To:	Grand County, Colorado Northern Colorado Water Conservancy District Denver Water Trout Unlimited Colorado River Water Conservation District
From:	Peggy Bailey, P.E. Tetra Tech Thomas A. Wesche, PhD. HabiTech, Inc. Lora B. Wesche, HabiTech Inc.
Date:	April 9, 2019
Subject:	2018 Substrate Monitoring, Grand County Colorado

INTRODUCTION/PURPOSE

The purpose of this technical memorandum is to report on the 2018 monitoring efforts which include tasks I through III, as described below. The field sampling, data collection and results are undertaken in support of the draft Grand County Stream Management Plan (SMP) (Tetra Tech et al. 2010) and the "Learning By Doing" (LBD) Cooperative Effort.

Task I

Monitor spawning habitats, particularly the content of finer sediments, at three sites located on the Colorado River. These sites are shown on **Figure 1** and listed in **Table 1**. Perform a pebble count (100 count) and substrate core sampling on the spawning bar and conduct a Riffle Stability Index (RSI) evaluation at each site during the sampling period if spring flows were sufficient to mobilize coarse bed particles and facilitate bar dynamics.

Previous years' spawning habitat monitoring included a site located on the Colorado River at Pump House (CR7 or RM-(9.7)), however, as the LBD cooperative effort area downstream terminus on the Colorado River is the confluence with the Blue River, at the direction of the LBD, this site was removed from the 2018 LBD monitoring effort. Spawning habitat and macroinvertebrate monitoring results for the White Water Feature at Pump House can be found in the annual monitoring report for the White Water Feature (Tetra Tech et al. 2019).

Spawning habitats on the Fraser River, Blue River and Muddy Creek were also not sampled this year. Results from these sites have been relatively consistent from year to year when flows have reached or exceeded recommended flushing flows. Thus, given the relatively high flows anticipated for spring of 2018, additional sampling at these sites was not included in this year's scope of work.

The surface substrate conditions and riffle stability results stemming from Task I can be used to evaluate the draft flushing flow recommendations; assess the condition of spawning gravel environments to promote survival–to-emergence (STE) of larval trout; investigate stream flows that may be needed periodically to maintain riffle habitat quality; and helps evaluate effects of LBD management actions.

Task II

Conduct a 100 count Pebble Count, including embeddedness, at riffles used by or in the vicinity of the LBD macroinvertebrate sample sites on the Fraser River, St. Louis Creek, Ranch Creek

and Colorado River. The macroinvertebrate sampling, listed in **Table 2**, was conducted and is reported by Timberline Aquatics under a separate contract with the LBD.

Task III

Convert the locations of the spawning bar monitoring locations and the SMP reach limits to river miles. This includes the assignment of river miles to the data files for all spawning bar monitoring sites sampled since monitoring began in 2010. The river miles for the spawning bar locations are presented in **Table 3**.

Task IV

Prepare this technical memorandum to describe the methods employed and transmit the results to the LBD Committee.

METHODS

Task I

Field sampling at the three Colorado River spawning bar sites (CR4_RM-22.3; CR5_RM-15.5; CR6_RM-9.6; Table 1 and Figure 1) was conducted on September 6 and 7, 2018 following the procedures described in previous monitoring reports (e.g. TetraTech and HabiTech, 2017). At each site, six bulk core substrate samples were taken to evaluate the composition of the inter-gravel environment using a 15-cm diameter McNeil-Ahnell sampler following procedures described by McNeil and Ahnell (1964) and Kondolph et al. (2008). Each sample was placed in a labeled plastic bucket, covered and transported to Kumar and Associates, Inc. Laboratory in Frisco, Colorado for dry sieve analysis. The sieve series ranged from 75 to 0.150 mm. Also, at each site a GPS location was recorded, photographs were taken, and a pebble count was conducted.

Pebble counts were made at each spawning bar site to describe the composition of the streambed surface and in particular to document the degree of embeddedness by finer sediments for each of the 100 measured particles. Pebble counts were made following the procedure described by Wolman (1954) and Kappesser (2002) with the investigator traversing the spawning bar in an upstream Z-pattern and measuring the intermediate diameter (mm) of 100 equally-spaced particles. This procedure assured spatial coverage of the entire bar and was in accordance with the guidance provided by the Colorado Water Quality Control Commission (CWQCC) in Policy 98-1 (CWQCC 2014) for the sampling of small, targeted stream habitat types such as trout spawning bars specifically identified for this study. A surface particle was recorded as embedded if the particle diameter was more than 50% covered by finer sediments. The 50% criterion was based on the relationship between density of juvenile salmonids and the percent embeddedness of the substrate as reported in Bjornn and Reiser (1991), as well as the embeddedness rating system presented in Bain and Stevenson (1999). In this system, 50% is the lower threshold for the “high” embeddedness classification. The presence of aquatic vegetation at each particle measured was also noted.

The Riffle Stability Index (RSI) (Kappesser 2002) protocol is intended for use only following runoff events of sufficient magnitude and duration to cause scour and deposition of coarse bed material. RSI analyses were not performed in 2018 at the three Colorado River sites because the magnitude and duration of spring runoff flows had not been sufficient to cause substantial bed-material mobilization and point bar deposition. Inspection of several point bars in the vicinity of each spawning bar revealed that no recently deposited coarse particles (e.g. gravel and cobble)

were present. Only fine sediment deposition with encroaching vegetation had occurred on the lower margins of the bars in 2018. These conditions were similar to those encountered in 2012 and 2013 when no RSI analyses could be performed.

Task II

Pebble counts were performed on September 5 and 6, 2018 at the fourteen riffle sites on the Colorado River, Fraser River, Ranch Creek, and St. Louis Creek at the macroinvertebrate sample sites. These sites are described on **Table 2** and their location is provided on Figure 1. Pebble count procedures were the same as those described above under Task 1.

Task III

Tetra Tech was provided with a shape file by LBD, showing the locations of the river miles (RM) previously used by LBD for labeling and identifying the macroinvertebrate sample sites. The shape file was created using Google Earth and drawing an elevation profile to map the distance, or for minor reaches the path function was used to map the river miles. Tetra Tech added the new river miles for the spawning bed habitat sites and reach limits by extending the Google Earth shape file or, where needed, by creating a new shape file using latitude and longitudinal locations and the line work from the SMP GIS data base. In some locations the river miles generated using the SMP data base did not match with the Google Earth river mile extraction. However, none of the deviations where significant and none of these changed the sequential order of the sites. Should additional sites be added in the future, a review of river miles should be undertaken to insure the new locations values provide sufficiently accurate locations and are sequential with the current locations.

A summary of the river miles is provided in **Table 3**. The SMP river reach naming protocol is also retained for use when a given reach is referenced as opposed to a specific location.

RESULTS

2018 streamflow hydrographs for the April through September period are presented in **Figures 2** and **3** for eight gage stations in the Fraser and Colorado River watersheds of Grand County. Comparisons of 2018 with previous monitoring years are included. Annual peak flows for the Fraser River, Ranch Creek and the Colorado River over the monitoring period are compared in **Table 4** with the flushing flow recommendations contained in the SMP (TetraTech et al. 2010). The durations that flows exceeded the flushing flow recommendations are also presented.

Particle size distributions for individual core samples collected at the three Colorado River spawning bar sites in 2018 are presented in **Figures 4, 5 and 6**, while temporal comparisons of these distributions with previous monitoring years are shown in **Figure 7**. 2018 composite median particle size and percent less than 2 mm for core samples is compared among sites in **Figure 8**, while temporal comparisons with previous monitoring years are presented in **Figure 9**. Results of the 2018 spawning bar pebble counts, including embeddedness, are presented in **Table 5**. Spatial and temporal comparisons of embeddedness for the three sites are made in **Table 6** and **Figure 10**.

Summaries of the 2018 pebble count results at the 14 macroinvertebrate sample sites are presented in **Table 7**. Temporal and spatial comparisons of pebble count results are provided for the Fraser River watershed sites in **Table 8** and for the Colorado River sites in **Table 9**.

Location maps and 2018 photographs of the three Colorado River spawning bar sites (Table 1) are presented in **Attachment 1**, while the 14 macroinvertebrate sample sites (Table 2) are presented in **Attachment 2**.

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Table 1. Locations for the three Colorado River spawning bar sites sampled in 2018

SMP Reach	RM	Site Name	Description	Latitude	Longitude	Years
CR4	CR-22.3	CR at Ppark	Colorado River at Pioneer Park	40.072185	-106.111498	2014-18
CR5	CR-15.5	CR Blw WF	Colorado River below Williams Fork	40.062829	-106.186273	2010-18
CR6	CR-9.6	CR Blw KB Ditch	Colorado River below KB Ditch	40.055494	-106.285214	2010-18

Table 2. Locations for the 2018 macroinvertebrate and pebble count sites in the Learning By Doing (LBD) study area sampled September 2018

SMP Reach	River Mile ID	Site Name	Description	Latitude	Longitude	Collected Sample
F2	FR-27.2	FR US JimCk	Fraser River upstream of Jim Creek and Mary Jane Entrance	39.8454	-105.7518	Timberline
F2	FR-23.2	FR abvWPSD	Fraser River upstream of Winter Park Sanitation District	39.8945	-105.7682	Timberline
F4	FR-20	FR Rendezvous	Fraser River at Rendezvous Bridge	39.9341	-105.7896	Timberline
F6	FR-15	FR FrSpProj	Fraser River upstream of Fraser Flats restoration	39.9813	-105.8249	Timberline
F6	FR-14	FR CR83	Fraser River upstream of Tabernash below bridge on CR83	39.9905	-105.8299	Timberline
F-RC2	RC-1.1	RC blwMC	Ranch Creek downstream of Meadow Creek	39.9991	-105.8275	Timberline
F-SLC	STC-0	STC FR	St Louis Creek at Fraser River	39.9518	-105.8147	Timberline
CR3	CR-31	CR WGU	Colorado River upstream of Fraser and Windy Gap	40.1005	- 105.9725	Timberline
CR4	CR-28.7	CR WGD	Colorado River downstream of Windy Gap	40.1083	-106.0036	Timberline
CR4	CR-22.9	CR HSU	Colorado River upstream of Hot Sulfur Springs	40.0803	-106.0986	Timberline
CR4	CR-16.7	CR WFU	Colorado River upstream of Williams Fork	40.0503	-106.1725	Timberline
CR6	CR-9.1	CR KBD	Colorado River at CR39 Bridge at KB Ditch	40.0538	-106.2895	Timberline
CR6	CR-7.4	CR BLW Troublesome	Colorado River downstream of Troublesome Creek	40.0509	-106.3112	Timberline
CR6	CR-1.7	CR US BR	Colorado River upstream of the Blue River	40.0436	-106.3751	Timberline

Table 3. River mile designations, SMP spawning bar locations and reach boundaries

SMP Reach	River Mile ID	Station ID	Description	Latitude	Longitude
FR1_US	FR-28.9		SMP reach boundary	39.82731	-105.76001
F1_DS F2_US	FR-26.3		SMP reach boundary	39.86171	-105.74970
F2	FR-26.2		Fraser River below Denver Water diversion dam	39.862833	-105.74931
F2B	FR-25.9		Downstream of F2, upstream of culvert	39.866972	-105.74958
F2_DS F3_US	FR-23.2		SMP reach boundary	39.89587	-105.769124
F3_DS F4_US	FR-21.2		SMP reach boundary	39.923275	-105.782688
F4-DS F5_US	FR-18.4		SMP reach boundary	39.946189	-105.812169
F5_DS F6_US	FR-17.1		SMP reach boundary	39.960661	-105.814594
F6_DS F7_US	FR-13.2		SMP reach boundary	39.998183	-105.841023
F-RC2_US	RC-10.2		SMP reach boundary	39.999175	-105.828374
F-RC2	RC-0.9	RC Miller	Ranch Creek below Meadow Creek (Miller Property)	39.999722	-105.82958
F-RC2_DS FR7_US	RC-0.0		SMP reach boundary	39.998183	-105.841023
F7_DS F8_US	FR-12.4		SMP reach boundary	40.00842	-105.847715
F8_DS F9_US	FR-7.3		SMP reach boundary	40.064752	-105.879471
F9	FR-5.5	FRGranbyRanch	Fraser River below Granby Ranch below golf course	40.079089	-105.904255
F9_DS F10_US	FR-3.5		SMP reach boundary	40.081472	-105.929433
CR_4 US	CR-31.4		SMP reach boundary	40.100082	-105.973895
CR4[1]	CR-27.7		At Chimney Rock Ranch	40.1006	-106.026767
CR4[3]	CR-22.3		Below Pioneer Park at Hot Sulphur Springs	40.072185	-106.111498
CR4[2]	CR-27.8		At Paul Gilbert Public Access Area	40.101056	-106.025861

Table 3. River mile designations, SMP spawning bar locations and reach boundaries

SMP Reach	River Mile ID	Station ID	Description	Latitude	Longitude
CR4_DS CR5_US	CR-16.3		SMP reach boundary	40.056245	-106.180566
CR5	CR-15.5	CRBlw WF	Colorado River below Williams Fk	40.062829	-106.186273
CR5_DS CR6_US	CR-9.7		SMP reach boundary	40.055591	-106.283928
CR6	CR-9.6	CRBlw KB Ditch	Colorado River below KB Ditch	40.055494	-106.285214
CR6_DS CR7_US	CR-0.20		SMP reach boundary	40.042608	-106.398225
CR7	CR-(9.6)	CR Pumphouse	Colorado River at Pumphouse below campground	39.978197	-106.515681
CR7_DS	CR -(16.0)		SMP reach boundary	39.925019	-106.578889
MC2_US	MC-13.8		SMP reach boundary	40.111025	-106.415562
MC2	MC-9.6		Muddy Creek	40.085233	-106.39885
MC2_DS CR7_US	BR-0/MC-0		SMP reach boundary	40.042608	-106.398225
BR-US	BR-15.3		SMP reach boundary	39.883492	-106.336169
BR-BVR-L	BR-3.3		Blue River, Blue Valley Ranch, lower	40.015837	-106.382918
BR-TR	BR-2.0		Blue River, Trough Road	40.031511	-106.38612
BR_DS CR7_US	BR-3.2		SMP reach boundary	40.042608	-106.398225

Table 4. Comparison of flushing flow recommendations (Q_{FF}) to stream flow records for Grand County monitoring sites, 2010-2018

SMP Reach	River Mile ID		Stream Gage	SMP Recommended Flushing FLow (CFS)	2010		2011		2012		2013		2014		2015		2016		2017		2018	
	From	To			Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days > Q_{FF}	Peak Flow (mean daily cfs)	#Days> Q_{FF} [1]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [1]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [1]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [1]	Peak Flow (mean daily cfs)	#Days> Q_{FF} [1]
F9	FR-7.3	FR-3.5	FR at Granby	400	1767	41	1519	81	157	0	650	16	2256	76	1425	44	1351	54	1028	21	702	14, 7
CR4	CR-31.4	CR-16.3	CR at Windy Gap	600	2160	40	4930	134	245	0	693	3	3210	10,60,4,4	4140	81	2501	60	2238	8, 28	758	3
CR5	CR-16.3	CR-9.7	CR near Parshall	800	3512	40	5718	137	460	0	1088	3	4419	93,4	4539	80	3206	63	2739	10, 5, 30	986	2, 1, 1
CR6	CR-9.7	CR-0.0	CR at KB	850	3596	38	4993	141	573	0	1119	4	4348	80,4,4	4565	77	3080	61	2972	10, 3, 28	1056	3
CR7	CR-0.0	CR-(16.0)	CR at Kremmling	2500	5870	30	9480	96	1160	0	1680	0	7670	79,3	7820	8,54	4770	49	4280	21	1610	0
F-RC2	RC-10.2	RC-0.0	RC blw MC	150											417	30	404	6, 43	274	12,5	239	6

[1] Consecutive days recommended flushing flow occurred.

Table 5. Pebble count summary for the three Colorado River spawning bar study sites, September 2018

SMP Reach	**CR4**	**CR5**	**CR6**
RM	**CR-22.3**	**CR-15.5**	**CR-9.6**
Class Size (mm)	CR at Ppark	CR Blw WF	CR Blw KB Ditch
	Sept 2018	***Sept 2018***	***Sept 2018***
0-2	0	1	0
2-4	0	0	0
4-8	0	0	0
8-16	3	1	2
16-32	17	16	12
32-64	46	31	63
64-128	29	36	19
128-256	6	17	4
256-512			0
512-1024			
1024-2048			
2048-4096			
Sum	101	102	100
% Embedded	9	27	9
%Aquatic veg	40	20	69
Water Temp F	60	50	56
Time	1430	941	1150

Table 6. Percent of embedded pebble count particles at Colorado River spawning bar monitoring sites, 2010-2018

% Embedded													
SMP Reach	**RM**	**Site Name**	**July 2010**	**Aug & Sept 2011**	**June 2012**	**Oct 2012**	**July 2013**	**July & Aug 2014**	**Oct-14**	**Aug & Oct 2015**	**Sept 2016**	**Sept & Oct 2017**	**Sept 2018**
CR4[3]	CR-22.3	Blw WG[1], Paul Gilbert[2],CR at Ppark[3]	30	0	36	78	7	13	30	5	5	0	9
CR5	CR-15.5	CRBlw WF	17	0	37	6	25	28	8	5	13	2.5	27
CR6	CR-9.6	CRBlw KB Ditch	18	1	45	10	10	1	4	5	8	0	9

Table 7. Pebble count summary at macroinvertebrate sites on the Fraser River, Ranch Creek, St Louis and Colorado River, 2018

Fraser River Watershed								Colorado River							
SMP Reach	**F2**	**F2**	**F4**	**F6**	**F6**	**F-StL**	**F-RC2**	**SMP Reach**	**CR3**	**CR4**	**CR4**	**CR4**	**CR6**	**CR6**	**CR6**
RM	**FR-27.2**	**FR-23.2**	**FR-20**	**FR-15**	**FR-14**	**STC-0**	**RC-1.1**	**RM**	**CR-31**	**CR-28.7**	**CR-22.9**	**CR-16.7**	**CR- 9.1**	**CR-7.4**	**CR-1.7**
Site Name	**FR_ab_MJ**	***FR AbvWPSD***	**FR Rendezvous**	**FR FrSpProj**	**FR-CR83**	**St Louis at FR**	**RC blw MC**	**Site Name**	**CR WGU**	**CR WGD**	**CR HSU**	**CR WFU**	**CR-KBD**	**CRbl Troublesome**	**CRabBR**
Class Size (mm)	**2018**	**2018**	**2018**	**2018**	**2018**	**2018**	**2018**	**Class Size (mm)**	**2018**	**2018**	**2018**	**2018**	**2018**	**2018**	**2018**
0-2								0-2							
2-4								2-4							
4-8								4-8							
8-16		1						8-16							
16-32		1		1		1	1	16-32			2	1	2	2	
32-64	30	27	10	12	5	13	31	32-64	1	10	18	10	9	35	10
64-128	60	53	46	55	39	56	56	64-128	56	69	69	58	77	65	62
128-256	10	14	36	32	46	30	10	128-256	42	23	13	31	12	2	23
256-512		4	8	2	10		3	256-512	2			3			8
512-1024								512-1024							
1024-2048								1024-2048							
2048-4096								2048-4096							
Sum	**100**	**100**	**100**	**102**	**100**	**100**	**101**	**Sum**	101	102	102	103	100	104	103
% Embedded	6	11	4	3	1	9	1	% Embedded	1	5	8	5	3	1	1
% Aquatic veg	0	15	6	86	61	2	17	% Aquatic veg	2	42	58	23	82	67	95
H_2O Temp F	44	48	50	50	50	52	50	H_2O Temp F	54	58	60	59	53	50	53
Time	1420	1330	1253	1040	955	1140	920	Time	1520	1548	1430	1155	1108	907	1018
Date	9/5/2018	9/5/2018	9/5/2018	9/5/2018	9/5/2018	9/5/2018	9/5/2018	Date	9/5/2018	9/6/2018	9/6/2018	9/6/2018	9/6/2018	9/6/2018	9/6/2018

Table 8. Pebble count summary at macroinvertebrate sites on the Fraser River, St. Louis Creek and Ranch Creek, 2015, 2016, 2017, and 2018

Fraser River Watershed																					
SMP Reach	**F2**	**F2**				**F4**				**F6**			**F6**				**FR-STC**	**F-RC2**			
RM	**FR-27.2**	**FR-23.2**				**FR-20**				**FR-15**			**FR-14**				**STC-0**	**RC-1.1**			
Site Name	**FR_ab_MJ**	**FR AbvWPSD**				**FR Rendezvous**				**FR FrSpProj**			**FR CR83**				**St Louis at FR**	**RC blw MC**			
Class Size (mm)	**2018**	**2015**	**2016**	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**	**2018**	**2015**	**2016**	**2017**	**2018**
0-2								1		1	4										
2-4																					
4-8																				1	
8-16				1	1					1	1								5	2	
16-32		5	3	7	1	3		3		2	1	1	2	3			1	2	26	4	1
32-64	30	19	30	27	27	18	11	7	10	18	25	12	9	8	15	5	13	37	58	29	31
64-128	60	56	50	48	53	46	71	53	46	46	57	55	57	57	49	39	56	55	10	44	56
128-256	10	15	16	16	14	27	18	35	36	29	13	32	28	33	35	46	30	6	2	17	10
256-512		8	2	2	4	10	1	4	8	3	2	2	5	5	2	10				4	3
512-1024		1											1	0							
1024-2048																					
2048-4096																					
Sum	100	104	101	101	100	104	101	103	100	100	103	102	102	106	101	100	**100**	100	101	101	**101**
%Embedded	6	27	2	8	11	14	1	4	4	20	17	3	6	10	14	1	9	5	8	13	1
% Aquatic Veg	0	38	0	3	15	18	0	0	6	53	12	86	2	0	69	61	2	1	4	10	17

Table 9. Pebble count summary at Colorado River macroinvertebrate sampling sites, 2015-2018

Colorado River																		
SMP Reach	**CR3**		**CR4**				**CR4**				**CR4**		**CR6**				**CR6**	**CR6**
RM	**CR-31**		**CR-28.7**				**CR-22.9**				**CR-16.7**		**CR-9.1**				**CR-7.4**	**CR-1.7**
Site Name	**CR WGU**		**CR WGD**				**CR HSU**				**CR WFU**		**CR KBDitch**				**CR Blw Troublesome**	**CR US BR**
Class Size (mm)	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**	**2018**	**2018**
0-2																		
2-4																		
4-8																		
8-16								2						0				
16-32	2			0			7	16	1	2	1	1		1		2	2	
32-64	8	1	12	8	5	10	40	59	19	18	12	10	14	23	4	9	35	10
64-128	61	56	72	68	71	69	48	19	72	69	59	58	86	71	82	77	65	62
128-256	30	42	20	24	26	23	5	4	9	13	26	31	9	7	16	12	2	23
256-512		2		1	1						2	3						8
512-1024																		
1024-2048																		
2048-4096																		
Sum	101	101	104	101	103	102	100	100	101	102	100	103	109	102	102	100	104	103
% Embedded	2	1	5	3	2	5	7	5	1	8	0	5	0	8	0	3	1	1
% Aquatic Veg	0	2	0	3	7	42	4	0	0	58	0	22	1	0	1	82	70	98

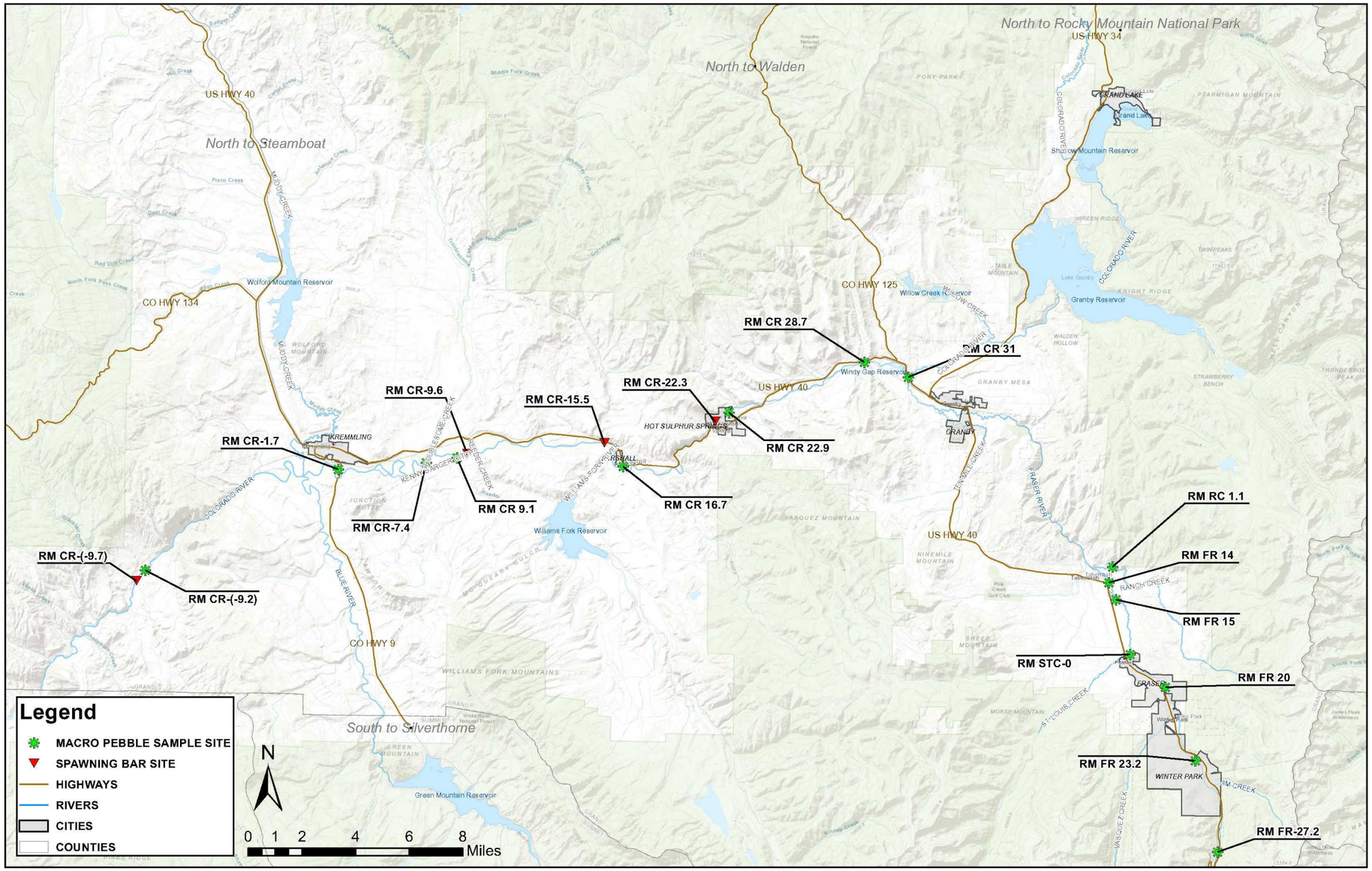
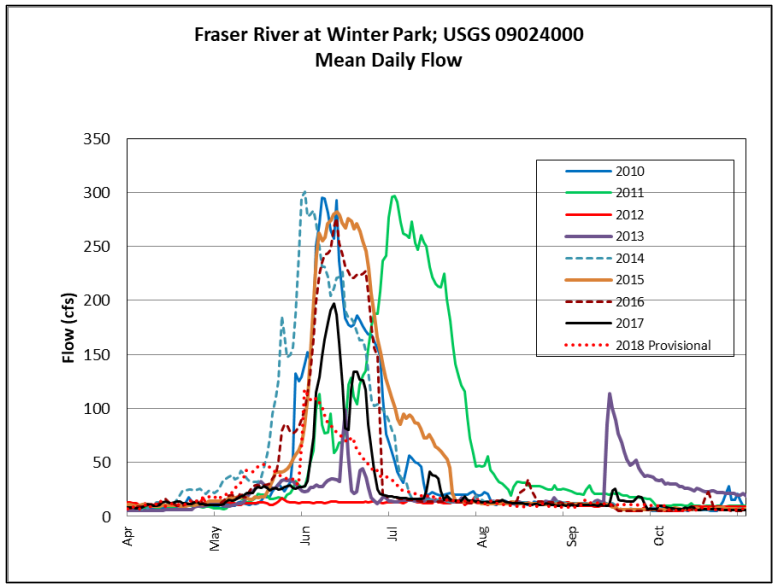
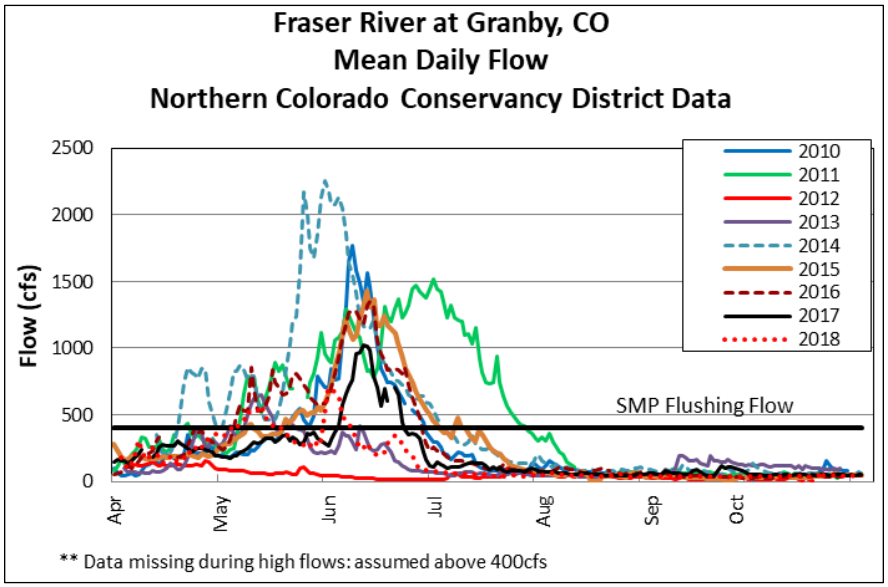


Figure 1. 2018 site map





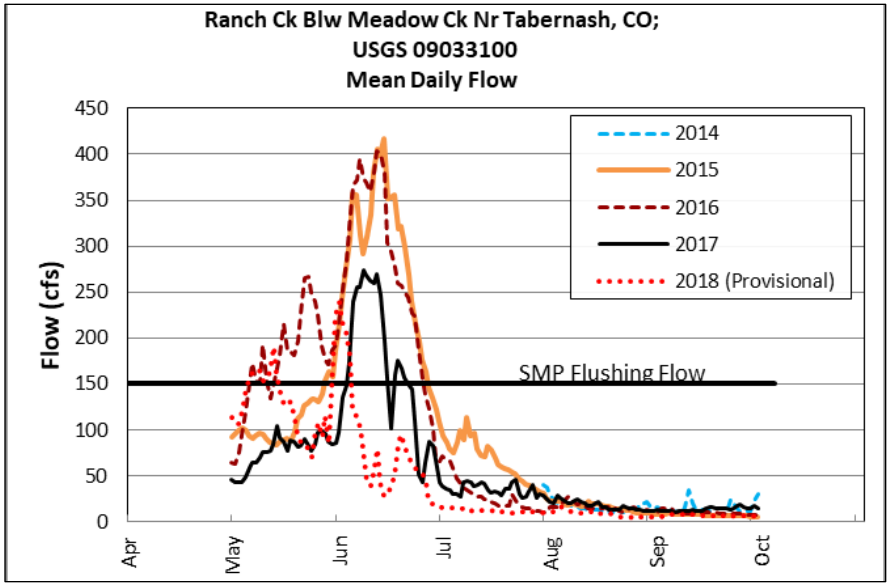
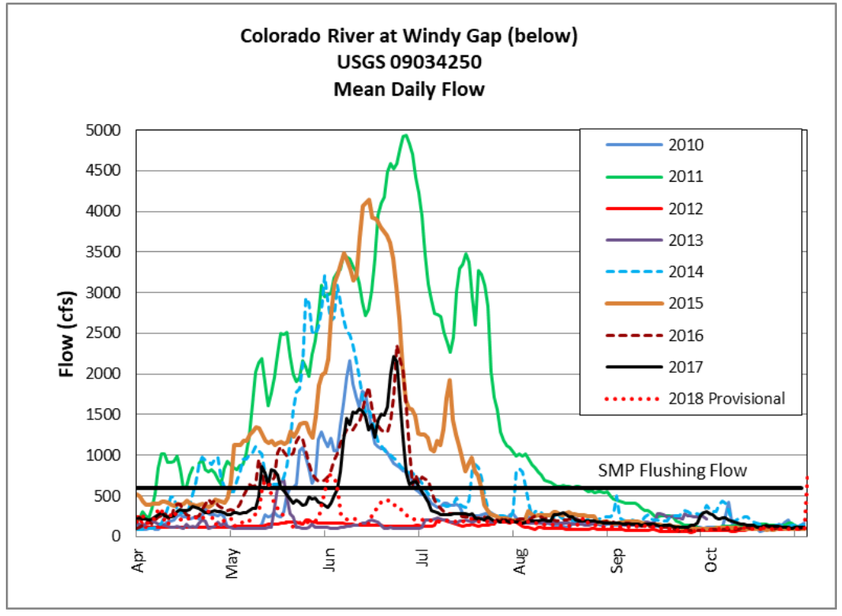
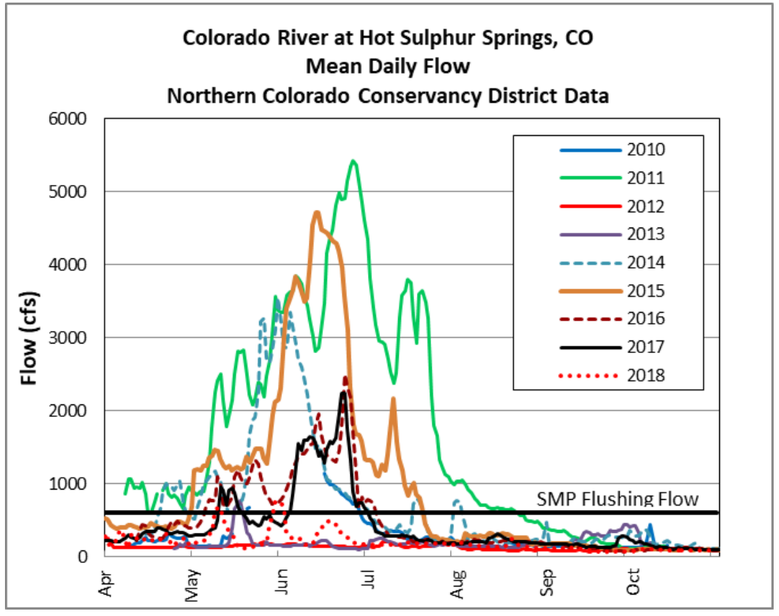
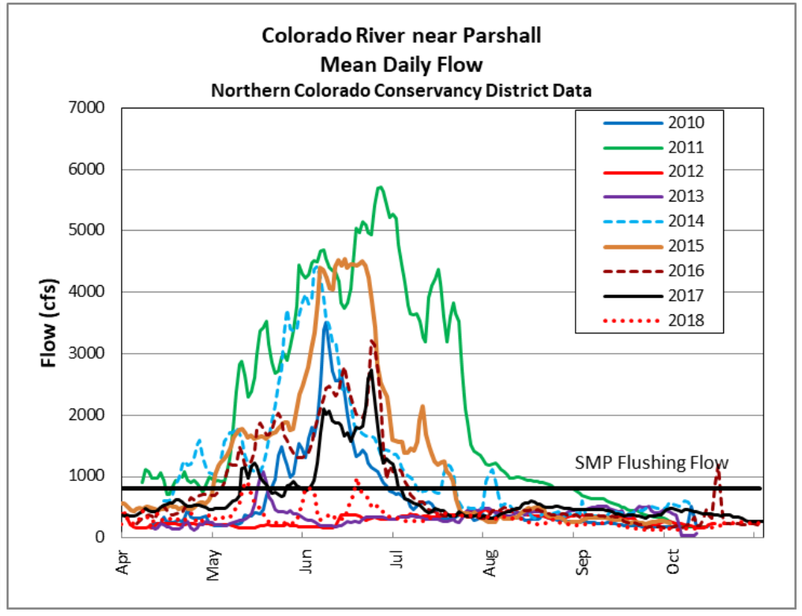
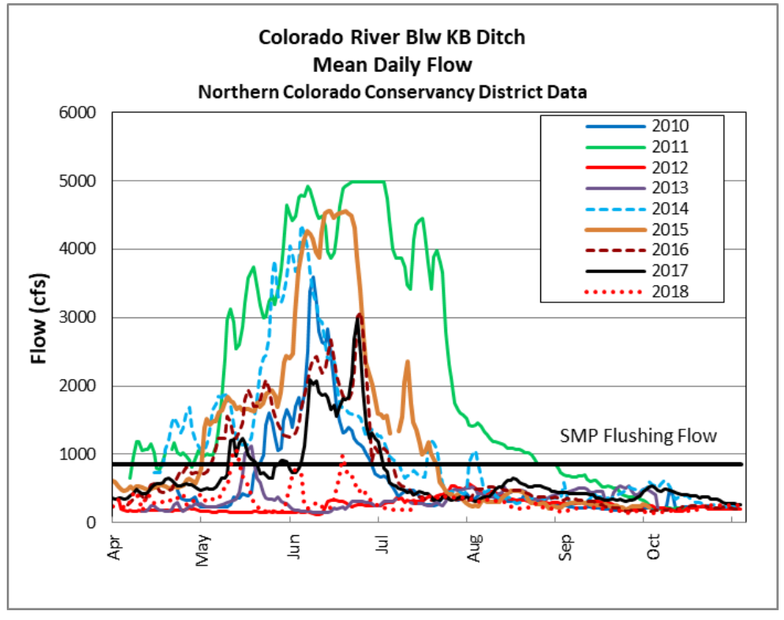


Figure 2. Streamflow hydrographs for Fraser River at Winter Park, Fraser River at Granby, and Ranch Creek blw Meadow Creek.









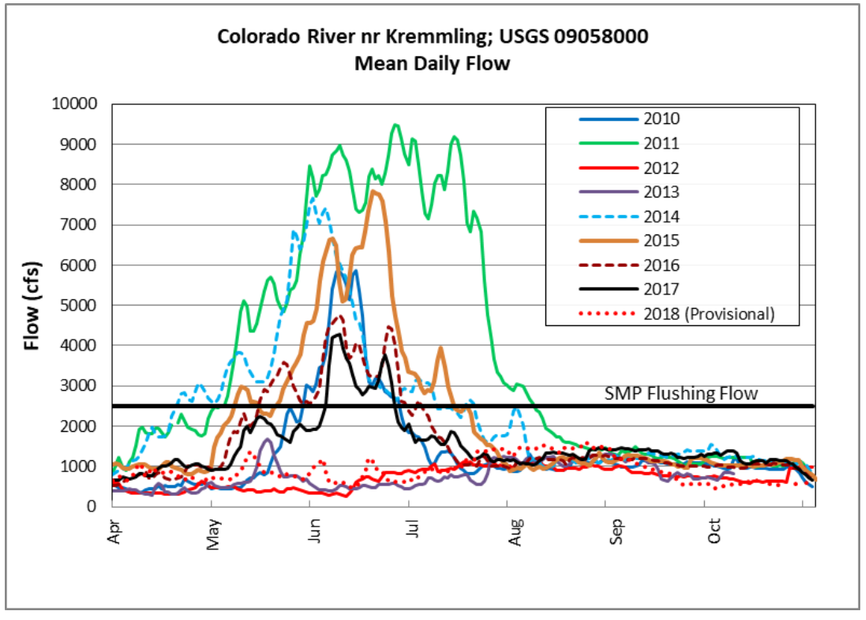
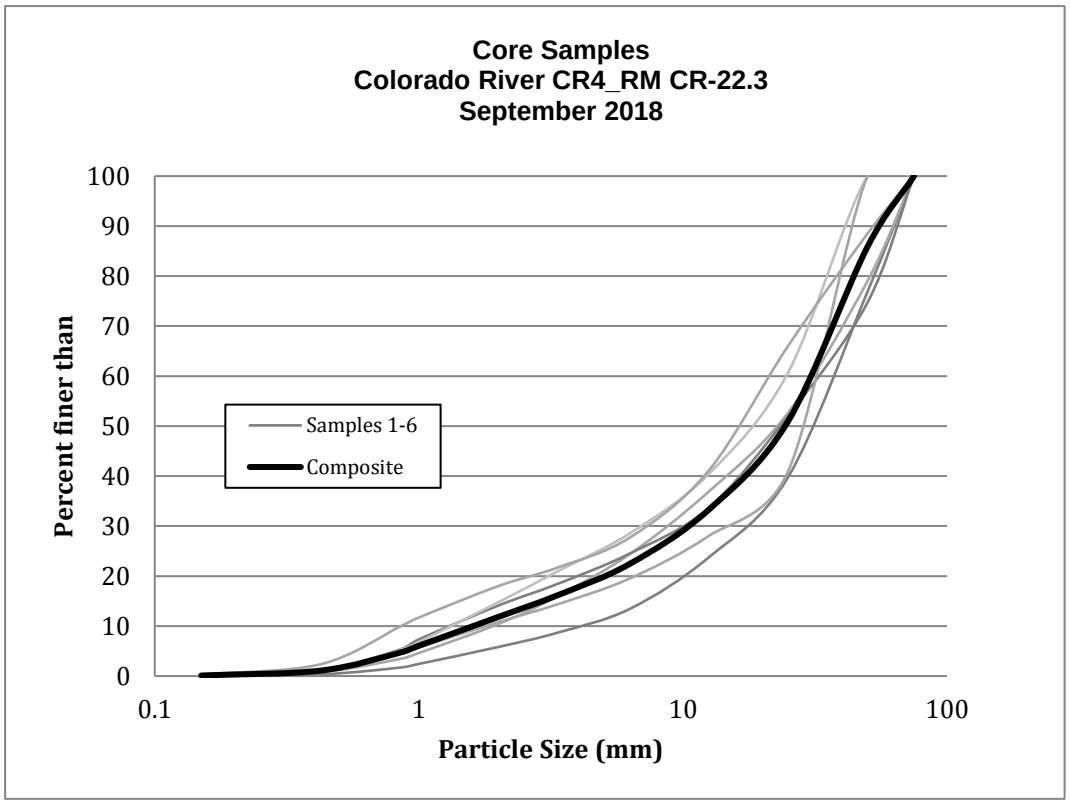
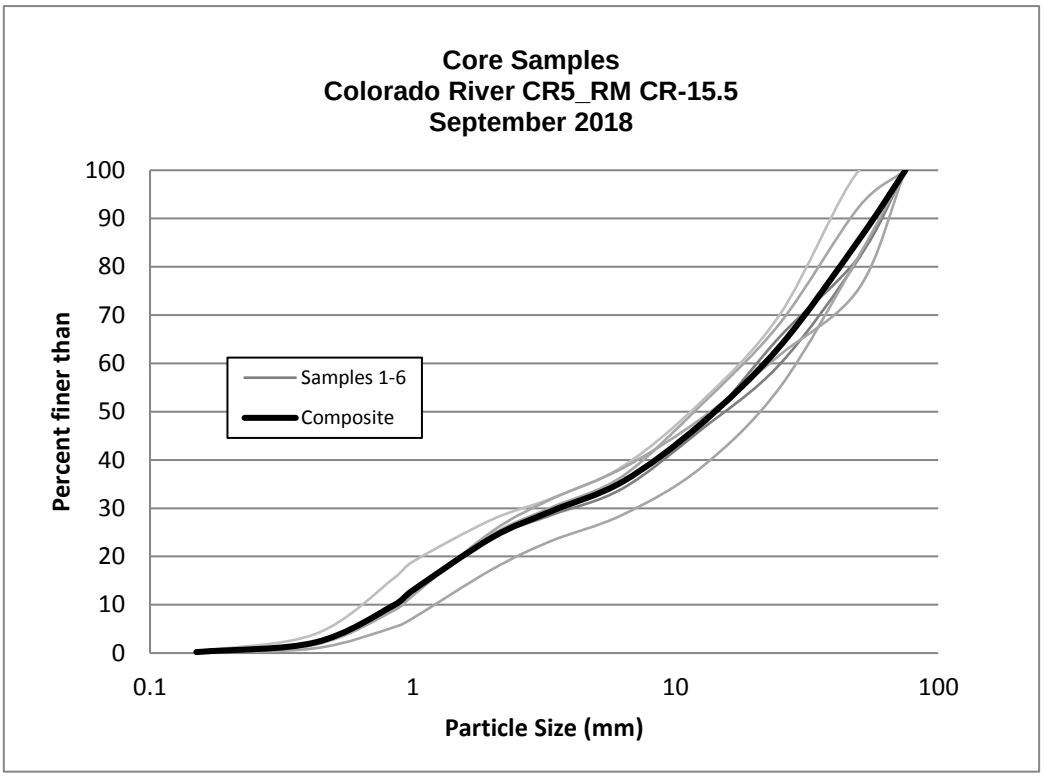


Figure 3. Hydrographs for Colorado River at Windy Gap (below), Colorado River at Hot Sulphur Springs, Colorado River near Parshall, Colorado River blw KB Ditch, and Colorado River nr Kremmling.



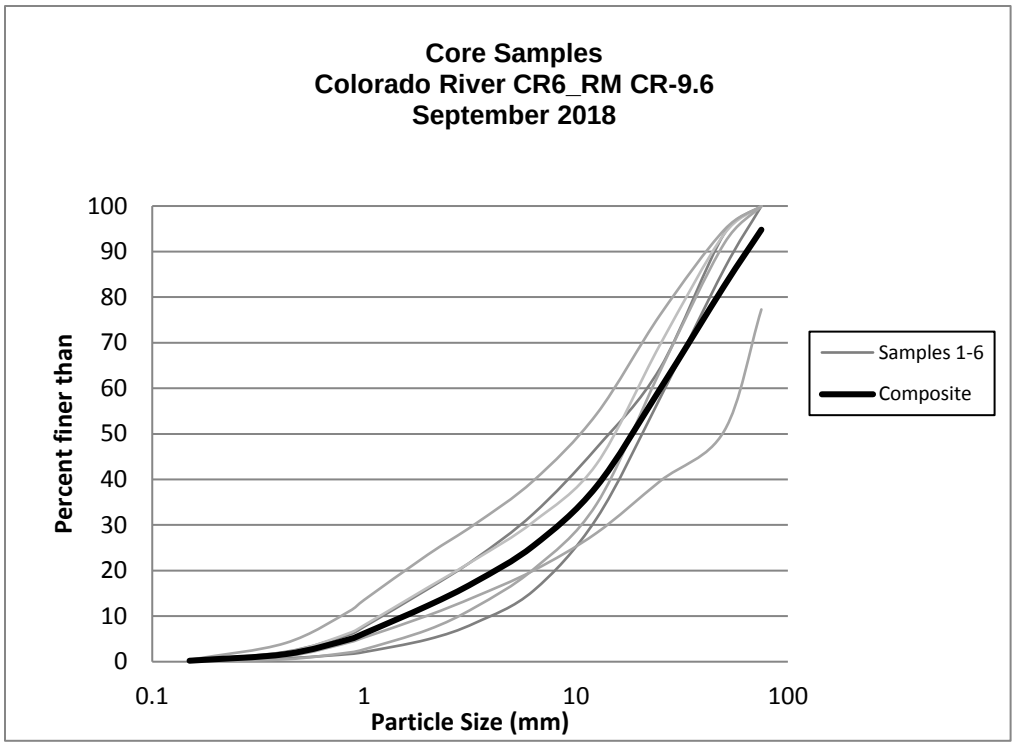
	Colorado River: CR 4_RM CR-22.3 Core Samples percent finer than						
Sieve Size (mm)	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Sample 6**	**Composite**
75	100.0	100.0	100.0	100.0	100.0	100.0	100.0
50	76.9	79.0	74.7	100.0	100.0	88.5	85.9
25	39.7	52.6	52.0	60.7	40.9	66.0	50.9
12.5	23.7	36.8	33.6	40.4	28.0	41.0	33.2
6.3	13.4	24.4	24.5	28.6	19.5	27.7	22.5
3.35	8.7	16.0	18.4	20.9	14.4	21.7	16.2
2	5.8	10.4	14.1	14.8	10.8	18.0	11.8
1	2.4	4.6	7.3	6.8	5.7	11.7	6.1
0.85	1.7	3.4	5.3	5.3	4.5	9.9	4.7
0.425	0.3	0.8	1.1	1.2	1.2	2.4	1.1
0.15	0.0	0.1	0.0	0.1	0.1	0.3	0.1

Figure 4. Particle size distribution of the six McNeil-Ahnell core samples collected from Colorado River at site CR4_RM-22.3 at Pioneer Park, September 2018.



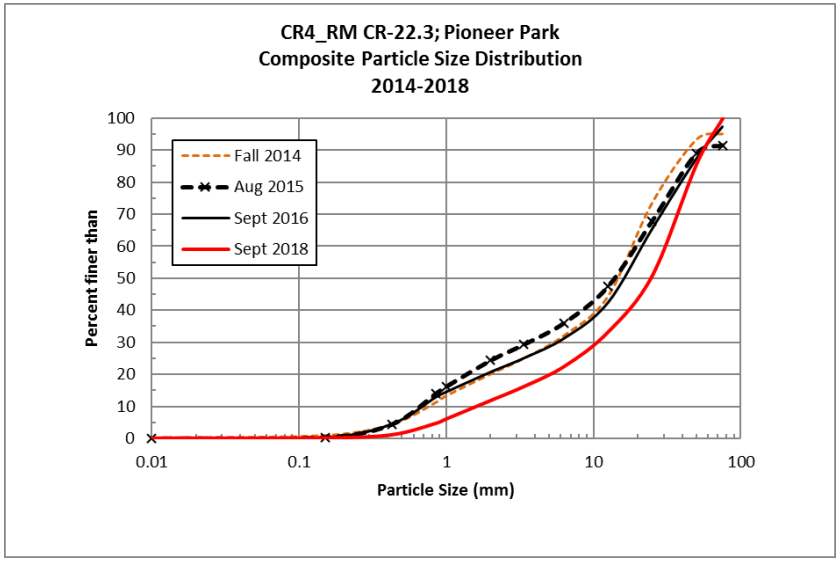
	Colorado River: CR5_RM CR-15.5 Core Samples percent finer than						
Sieve Size (mm)	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Sample 6**	**Composite**
75	100.0	100.0	100.0	100.0	100.0	100.0	100.0
50	81.8	92.5	82.1	100.0	82.4	75.6	85.7
25	59.9	68.3	65.6	70.2	55.1	61.8	63.6
12.5	46.2	51.4	46.8	52.0	38.4	48.5	47.5
6.3	34.1	36.7	35.5	38.7	28.7	38.3	35.5
3.35	28.5	30.1	29.3	32.0	23.2	31.8	29.3
2	23.8	24.5	23.7	27.7	17.3	25.2	23.9
1	13.3	13.0	12.7	18.9	7.2	11.9	13.0
0.85	10.0	9.9	9.3	15.6	5.4	8.9	10.0
0.425	1.8	2.3	2.3	3.9	1.0	1.7	2.2
0.15	0.2	0.2	0.2	0.3	0.1	0.2	0.2

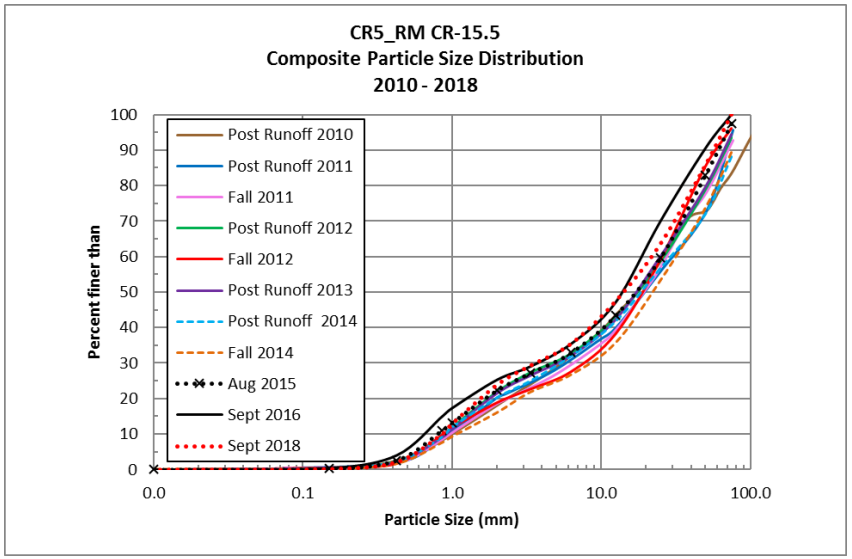
Figure 5. Particle size distribution of the six McNeil-Ahnell core samples collected from Colorado River at site CR4_RM-22.3 at Pioneer Park, September 2018.



	Colorado River: CR6_RM CR-9.6 Core Samples percent finer than						
Sieve Size (mm)	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Sample 6**	**Composite**
75	100.0	77.3	100.0	100.0	100.0	100.0	94.8
50	86.1	50.6	93.9	93.8	94.7	91.7	82.4
25	58.0	39.7	64.5	69.7	76.2	63.8	59.9
12.5	31.4	28.2	46.9	43.4	54.3	34.6	38.5
6.3	15.6	20.0	32.5	30.7	39.7	20.3	25.5
3.35	8.5	14.3	22.6	22.4	30.2	12.0	17.5
2	4.9	10.1	16.0	16.3	23.5	7.0	12.3
1	2.1	5.3	7.7	8.0	13.6	2.7	6.2
0.85	1.7	4.2	5.9	6.3	11.1	2.0	4.9
0.425	0.8	1.2	2.2	2.0	4.1	0.5	1.7
0.15	0.2	0.2	0.3	0.3	0.4	0.1	0.2

Figure 6. Particle size distribution of the six McNeil-Ahnell core samples collected from Colorado River at site CR6_RM-9.6 at the KB Ditch, September 2018.





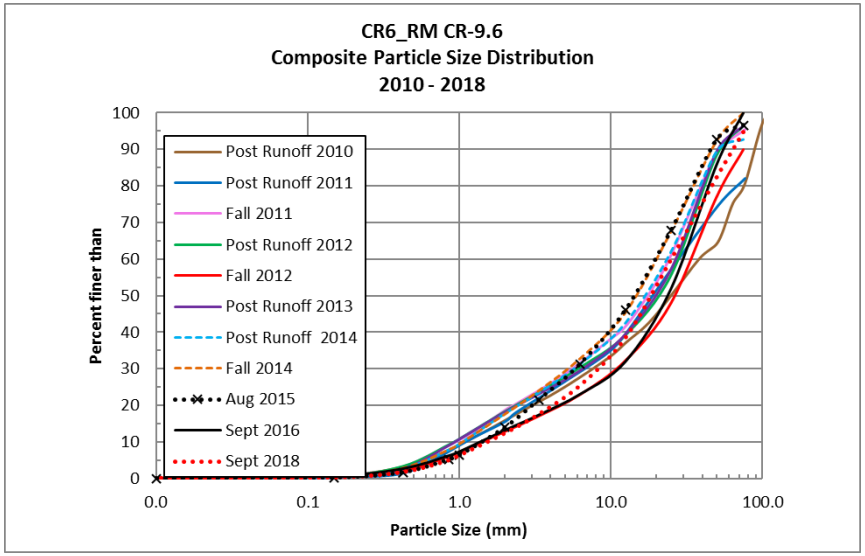
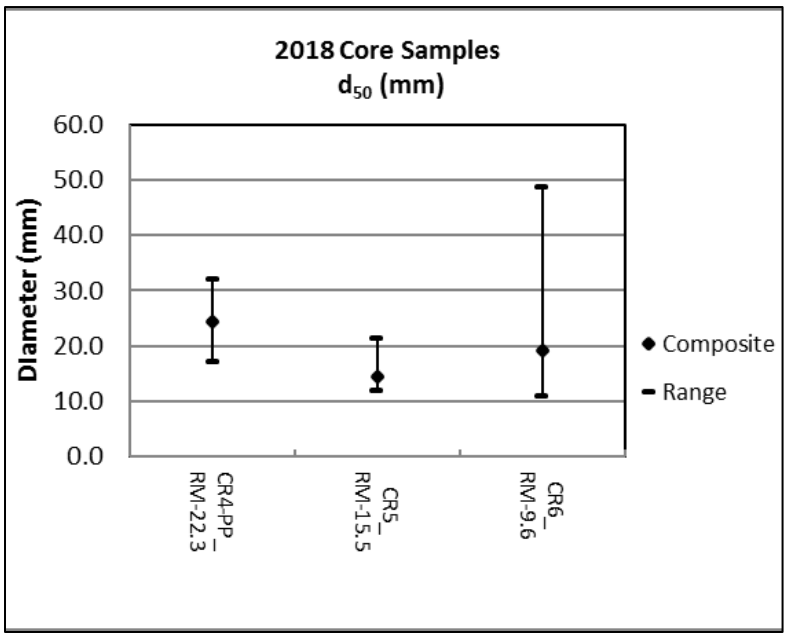


Figure 7. Comparison of the 2018 composite particle size distribution with previous sampling events at each of the three Colorado River spawning bar sites.



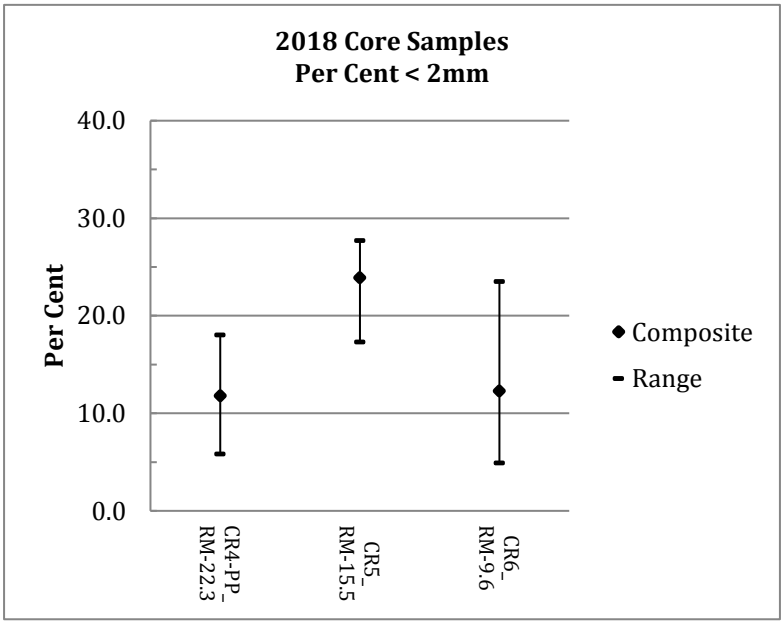
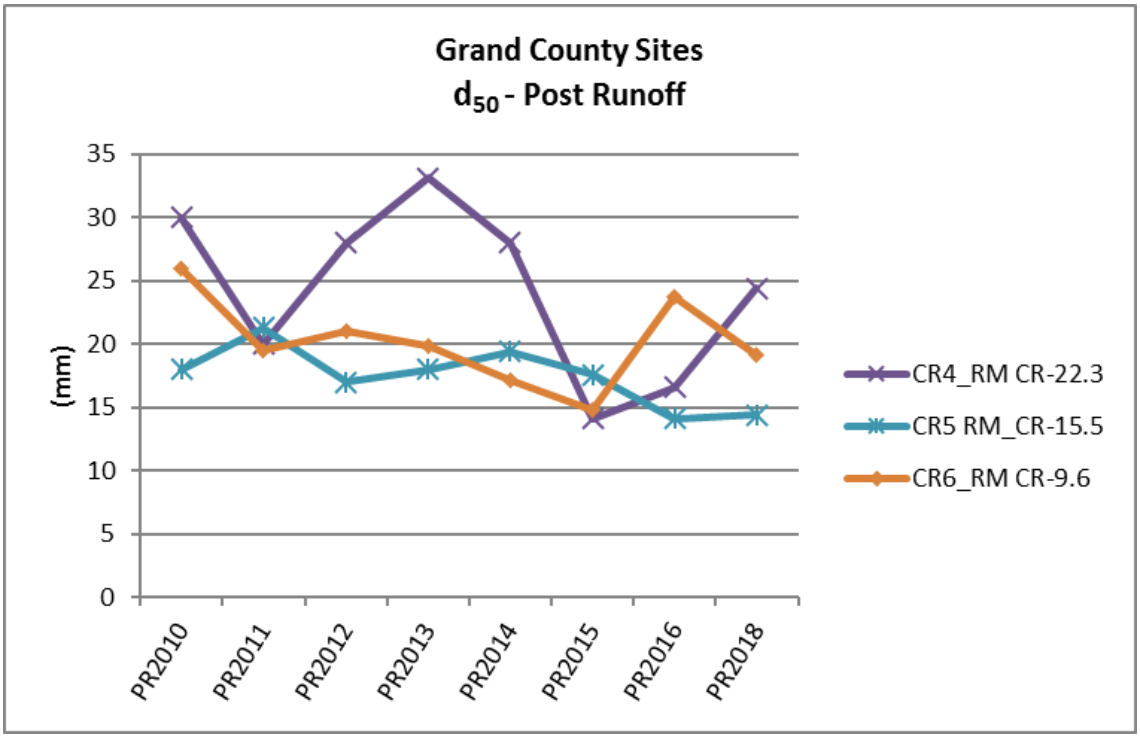


Figure 8. Composite and range of median particle sizes (d50, mm) and percentages of sediment <2mm for the six core samples collected at three Colorado River spawning bar study sites, 2018.



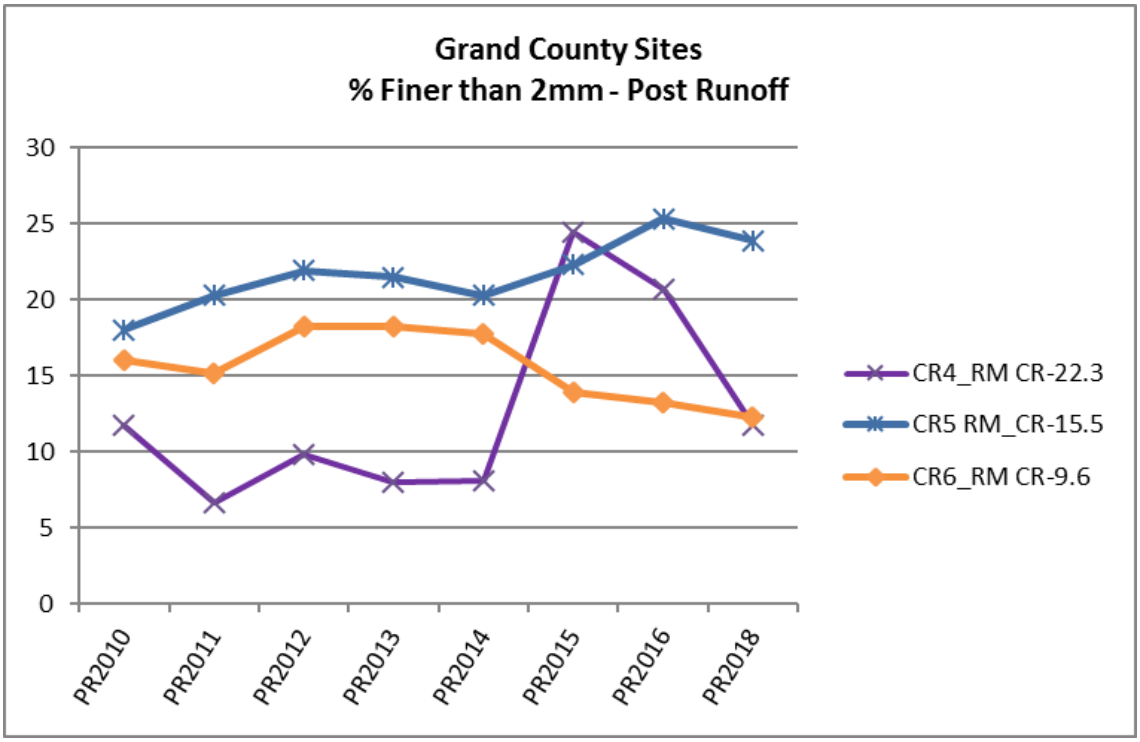


Figure 9. Comparison of composite median particle size (d50, mm) and percent finer <2mm at three Colorado River spawning bar sites, post-runoff 2010-2018.

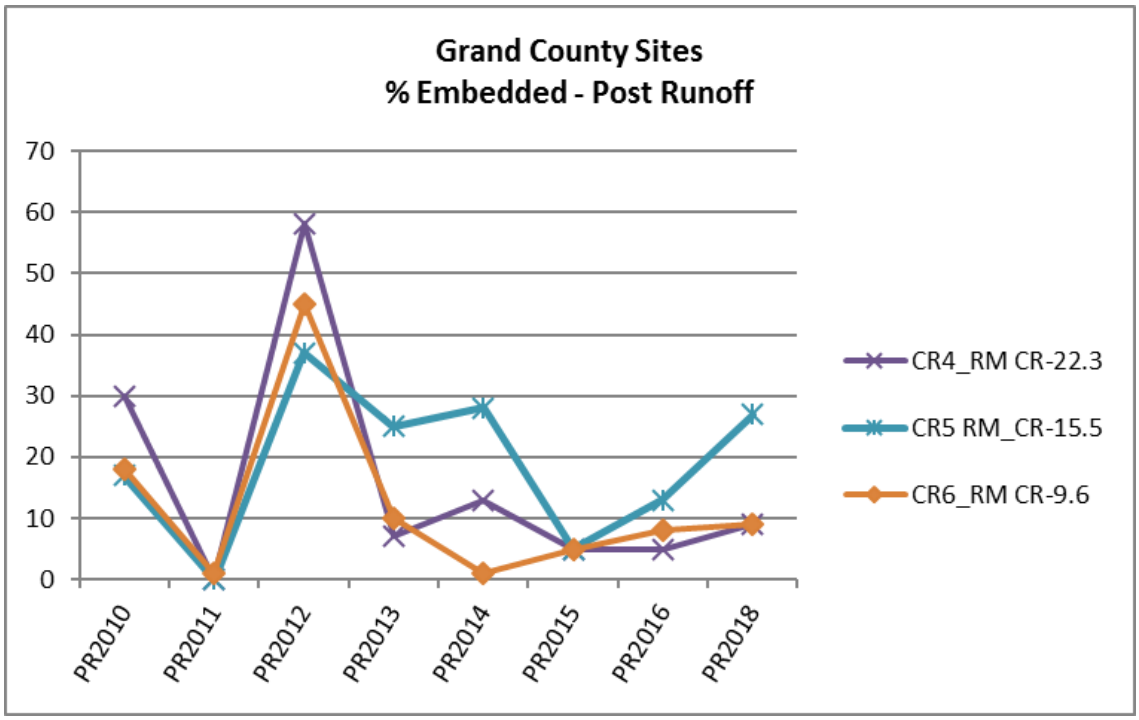


Figure 10. Comparison of % embedded substrate at three Colorado River spawning bar sites, post-runoff 2010-2018.

Attachment 1
Core Sample Location Maps, GPS, and Photo Logs

RM FR-27.2
Location Map: Fraser River. F2, coordinates represent downstream limits of ocular survey.
N39° 52' 1.1" W105° 44' 58.5"

No photos: core sampling at F2 not conducted in 2018.

RM RC-1.1
Location Map: Ranch Creek, F-RC2

N39° 59' 57.96"	W105° 49' 48.36"

No photos; core sampling at Ranch Creek, F-RC2 not conducted in 2018.

RM FR-5.5
Location Map: Fraser River, FR9

N40° 04' 43.74"	W106° 54' 15"

No photos; core sampling at Fraser River, FR9 not conducted in 2018.

RM CRCR-27.7

Location Map: Colorado River CR4 (Chimney Rock Ranch)

N40° 06' 2.16"	W106° 01" 36.36"

No photos; core sampling at Colorado River CR4 (Chimney Rock Ranch) not conducted in 2018.

RM CR-27.8
Location Map: Colorado River, CR4 (CDPW Paul Gilbert Public Access)

N40^0 06' 03.8"	W106^0 01' 33.1"

No photos; core sampling at CR4 (CDPW Paul Gilbert Public Access) not conducted in 2018.

RM CR-22.3
Location Map: Colorado River, CR4-(Pioneer Park)
N 40° 4' 20.35", W 106° 6' 41.60"

RM CR-22.3
Colorado River, CR4-PP
Sample Date: September 6, 2018

Colorado River, CR4-PP looking upstream.

Colorado River, CR4-PP looking downstream.

RM CR-15.5
Location Map: Colorado River, CR5

N40° 03' 46.08"	W106° 11' 0.216"

RM CR-15.5
Colorado River, CR5
Sample Date: September 7, 2018

Colorado River, CR5, looking upstream.

Colorado River, CR5, on island looking downstream.

RM CR-9.6
Location Map: Colorado River, CR6

N40° 03' 19.68"	W106° 17' 0.45"

RM CR-9.6
Colorado River, CR6.
Sample Date: September 7, 2018

Colorado River, CR6, looking upstream.

Colorado River, CR6, looking downstream.

RM CR-(9.6)
Location Map: Colorado River, CR7

N39^0 58' 40.8"	W106^0 30' 56.6"

RM CR-(9.6)
Site: Colorado River, CR7.
Sample date: October 7, 2018

Colorado River, CR7, looking upstream.

Colorado River, CR7, looking downstream.

RM CR-(9.6)
Colorado River, CR7.
Sample date: October 7, 2018

Colorado River, CR7, looking at bar for pebble count.

Attachment 2
Pebble Counts at Macroinvertebrate Sites, Location Maps, GPS, and Photo Logs

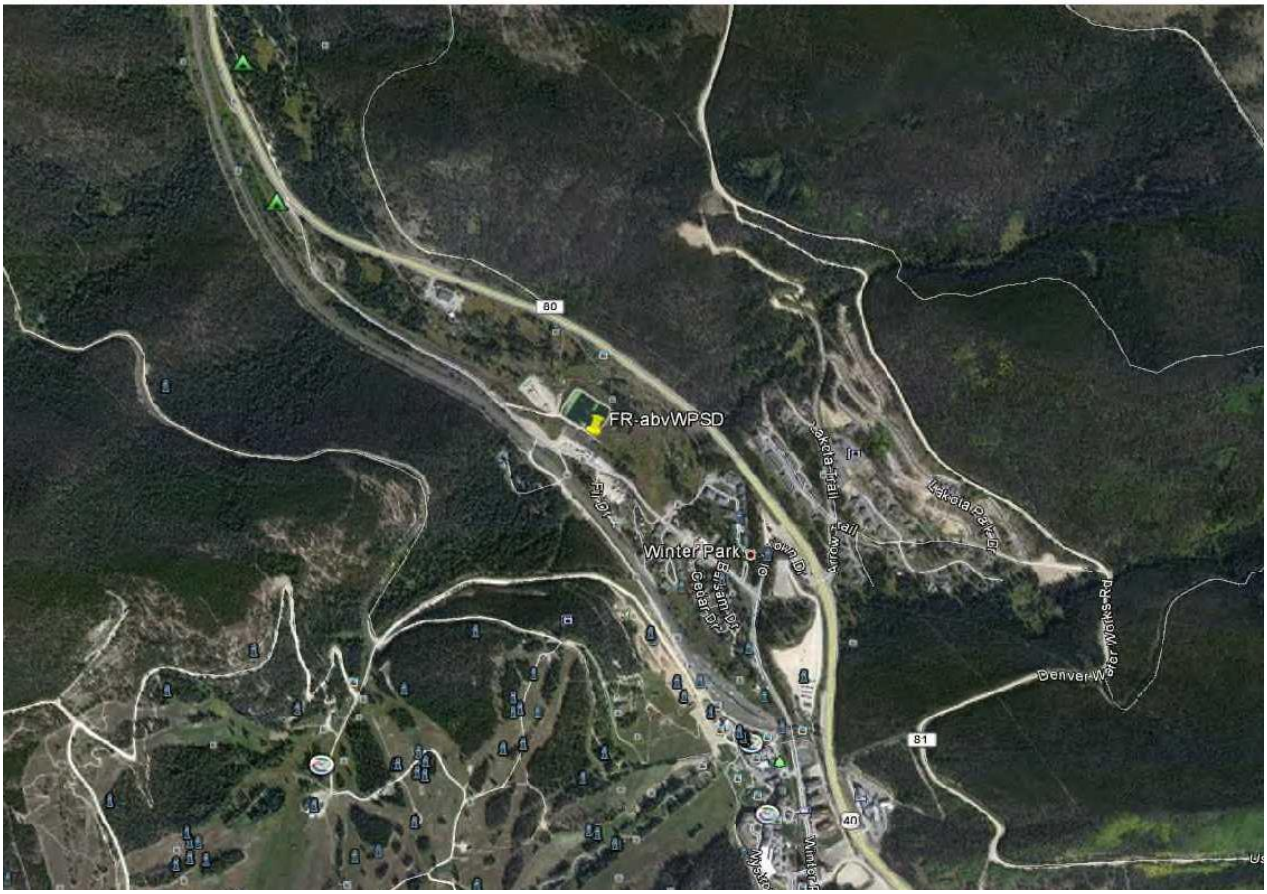
RM FR-27.2
Location Map: Fraser River upstream of Jim Creek and Mary Jane
N39° 50’ 43.30”, W105° 45’ 06.37”

RM FR-27.2
Fraser River upstream of Jim Creek and Mary Jane
September 5, 2018

RM FR-27.2 looking upstream.

RM FR-27.2 looking downstream.

RM FR-23.2
Location Map: Fraser River upstream of Winter Park Sanitation District
N39° 53’ 40.02”, W105° 46’ 05.52”



RM FR-23.2
Fraser River upstream of Winter Park Sanitation District
September 5, 2018

RM FR-23.2 looking upstream.

RM FR-23.2 looking downstream.

RM FR-20
Location Map: Fraser River at Rendezvous Bridge
N39° 56’ 02.832”, W105° 47’ 22.56”

RM FR-20
Fraser River at Rendezvous Bridge
September 5, 2018

RM FR-20 looking upstream.

RM FR-20 looking downstream.

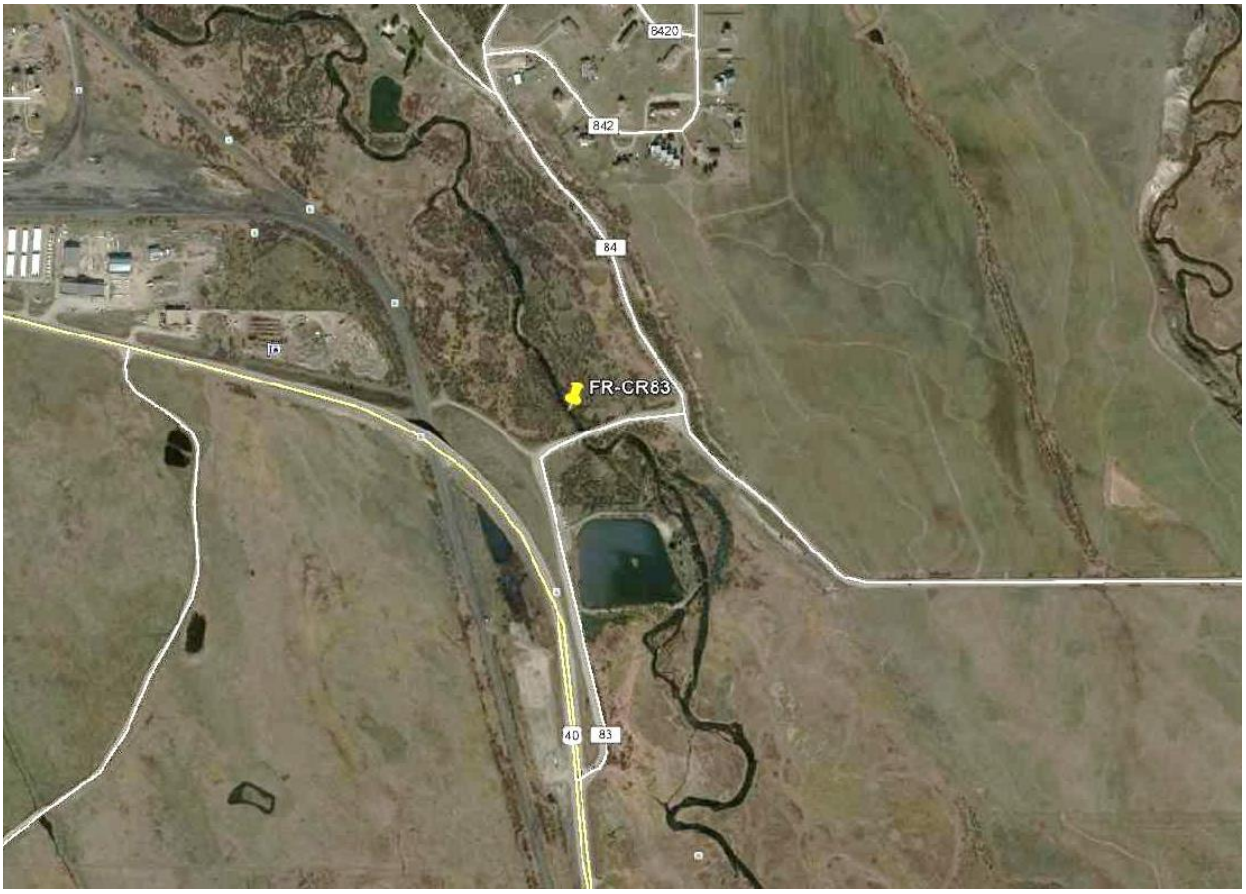
RM FR-15
Location Map: Fraser River upstream of Fraser Flats
N39° 58’ 54.11”, W105° 49’ 49.50”

RM FR-15
Fraser River upstream of Fraser Flats
Date: September 5, 2018

RM FR-15 looking upstream at site.

RM FR-15 looking downstream at site.

RM FR-14
Location Map: Fraser River upstream of Tabernash below bridge on CR 83
N39° 59’ 25.99”, W105° 49’ 45.83”



RM FR-14
Fraser River upstream of Tabernash below bridge on CR 83
September 5, 2018

RM FR-14 looking upstream

RM FR-14 looking downstream.

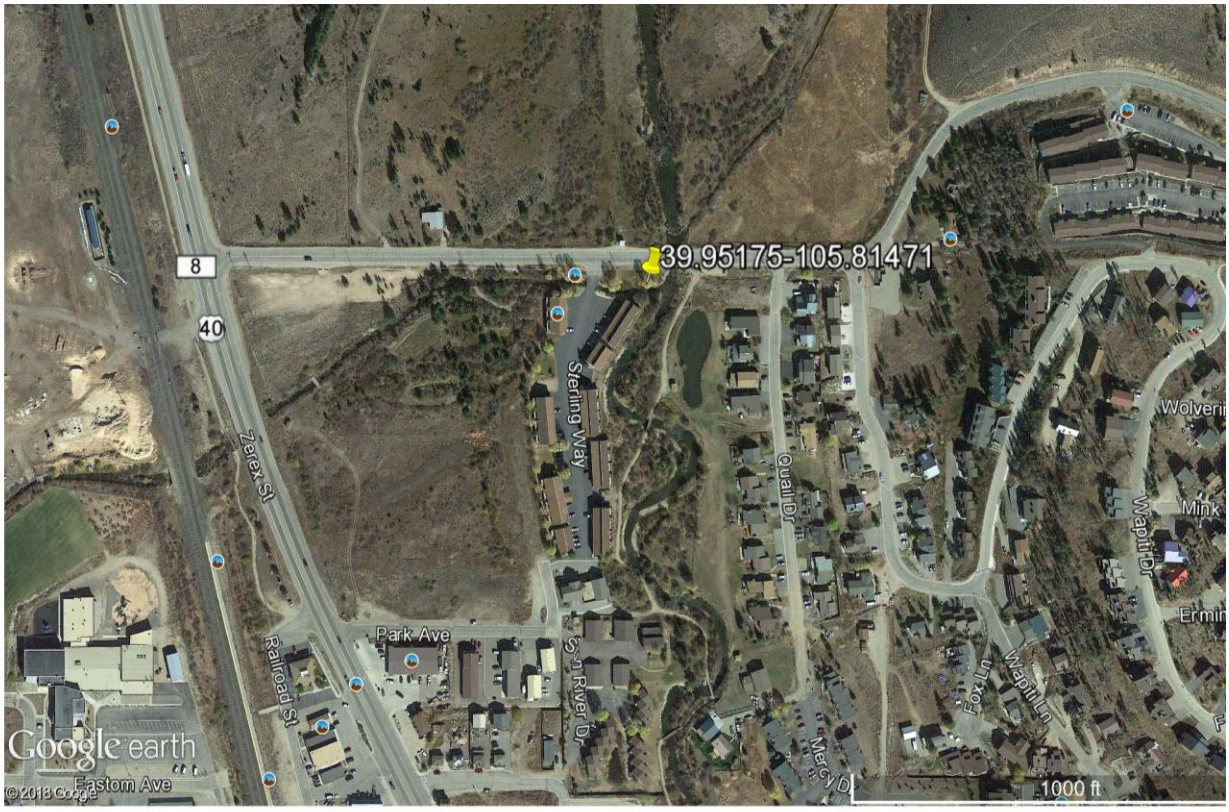
RM RC-1.1
Location Map: Ranch Creek downstream of Meadow Creek
N39° 59’ 56.57”, W105° 49’ 39.11”

RM RC-1.1
Ranch Creek downstream of Meadow Creek
September 5, 2018

RM RC-1.1 looking upstream.

RM RC-1.1 looking downstream.

RM STC-0
Location Map: Saint Louis Creek at Fraser River
N 40º 57’ 6.30”, W 105° 48’ 52.96”



RM STC-0
Saint Louis Creek at Fraser River
September 5, 2018

RM STC-0 looking upstream

RM STC-0 looking downstream

RM CR-31
Location Map: Colorado River upstream of Fraser and Windy Gap
N 40º 06’ 01.80”, W 105° 58’ 21.00”

RM CR-31
Colorado River upstream of Fraser and Windy Gap
September 5, 2018

RM CR-31 looking upstream

RM CR-31 looking downstream.

RM CR RM-28.7
Location Map: Colorado River downstream of Windy Gap
N 40º 06’ 29.88”, W 106° 00’ 12.96”

RM CR RM-28.7
Colorado River downstream of Windy Gap
September 6, 2018

RM CR RM-28.7 looking upstream

RM CR RM-28.7 looking downstream

RM CR-22.9
Location Map: Colorado River upstream of Hot Sulfur Springs
N 40º 04’ 25.60”, W 106° 06’ 36.00”

RM CR-22.9
Colorado River upstream of Hot Sulfur Springs
September 6, 2018

RM CR-22.9 abvHSR, looking upstream

RM CR-22.9 looking downstream

RM CR-16.7
Location Map: Colorado River upstream of Williams Fork
N 40º 03’ 01.08”, W 106° 10’ 21.00”

RM CR-16.7
Colorado River upstream of Williams Fork
September 6, 2018

RM CR-16.7 looking upstream

RM CR-16.7 downstream

RM CR-9.1
Location Map: Colorado River at CR39 Bridge at KB Ditch
N 40º 03’ 19.76”, W 106° 17’ 06.76”

RM CR-9.1
Colorado River at CR39 Bridge at KB Ditch
September 6, 2018

RM CR-9.1 looking upstream

RM CR-9.1 looking downstream

RM CR-7.4
Location Map: Colorado River downstream of Troublesome
N 40º 03 ’ 03.17”, W 106° 18’ 40.25”

RM CR-7.4
Colorado River downstream of Troublesome
September 6, 2018

RM CR-7.4 looking upstream

RM CR-7.4 looking downstream

RM CR-1.7
Location Map: Colorado River upstream of Blue River
N 40º 02’ 36.96”, W 106° 22’ 30.36”

RM CR-1.7
Colorado River upstream of Blue River
September 6, 2018

RM CR-1.7 looking upstream

RM CR-1.7 looking downstream