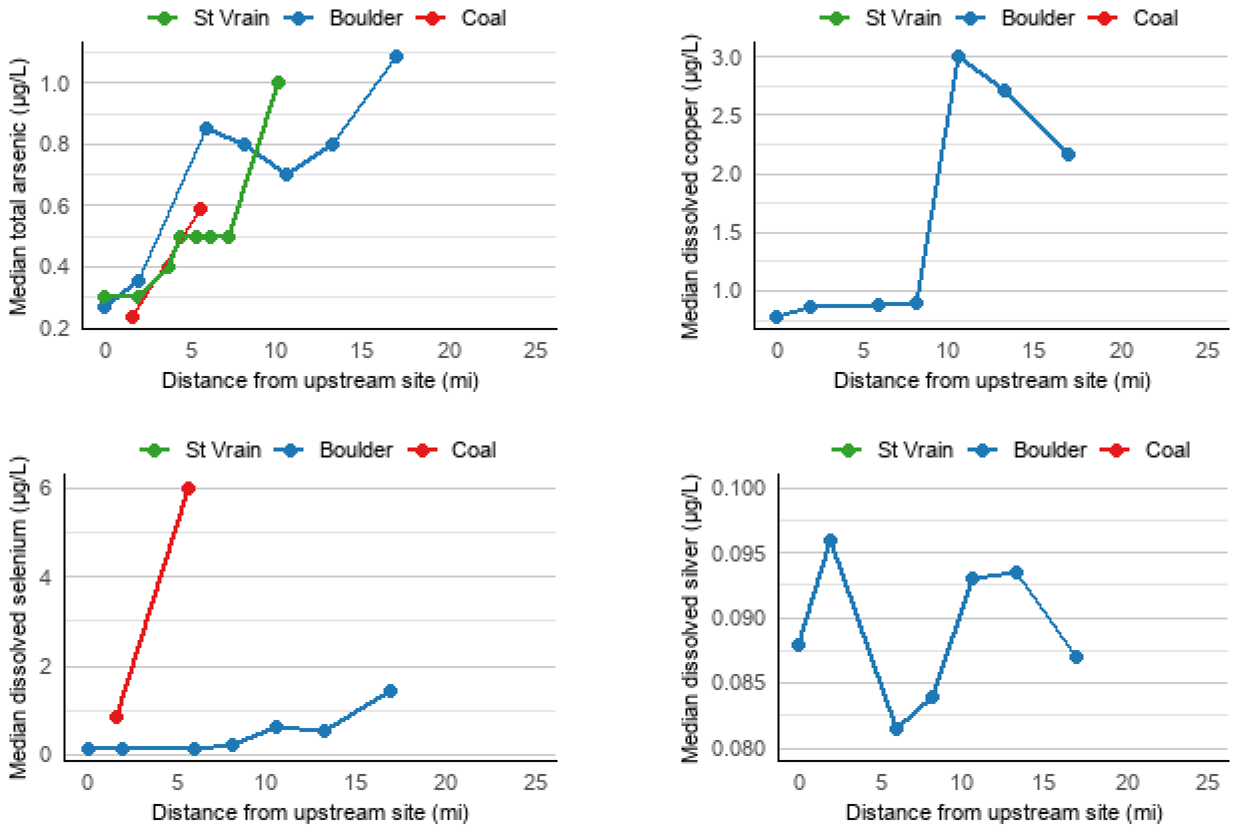


Figure 4.11 2018 median metals values by distance from upstream site

Dissolved copper was relatively low above the Boulder WWTP and increased downstream, but indicated attainment of stream standards at all locations (Figure 4.12).

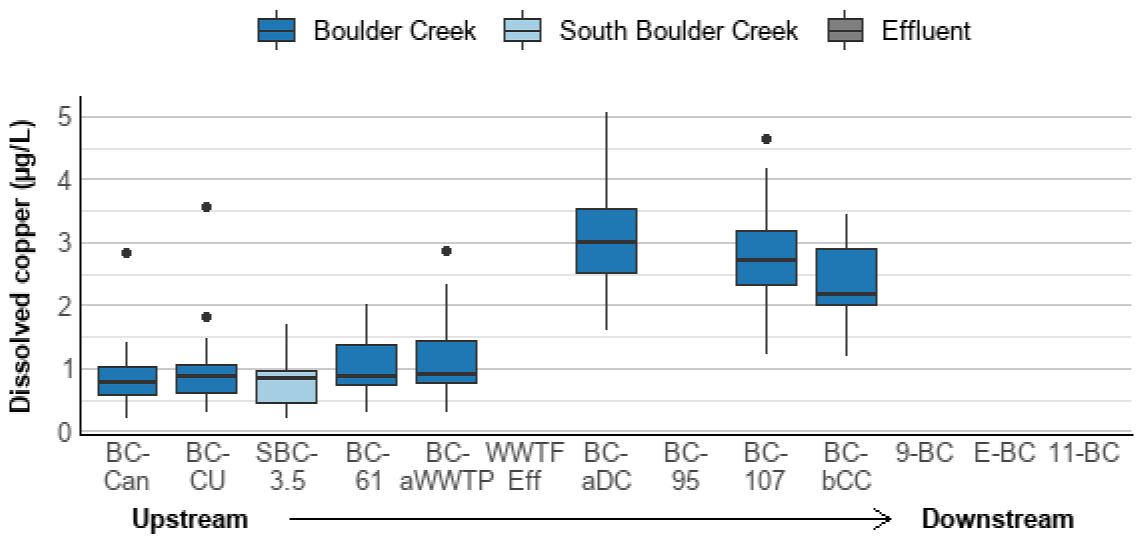


Figure 4.12 2018 dissolved copper in Boulder Creek and South Boulder Creek

Dissolved silver was similar between all Boulder Creek sites, but upstream sites with lower hardness did not indicate attainment of the stream standard (Figure 4.13).

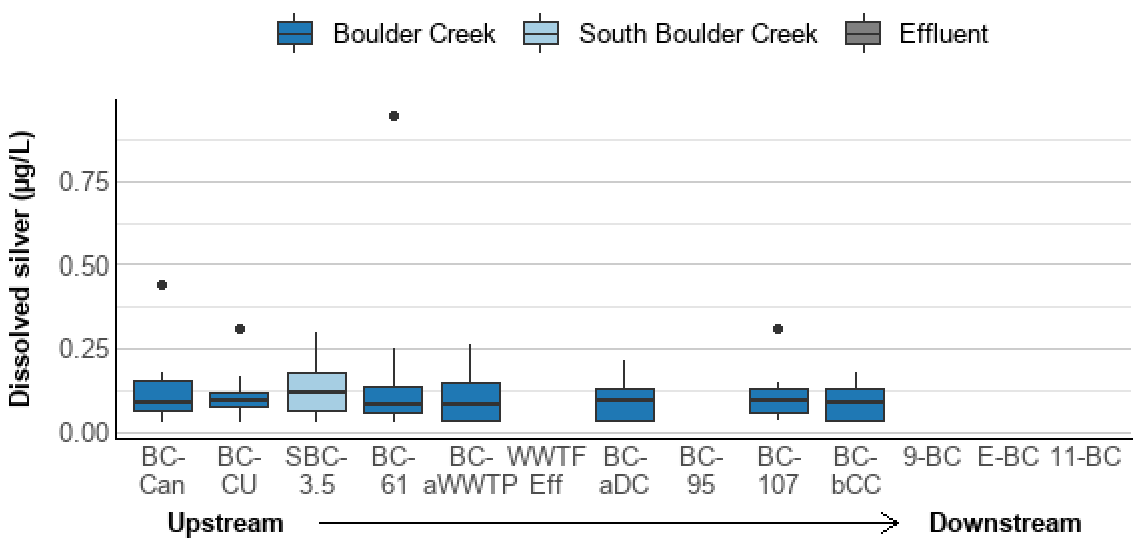
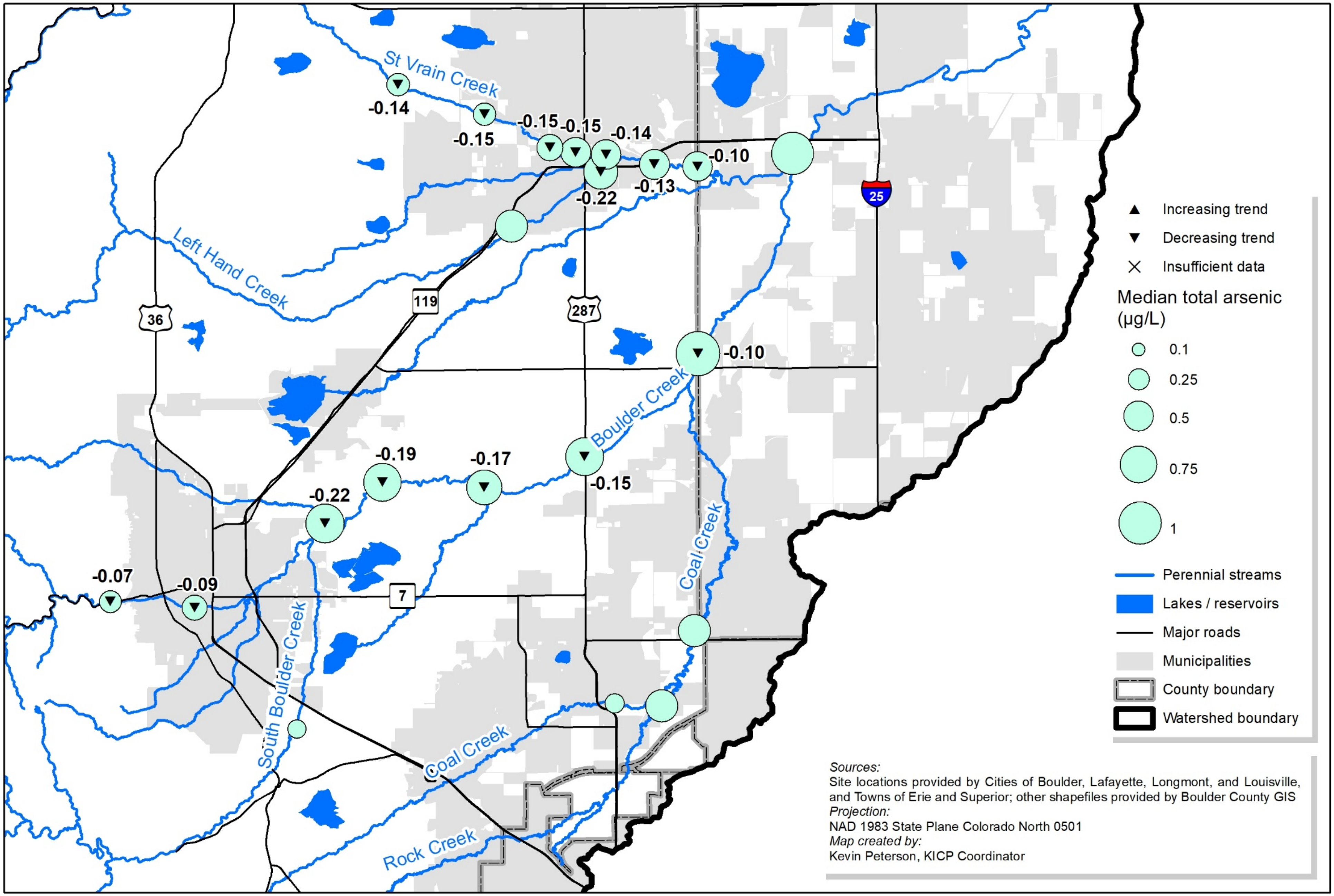


Figure 4.13 2018 dissolved silver in Boulder Creek and South Boulder Creek

Total arsenic has generally decreased over the last 5 years in St. Vrain Creek and Boulder Creek (Figure 4.14).

TOTAL ARSENIC TRENDS



Note: several site locations adjusted slightly to enhance readability

Figure 4.14 2018 total arsenic values and significant 5 year trends (average change in µg/L per year)

DATA CHARACTERISTICS

Quality Control

With the 2015 shared Keep it Clean Partnership (KICP) monitoring plan, a certain frequency of field replicates and field blanks were recommended for participating entities. Table 5.1 depicts recommended frequencies, acceptance criteria, and corrective actions. Field blanks and field replicates are not currently reported by all participating entities, but thorough quality control procedures are highly encouraged.

QC sample	Recommended frequency	Acceptance criteria	Corrective action
Field blank	5% of samples	< reporting limit	Flag suspect data and eliminate source of contamination
Field replicate	5% of samples	< 25% relative percent difference (if > reporting limit)	Flag sample, request re-analysis, and investigate cause

Table 5.1 Recommended field quality control samples

Correlations

Spearman ranked correlations between variables were evaluated for 2014-2018 pairwise complete observations with results presented in Table 5.1. Correlations above 0.6 or below -0.6 are highlighted to indicate instances of relatively high correlation. Hardness, alkalinity, and conductivity were highly correlated with each other (≥ 0.90). Total nitrogen, nitrites/nitrates (NOx), and total phosphorus were also strongly correlated (0.74 – 0.98). Temperature and dissolved oxygen had a negative correlation (-0.66) as expected. Some variables, including copper, selenium, and silver, were not measured at all sites and correlations are only for a subset of monitoring locations.

	Temp	Hardness	Alkalinity	Conductivity	TSS	DO	pH	TN	NOx	NH3	TP	*E. coli*	Arsenic (T)	Copper	Selenium
Hardness	.02														
Alkalinity	.04	.91													
Conductivity	.02	.91	.90												
TSS	.22	.10	.11	.13											
DO	-.66	.02	-.01	-.03	-.14										
pH	-.12	.47	.57	.43	.09	.20									
TN	.18	.52	.46	.57	.18	-.15	.08								
NOx	.08	.34	.34	.54	.10	-.24	-.15	.98							
NH3	.12	.28	.25	.39	.32	-.20	-.19	.48	.53						
TP	.11	.26	.22	.35	.14	-.23	.03	.74	.79	.36					
E. coli	.23	.08	.14	.39	.33	-.19	.16	-.16	-.29	.03	-.13				
Arsenic (T)	.22	.24	.21	.18	.47	-.10	.35	.22	-.03	.11	.05	.20			
Copper	.36	.53	.48	.57	.21	-.24	.11	.73	.54	.39	.78	-.04	.07		
Selenium	-.01	.79	.78	.73	.18	-.03	.11	.30	.43	.29	.19	.00	-.13	.28	
Silver	.03	-.08	-.08	-.09	.14	-.09	-.03	-.04	-.15	-.06	.00	.01	-.03	-.07	-.03

Table 5.2 2014-2018 correlations between primary analytes at KICP monitoring sites

CONCLUSIONS

Observations

General water quality

- pH values no longer appear elevated in Boulder Creek between Coal Creek and St. Vrain Creek. No long term trends were detected, but previous observations of high pH appear to be uncommon and CDPHE has proposed removal of this impairment accordingly.
- Dissolved oxygen values were particularly low in Rock Creek and did not attain the stream standard for unknown reasons meriting further investigation.
- Conductivity has increased somewhat over the last 5 years in Boulder Creek. There is no stream standard for conductivity and there are no observations of any issues related to this trend.

Nutrients

- Total nitrogen has generally decreased slightly over the last 5 years at KICP monitoring sites, while total phosphorus has generally increased slightly. The reason for these trends is unclear and could merit further investigation.
- While all sites above wastewater treatment facilities where the interim nitrogen standard currently applies attain the standard, no sites below major wastewater facilities would attain either the total nitrogen or total phosphorus standards. See Figure 4.7 for locations of major WWTPs. Standards for total nitrogen and total phosphorus are scheduled to be adopted statewide in 2027.

Bacteria

- Although the problem has not increased over the last 5 years, elevated *E. coli* continues to be an issue throughout the urban corridor. New impairments added by CDPHE are the result of a new more stringent assessment method rather than increasing concentrations.

Metals

- Dissolved copper does not appear to be elevated at the KICP monitoring site on South Boulder Creek (SBC-3.5) and CDPHE has proposed removal of this impairment accordingly. The dissolved copper impairment on South Boulder Creek remains further upstream. Left Hand Creek continues to be impaired for dissolved copper and was not assessed in this report since only total copper data is collected in this area.
- A stream impairment for dissolved silver has been identified in Boulder Creek upstream of 13th Street. Dissolved silver values are not notably higher in this area, but due to particularly low hardness the allowable concentrations are much lower than further downstream and are exceeded by observed values.
- A stream impairment for dissolved manganese has been identified in portions of Coal Creek and Left Hand Creek. Manganese is not currently monitored in Coal Creek and only total manganese data is collected in Left Hand Creek.

- Total arsenic concentrations are not dramatically higher in Boulder Creek and South Boulder Creek than the rest of the watershed, but due to more stringent standards an impairment remains in this area, despite an overall trend of decreasing arsenic over the last 5 years.
- Dissolved selenium remains impaired in Coal Creek and Rock Creek. There is insufficient data to evaluate long-term trends and further context for this issue is still needed.

Recommendations

- Further investigation is needed of low dissolved oxygen values in Rock Creek to determine if there is a clear reason for this potential impairment.
- Further study of long-term trends in conductivity, total nitrogen, total phosphorus, and total arsenic are suggested to provide more clarity on potential reasons or correlations to other notable trends and events.
- KICP Partners should plan to take an active role in rulemaking sessions for new nutrient standards to be drafted in 2026 and adopted in 2027. Any work that can be done in the interim to provide context for feasibility or demonstrate progress is suggested as well.
- Efforts on *E. coli* should be focused on source determination based on established methods in the Colorado *E. coli* Toolbox (WWE 2016) and emerging best practices for effective management techniques. Some dialogue with CDPHE about the usefulness and feasibility of proposed actions could also be beneficial.
- Monitoring of dissolved fractions of copper and manganese is suggested at all sites to improve ability to evaluate stream standards and compare all data compiled for this report.
- Further study is needed of arsenic, silver, and selenium standards to determine the appropriateness of their current application. Feasibility of attainment is uncertain due to factors such as low hardness and underlying geology and KICP Partners should participate in future rulemakings of these standards. Updated arsenic standards are set to be drafted in 2020 and adopted in 2021, while selenium standards will be drafted in 2024 and adopted in 2027.
- Additional review of monitoring and analysis procedures of participating entities and statistical methods used within this report is suggested for future water quality reports.

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APPENDIX A: SUMMARY BOXPLOTS

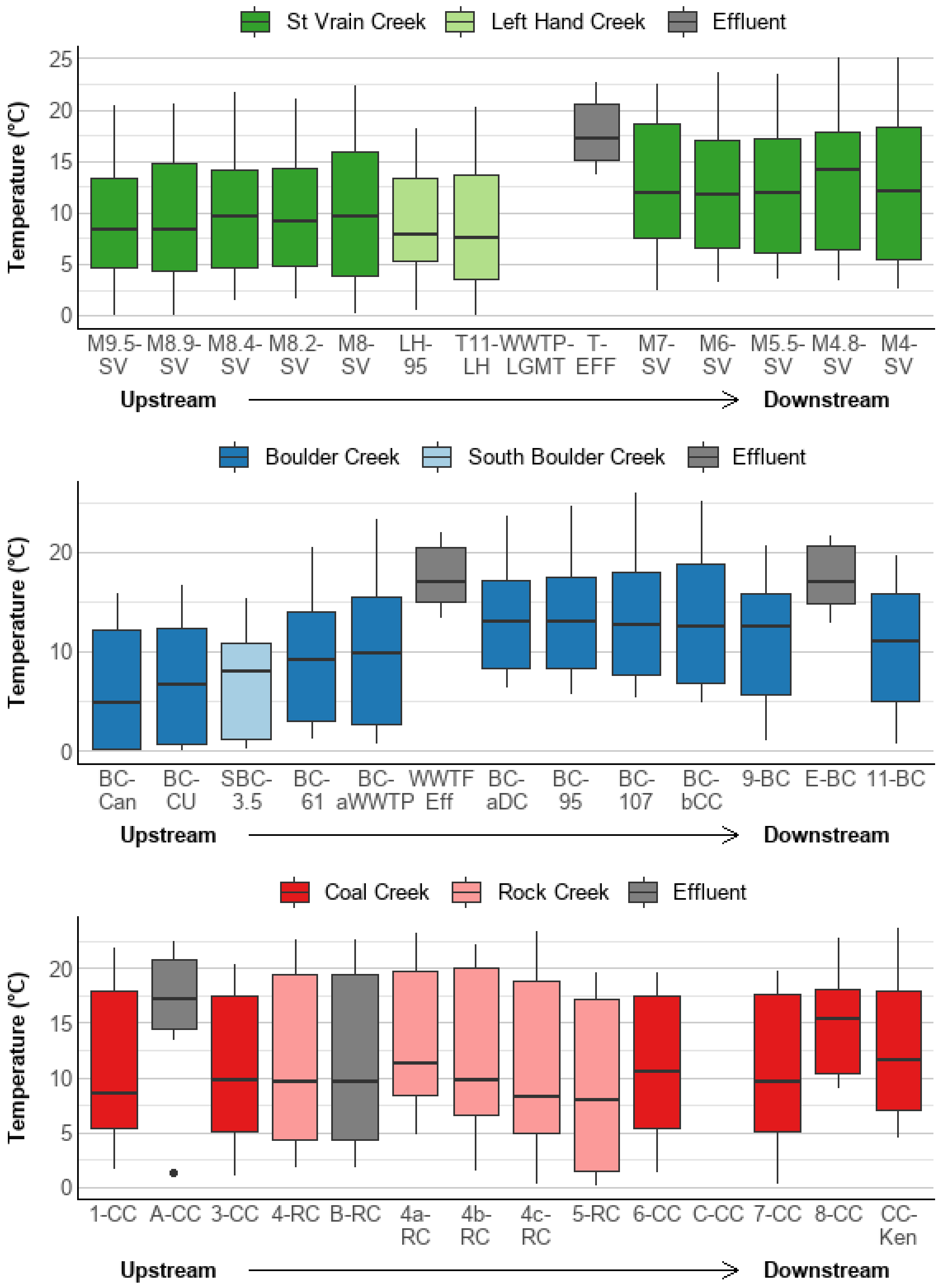

Figure A.1 2018 water temperature boxplot summaries

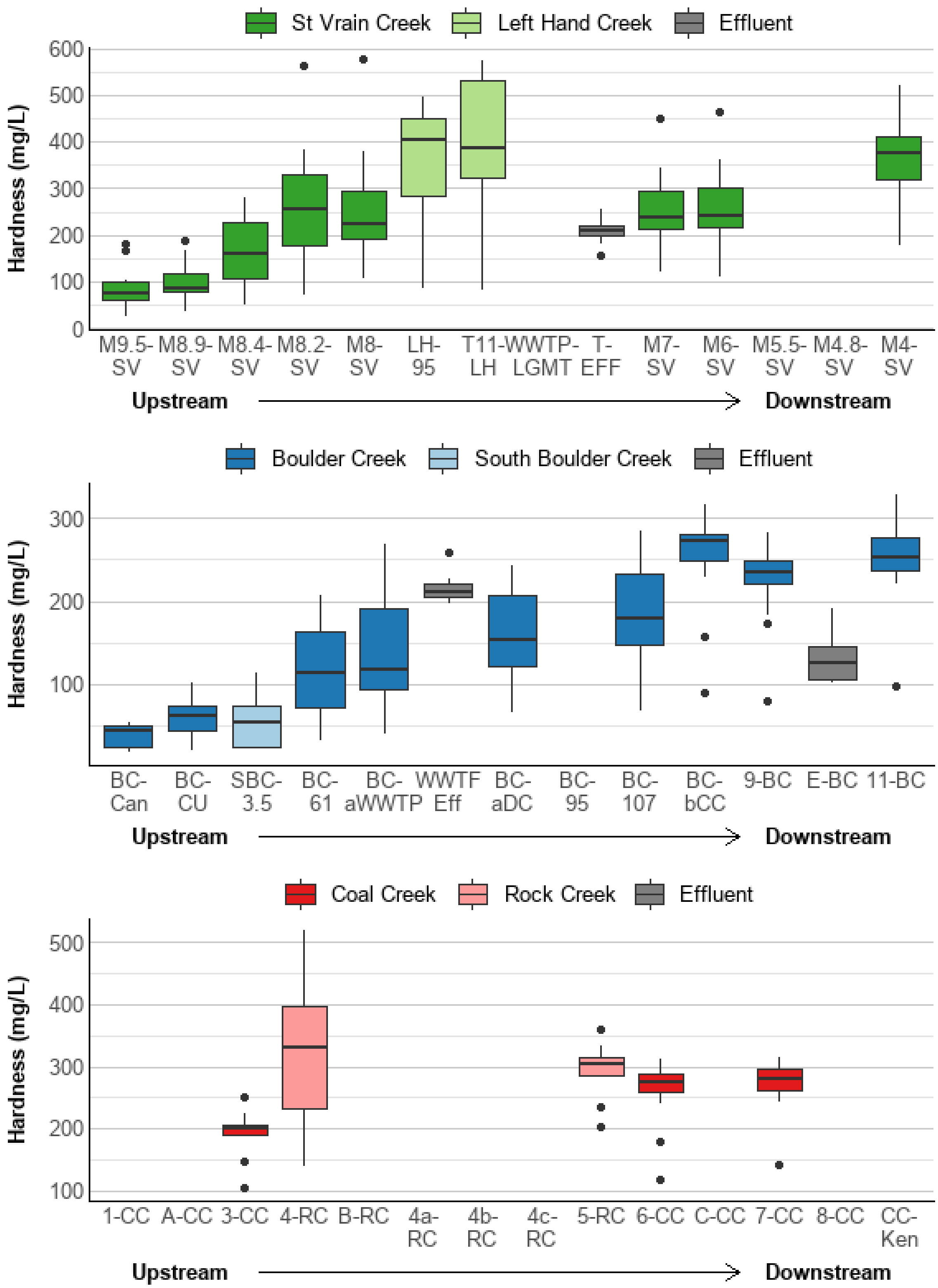

Figure A.2 2018 hardness boxplot summaries

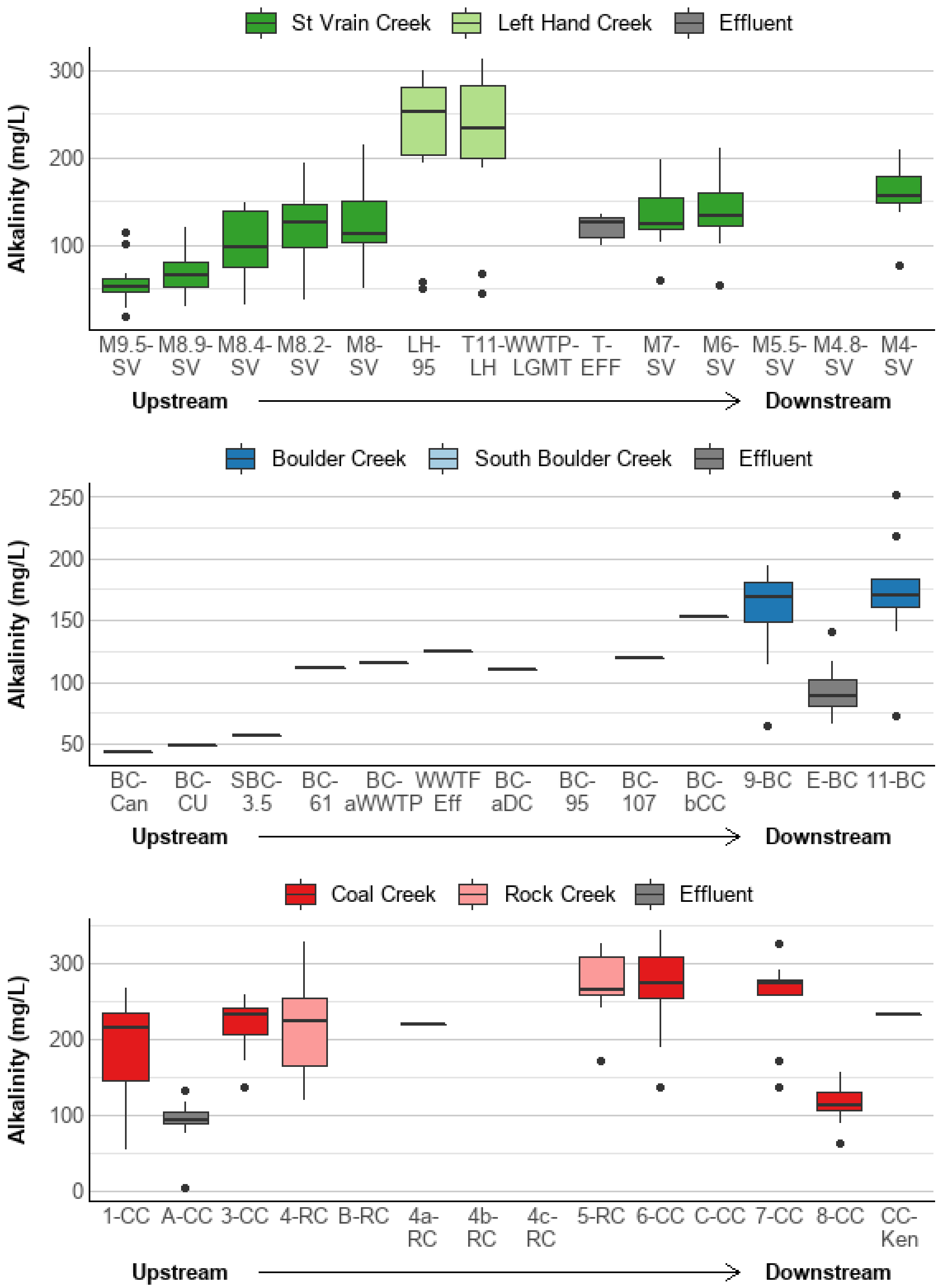

Figure A.3 2018 alkalinity boxplot summaries

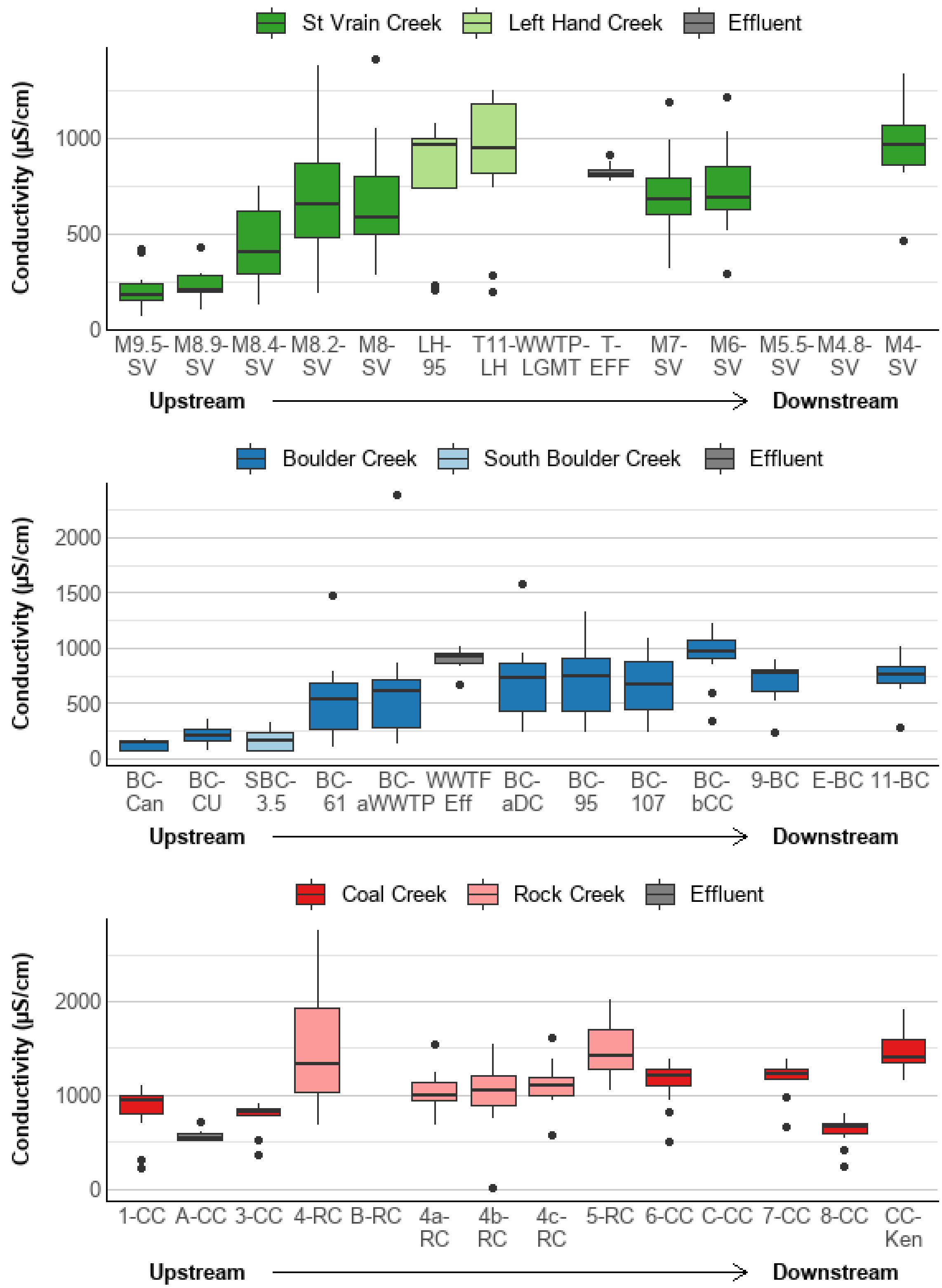

Figure A.4 2018 conductivity boxplot summaries

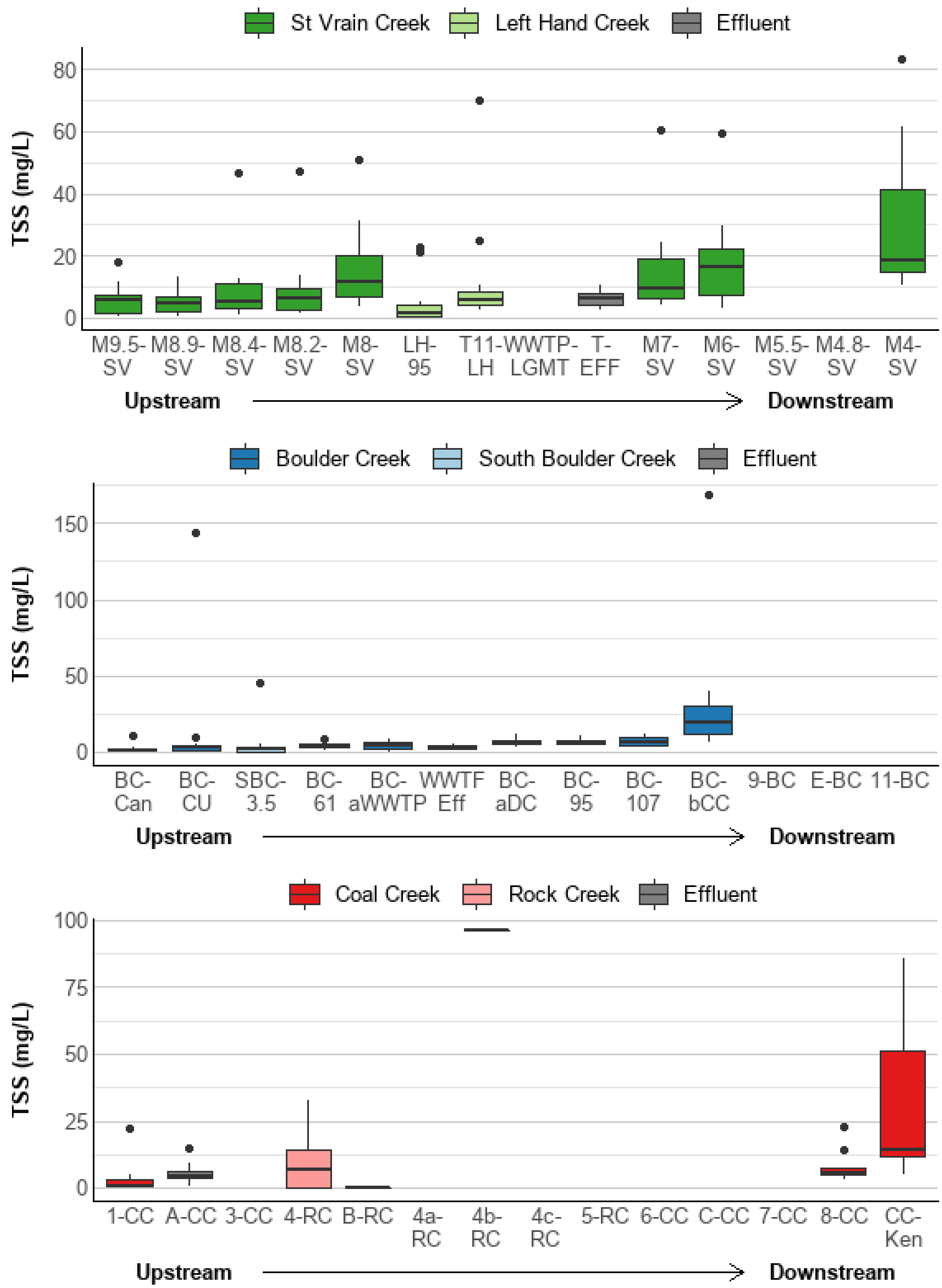

Figure A.5 2018 total suspended solids boxplot summaries

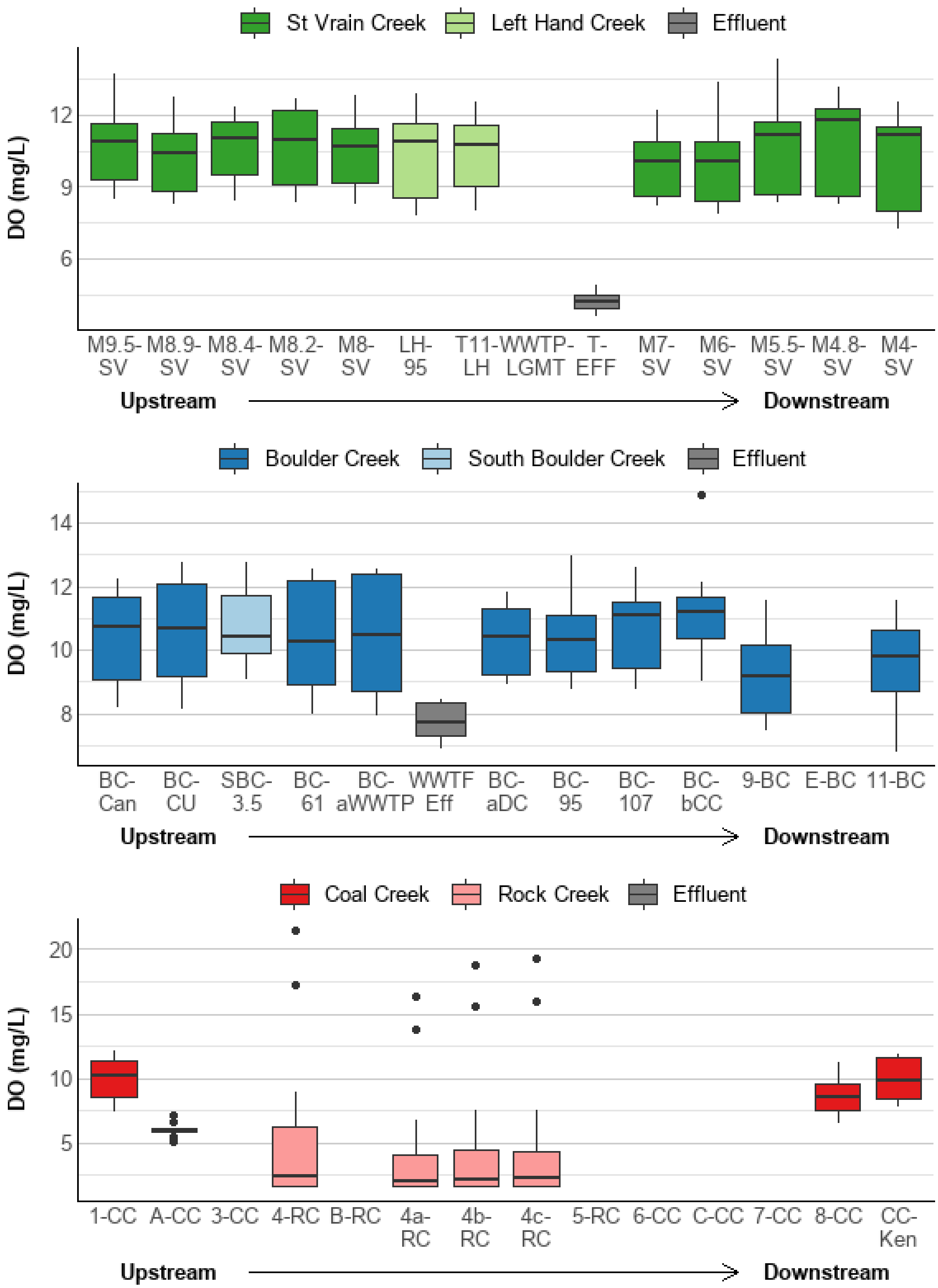

Figure A.6 2018 dissolved oxygen boxplot summaries

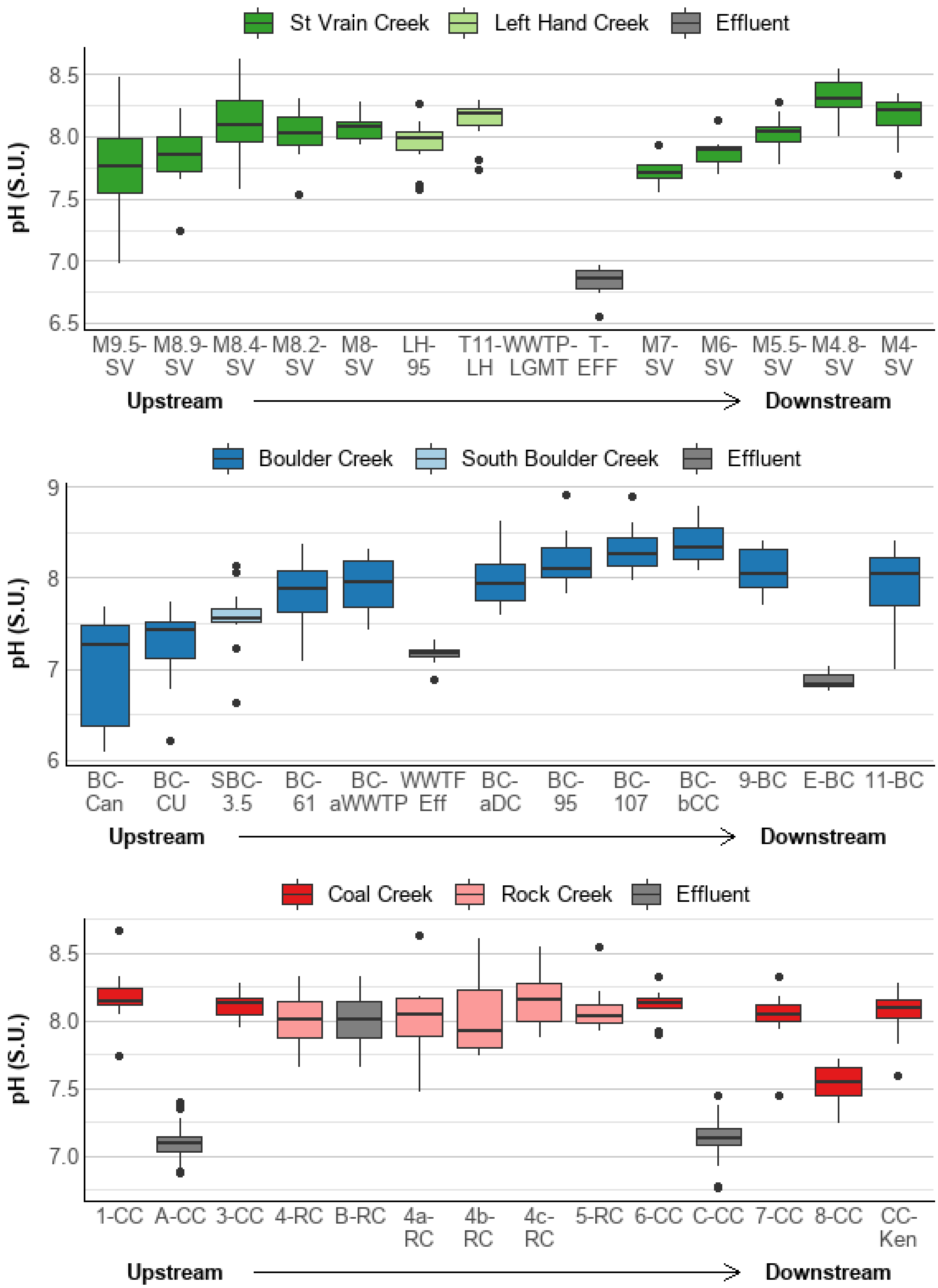

Figure A.7 2018 pH boxplot summaries

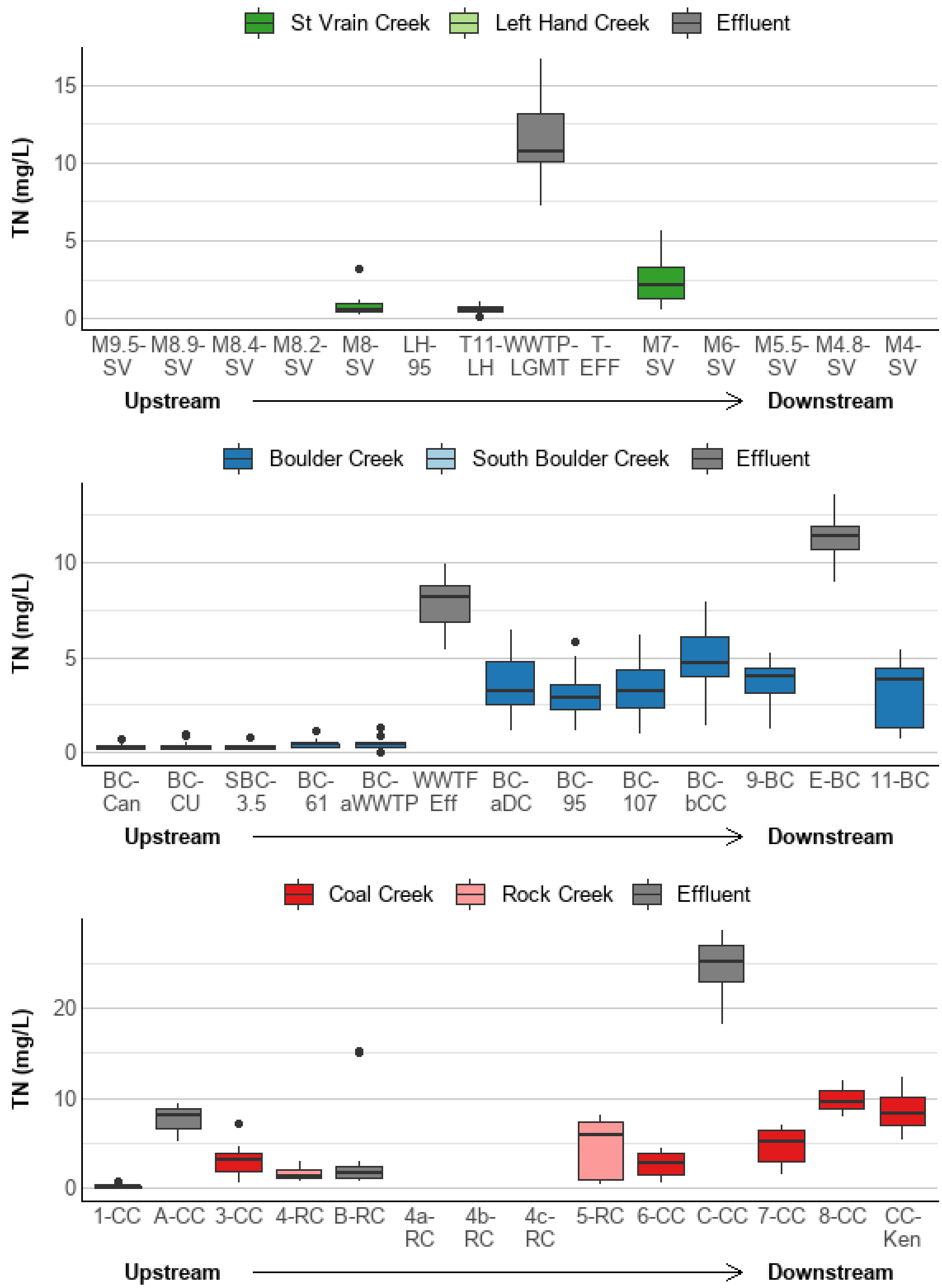

Figure A.8 2018 total nitrogen boxplot summaries

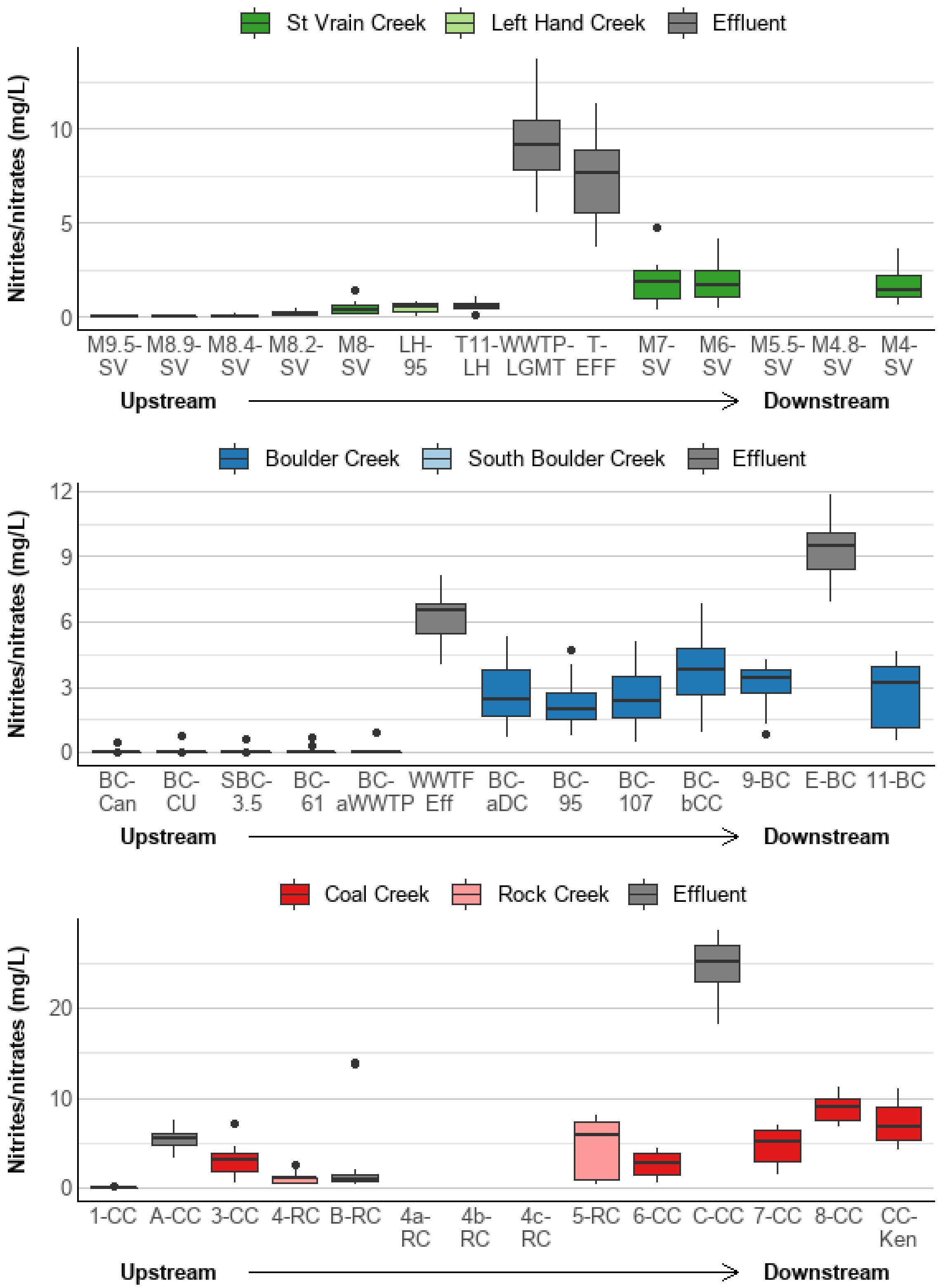

Figure A.9 2018 nitrites and nitrates boxplot summaries

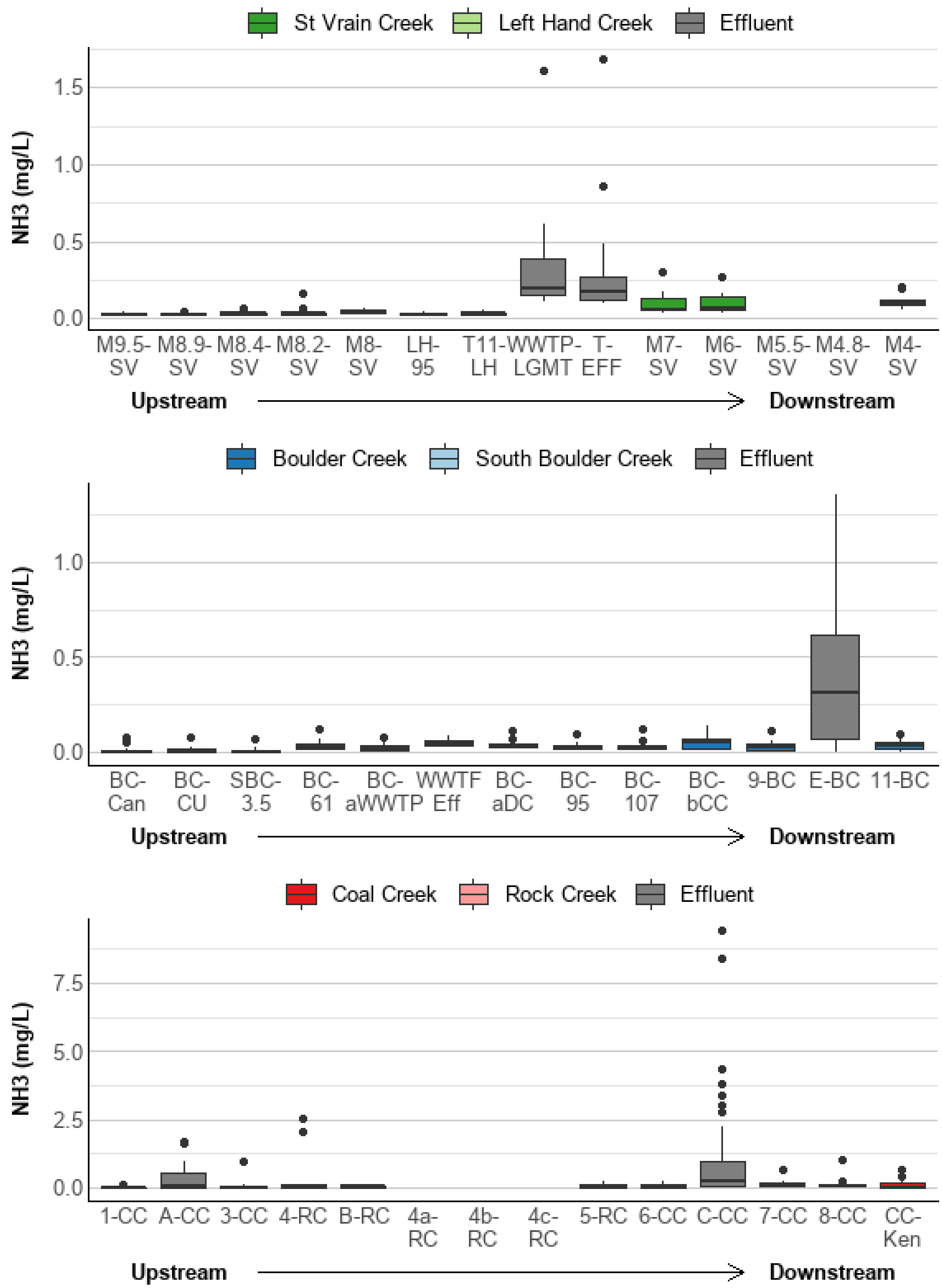

Figure A.10 2018 total ammonia boxplot summaries

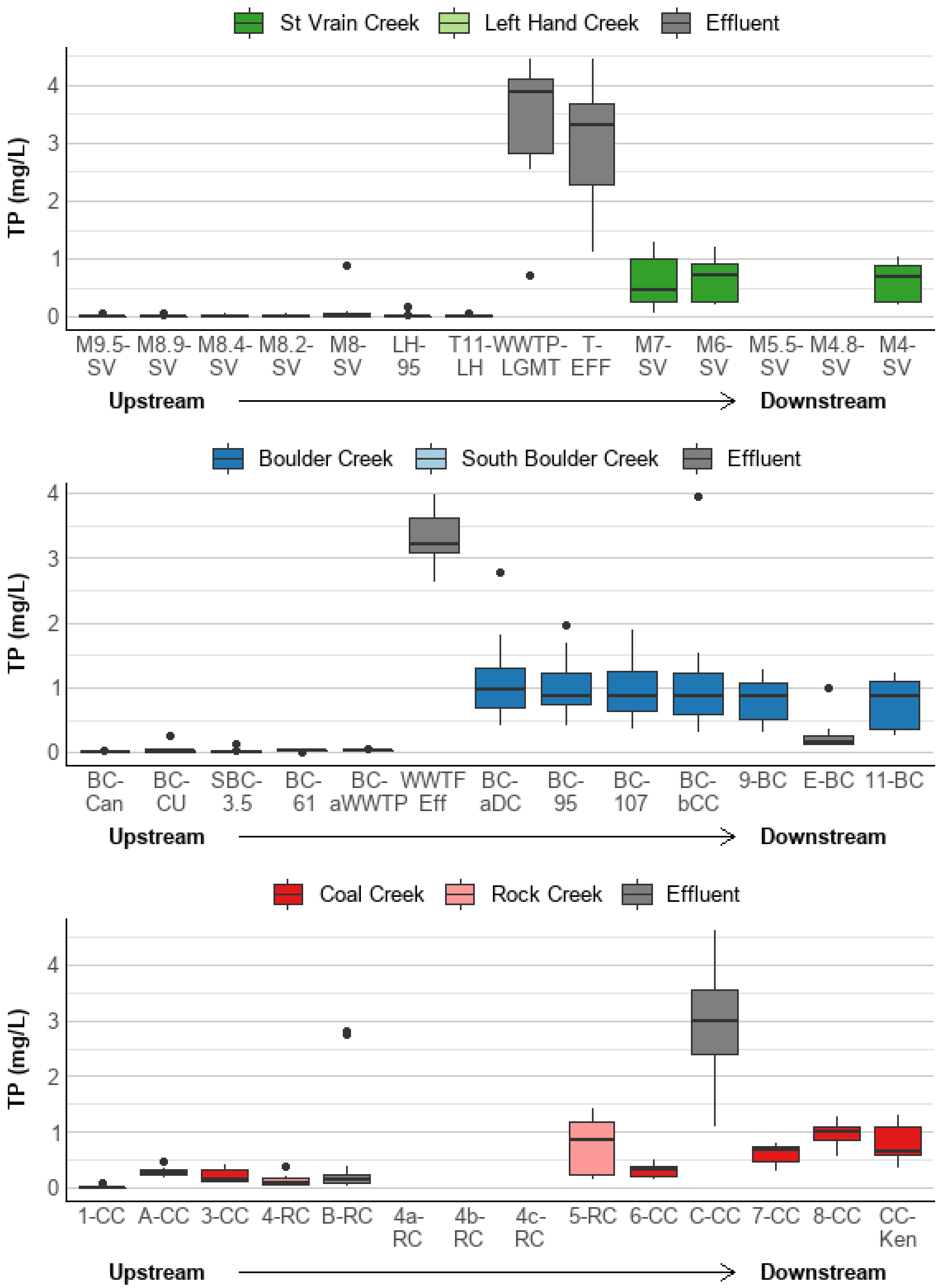

Figure A.11 2018 total phosphorus boxplot summaries

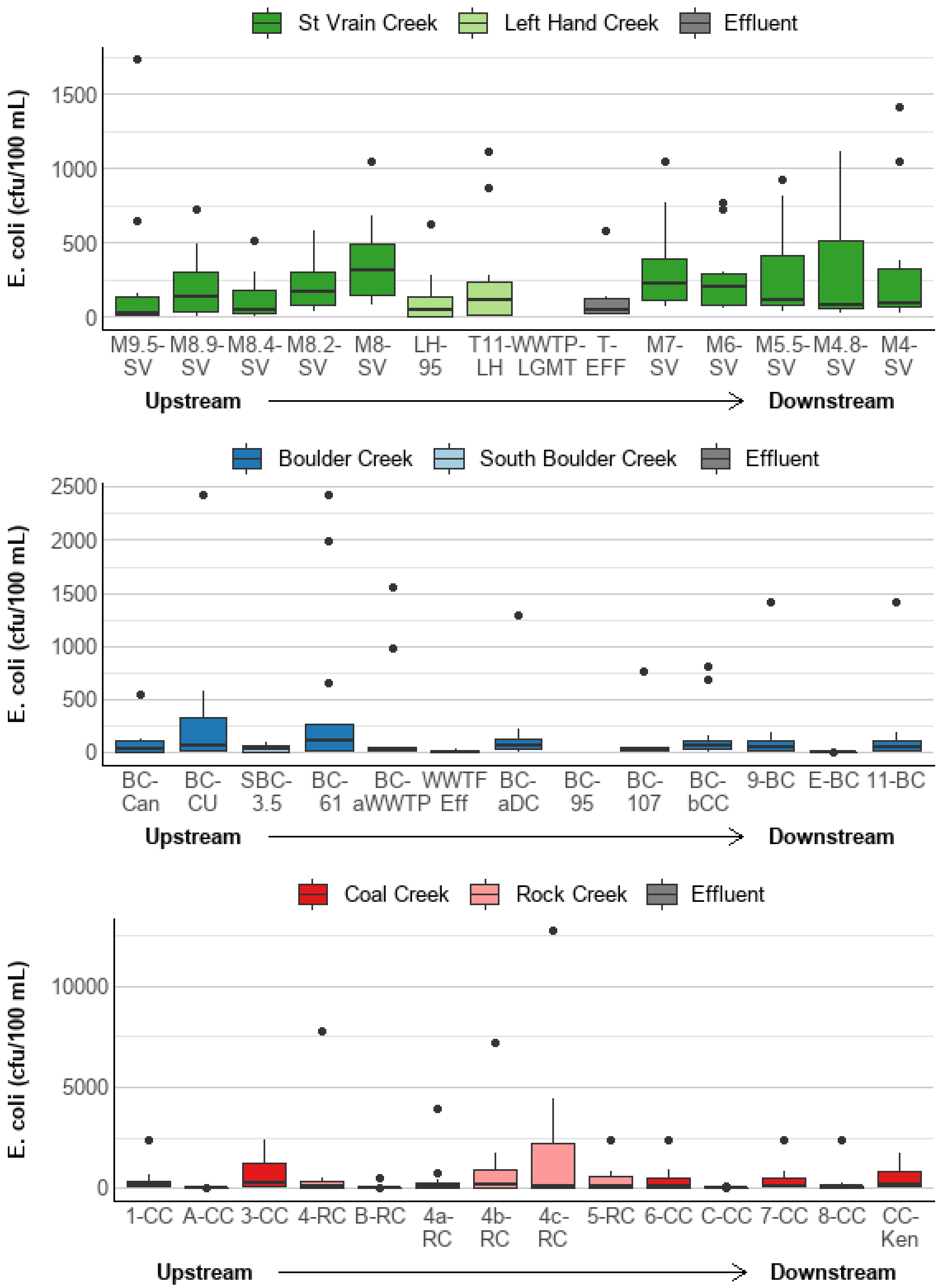

Figure A.12 2018 *E. coli* boxplot summaries

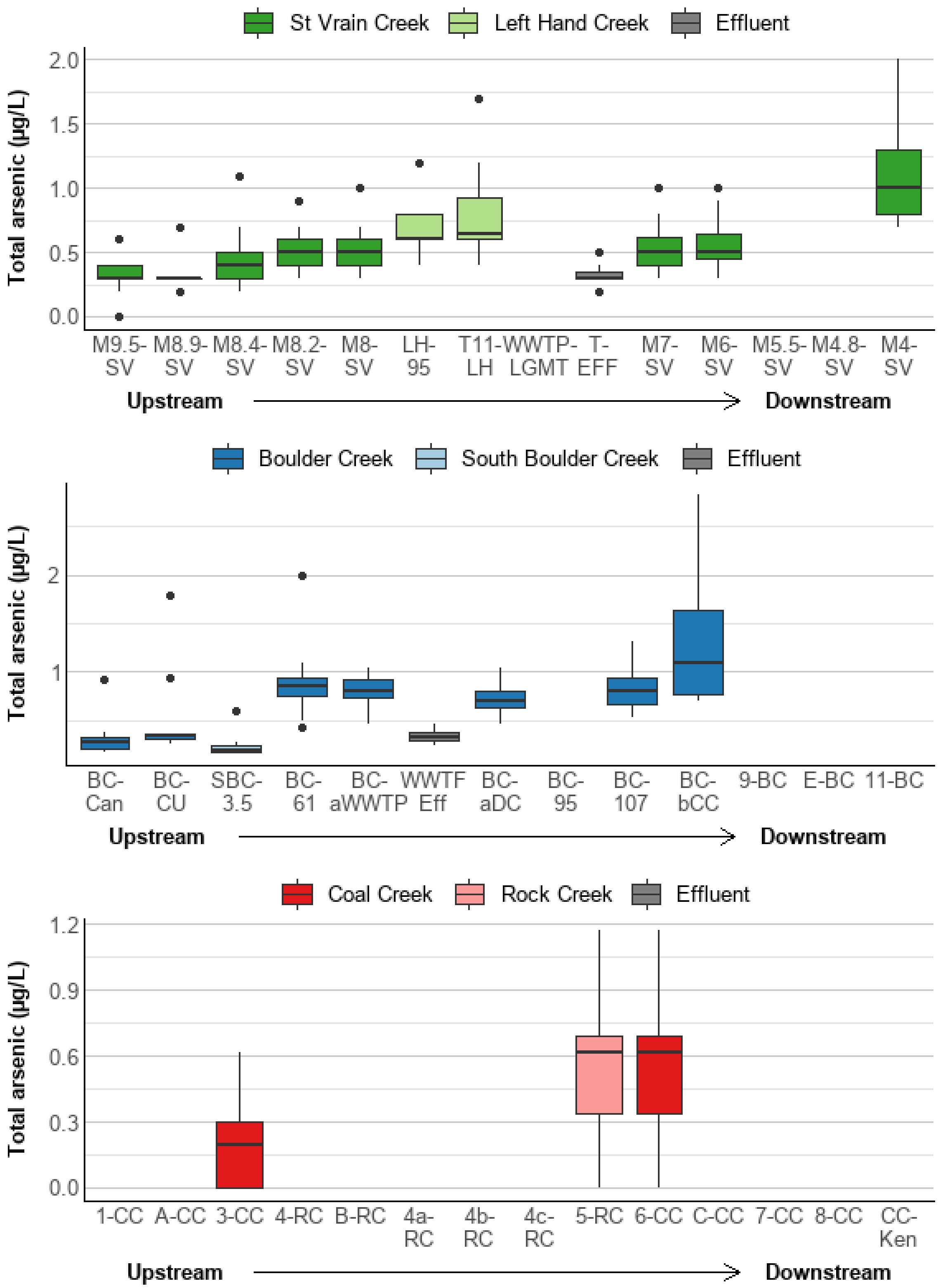

Figure A.13 2018 total arsenic boxplot summaries

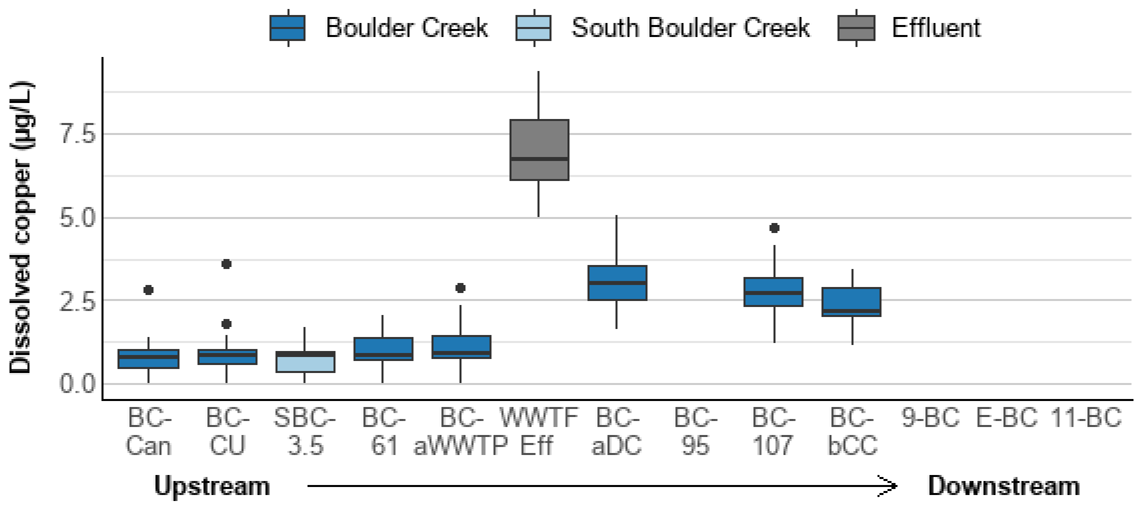

Figure A.14 2018 dissolved copper boxplot summary

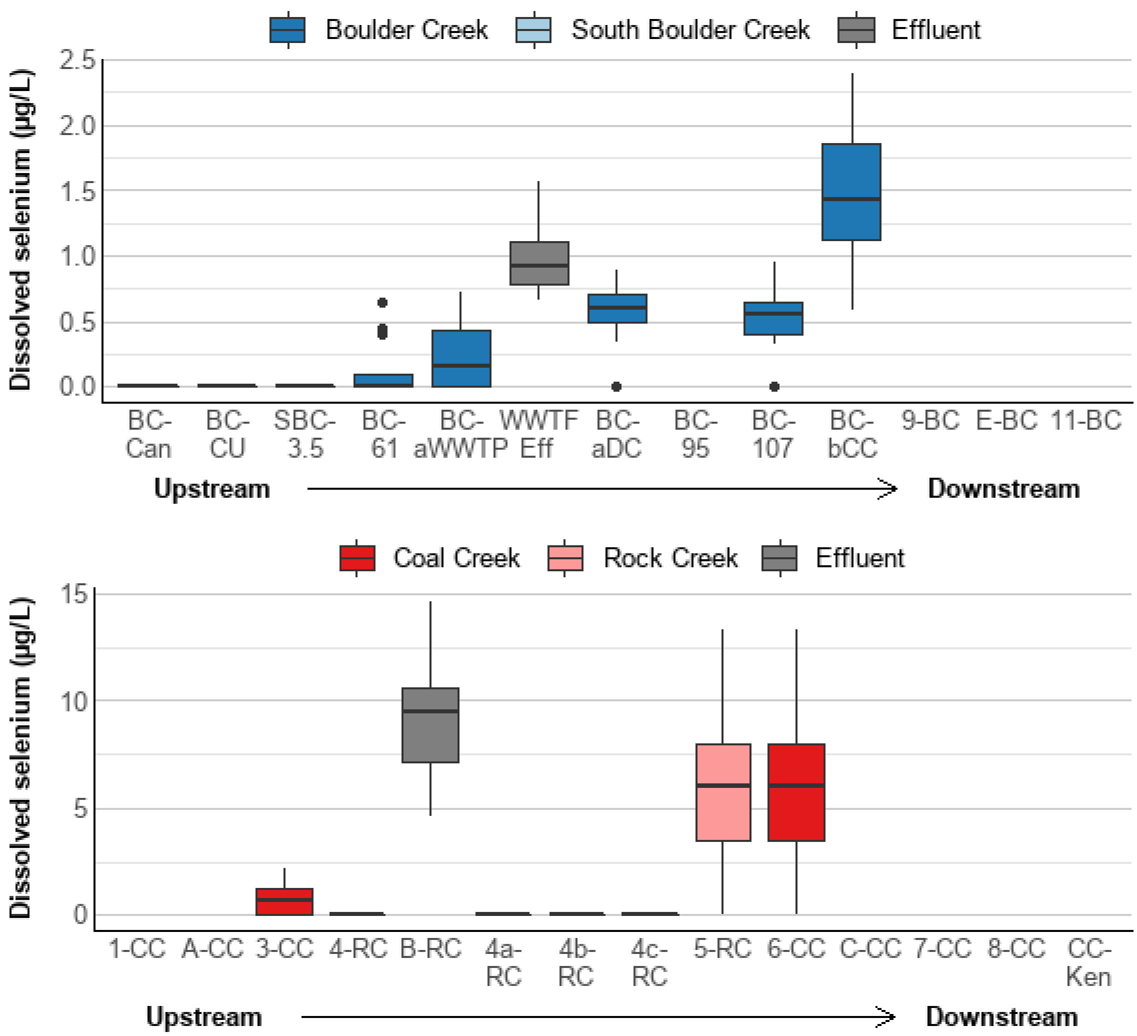

Figure A.15 2018 dissolved selenium boxplot summaries

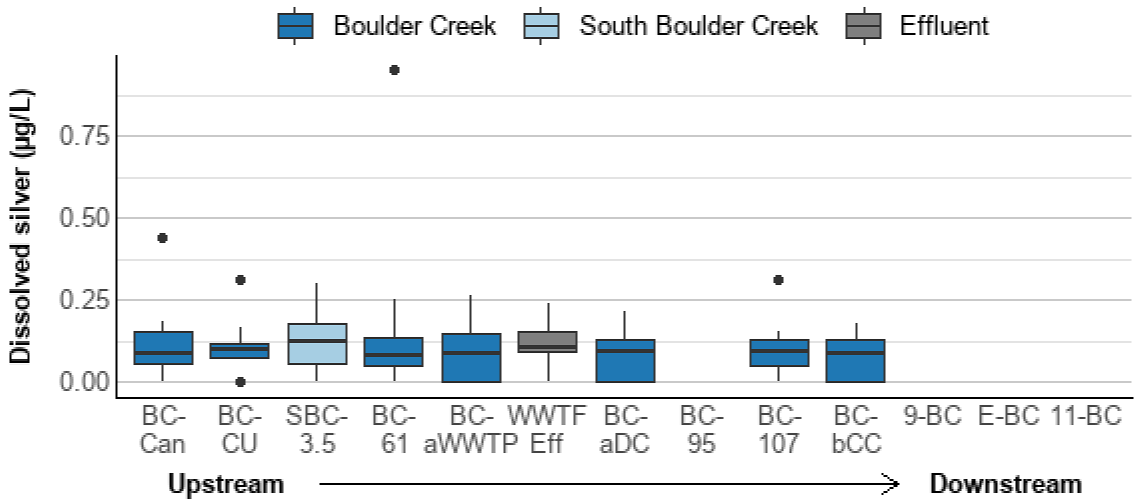

Figure A.16 2018 dissolved silver boxplot summary

APPENDIX B: SAMPLING EVENTS

Table B.1 provides a summary of all reported field duplicate samples. The City of Longmont was the only participating entity to provide field duplicate data for this report.

Site	Date	Analytes
M9.5-SV	6-19-2018	Hardness, Alkalinity, Conductivity, TSS, NOx, NH3, TP, *E. coli*, Arsenic (T)
M8.9-SV	5-22-2018	
M8.4-SV	3-21-2018	
M8.4-SV	12-18-2018	
M8.2-SV	11-29-2018	
LH-95	1-24-2018	
LH-95	7-24-2018	
M7-SV	8-22-2018	
M6-SV	10-18-2018	
M4-SV	2-14-2018	

Table B.1 Summary of reported 2018 field duplicate samples

Table B.2 depicts 2018 samples where a field replicate exceeded the 25% relative percent difference threshold in addition to the reporting limit. The acceptance criteria were exceeded by several *E. coli* samples, but this is not unexpected given the high variability of bacteria concentrations and these samples were retained in the data set.

Data provider	Date	Site	Analyte	Sample 1	Sample 2	Relative % difference
City of Longmont	2/14/2018	M4-SV	*E. coli*	21.6	9.6	77%
City of Longmont	8/22/2018	M7-SV	*E. coli*	1046.2	727.0	36%
City of Longmont	10/18/2018	M6-SV	*E. coli*	235.9	128.1	59%
City of Longmont	11/29/2018	M8.2-SV	*E. coli*	165.0	104.3	45%

Table B.2 2018 samples with field replicates exceeding 25% relative percent difference

Table B.3 provides a summary of all reported field blank samples. The City of Longmont was the only participating entity to provide field blank data for this report.

Data provider	Date	Analytes
City of Longmont	1-25-2018	Hardness, Alkalinity, Conductivity, TSS, NOx, NH3, TP, *E. coli*, Arsenic (T)
	2-14-2018	
	3-22-2018	
	4-25-2018	
	5-23-2018	
	6-20-2018	
	7-25-2018	
	8-22-2018	
	9-26-2018	
	10-18-2018	
	11-30-2018	
	12-19-2018	

Table B.3 Summary of reported 2018 field blank samples

Table B.4 depicts 2018 samples where a field blank exceeded the reporting limit or data was provided with a “B” qualifier, indicating that the associated field blank exceeded the reporting limit.

Data provider	Date	Analytes
City of Longmont	7/28/2018	Selenium
City of Louisville	1/3/2018	Total nitrogen, nitrite
City of Louisville	2/7/2018	Total nitrogen
City of Louisville	3/7/2018	Total nitrogen, nitrate/nitrite
City of Louisville	4/4/2018	Total nitrogen
City of Louisville	6/6/2018	Total nitrogen, total phosphorus, nitrate/nitrite, ammonia
City of Louisville	8/8/2018	Total nitrogen, total phosphorus, nitrite, ammonia
City of Louisville	9/5/2018	Nitrite, ammonia
City of Louisville	10/10/2018	Total nitrogen, nitrate/nitrite, nitrite, ammonia
City of Louisville	11/7/2018	Nitrite

Table B.4 2018 samples with field blanks exceeding reporting limit

Table B.5 provides a summary of all 2018 sampling dates for the analytes at stream sampling sites considered within this report.

Site	Temperature	Hardness	Alkalinity	Conductivity	TSS	DO	pH	TN	NOx	NH3	TP	*E. coli*	Arsenic (T)	Copper	Selenium	Silver
M9.5-SV	11	11	11	11	11	11	11	0	8	11	7	11	11	0	0	0
M8.9-SV	11	11	11	11	11	10	11	0	6	11	6	11	11	0	0	0
M8.4-SV	11	11	11	11	11	11	11	0	8	11	9	11	11	0	0	0
M8.2-SV	11	11	11	11	11	11	11	0	10	11	9	11	11	0	0	0
M8-SV	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0
LH-95	11	11	11	11	11	11	11	0	11	11	7	11	11	0	0	0
T11-LH	12	12	12	12	12	12	12	12	12	12	9	12	12	0	0	0
M7-SV	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0
M6-SV	11	11	11	11	11	11	11	0	11	11	11	11	11	0	0	0
M5.5-SV	11	0	0	0	0	11	11	0	0	0	0	11	0	0	0	0
M4.8-SV	11	0	0	0	0	11	11	0	0	0	0	11	0	0	0	0
M4-SV	11	11	11	11	11	11	11	0	11	11	11	11	11	0	0	0
BC-Can	12	12	1	12	12	12	12	12	12	12	12	12	12	12	12	12
BC-CU	12	12	1	11	12	12	12	12	12	12	12	12	12	12	12	12
SBC-3.5	12	12	1	12	12	12	12	11	11	12	12	12	12	12	12	12
BC-61	12	12	1	11	12	12	12	11	11	12	12	12	12	12	12	12
BC-aDC	12	12	1	11	12	12	12	12	12	12	12	12	12	12	12	12
BC-95	12	0	0	11	12	12	12	12	12	12	12	0	0	0	0	0
BC-107	12	12	1	12	12	12	12	12	12	12	12	12	12	12	12	12
BC-bCC	12	12	1	12	12	12	12	12	12	12	12	12	12	12	12	12
9-BC	12	12	12	12	0	12	12	12	12	12	12	12	0	0	0	0
11-BC	12	12	12	12	0	12	12	12	12	12	12	12	0	0	0	0
1-CC	11	0	11	11	11	11	11	10	9	10	10	11	0	0	0	0
3-CC	12	12	12	12	0	0	12	12	12	12	12	12	23	0	23	0
4-RC	11	11	11	12	11	12	12	11	11	11	11	12	0	0	1	0
4a-RC	11	0	1	12	0	12	12	0	0	0	0	12	0	0	1	0
4b-RC	12	0	0	12	1	12	12	0	0	0	0	12	0	0	1	0
4c-RC	12	0	0	12	0	12	12	0	0	0	0	12	0	0	1	0
5-RC	12	12	12	12	0	0	12	12	12	11	12	12	23	0	23	0
6-CC	12	12	12	12	0	0	12	12	12	12	12	12	23	0	23	0
7-CC	12	12	12	12	0	0	12	12	12	12	12	12	0	0	0	0
8-CC	11	0	11	11	11	11	11	12	12	12	12	11	0	0	0	0
CC-Ken	12	0	1	12	12	12	12	12	12	12	12	12	0	0	0	0

Table B.5 Number of 2018 sampling dates for each analyte and sample stream site