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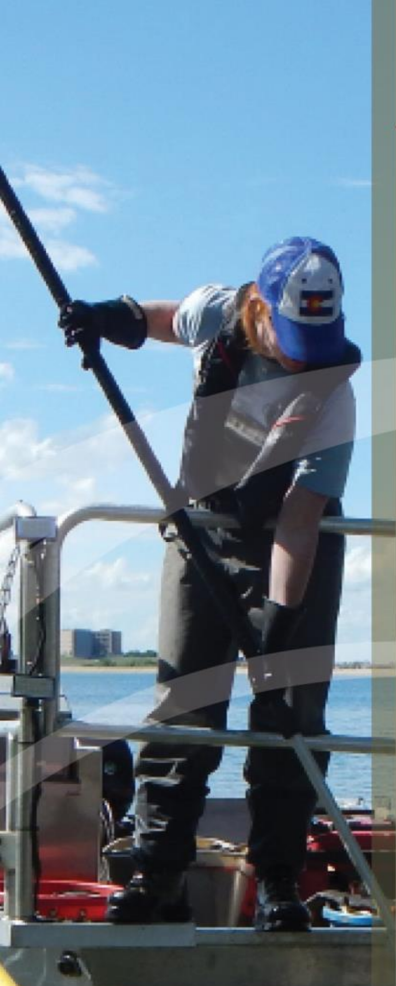
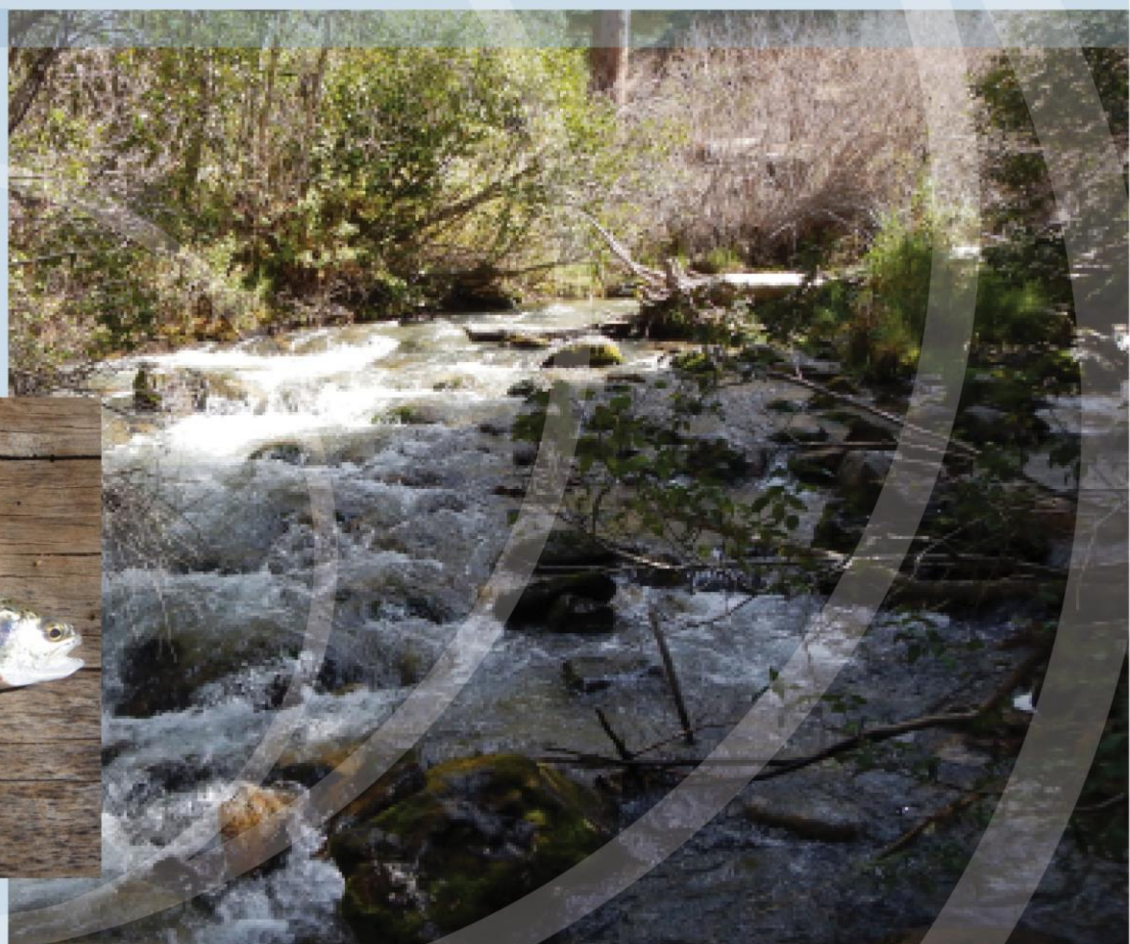


Sediment and Algae Assessment in the Colorado River and Fraser River Basins 2019

DRAFT Report
February 2020



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Sediment and Algae Assessment in the Colorado River and Fraser River Basins 2019

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Table of Contents

List of Figures

List of Tables

List of Appendices

1. Introduction

At the request of Grand County Learning By Doing (LBD), GEI Consultants, Inc. (GEI) conducted assessments of the substrate and algae present at multiple sampling locations in the Colorado River and Fraser River basins in Grand County in the fall of 2019. A total of fourteen sites were sampled from September 24, 2019 through October 1, 2019, with seven sites located on the Colorado River, six sites located on the Fraser River, and one site located on Ranch Creek. The sites sampled by GEI for substrate and algae characteristics were previously established throughout Grand County Learning By Doing's Cooperative Effort Area (CEA).

At each site location, GEI performed pebble counts and measured percent fines, percent embeddedness, riffle stability index, and algal cover. The data collected at each site location may be used to assess potential sediment transport issues in the basin and to address questions related to biological integrity such as the Sediment Tolerance Indicator Value (TIV_{SED}) for macroinvertebrates and a salmonid spawning habitat assessment.

2. Cooperative Effort Area

All sites sampled were located within the Grand County LBD's Cooperative Effort Area (CEA) in Grand County. This area stretches from the town of Winter Park, CO approximately 50 miles downstream to the town of Kremmling, CO (Figure 2-1; Table 2-1). The seven sites on the Colorado River extend from the town of Granby, CO to the town of Kremmling, CO. The six sites on the Fraser River extend from the town of Winter Park, CO to the town of Granby, CO. The one site established on Ranch Creek is located in the town of Tabernash, CO, approximately 0.75 miles (mi) upstream from the confluence with the Fraser River (Figure 2-1).

Figure 2-1: All sediment and algae assessment site locations on the Colorado River, Fraser River, and Ranch Creek.

Table 2-1: Names and locations for all 14 sites sampled in 2019.

Site Name	Station Description	Latitude	Longitude
CR-1.7	Colorado River upstream of Blue River	40.044	-106.374
CR-7.4	Colorado River downstream of Troublesome Creek	40.051	-106.311
CR-9.1	Colorado River at CR39 Bridge at KB Ditch	40.054	-106.289
CR-16.7	Colorado River upstream of Williams Fork	40.050	-106.173
CR-22.9	Colorado River upstream of Hot Sulphur Springs	40.080	-106.099
CR-28.7	Colorado River downstream of Windy Gap	40.108	-106.004
CR-31	Colorado River upstream of Fraser and Windy Gap	40.101	-105.973
FR-1.9	Fraser River upstream of Granby Sanitation District	40.084	-105.954
FR-14	Fraser River upstream of Tabernash	39.992	-105.830
FR-15	Fraser River upstream of Fraser Flats restoration	39.983	-105.826
FR-20	Fraser River at Rendezvous Bridge	39.935	-105.791
FR-23.2	Fraser River upstream of Winter Park Sanitation	39.896	-105.769
FR-25.1	Fraser River upstream of UP Moffat Tunnel discharge	39.878	-105.754
RC-1.1	Ranch Creek downstream of Meadow Creek	39.999	-105.828

3. Methods

3.1 Pebble Counts and Embeddedness

At each site location, pebble counts were performed utilizing the method outlined by Colorado WQCD Policy 98-1 which describes the Modified Wolman Pebble Count Method (CDPHE 2014). A total of ten transects were established at each site, evenly spacing each transect along a length of stream approximately twenty times the average bankfull width. At each of these ten transects, a 60 by 60-centimeter (cm) sampling frame was used to designate 4 substrate particles for measurement at ten evenly spaced points across the transect (Photo 3-1). This accounted for a total of 40 substrate particle measurements per transect, and a total of 400 measurements per sampling location. The 60 by 60 cm sampling frame consisted of 4 aluminum bars connected to form a square, with an inside width of 60 cm, and 4 elastic bands placed forming four cross sections with a width of 50 cm. The intermediate axis of each particle designated by the elastic band cross sections on the sampling frame was measured using a gravelometer or ruler (if the particle was too large to fit through the apertures in the gravelometer). Ocular estimates were used for substrate particles that could not be removed from the bed and measured with a ruler (i.e., due to size).

A subset of the particles measured at each of the transects at each site location were used to determine percent embeddedness, or the extent to which larger particles are surrounded by or buried in fine substrate. A minimum of four or five large gravel or cobble-sized particles at each transect were measured for percent embeddedness, for a total of 40 to 50 embeddedness measurements per sampling location. Embeddedness percentages were determined by measuring the height that each particle was buried and dividing by the total particle height. This method allowed for a quantitative estimate of the total percent embeddedness at each site.

Photo 3-1: Substrate being measured with a gravelometer at Site CR-16.7 on the Colorado River.

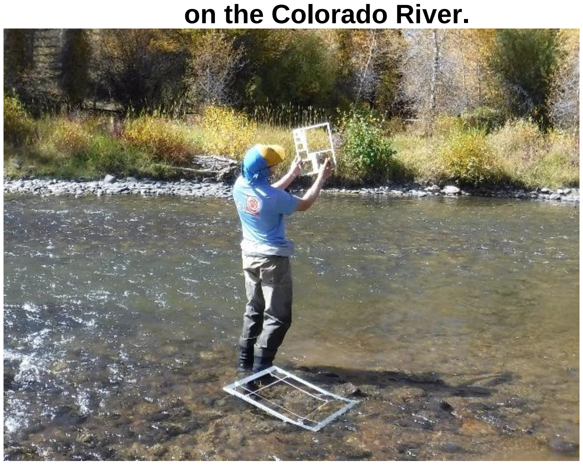
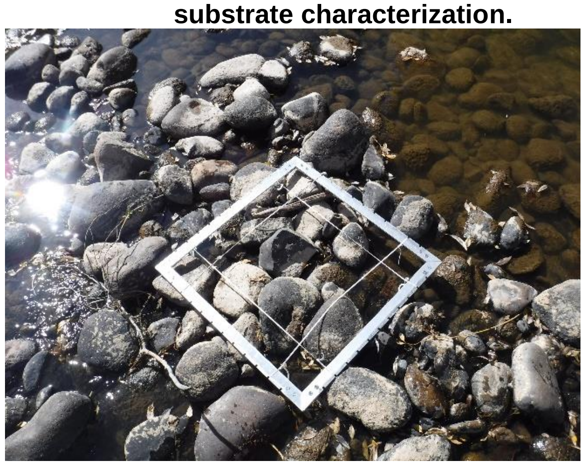


Photo 3-2: Sampling frame with four cross sections for randomized substrate characterization.



3.2 Riffle Stability Index

The Riffle Stability Index (RSI) was determined at each site using the methods outlined by Kappesser (2002). The RSI value indicates the percentage of mobile bed material in the riffle. A point bar, lateral bar, or similar depositional feature at each site location was identified in close proximity to a riffle. A transect was established in a riffle, across its bankfull width, and 200 substrate particles were selected. In smaller streams with insufficient width to allow selection of 200 particles, a second transect was established. The intermediate axis of each particle was measured. On the depositional feature, the intermediate axis of 10 to 30 of the largest recently deposited particles were measured, and the geometric mean of these particles was calculated. The geometric mean was then compared to the cumulative distribution of particle sizes from the 200-riffle pebble count. This determined the percentage of particles in the riffle that were smaller than the representative large mobile particles in the depositional feature at each site. The mobile fraction on the riffle can be estimated by comparing the relative abundance of various particle sizes present on the riffle with the dominant large particles on an adjacent bar (Kappesser 2002).

Photo 3-3: An example of a depositional point bar, from Site FR-23.2 on the Fraser River.

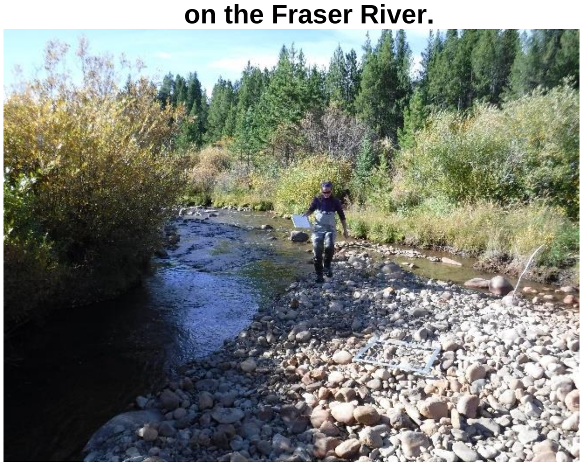
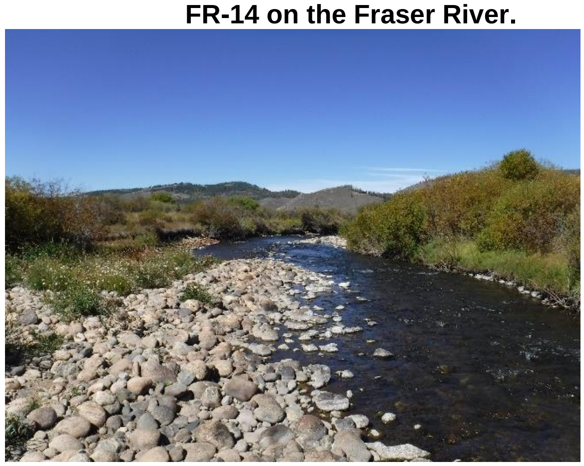


Photo 3-4: An example of a lateral depositional bar, from Site FR-14 on the Fraser River.



3.3 Algae Presence, Percent Cover, and Thickness

Algae presence (filamentous algae and diatoms), the percent filamentous algae cover, and diatom thickness data were recorded using a combined method that included protocols taken from the Colorado Water Quality Control Division Standard Operating Procedures for the Collection of Stream Periphyton Samples (CDPHE, no year) combined with the grid-based pebble count method. Along each transect established for pebble counts, the presence of filamentous algae, the presence of diatoms, the percent filamentous algae cover, and diatom thickness was measured or visually estimated.

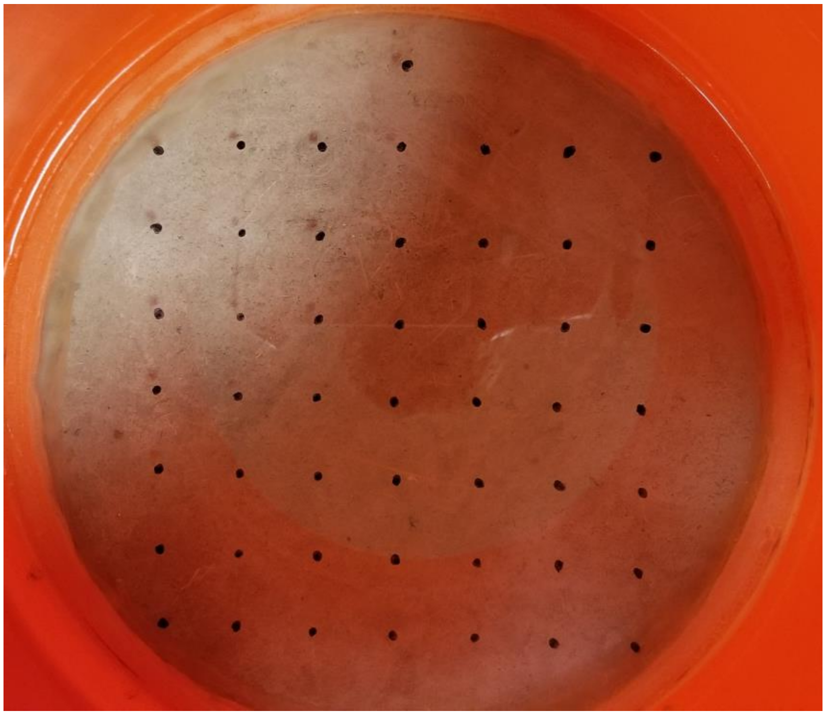
The algal communities were observed at three distances per transect: 25%, 50%, and 75% from the streambank, for a total of 30 points evaluated at each site. The algae viewing bucket consisted of a 5-gallon bucket with its bottom replaced with transparent plexiglass with 50 evenly spaced points marked with permanent marker. At each of the three transect positions, the presence of filamentous algae and/or diatoms was recorded. For filamentous algae cover data, the viewing bucket was used twice at each of the three points along each transect. The total number of points where filamentous algae was growing was divided by 100 to calculate the percent filamentous algae cover at each of the three distances per transect. At each of the three distances the thickness of diatom growth was visually estimated in millimeters (mm) and categorized in accordance to Stevenson and Bahls 1999 (Table 3-1).

Table 3-1: Diatom thickness categories as defined by Stevenson and Bahls 1999.

Category	Categorical Description
0	Substrate rough with no visual evidence of microalgae
0.5	Substrate slimy, but no visual accumulation of microalgae evident
1	A thin layer of microalgae is visually evident
2	Accumulation of microalgal layer from 0.5 to 1 mm thick is evident
3	Accumulation of microalgal layer from 1 to 5 mm thick is evident
4	Accumulation of microalgal layer from 5mm to 2 cm thick is evident
5	Accumulation of microalgal layer greater than 2 cm thick is evident

Photo 3-5: An example of substrate and the algal community present at Site FR-14 on the Fraser River. The piece of cobble substrate pictured below is covered with diatom algal growth, with a thickness between 1 to 5 mm.

Photo 3-6: The 5-gallon algae viewing bucket with transparent bottom and grid. The grid encompasses an area of roughly 100 in^2.



4. Results

4.1 Pebble Counts and Embeddedness

A pebble count was performed at each site location from September 24, 2019 through October 1, 2019. A total of 10 transects were sampled at each site except Site CR-1.7, where four transects were sampled because a majority of the site was not wadeable. At this site, conditions in the riffles, which constituted approximately 20% of the site, were represented by two riffle cross sections. The remainder of the site consisted of deep, monotonous, homogeneous slow-water habitat, which was represented by the other two cross sections. Most sites on the Colorado River and Fraser River were dominated by substrate sizes categorized as small cobble and/or cobble (Table 4-1). The substrate at the Ranch Creek site was dominated by small cobble and gravel-sized substrate. Bedrock was only present in a small proportion at Site CR-16.7. Fine substrate, particles with an intermediate width less than 2 mm, was most common at the two farthest downstream sites on the Colorado River and at the Ranch Creek site (Table 4-1), but Site CR-1.7 was the only site that had a proportion of fine sediment that exceeded the threshold of 29.3% set by CDPHE (CDPHE 2014).

Table 4-1: Percent average substrate size classes at all sites sampled in 2019.

Sites	Substrate Size Categories							
	Fines	Small Gravel	Gravel	Small Cobble	Cobble	Small Boulder	Boulder	Bedrock
	<2 mm	2-8 mm	8-64 mm	64-128 mm	128-256 mm	256-512 mm	>512mm	
CR-1.7	65.8	13.8	6.5	5.8	7.0	1.3	0.0	0.0
CR-7.4	25.7	5.5	33.9	27.7	7.2	0.0	0.0	0.0
CR-9.1	12.0	1.7	17.7	27.2	38.7	2.7	0.0	0.0
CR-16.7	12.3	3.8	23.5	27.0	26.0	4.0	2	1.5
CR-22.9	4.1	2.7	15.2	20.7	46.0	10.6	0.7	0.0
CR-28.7	5.8	3.5	16.1	27.9	36.4	10.3	0.0	0.0
CR-31	5.5	3.3	18.8	32.0	29.0	11.5	0.0	0.0
FR-1.9	8.8	3.8	22.8	35.8	22.3	6.5	0.0	0.0
FR-14	5.9	5.1	23.3	26.2	30.9	8.1	0.5	0.0
FR-15	13.4	2.5	21.3	24.3	22.3	13.6	2.5	0.0
FR-20	15.5	4.0	18.0	28.8	17.3	11.8	4.8	0.0
FR-23.2	4.7	2.5	24.6	35.2	28.3	3.5	1.2	0.0
FR-25.1	8.5	3.0	7.2	8.2	8.0	14.7	50.4	0.0
RC-1.1	21.0	4.5	24.0	27.0	17.5	2.5	3.5	0.0

Average percent embeddedness was equal to or greater than 37.4 at all sites, with the largest average percent embeddedness observed at sites CR-1.7, CR-7.4, FR-25.1, and RC-1.1 (Table 4-2). Average percent embeddedness values were in general lower in the upper portion of the Colorado River, and greatest at the two most downstream sites. These two sites were also observed to have the greatest percentage of fine substrate (<2 mm), with 25.7% fines at Site CR-7.4, and 49.7% fines at Site CR-1.7 (Table 4-1).

The percentage of substrate sizes observed in 2019 at sites on the Colorado River varied between sites. The substrate classes between <2 mm to ≤256 mm were observed at all sites. There was little to no substrate greater than the 256 mm at the two most downstream sites, Site CR-7.4 and Site CR-1.7. These two sites noticeably had a greater percentage of smaller substrate, between <2 mm to ≤64 mm, than all other Colorado River sites (Figure 4-1). The Colorado River sites in general decreased in average substrate size from upstream to downstream (Figure 4-1). In general, channel gradient decreases in a downstream direction with commensurate increases in streamflow and corresponding general decrease in sediment size (Rosgen 1996).

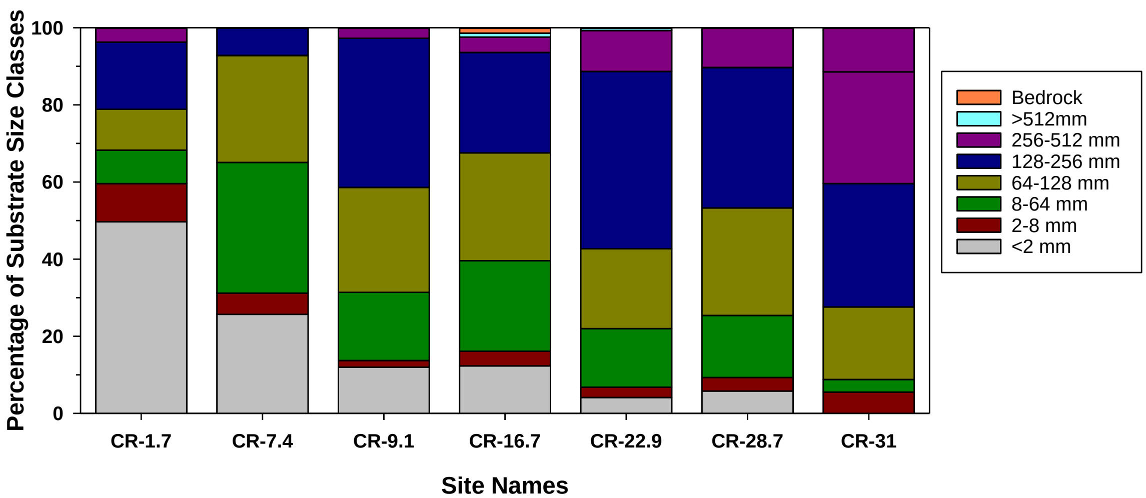


Figure 4-1: Percentage of substrate size classes for all sites on the Colorado River.

Substrate composition varied less between the Fraser River sites than observed on the Colorado River, with the exception of Site FR-25.1 (Figure 4-2). Site FR-25.1 was the most upstream site on the Fraser River, and the hydraulic and geomorphic properties of this site were substantially different from the other sites sampled on the Fraser River in 2019. Site FR-25.1 had a strikingly greater percentage of larger substrate, with the majority of substrate categorized as being greater than 512 mm (Figure 4-2). This site had a higher slope and lower sinuosity than all other Fraser River sites. Site FR-25.1 is mainly composed of step-pool complexes with a limited capacity to store sediment; this site is a "transport reach" that supplies sediment to downstream reaches (Rosgen 1996). Even though sites FR-25.1, FR 23.2, FR-20, and FR-15 had a greater percentage of >512 mm substrate than the most two downstream sites (Figure 4-2), the substrate composition changed less than expected from the upstream-most to downstream-most sampling site. The general homogenous state of the percentages of substrate size across sites on the Fraser River, from site FR-23.2 to FR-1.9, may be attributable a decrease in the natural magnitude of flows that were historically present.

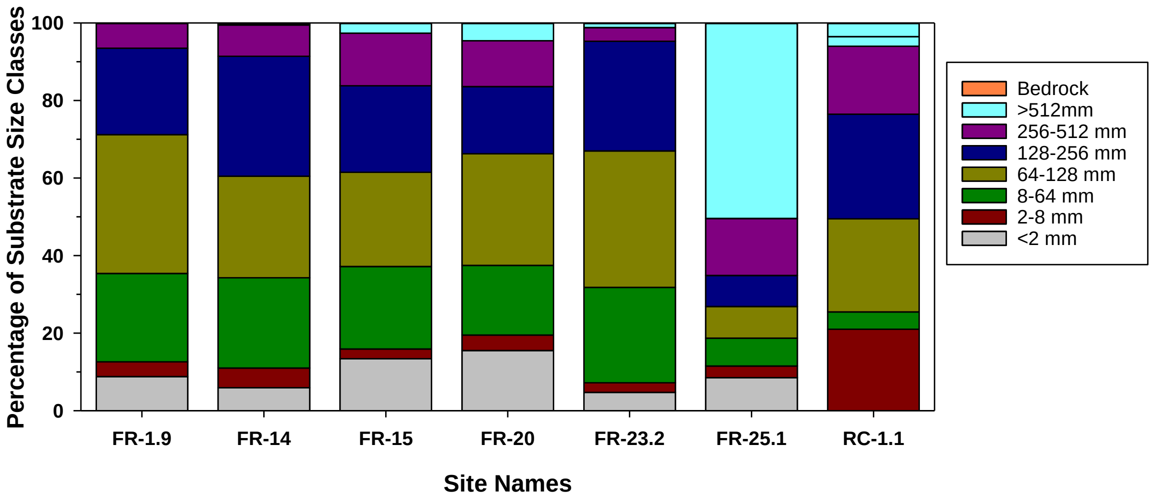


Figure 4-2: Percentage of substrate size classes for all sites on the Fraser River and Ranch Creek.

The one site located on Ranch Creek, Site RC-1.1, was approximately 0.75 mi upstream from the confluence of Ranch Creek with the Fraser River, roughly the same distance upstream from the confluence as Site FR-14 on the Fraser River. Site RC-1.1 on Ranch Creek was observed to have similar sinuosity, slope, and habitat types as Site FR-14 on the Fraser River. Additionally, Site RC-1.1 was observed to have comparable values for the types and percentages of substrate sizes observed in the middle portion of the Fraser River that was sampled, sites FR-20, and FR-15 (Figure 4-2).

Average percent embeddedness values on the Fraser River were all comparable between sites, except for at Site FR-25.1, the farthest upstream site location (Table 4-2). Among the Fraser River sites, Site FR-25.1 had the highest average percent embeddedness value observed (Table 4-2). Site FR-25.1 was dissimilar to all other sites on the Fraser River, Colorado River, and Ranch Creek. This site was dominated by very large boulders with a steep grade, and greatly influenced by surrounding human-made alterations to the riverbanks, portions of the river, and nearby roadways.

Table 4-2: Average embeddedness by site location.

Sites	Waterbody	Average Percent Embeddedness
CR-1.7	Colorado River	65.5
CR-7.4	Colorado River	55.5
CR-9.1	Colorado River	42.3
CR-16.7	Colorado River	49.0
CR-22.9	Colorado River	43.7
CR-28.7	Colorado River	48.8
CR-31	Colorado River	44.8
FR-1.9	Fraser River	40.0
FR-14	Fraser River	40.5
FR-15	Fraser River	46.9
FR-20	Fraser River	37.4
FR-23.2	Fraser River	39.4
FR-25.1	Fraser River	51.8
RC-1.1	Ranch Creek	51.4

4.2 Riffle Stability Index

A 200-riffle pebble count and a 10 to 30 pebble count on a nearby depositional feature were performed at thirteen of the fourteen sites in 2019. Site FR-25.1, the farthest upstream site on the Fraser River did not have depositional features appropriate for a depositional substrate characterization. Site FR-25.1 was distinctly different than any other site sampled on the Fraser River, Colorado River, or Ranch Creek. This site had very high relief, a slope of approximately 10%, and was dominated by very large substrate. Streams of this type exhibit a high sediment transport potential and a relatively low in-channel sediment storage capacity (Rosgen 1996).

The RSI value indicates the cumulative percentage of riffle particles that are smaller than the dominant large particles on a depositional bar (Kappesser 2002). A higher RSI indicates that sand and small gravel loading is occurring in riffles. The minimum RSI value observed occurred at Site FR-15 on the Fraser River and the maximum observed value was observed at Site CR-22.9 on the Colorado River. In general, the RSI values were relatively high, with an average RSI of 81 on the Colorado River, 78 on the Fraser River, and 71 at Ranch Creek.

Table 4-3: Average Riffle Stability Index (RSI) by site location.

Sites	Waterbody	Riffle Stability Index
CR-1.7	Colorado River	77
CR-7.4	Colorado River	77
CR-9.1	Colorado River	85
CR-16.7	Colorado River	73
CR-22.9	Colorado River	93
CR-28.7	Colorado River	79
CR-31	Colorado River	85
FR-1.9	Fraser River	89
FR-14	Fraser River	90
FR-15	Fraser River	65
FR-20	Fraser River	74
FR-23.2	Fraser River	73
FR-25.1	Fraser River	--
RC-1.1	Ranch Creek	71

4.3 Algae Presence, Percent Cover, and Thickness

The algae community at a total of 30 points within each site reach was assessed in conjunction with pebble count surveys from September 24, 2019 through October 1, 2019. The percent average presence of filamentous algae varied considerably across all sampling locations. Values ranged from 0 percent filamentous algae presence at Site FR-20 on the Fraser River, to a maximum of 100 percent presence at Site CR-22.9 on the Colorado River. The percent filamentous algae cover at each site also varied widely, and was generally low, with the exception of sites CR-1.7 and CR-22.9 on the Colorado River, and at sites FR-14 and FR-15 on the Fraser River (Table 4-4).

Table 4-4: Filamentous algae and diatom data by site location.

Sites	Waterbody	Percent Average Filamentous Presence	Percent Average Filamentous Algae Cover	Percent Average Diatom Presence	Average Categorical Diatom Thickness
CR-1.7	Colorado River	58.3	40.2	50.0	3.9
CR-7.4	Colorado River	13.3	2.1	93.3	1.5
CR-9.1	Colorado River	30.0	5.2	96.7	1.5
CR-16.7	Colorado River	66.7	8.2	96.7	2.8
CR-22.9	Colorado River	100	82.6	86.7	1.3
CR-28.7	Colorado River	13.3	1.4	100.0	1.8
CR-31	Colorado River	26.7	2.8	100.0	1.8
FR-1.9	Fraser River	63.6	11.9	100.0	0.7
FR-14	Fraser River	86.7	39.0	100.0	0.7
FR-15	Fraser River	73.3	30.9	90.0	2.6
FR-20	Fraser River	0.0	0.0	100.0	0.5
FR-23.2	Fraser River	6.7	3.7	96.7	0.6
FR-25.1	Fraser River	6.7	1.1	100.0	0.6
RC-1.1	Ranch Creek	50.0	7.6	93.3	1.1

Diatom algae was present at every site in 2019, and with the exception of a relatively low percentage of presence at Site CR-1.7 on the Colorado River, the percentage of diatom presence at each site was high, ranging from a minimum of 86.7 percent to 100 percent (Table 4-4). The diatom species *Didymosphenia geminata* (Didymo) is a stalked diatom that can form nuisance blooms in rivers in the western United States (Spaulding and Elwell 2007). This species was present at almost all sites sampled and prevalent at sites CR-28.7, CR-22.9, and CR-16.7. Didymo accounted for almost all of the diatoms observed with a thickness greater than 1-2 mm, except at sites FR-14 and FR-15. Diatom thickness was categorized as less than 1 mm at sites FR-1.9, FR-20, FR-23.2, and FR-25.1 on the Fraser River. All other sites sampled had thickness categories that exceeded a thickness of 1 mm (Table 4-4; Table 3-1).

5. Discussion

The substrate and algae community data gathered in the fall of 2019 at multiple sites along representative stretches of both the Colorado River and Fraser River, and one site on Ranch Creek have enabled a basin-wide assessment of substrate size, substrate mobility, substrate deposition, and algae population data. This in turn allows inference about the effects of current substrate conditions on fish and macroinvertebrate habitat quality.

5.1 Pebble Counts and Embeddedness

5.1.1 Colorado River

Based on observed changes between sites, sediment composition in the CEA is likely affected by large-scale factors such as reservoirs, and tributary inputs and by local-scale factors such as hillslope erosion and stream diversion infrastructure.

Near the upstream end of the CEA on the Colorado River, just below the Colorado River and Fraser River confluence between Site CR-31 and Site CR-28.7 is the Windy Gap Reservoir. This reservoir is a relatively small flow-through system that extends about 0.4 miles from the inlet to the outlet. A large proportion of the sediment transported into the reservoir is retained, inhibiting the natural sediment transport historically observed in the upper portion of the Colorado River. This is evident from the decrease in material smaller than 128 mm (i.e., gravel and sand) between Site CR-31, which is upstream of Windy Gap Reservoir, and sites CR-28.7 and CR-22.9, the next two downstream sites from Windy Gap Reservoir. The proportion of sand and gravel decreases from 59.6% at Site CR-31 to 53.3% at Site CR-28.7 to 42.7% at Site CR-22.9, indicating a lack of smaller substrate availability and transport. As expected, the percentages of these smaller substrate classes decreased below the reservoir, until the river passed through areas that receive sediment input. Diagonal cobble bars and mid-channel cobble bars, both of which indicate a lack of sediment mobility (Rosgen 2006), were observed downstream of Windy Gap Reservoir. Substantial additions of new substrate material into the Colorado River likely do not occur until the river reaches Byers Canyon, downstream of the town of Hot Sulphur Springs, below Site CR-22.9.

Byers Canyon and Muddy Creek are both located between Site CR-22.9 and Site CR-16.7 on the Colorado River. Byers Canyon is characterized by escarpments adjacent to the stream along with a steep stream corridor composed of mainly large boulder substrate. This section of the river extends approximately 1.9 miles just downstream of Hot Sulphur Springs. The river in the canyon is narrow and has a higher slope than adjacent reaches, resulting in greater water velocities than the sections of river just upstream and just downstream of the canyon. This creates a higher potential for sediment transport and a lower potential for sediment storage. The steep canyon walls also provide material ranging from silt to boulders to the river, largely through natural processes. Muddy Creek is downstream of Byers

Canyon; this small, unregulated system likely also serves as a source of new material to the Colorado River. Because of these new sources of sediment, sand and gravel (i.e., substrate <128 mm in size) increases from 42.7% to 66.4% between Site CR-22.9 and Site CR-16.7, the first study site located below Byers Canyon.

There are two relatively large tributaries to the Colorado River in the downstream portion of the study reach that likely influence substrate characteristics in the river. The Williams Fork of the Colorado River (Williams Fork) flows into the Colorado River just downstream of Site CR-16.7 in the town of Parshall, CO, and Troublesome Creek flows into the Colorado River between Site CR-9.1 and Site CR-7.4. The Williams Fork downstream of Williams Fork Reservoir is a short section of river about 2.0 miles in length before the confluence. This reservoir disrupts the continuity of sediment transport in the Williams Fork and likely diminishes the amount of substrate provided to the Colorado River. The Williams Fork adds a relatively large amount of volume to the flow in the Colorado River, which assists with transporting sediment downstream. Substrate at Site CR-9.1, the first sampling site downstream of the Williams Fork confluence, had smaller proportions of substrate material smaller than 128 mm than observed at the next upstream site, Site CR-16.7. The additional river flow (and therefore, increased water velocity) from the Williams Fork River, combined with its low sediment input, increases the capacity of the Colorado River to move the existing substrate in the vicinity of Site CR-9.1. As expected, the proportion of sediment less than 128 mm in diameter decreases from 66.4% to 58.6% between sites CR-16.7 and CR-9.1. The KB Ditch Diversion also appears to affect sediment dynamics at Site CR-9.1. The KB Ditch is located approximately 0.4 miles upstream of Site CR-9.1 on the Colorado River and diverts flow from the Colorado River for agricultural use. The diversion runs the width of the river at the ditch inlet, with the exception of a small bypass on river right (looking in a downstream direction). This structure also has the potential to trap sediment. The KB Ditch and Williams Fork confluence with the Colorado River are both upstream of Site CR-9.1; without a monitoring site between these two potentially influencing factors. An additional site located between Williams Fork and KB Ditch might determine their relative influences on the sediment characteristics at Site CR-9.1.

Photo 5-1: Aerial image of the KB Ditch diversion and inlet (Google Earth, earth.google.com/web/). The Colorado River flows towards the left of the photo.

Troublesome Creek is a moderately sized tributary to the Colorado River, and the confluence is located between Site CR-9.1 and CR-7.4, approximately 0.4 miles upstream from Site CR-7.4. This creek is low-gradient, sinuous (i.e., meandering), and runs adjacent to agricultural fields for much of its length. The confluence of Troublesome Creek and the Colorado River is located just upstream of where the sinuosity of the Colorado River increases dramatically, the slope decreases, and the water velocity decreases in comparison to the upstream reaches. The highly sinuous section of the Colorado River extends approximately 9 miles through the most downstream site CR-1.7 before entering Gore Canyon just downstream of the town of Kremmling.

Due to higher sinuosity, lower slope, reduced water velocity, and the addition of sediment from Troublesome Creek, the Colorado River transitions from being dominated by small cobble and cobble substrate to being dominated by smaller substrate size classes. Site CR-7.4 was dominated by gravel substrate with a large proportion of fine substrate, and Site CR-1.7 was dominated by fine substrate.

Based on observed changes between sites, sediment composition throughout the CEA is likely affected by a combination of natural and man-made factors. Troublesome Creek, Muddy Creek, and Byers Canyon likely act as sources of sand and gravel in an otherwise sediment-limited system. While the Williams Fork provides additional flow, it is also sediment-limited and probably does not provide substantial amounts of gravel to the system. The predominance of fine substrate at Kremmling is likely due to transport capacity being limited by low gradient and high sinuosity. Low-gradient, sinuous systems have low water velocity and allow for small substrate particles to fall out of the water column and become deposited, and the low velocity inhibits larger particles from being transported. Based on observations at sites downstream of Windy Gap and KB Ditch, with a lower amount of gravel substrate compared to their adjacent upstream sites, much of the gravel in the CEA remains trapped behind dams or diversions instead of being moved downstream, as is typical in managed systems.

5.1.2 Fraser River and Ranch Creek

As with the Colorado River, sediment composition on the Fraser River is affected by large-scale and local-scale factors. The primary large-scale factor is flow management, but local features such as unpaved roads, erodible hillslopes, beaver ponds and man-made ponds appear to have a larger effect on the proportion of fine sediment in the watershed, as opposed to the cumulative proportion of sediment less than 128 mm in diameter.

The percentage of substrate <2 mm was greater at Site RC-1.1 than all sites on the Fraser River (21% versus an average of 9.5 for the six Fraser River sites). The higher proportion of fine sediment may be due to a combination of low flows from multiple diversions in the Ranch Creek Watershed and the high availability of sediment from unpaved roads and hillslopes in the watershed.

The Fraser River in the CEA has four relatively large tributaries: Vasquez Creek, which enters the Fraser River between sites FR-23.2 and FR-20, Elk Creek and St. Louis Creek, both of which enter the Fraser River between sites FR-20 and FR-15, and Ranch Creek, which enters the Fraser River downstream of Site FR-14. Surprisingly, despite these tributary inputs, the proportion of sediment from 2 – 128 mm in size is remarkably consistent between sites FR-23.2 and FR-14. The individual influences of tributaries like Vasquez Creek and St. Louis Creek on Fraser River sediment dynamics were not pronounced in 2019, perhaps because the tributaries are highly regulated by diversions.

The local factors in the Fraser River Drainage include stream diversions, beaver dams, and unpaved roads. The proportion of fine sediment decreased by almost 50% between sites FR-25.1 and FR-23.2, perhaps because there is a municipal diversion and a large beaver pond between the two sites. Beaver dams affect streams in similar but less pronounced ways than dams and larger diversions; while they slow the water velocity, allowing for substrate particles to be deposited and stored on their upstream side instead of being moved downstream, they tend not to last as long as larger, engineered structures and likely have a lesser effect on sediment dynamics. It is possible that there are multiple beaver dams within the CEA that were not observed but could affect sediment dynamics in the drainage.

The proportion of substrate <2 mm at Site FR-20 was the highest among all Fraser River sites at 15.5%. This could be due to the high density of unpaved roads and cleared areas under construction in the valley between sites FR-23.2 and FR-20. Both unpaved roads and construction sites could cause elevated rates of fine sediment in the river, particularly on a localized scale of tens to hundreds of meters.

Mid-channel and diagonal bars were also observed in the Fraser River drainage and are evidence of its highly managed status. These depositional bars form when powerful, rapid flows recede and leave behind sediment deposits that cannot be moved by subsequent, lower flows; additional high flow events are required to move these features. These bars were likely created during the last significant flow event on the river. Almost all of the mid-channel and diagonal bars observed on the Fraser River did not show signs of recent formation and are likely not a result of recent flows.

Embeddedness values were in general comparable between sites on the Fraser River with the exception of Site FR-25.1 and Site FR-15. Site FR-25.1 is a "transport reach" that receives fine sediment directly from the valley walls, because it is a confined reach with a very limited floodplain. However, historic and actively used/maintained roads in close vicinity to this site have also probably contributed a disproportionate amount of fine sediment to this reach. Site FR-15 had the second highest average percent embeddedness observed in 2019, noticeably greater than values observed at all sites other than Site FR-25.1. The relatively high amount of embeddedness at Site FR-15 is likely attributable to a widening of the river downstream of the town of Fraser, just upstream of Site FR-15, that results in a decrease in water velocity that inhibits the transport of smaller substrate material downstream. There was an observed decrease in the embeddedness and substrate <2 mm at Site FR-14, the next site downstream from Site FR-15, and an increase in the percentage of small gravel at Site FR-14. This is an indication that the stretch of river between these two sites is likely enabling the transport of smaller substrate material, and likely has a greater average water velocity than the portion of the river upstream of Site FR-15. The section of river between Site FR-15 and Site FR-14 was the focus of restoration efforts, and the narrowing of the river coupled with an increase in stream velocity has allowed this section of river to transport sediment more successfully than the other sections of the Fraser River below Site FR-25.1.

5.2 Riffle Stability Index

The mobile percentile of particles in a riffle, or RSI, is a useful estimate of the degree of increased sediment supply to riffles in mountain streams (Kappesser 2002). A stable stream reach in dynamic equilibrium has similar sediment size and sediment transport rates at the beginning of a reach compared to the end of a reach, so that there is no net gain or loss of sediment (Kappesser 2002).

In the Kappesser 2002 study in north Idaho, reference streams had a median RSI value of 58 and managed watersheds had a median RSI value of 80. The median RSI value for the sites on the Colorado and Fraser drainages was 78. A higher RSI value shows that a higher proportion of the material in a riffle is smaller than the larger materials on depositional features. This indicates that a riffle is storing a higher proportion of fine materials such as sand. The RSI values from the 2019 sampling sites suggest that stream flows in these drainages have a limited capacity to flush sand and gravel from riffles, which is typical of managed streams. The RSI decreased noticeably from a relatively high value at Site FR-15 to the lowest value observed in the CEA at Site FR-14. This decrease is likely attributable to the increased velocity in the restored reach between these two sites transporting substrate material more readily than in the remainder of the CEA. Riffles with a lower RSI value (i.e., those with a lower proportion of fine material) provide more clean substrate with interstitial spaces, or small spaces between clean substrate particles. These interstitial spaces provide high-quality habitat for macroinvertebrates, some species of juvenile fishes, and benthic, or bottom-dwelling, fishes.

Compaction of the substrate, or the packing of embedded substrate such that it is difficult to remove from the streambed was common in the Fraser River and in Ranch Creek, but not in the Colorado River. Compaction occurs when interstitial spaces become filled with too much fine substrate, which is transported as suspended load in the water column, as opposed to an unconsolidated mix of fines and gravels that move along the streambed (Babbitt and Bidelspach, personal communication, 10/29/2019). The gravels that move as bedload tend to become trapped behind diversions in highly managed streams systems such as the Fraser and Colorado rivers. Substrate compaction negatively affects aquatic organisms by clogging interstitial spaces, as discussed above, and it limits spawning habitat by preventing fish from moving substrate to make nests or redds.

5.3 Algae Presence, Percent Cover, and Thickness

Diatoms were present at all sites unless the substrate was occluded by green algae. Didymo was the reason for thick diatom cover at all sites except CR 1.7, FR-14, and FR-15 and was most common in the CEA between Windy Gap and the mouth of the Williams Fork. This species tends to create blooms in stable, low velocity flow regimes (Kirkwood et al. 2007; Miller at al. 2009), and it is possible that flow variation outside of this reach is sufficient to discourage its proliferation. Although Didymo was present at most sites, it did not occur at nuisance levels; it is possible that relatively high flows in 2019 flushed much of the Didymo from the CEA.

Green filamentous algae coverage was only extensive upstream of Hot Sulphur Springs at Site CR-22.9 and in Kremmling at Site CR-1.7 on the Colorado River. The abundance of filamentous algae at Site CR-22.9 is likely partially due to excessive nutrient inputs from agricultural run-off. This site is also relatively wide and low-sloped, creating shallow and low-velocity conditions preferable to filamentous algae. At Site CR-1.7, nutrients for algae production would be available due to the presence of extensive agricultural fields upstream of the site. The filamentous algae at Site CR-1.7 persists in the two short riffles that have a relatively high gradient compared to the remainder of the site. These riffles are the only locations at the site with hard substrate that algae can colonize. It was also apparent in 2019 that flow conditions had been low for an extended period and were insufficient to scour away algae growth at these two sites. However, the high spring flows in 2019 could have flushed much of the green algae from the system, with the exception of Sites CR-22.9 and CR-1.7.

On the Fraser River, green filamentous algae were only present in relatively high concentrations at Site FR-14 and site FR-15. A large percentage of the river extending upstream from Site FR-15 all the way to Site FR-1.9, just upstream of the town of Fraser, runs adjacent to agricultural fields. The addition of run-off from these agricultural areas likely provide ample nutrients to allow for robust algae growth. Additionally, the lack of natural scouring flows in the Fraser River allow the algae to persist.

6. Conclusion

The sediment conditions in the CEA in the Colorado and Fraser River drainages are typical of managed systems, and a combination of natural and man-made features influence the river's sediment dynamics. The 2019 annual daily flows observed in Grand County, CO during spring run-off and during the remainder of the year in the Colorado River, Fraser River, and Ranch Creek were greater than in 2018, and comparable to observed values in 2017 (Appendix B). These flows probably flushed a large amount of accumulated fine sediment and Didymo from the CEA. On a more local scale, ditches/dams and beaver ponds trap gravels, and unpaved roads, unregulated tributaries, and erodible hillslopes provide sources of sand and gravel. Although the proportion of sand and silt at all sites except Site CR-1.7 was typical for rivers in this region, gravel was limited at most sampling sites. Embeddedness was over 35% at all sites, and the sediment was compacted at most of the sampling locations. Didymo was present at several sites, and green filamentous algae blooms were present at a small number of sites, but nuisance blooms were generally absent in 2019. The sediment and algae conditions in the CEA have some implications for aquatic habitat quality, as discussed briefly below.

A low proportion of gravels and embeddedness of cobbles limit habitat for macroinvertebrates and small fishes (Waters 1995). Furthermore, the compaction of the substrate also limits spawning habitat, as trout cannot move the particles in the substrate to create redds. Dense blooms of Didymo have the potential to affect macroinvertebrates (Kilroy et al. 2009) and small benthic fish by limiting their habitat quality and availability. A limited number of studies indicate that the effects of Didymo on macroinvertebrate communities is variable (Spaulding and Elwell 2007), but reduction of sensitive taxa like mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) have been documented in some studies (Kilroy et al. 2009). Historic flows in the CEA were substantially greater in magnitude and duration during spring run-off than they are in modern times, multiple instream structures disrupt sediment transport, and human land use has altered the nutrient dynamics of the Colorado and Fraser rivers. Aquatic habitat conditions are somewhat limited within the CEA. However, this is unsurprising, given that the Colorado and the Fraser are both working rivers.

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Appendix A 2019 Sediment and Algae Data

Site: CR-1.7
Date: 9/27/2019
Notes: Transects 1 and 4 were in riffles, the only 2 riffles present in site reach. Transects 2 and 3 likely represent the rest of the reach (80%). Remainder of transects were non-wadeable.

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1 (riffle)	12	1	7	7	10	3		
2	33	5		2				
3	28	8	4					
4 (riffle)	7	2	3	8	18	2		
5								
6								
7								
8								
9								
10								
total	80	16	14	17	28	5	0	0
% of total	50	10	8.8	10.6	17.5	3.1	0	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition					12	3		
% of total	0	0	0	0	80	20	0	0
200 Riffle Count	14	14	33	38	76	15	9	0
% of total	7	7	16.6	19.1	38.2	7.5	4.5	0
cumulative percent	7	14	30.6	49.7	87.9	95.4	99.9	99.9

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	20	30	50	30	30	32.0
2	100	100	100	100	100	100.0
3	100	100	100	80	50	86.0
4	20	20	60	50	70	44.0
5						
6						
7						
8						
9						
10						
					Total Avg.	**65.5**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	12	x	x	3	0	x		4
2	100		x	5	0			
3	100		x	5	0			
4	72	x	x	3	0	x		3
5								
6								
7								
8								
9								
10								
average/count	71	2	4	4	0	2	0	3.5

Transect	75% Fil. Cover	75% Diatom Presence	75% Filamentous Presence	75% Diatom Thickness (categorical)
1	70	x	x	4
2	0			
3	100		x	5
4	28	x	x	3
5				
6				
7				
8				
9				
10				
average/count	49.5	2	3	4

Total avg. Fil. Cover	40.2
Total avg. Diatom Presence	50.0
Total avg. Fil. Presence	58.3
Mean Diatom Thickness	3.9

Site: CR-7.4
Date: 9/27/2019
Notes:

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	2	3	17	15	3			
2	8	3	12	8	9			
3	5		19	11	5			
4	5	3	24	7	1			
5	5	1	16	18				
6	1	2	16	20	2			
7	12	3	16	8	1			
8	26	3	3	8				
9	19		4	10	7			
10	20	4	9	6	1			
total	103	22	136	111	29	0	0	0
% of total	25.7	5.5	33.9	27.7	7.2	0	0	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition			1	16	3			
% of total	0	0	5	80	15	0	0	0
200 Riffle Count	38	10	73	71	20			
% of total	17.9	4.7	34.4	33.5	9.4	0	0	0
cumulative percent	17.9	22.6	57	90.5	99.9	99.9	99.9	99.9

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	40	40	60	50	50	48.0
2	30	70	50	50	40	48.0
3	50	50	70	50	30	50.0
4	50	60	60	50	40	52.0
5	40	50	50	50	60	50.0
6	30	50	30	30	50	38.0
7	40	40	50	60		47.5
8	100	60	60	60	70	70.0
9	100	60	60	50	40	62.0
10	70	70	100	100	100	88.0
					Total Avg.	**55.5**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	0	x		0.5	16	x	x	1
2	8	x		2	25	x	x	2
3	0	x		1	0	x		1
4	0	x		2	0	x		2
5	0	x		3	0	x		3
6	25	x	x	2	0	x		2
7	0	x		3	4	x	x	2
8	0	x		0.5	0	x		0
9	0	x		0.5	0	x		0.5
10	0			0	0	x		0.5
average/count	3.3	9	1	1.5	4.5	10	3	1.4

Transect	75% Fil. Cover	75% Diatom Presence	75% Filamentous Presence	75% Diatom Thickness (categorical)
1	0	x		2
2	0	x		2
3	0	x		2
4	0	x		2
5	0	x		3
6	0	x		2
7	0	x		0.5
8	0	x		1
9	0	x		1
10	0			0
average/count	0	9	0	1.6

Total avg. Fil. Cover	2.6
Total avg. Diatom Presence	93.3
Total avg. Fil. Presence	13.3
Mean Diatom Thickness	1.47

Site: CR-9.1
Date: 9/27/2019
Notes:

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	5		9	11	16			
2	12	1	9	10	7	1		
3	4	1	5	11	18	1		
4	1		5	9	21	4		
5		1	7	9	21	2		
6	9	2	6	8	15			
7	7		7	10	16			
8	3	2	6	16	13			
9			5	12	21	2		
10	7		12	13	7	1		
total	48	7	71	109	155	11	0	0
% of total	12	1.7	17.7	27.2	38.7	2.7	0	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				1	24	5		
% of total	0	0	0	3.3	80	16.7	0	0
200 Riffle Count	2	1	29	82	88			
% of total	1	0.5	14.4	40.6	43.6	0	0	0
cumulative percent	1	1.5	15.9	56.5	100.1	100.1	100.1	100.1

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	40	60	60	30	40	46.0
2	50	70	40	40	15	43.0
3	30	50	50	40	30	40.0
4	30	60	30	40	40	40.0
5	10	50	60	40	40	40.0
6	60	50	30	30	20	38.0
7	20	30	60	50	50	42.0
8	30	50	60	40	40	44.0
9	10	40	50	40	50	38.0
10	50	60	60	50	40	52.0
					Total Avg.	**42.3**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	4	x	x	3	8	x	x	3
2	100		x		0	x		0.5
3	4	x	x	2	4	x	x	2
4	0	x		2	4	x	x	1
5	0	x		3	0	x		3
6	0	x		0.5	0	x		0.5
7	0	x		1	4	x	x	1
8	0	x		0.5	0	x		0.5
9	0	x		1	0	x		1
10	0	x		2	0	x		2
average/count	10.8	9	3	1.7	2	10	4	1.5

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	8	x	x	3
2	0	x		0.5
3	12	x	x	2
4	0	x		0.5
5	0	x		3
6	0	x		1
7	0	x		0.5
8	0	x		1
9	0	x		1
10	8	x		2
average/count	2.8	10	2	1.5

Total avg. Fil. Cover	5.2
Total avg. Diatom Presence	96.7
Total avg. Fil. Presence	30.0
Mean Diatom Thickness	1.52

Site: CR-16.7
Date: 10/1/2019
Notes:

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	4	2	13	12	6		3	
2		3	11	17	9			
3	3	2	21	9	5			
4	12		11	11	6			
5	13		2	6	11	2	6	
6	2		4	12	17	2		3
7	7		8	10	10	2		3
8		3	7	10	13	7		
9	5	5	4	13	10	3		
10	3		13	7	17			
total	49	15	94	107	104	16	9	6
% of total	12.3	3.8	23.5	26.8	26	4	2.3	1.5

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				22	8			
% of total	0	0	0	73.3	26.7	0	0	0
200 Riffle Count	10	12	76	59	41	2		
% of total	5	6	38	29.5	20.5	1	0	0
cumulative percent	5	11	49	78.5	99	100	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	80	70	50	60	70	66.0
2	50	30	60	50	50	48.0
3	40	50	30	40	50	42.0
4	60	40	60	60	40	52.0
5	45	40	50	40	70	49.0
6	30	35	40	50	40	39.0
7	100	100	60	40	30	66.0
8	50	60	30	30	60	46.0
9	60	40	40	50	30	44.0
10	50	20	30	50	40	38.0
					Total Avg.	**49.0**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	0	x		2	68	x	x	3
2	7	x	x	3	6	x	x	3
3	0	x		4	0	x		3
4	15	x	x	3	3	x	x	2
5	0	x		1	0	x		2
6	0	x		3	0	x		3
7	0	x		2	0	x		3
8	0	x		3	0	x		3
9	10	x	x	2	0	x		3
10	8	x	x	3	0	x		3
average/count	4	10	4	2.6	7.7	10	10	2.8

Algae Data				
Transect	75% Fil. Cover	75% Diatom Presence	75% Filamentous Presence	75% Diatom Thickness (categorical)
1	75	x	x	3
2	6	x	x	4
3	0	x		2
4	25	x	x	3
5	0			0
6	2	x	x	3
7	5	x	x	3
8	7	x	x	4
9	8	x		1
10	0	x		3
average/count	12.8	9	6	2.6

*Transect located on macrophyte bed.

Total avg. Fil. Cover	8.2
Total avg. Diatom Presence	96.7
Total avg. Fil. Presence	66.7
Mean Diatom Thickness	2.67

Site: CR-22.9
Date: 10/1/2019
Notes: Bar Lazy J, upstream from bridge

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	1	3	11	8	14	3		
2		1	5	9	21	8		
3	2		8	15	26			
4		2	7	5	21	5		
5	6		5	9	18	2		
6		1	9	12	16	2		
7	2	2	5	7	18	3	3	
8	3	1	7	7	18	4		
9	2	1		8	22	7		
10	1		6	6	17	10		
total	17	11	63	86	191	44	3	0
% of total	4.1	2.7	15.2	20.7	46	10.6	0.7	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition					5	15		
% of total	0	0	0	0	25	75	0	0
200 Riffle Count		3	36	46	116	22		
% of total	0	1.3	16.1	20.6	52	9.9	0	0
cumulative percent	0	1.3	17.4	38	90	99.9	99.9	99.9

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	10	50	40	40	40	36.0
2	50	50	50	60	40	50.0
3	50	60	60	60	60	58.0
4	40	50	60	30	30	42.0
5	50	60	40	20	50	44.0
6	70	60	40	40	40	50.0
7	60	50	30	50	30	44.0
8	40	30	30	30	25	31.0
9	60	40	30	30	30	38.0
10	50	60	50	20	40	44.0
					Total Avg.	**43.7**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	80	x	x	0.5	76	x	x	3
2	86	x	x	3	84	x	x	3
3	92	x	x	0.5	54	x	x	0.5
4	100		x	0	100		x	0
5	100	x	x	1	100	x	x	1
6	100	x	x	1	100	x	x	1
7	4	x	x	1	94	x	x	1
8	76	x	x	0.5	76	x	x	2
9	74	x	x	2	72	x	x	2
10	80	x	x	0.5	78	x	x	0.5
average/count	79.2	9	10	1	83.4	9	10	1.4

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	90	x	x	3
2	80	x	x	3
3	100		x	0
4	96		x	0
5	100	x	x	1
6	100	x	x	1
7	86	x	x	1
8	70	x	x	3
9	74	x	x	1
10	56	x	x	2
average/count	85.2	8	10	1.5

Total avg. Fil. Cover	82.6
Total avg. Diatom Presence	86.7
Total avg. Fil. Presence	100.0
Mean Diatom Thickness	1.3

Site: CR-28.7
Date: 9/24/2019
Notes: No point bars at site. Used small gravel bar at channel margin.

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1			3	19	15	3		
2	4	4	4	15	13			
3	8	3	6	10	10	3		
4	2		11	15	9	2		
5	1	1	13	11	13	1		
6	2	1	4	7	16	9		
7	2	1	8	6	15	8		
8	2	1	3	9	19	6		
9		1	5	13	15	6		
10	2	2	7	6	20	3		
total	23	14	64	111	145	41	0	0
% of total	5.8	3.5	16.1	27.9	36.4	10.3	0	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				3	7	5		
% of total	0	0	0	20	46.7	33.3	0	0
200 Riffle Count		3	40	54	102	5		
% of total	0	1.5	19.6	26.5	50	2.5	0	0
cumulative percent	0	1.5	21.1	47.6	97.6	100.1	100.1	100.1

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	40	40	40	50	30	40.0
2	40	60	20	20	50	38.0
3	50	50	50	50	30	46.0
4	40	50	40	40	50	44.0
5	60	50	60	30	30	46.0
6	70	60	60	60	50	60.0
7	40	50	50	50	60	50.0
8	70	40	60	60	50	56.0
9	60	40	60	70	50	56.0
10	70	50	50	60	30	52.0
					Total Avg.	**48.8**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	9	x	x	1	0	x		2
2	0	x		2	0	x		2
3	4	x	x	2	0	x		2
4	0	x		3	0	x		3
5	0	x		2	25	x	x	2
6	0	x		1	0	x		2
7	0	x		2	0	x		2
8	0	x		1	0	x		2
9	0	x		1	0	x		2
10	0	x		1	0	x		2
average/count	1.3	10	2	1.6	2.5	10	1	2.1

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	0	x		2
2	0	x		2
3	0	x		2
4	0	x		2
5	4	x	x	1
6	0	x		1
7	0	x		2
8	0	x		2
9	0	x		1
10	0	x		1
average/count	0.4	10	1	1.6

Total avg. Fil. Cover	1.4
Total avg. Diatom Presence	100.0
Total avg. Fil. Presence	13.3
Mean Diatom Thickness	1.77

Site: CR-31
Date: 9/26/2019
Notes:

Transect Substrate Count								
	Fines	Sm. Gravel	Gravel	Sm. Cobble	Cobble	Sm. Boulder	Boulder	Bedrock
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	3	2	8	13	13	1		
2	1	3	8	19	6	3		
3		1	12	18	6	3		
4			7	11	17	5		
5		1	7	11	13	8		
6	4	3	1	12	12	8		
7	2	1	9	11	12	5		
8	1	2	3	13	17	4		
9	3		7	12	13	5		
10	8		13	8	7	4		
total	22	13	75	128	116	46	0	0
% of total	5.5	3.3	18.8	32	29	11.5	0	0

	Fines	Sm. Gravel	Gravel	Sm. Cobble	Cobble	Sm. Boulder	Boulder	Bedrock
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				6	10	8		
% of total	0	0	0	25	41.7	33.3	0	0
200 Riffle Count	3	5	44	58	81	13	1	
% of total	1.5	2.4	21.5	28.3	39.5	6.3	0.5	0
cumulative percent	1.5	3.9	25.4	53.7	93.2	99.5	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	40	50	50	60	40	48.0
2	50	50	50	50	60	52.0
3	60	50	50	50	40	50.0
4	50	60	50	60	40	52.0
5	50	50	50	20	40	42.0
6	30	50	40	50	40	42.0
7	50	20	30	50	40	38.0
8	40	30	50	30	30	36.0
9	40	30	40	40	40	38.0
10	100	30	40	50	30	50.0
					Total Avg.	**44.8**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	4	x	x	0.5	12	x	x	1
2	0	x		4	0	x		0.5
3	8	x	x	1	12	x	x	3
4	0	x		3	0	x		3
5	0	x		1	0	x		1
6	0	x		3	0	x		3
7	0	x		3	0	x		2
8	0	x		0.5	0	x		2
9	0	x		2	0	x		1
10	0	x		1	0	x		1
average/count	1.2	10	2	1.9	2.4	10	2	1.8

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	12	x	x	1
2	16	x	x	3
3	0	x		3
4	0	x		2
5	0	x		3
6	16	x	x	1
7	4	x	x	0.5
8	0	x		2
9	0	x		1
10	0	x		1
average/count	4.8	10	4	1.8

Total avg. Fil. Cover	2.8
Total avg. Diatom Presence	100.0
Total avg. Fil. Presence	26.7
Mean Diatom Thickness	1.8

Site: FR-1.9
Date: 9/25/2019
Notes:

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	3		7	5	15	9		
2	1		11	21	5	2		
3	6	2	2	18	9	3		
4	6	1	2	14	15	2		
5	6	2	11	9	10	2		
6	2	2	10	16	9	1		
7	8	2	10	11	8	1		
8	1	4	17	13	4	1		
9	1	1	10	18	8	2		
10	1	1	11	18	6	3		
total	35	15	91	143	89	26	0	0
% of total	8.8	3.8	22.8	35.8	22.3	6.5	0	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				4	15	10		
% of total	0	0	0	13.8	51.7	34.5	0	0
200 Riffle Count	1	3	42	101	42	11		
% of total	0.5	1.5	21	50.5	21	5.5	0	0
cumulative percent	0.5	2	23	73.5	94.5	100	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	30	15	40	20	10	23.0
2	30	15	50	50		36.3
3	40	50	50			46.7
4	30	50	50	40		42.5
5	55	40	30	30		38.8
6	55	65	50	50		55.0
7	35	90	60	55		60.0
8	30	15	20	40		26.3
9	40	40	35	50		41.3
10	50	35	30	30		36.3
					Total Avg.	**40**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	80	x	x	0.5	8	x	x	0.5
2	4	x		0.5	16	x	x	0.5
3	0	x		0.5	0	x		0.5
4	8	x	x	2	24	x	x	1
5	9	x	x	0.5	2	x	x	0.5
6	0	x		0.5	6	x	x	0.5
7	24	x	x	2	0	x		0.5
8	0	x		0.5	69	x	x	0.5
9	0	x		0.5	16	x	x	2
10	4	x	x	0.5	8	x	x	0.5
average/count	12.9	10	5	0.8	14.9	10	8	0.7

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	0	x		0.5
2	4	x	x	0.5
3	20	x	x	0.5
4	20	x	x	0.5
5	0	x		0.5
6	12	x	x	0.5
7	0	x		0.5
8	8	x	x	0.5
9	0	x		0.5
10	16	x	x	2
average/count	8	10	6	0.7

Total avg. Fil. Cover	11.9
Total avg. Diatom Presence	100.0
Total avg. Fil. Presence	63.3
Mean Diatom Thickness	0.72

Site: FR-14
Date: 9/25/2019
Notes: Worked US to DS, so transects are backwards

Transect Substrate Count								
	Fines	Sm. Gravel	Gravel	Sm. Cobble	Cobble	Sm. Boulder	Boulder	Bedrock
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
10	1		15	12	5	9		
9	5	2	6	6	17	3		
8	4	3	7	9	13	3	1	
7		2	8	12	14	4		
6	1	1	6	17	16	4	1	
5	4	2	7	10	16	2		
4	2	1	10	12	12	3		
3	1	7	12	10	8	2		
2	1	1	14	10	12	2		
1	5	2	10	9	13	1		
total	24	21	95	107	126	33	2	0
% of total	5.9	5.1	23.3	26.2	30.9	8.1	0.5	0

	Fines	Sm. Gravel	Gravel	Sm. Cobble	Cobble	Sm. Boulder	Boulder	Bedrock
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition					16	4		
% of total	0	0	0	0	80	20	0	0
200 Riffle Count	1	3	35	97	67	1		
% of total	0.5	1.5	17.2	47.5	32.8	0.5	0	0
cumulative percent	0.5	2	19.2	66.7	99.5	100	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
10	30	30	40	20	20	28.0
9	55	40	40	40	50	45.0
8	40	30	40	50	20	36.0
7	15	40	30	20	20	25.0
6	20	20	65	40	20	33.0
5	40	40	60	60	60	52.0
4	40	40	50	40	50	44.0
3	70	75	40	50	30	53.0
2	60	50	30	40	40	44.0
1	40	45	50	40	50	45.0
					Total Avg.	**40.5**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
10	8	x	x	1	0	x		0.5
9	0	x		3	8	x	x	0.5
8	40	x	x	0.5	12	x	x	0.5
7	40	x		0.5	50	x	x	0.5
6	52	x	x	0.5	60	x	x	0.5
5	56	x	x	0.5	52	x	x	0.5
4	6	x	x	0.5	24	x	x	0.5
3	0	x		3	28	x	x	0.5
2	44	x	x	0.5	64	x	x	0.5
1	24	x	x	2	11	x	x	0.5
average/count	27	10	7	1.2	30.9	10	9	0.5

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
10	25	x	x	0.5
9	25	x	x	0.5
8	50	x	x	0.5
7	68	x	x	0.5
6	52	x	x	0.5
5	80	x	x	0.5
4	100	x	x	0.5
3	56	x	x	0.5
2	48	x	x	0.5
1	88	x	x	0.5
average/count	59.2	10	10	0.5

Total avg. Fil. Cover	39
Total avg. Diatom Presence	100.0
Total avg. Fil. Presence	86.7
Mean Diatom Thickness	0.73

Site: FR-15
Date: 9/26/2019
Notes: Started above split channel

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	4		9	10	3	8	6	
2	3	2	7	10	11	11		
3	1	1	5	15	12	6		
4	2	1	5	3	21	8		
5	6	2	9	12	7	4		
6			5	9	16	7	2	
7	4	1	19	15	1			
8	8	2	12	7	6	3	2	
9	2	1	12	12	8	5		
10	24		3	5	5	3		
total	54	10	86	98	90	55	10	0
% of total	13.4	2.5	21.3	24.3	22.3	13.6	2.5	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				12	3			
% of total	0	0	0	80	20	0	0	0
200 Riffle Count	4	1	62	85	36	10	2	
% of total	2	0.5	31	42.5	18	5	1	0
cumulative percent	2	2.5	33.5	76	94	99	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	30	40	40	60	30	40.0
2	30	50	30	50	30	38.0
3	40	60	30	30	60	44.0
4	25	30	50	80	40	45.0
5	40	60	50	60	50	52.0
6	50	50	30	60	40	46.0
7	40	30	60	50	70	50.0
8	20	50	50	70	70	52.0
9	50	40	50	40	40	44.0
10	30	30	80	80	70	58.0
					Total Avg.	**46.9**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	52	x	x	2	40	x	x	2
2	56	x	x	2	8	x	x	2
3	68	x	x	2	58	x	x	2
4	8	x	x	2	32	x	x	2
5	36	x	x	2	0	x		3
6	24	x	x	1	48	x	x	1
7	0	x		3	0	x		3
8	84	x	x	4	96	x	x	4
9	16	x	x	5	56	x	x	3
10	0			0	0			0
average/count	34.4	9	8	2.3	33.8	9	7	2.2

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	56	x	x	2
2	16	x	x	2
3	46	x	x	2
4	0	x		3
5	8	x	x	4
6	8	x	x	1
7	0	x		4
8	96	x	x	4
9	16	x	x	2
10	0			0
average/count	24.6	9	7	2.4

Total avg. Fil. Cover	30.9
Total avg. Diatom Presence	90.0
Total avg. Fil. Presence	73.3
Mean Diatom Thickness	2.3

Site: FR-20
Date: 9/25/2019
Notes:

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	7	2	11	11	5	3	1	
2	7		8	13	4	6	2	
3	7	2	8	11	6	5	1	
4	17		2	10	9		2	
5	3	4	6	8	10	5	4	
6	4	1	10	8	9	5	3	
7	2	4	10	16	3	5		
8		1	5	10	10	8	6	
9	8	2	7	17	5	1		
10	7		5	11	8	9		
total	62	16	72	115	69	47	19	0
% of total	15.5	4	18	28.8	17.3	11.8	4.8	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				9	5	1		
% of total	0	0	0	60	33.3	6.7	0	0
200 Riffle Count	12	16	33	85	27	14	13	
% of total	6	8	16.5	42.5	13.5	7	6.5	0
cumulative percent	6	14	30.5	73	86.5	93.5	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	35	45	70	40	30	44.0
2	50	60	40	50	65	53.0
3	40	15	50	40	40	37.0
4	50	60	50	70	50	56.0
5	25	30	40	20	30	29.0
6	55	40	5	50	40	38.0
7	25	50	20	50	30	35.0
8	30	40	20	20	30	28.0
9	50	10	10	15	20	21.0
10	40	35	20	30	40	33.0
					Total Avg.	**37.4**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	0	x		0.5	0	x		0.5
2	0	x		0.5	0	x		0.5
3	0	x		0.5	0	x		0.5
4	0	x		0.5	0	x		0.5
5	0	x		0.5	0	x		0.5
6	0	x		0.5	0	x		0.5
7	0	x		0.5	0	x		0.5
8	0	x		0.5	0	x		0.5
9	0	x		0.5	0	x		0.5
10	0	x		0.5	0	x		0.5
average/count	0	10	0	0.5	0	10	0	0.5

Algae Data				
Transect	75% Fil. Cover	75% Diatom Presence	75% Filamentous Presence	75% Diatom Thickness (categorical)
1	0	x		0.5
2	0	x		0.5
3	0	x		1
4	0	x		0.5
5	0	x		0.5
6	0	x		0.5
7	0	x		0.5
8	0	x		0.5
9	0	x		0.5
10	0	x		0.5
average/count	0	10	0	0.6

Total avg. Fil. Cover	0
Total avg. Diatom Presence	100.0
Total avg. Fil. Presence	0.0
Mean Diatom Thickness	0.52

Site: FR-23.2
Date: 9/25/2019
Notes:

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1			20	17	3	1		
2			8	14	16	2		
3	8	4	13	5	8	2		
4	4		8	11	16		1	
5	2	2	11	8	18			
6	2	1	2	14	18	2	1	
7		1	10	15	11	2	1	
8	1	1	13	18	6	1		
9	1	1	9	13	13	2	1	
10	1		5	27	5	2	1	
total	19	10	99	142	114	14	5	0
% of total	4.7	2.5	24.6	35.2	28.3	3.5	1.2	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition				8	8			
% of total	0	0	0	50	50	0	0	0
200 Riffle Count	2	2	44	95	55	1	1	
% of total	1	1	22	47.5	27.5	0.5	0.5	0
cumulative percent	1	2	24	71.5	99	99.5	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	30	30	25	30	40	31.0
2	30	60	20	30	20	32.0
3	50	90	15	20	30	41.0
4	30	20	50	50	70	44.0
5	50	40	50	30	50	44.0
6	50	50	20	30	30	36.0
7	50	40	40	50	30	42.0
8	30	20	30	40	50	34.0
9	50	40	50	60	20	44.0
10	40	50	40	50	50	46.0
					Total Avg.	**39.4**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	0	x		1	0	x		1
2	0	x		0.5	0	x		0.5
3	0	x		1	0	x		1
4	0	x		0.5	0	x		0.5
5	0	x		0.5	0	x		0.5
6	0	x		1	0	x		1
7	12	x	x	0.5	0	x		1
8	0	x		0	0	x		0
9	0	x		0.5	0	x		1
10	0	x		0.5	0	x		0.5
average/count	1.2	10	1	0.6	0	10	0	0.7

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	0	x		1
2	0	x		0.5
3	0	x		1
4	0	x		0.5
5	0	x		0.5
6	0	x		1
7	0	x		0.5
8	0	x		0
9	0	x		1
10	100		x	0
average/count	10	9	1	0.6

Total avg. Fil. Cover	3.7
Total avg. Diatom Presence	96.7
Total avg. Fil. Presence	6.7
Mean Diatom Thickness	0.63

Site: FR-25.1
Date: 9/25/2019
Notes: very high gradient

Transect Substrate Count								
	Fines	Sm. Gravel	Gravel	Sm. Cobble	Cobble	Sm. Boulder	Boulder	Bedrock
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	5	1	1	2	2	8	21	
2	2	1	3	1		4	29	
3	2	1	1	6	3	8	19	
4	14	2	2	5	7	2	8	
5	3	1	2	5	1	3	25	
6	5		5	3	2	3	22	
7		1	4		2	6	28	
8		1	5	4	5	8	17	
9	3	4	3	5	7	5	13	
10			3	2	3	12	20	
total	34	12	29	33	32	59	202	0
% of total	8.5	3	7.2	8.2	8	14.7	50.4	0

	Fines	Sm. Gravel	Gravel	Sm. Cobble	Cobble	Sm. Boulder	Boulder	Bedrock
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition	none, very high gradient							
% of total	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
200 Riffle Count	none, very high gradient							
% of total	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	70	30	50	60	60	54.0
2	20	50	80	50	60	52.0
3	70	50	5	30	25	36.0
4	80	50	50	50	30	52.0
5	50	40	20	70	50	46.0
6	50	60	30	40	50	46.0
7	80	70	60	60	50	64.0
8	10	50	60	60	65	49.0
9	65	60	70	60	70	65.0
10	50	60	70	50	40	54.0
					Total Avg.	**51.8**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	0	x		0.5	0	x		0.5
2	0	x		0.5	0	x		0.5
3	0	x		0.5	0	x		0.5
4	0	x		0.5	0	x		0.5
5	0	x		0.5	0	x		0.5
6	0	x		0.5	0	x		0.5
7	0	x		0.5	0	x		0.5
8	24	x	x	2	0	x		0.5
9	0	x		0.5	8	x	x	1
10	0	x		0.5	0	x		0.5
average/count	2.4	10	1	0.7	0.8	10	1	0.6

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	0	x		0.5
2	0	x		0.5
3	0	x		0.5
4	0	x		0.5
5	0	x		0.5
6	0	x		0.5
7	0	x		0.5
8	0	x		0.5
9	0	x		0.5
10	0	x		0.5
average/count	0	10	0	0.5

Total avg. Fil. Cover	1.1
Total avg. Diatom Presence	100.0
Total avg. Fil. Presence	6.7
Mean Diatom Thickness	0.57

Site: RC-1.1
Date: 9/26/2019
Notes:

Transect Substrate Count								
	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
Transect	**<2mm**	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
1	7		5	9	8	6	5	
2	3	1	14	12	8		2	
3	3	2	10	16	6	3		
4	13	3	10	9	3		2	
5	18	2	2	10	8			
6		1	8	18	13			
7	18	2		9	6	1	4	
8	3	4	9	13	10		1	
9	13	2	18	6	1			
10	6	1	20	6	7			
total	84	18	96	108	70	10	14	0
% of total	21	4.5	24	27	17.5	2.5	3.5	0

	Fines	**Sm. Gravel**	**Gravel**	**Sm. Cobble**	**Cobble**	**Sm. Boulder**	**Boulder**	**Bedrock**
	<2mm	**2-8mm**	**8-64mm**	**64-128mm**	**128-256mm**	**256-512mm**	**>512mm**	**Bedrock**
Point Bar Deposition			2	6	2			
% of total	0	0	20	60	20	0	0	0
200 Riffle Count	14	15	59	70	46			
% of total	6.9	7.4	28.9	34.3	22.5	0	0	0
cumulative percent	6.9	14.3	43.2	77.5	100	100	100	100

Embeddedness						
Transect	**Emb. 1**	**Emb. 2**	**Emb. 3**	**Emb. 4**	**Emb. 5**	Avg.
1	40	30	40	50	30	38.0
2	60	30	60	50	40	48.0
3	40	50	30	40	30	38.0
4	60	50	70	70	60	62.0
5	70	30	50	60	90	60.0
6	40	40	50	30	30	38.0
7	70	50	100	100	80	80.0
8	30	40	20	60	30	36.0
9	70	40	80	60	50	60.0
10	50	70	50	40	60	54.0
					Total Avg.	**51.4**

Algae Data								
Transect	**25% Fil. Cover**	**25% Diatom Presence**	**25% Filamentous Presence**	**25% Diatom Thickness (categorical)**	**50% Fil. Cover**	**50% Diatom Presence**	**50% Filamentous Presence**	**50% Diatom Thickness (categorical)**
1	12	x	x	3	60	x	x	4
2	12	x	x	3	12	x	x	3
3	0	x		0.5	8	x	x	0.5
4	0	x		0.5	0	x		0.5
5	0	x		0.5	0	x		1
6	4	x	x	1	32	x	x	5
7	12		x	0	0			0
8	0	x		0.5	0	x		0.5
9	0	x		0.5	0	x		0.5
10	0	x		0.5	0	x		0.5
average/count	4	9	4	1	11.2	9	4	1.6

Algae Data				
Transect	**75% Fil. Cover**	**75% Diatom Presence**	**75% Filamentous Presence**	**75% Diatom Thickness (categorical)**
1	24	x	x	3
2	0	x	x	0.5
3	16	x	x	0.5
4	12	x	x	0.5
5	12	x	x	0.5
6	4	x	x	0.5
7	0	x		0.5
8	4	x	x	0.5
9	4	x	x	0.5
10	0	x		0.5
average/count	7.6	10	8	0.8

Total avg. Fil. Cover	7.6
Total avg. Diatom Presence	93.3
Total avg. Fil. Presence	53.3
Mean Diatom Thickness	1.1

Appendix B Long-term Flow Data

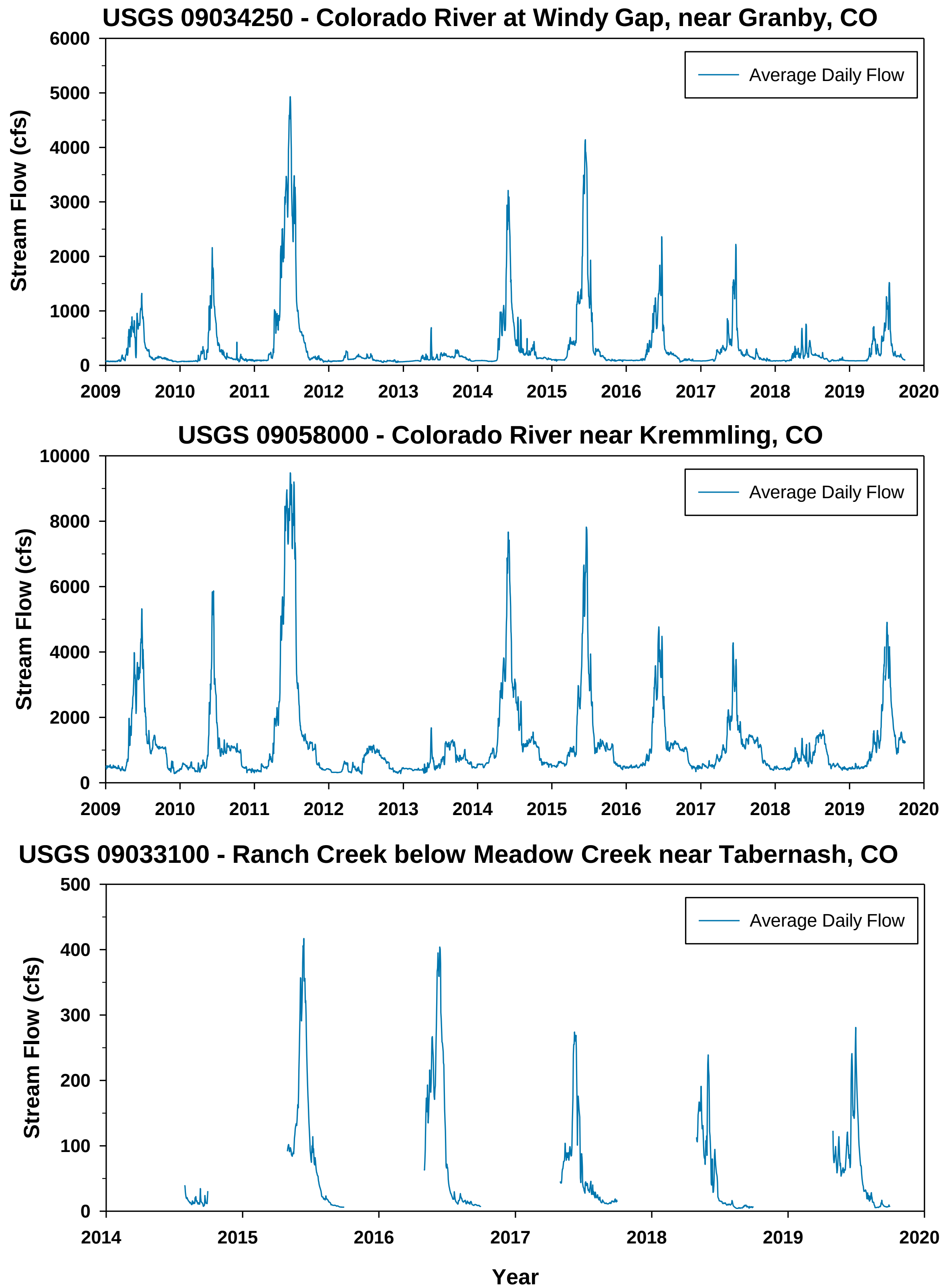

Figure 7-1: **Average daily flow data for USGS stream gages on the Colorado River and Ranch Creek in Grand County, CO.**

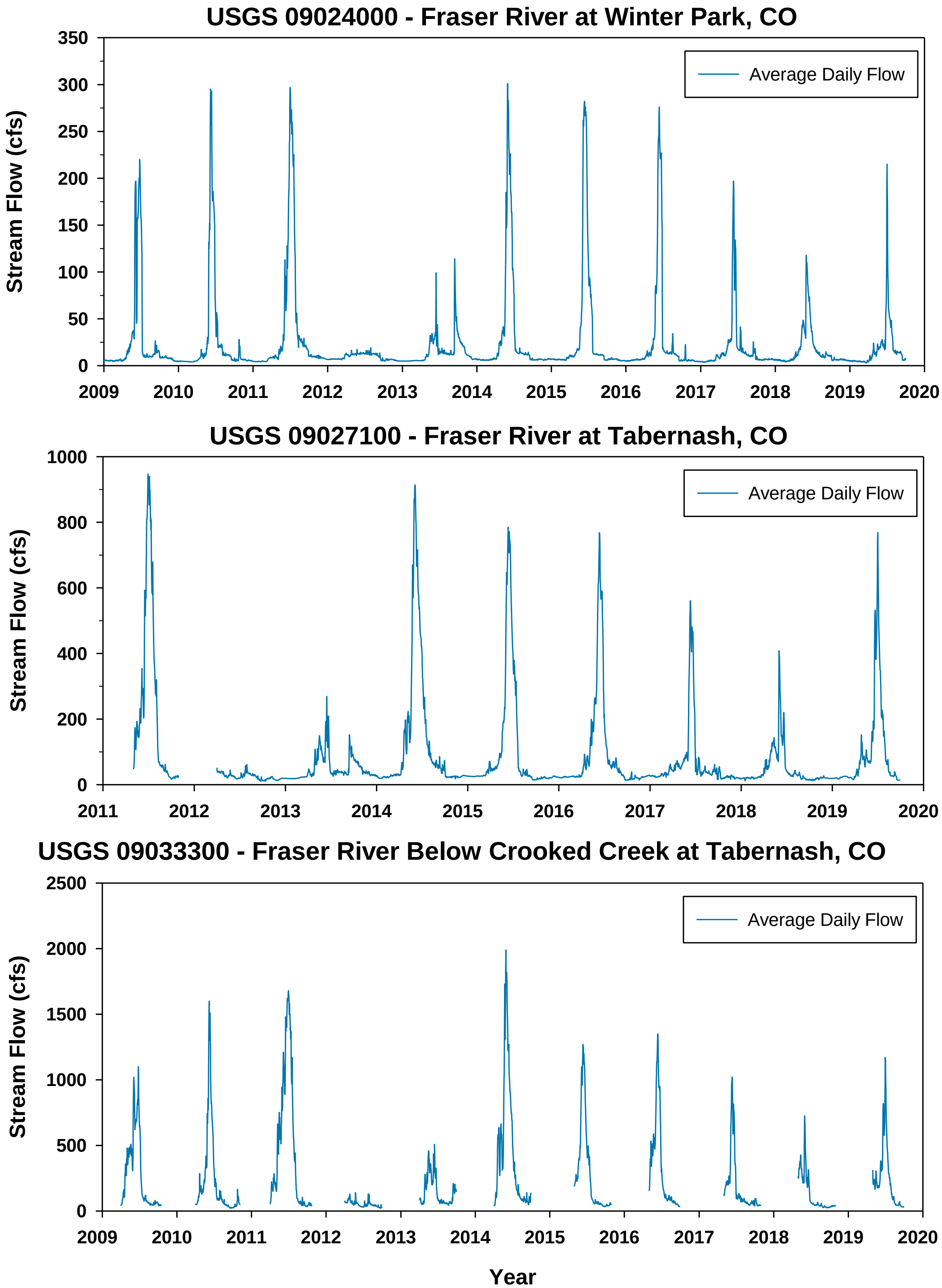

Figure 7-2: Average daily flow data for USGS stream gages on the Fraser River in Grand County, CO.