Salmonid Redd Study
SUMMARY

Consistent with Section 6.0 of the *Salmonid Redd Study Plan* (Plan) as filed with FERC on January 9, 2017,[1] the SSWD provides the following summary for the *Salmonid Redd Study* (Study). The summary includes a description of work completed to date, key findings, variances and remaining work. Links to associated data files are also included. SSWD considers these data to be public.

Work Completed to Date (Study as of 10/1/18):

The Study is complete. SSWD has completed all of the four steps listed in the Plan; Step 1 (spawning gravel mapping), Step 2 (gravel permeability), Step 3 (redd surveys), and Step 4 (QA/QC). Step 1 was initiated in July 2017, but was not completed prior to the onset of winter conditions; approximately one-third of the data were collected in that initial effort. When work resumed in 2018, surveyors found that winter flows had mobilized the substrate and significantly altered the distribution. Additional effort was made to thoroughly document the entire revised gravel distribution. Gravel mapping was completed on June 12, 2018. Step 2 Gravel permeability measurements were collected on August 9, 2017, throughout the two intensive Study sites selected for the *Instream Flow Study* as directed by the Plan. Site 1 is located between RM 14.2 and RM 15.0, and a total of 10 riffles were surveyed. Site 2 is located between RM 7.9 and RM 8.5, and a total of 6 riffles were surveyed. Five redd surveys, as required by Step 3, were conducted between October and December 2016 and four were conducted between January and March 2018 from the non-Project diversion dam to the Highway 70 Bridge. Step 4 (QA/QC) of all collected data is complete.

Key Findings:

Reach Renaming

SSWD identified an inconsistency in the naming of sub-reaches between this Study and Study 3.2, *Stream Fish Populations*. The lower Bear River was subdivided into three subreaches in this Study and four subreaches in Study 3.2, because Study 3.2 included the reach between Camp Far West Dam and the non-Project diversion dam and Study 3.1 did not. Subreach numbering for this Study was updated to be consistent with Study 3.2 (Table 1).

Table 1. Corrected subreach names.

Description of Reach	Non-Project diversion dam (RM 16.9) to the Highway 65 Bridge (RM 11.5)	Highway 65 Bridge (RM 11.5) to the Pleasant Grove Bridge (RM 6.8)	Pleasant Grove Bridge (RM 6.8) to the Highway 70 Bridge (RM 3.5)
Original - Study 3.1	Reach 1	Reach 2	Reach 3
Corrected – Consistent with Study 3.2	Reach 2	Reach 3	Reach 4

Step 1: Spawning Gravel Mapping

Due to the extensive distribution of gravel in the D_{50} diameter of 0.11 to 5.9 in. (2.8-150 mm), a two tiered classification system was devised to provide higher resolution to the Study results. Areas that were identified in the Low Flow Active Channel (LFAC) were classified as primary

[1] The Study Plan is available on SSWD's public relicensing website (www.sswdrelicensing.com) under 'Study Plans.'

spawning gravel. These were areas that adult Chinook salmon could use to spawn under current minimum instream flows. All other gravels falling within the D_{50} of 0.11 to 5.9 in. that were identified outside the LFAC, but within the bank full channel, were classified as secondary spawning gravel. Deep pools with little potential for use as spawning habitat were included in the surveys due to the systematic sampling design employed, but were accounted for separately in the calculations. Velocity transects and pebble counts were collected at areas of primary spawning gravel, but not secondary. A full description of the methodology used for assessing abundance of spawning gravels is provided in the associated document: SpawningGravel_Protocol.docx.

Representative areas surveyed at intervals showed that spawning gravels were found to be present throughout the majority of the Lower Bear River in moderate amounts with significant deposits in river miles 5 to 8 and 14. The primary concentration of gravel lied within Reach 3 (RM 6.8-11.5), where the majority of spawning activity was noted between surveys in 2016 and 2018 (n=20 and 23, respectively). In primary habitats of surveyed areas (i.e. wetted active channel), suitable spawning gravels comprised an average of 24.1 percent of available non-pool habitats (i.e. riffle, run, or glide) by river mile (minimum 0.0 percent, maximum 56.8 percent; Table 2), and an average of 6.9 percent of available pool habitats by river mile (minimum 0 percent, maximum 32.2 percent). Much of pool habitat is not considered spawning habitat due to depth, but the tailouts of pools offered suitable deposits. While deposits were concentrated in Reach 3, 9 of 16 river miles had deposits greater than 20 percent of the represented area, offering a broad spatial range for spawning opportunities. In secondary habitats that were surveyed (i.e. outside of the wetted channel, but within bank full width), spawning gravels comprised an average of 26.8 percent of available habitats by river mile (minimum 0 percent, maximum 70.5 percent). Reach 4 had the highest individual maximum deposit of surveyed areas, but Reach 3 again had the greatest average overall.

Where spawning gravels were present in primary habitats, pebble counts were conducted. The average median particle size, or D_{50}, was approximately 0.98 in. (25mm, Figure 1), a value that corresponds with coarse gravels. The range of D_{50} particle sizes that is commonly accepted to comprise suitable spawning gravels for Chinook salmon and steelhead is 0.11 to 5.9 in.; all but one sample site had D_{50} values within that range. The one site that had a D_{50} value of approximately 0.06 in. (1.6mm) had a subdominant substrate component of silt/clay. Velocities were also measured where primary spawning gravels were identified. Velocities ranged from 0.03 ft/s to 5.48 ft/s, and the average median velocity (averaged across all sites) was 1.86 ft/s (Figure 2). General patterns of velocity were within an acceptable range for spawning adults. The complete data set of gravel surveys, pebble counts, and velocity transects are included in the associated data file: GravelMapping_Final.xlsx.

Table 2. Spawning gravel availability for primary (i.e. within the low-flow active channel) and secondary habitats that were surveyed, presented as the average percent of available habitat comprised by spawning gravels and shown by river mile. Primary habitats are further partitioned into non-pool (i.e. riffle/run/glide) and pool habitats.

General Reach Boundary	River Mile	Average Percent of *Primary* Spawning Gravels in:		Proportion of Non-Pool Habitats	Average Percent of *Secondary* Spawning Gravels
		Non-Pool Habitats (Riffle/Run/Glide)	Pool Habitats		
4	3	5.0	0.0	0.33	12.0
	4	16.2	8.9	0.25	27.1
	5	32.8	6.7	0.33	32.4
	6	30.0	0.0	0.25	0.0
3	7	56.8	20.4	0.57	62.1
	8	49.0	32.2	0.71	48.4
	9	20.0	0.9	0.14	45.7
	10	20.7	1.7	0.43	26.5
	11	21.6	12.2	0.50	23.0
2	12	26.9	8.2	0.43	70.5
	13	19.4	3.1	0.29	19.0
	14	32.5	2.1	0.57	8.6
	15	0.0	0.7	0.17	0.0
	16	7.0	0.0	0.57	0.3
All Reaches	**Average**	**24.1**	**6.9**	**0.40**	**26.8**

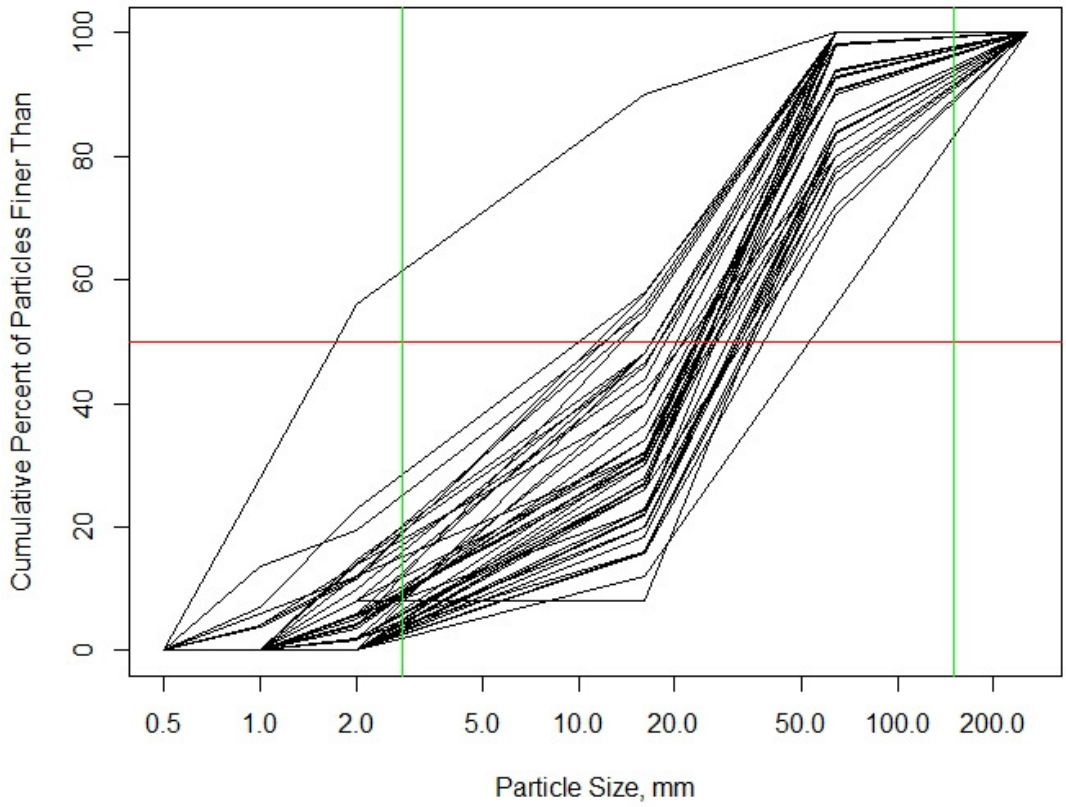

Figure 1. Cumulative size distribution of gravels at sites in the lower Bear River deemed to be suitable for salmonid spawning. Each black line represents a distribution of substrate sizes at a single site. The horizontal red line indicates the location of the 50th percentile of particle diameters, or D50 value. The vertical green lines indicate the lower and upper threshold diameters of gravel particle sizes that are commonly deemed suitable for salmonid spawning (0.11-5.9 in., or 2.8-150 mm).

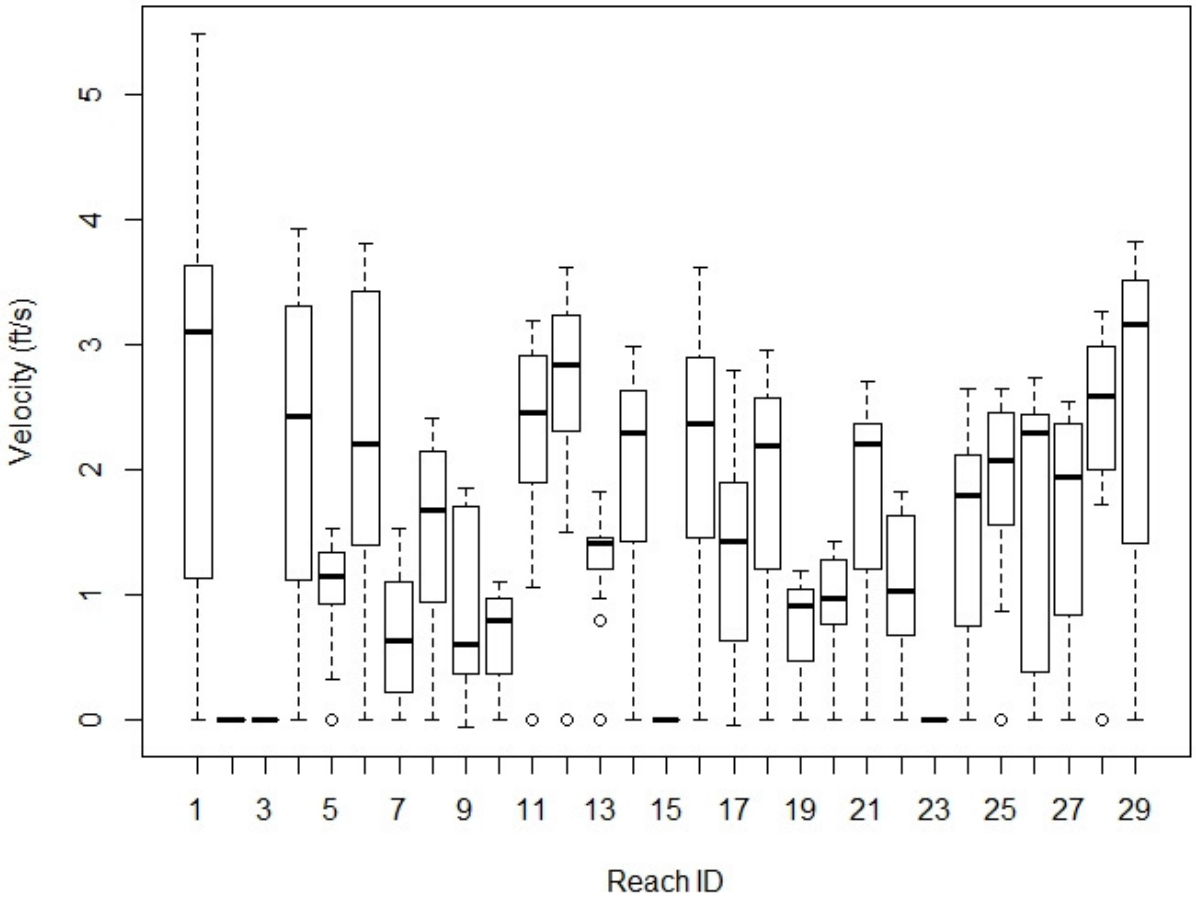

Figure 2. Velocity distributions at sites deemed to contain suitable salmonid spawning gravels. Velocities were measured at the 60 percent depth, and transects completely spanned the wetted channel at each site. Distributions are shown as standard box plots and are presented by sample reach ID number – Reach 1 is at the non-Project Diversion Dam at River Mile 16.9, and Reach 29 is at the Highway 70 bridge at River Mile 3.5.

Step 2: Gravel Permeability

Gravel permeability measurements were conducted at both instream flow sites on August 9, 2017. At Site 1, water temperature ranged from 25.6°C to 28.1°C and flow as measured in the intragravel measurement stand pipe over time ranged from 0 mL/sec to 37.2 mL/sec. At Site 2, water temperature ranged from 26.5°C to 28.3°C and flow as measured in the stand pipe ranged

from 0 mL/sec to 152.9 mL/sec. Average DO ranged from 7.2 to 8.6 mg/L, which represents suitable water quality conditions for coldwater fishes.

Table 3. Water quality and average flow data for intragravel flow in the two instream flow study sites on the lower Bear River. Measurements were collected on August 9, 2017.

Site		Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (micro siemens/centimeter)	Average Flow (mL/sec)
Site 1	Minimum	25.6	3.8	78.3	0.0
	Average	27.3	8.6	89.7	14.8
	Maximum	28.1	10.8	123.1	37.2
Site 2	Minimum	26.5	5.1	93.1	0.0
	Average	27.1	7.2	96.2	28.8
	Maximum	28.3	8.3	98.5	152.9

Step 3: Redd Surveys

Redd surveys were conducted from October 17, 2016 through December 8, 2016. No redds were observed during the first survey from October 17 through19, 2016. The second survey was conducted on November 7 and 8, 2016, earlier than required by the Study Plan but in response to a rain event that caused a short increase in flows. Redds were documented during this visit (Figure 3), which triggered bimonthly surveys that continued through December 8, 2016. Surveys ceased as a result of high flows and low visibility beginning with the December 22, 2016 survey. River conditions were monitored approximately every two weeks to determine if redd surveys could be resumed during the monitoring period. Secchi depths ranged from 0.2 to 0.6 m; less than 1.2 m, which field technicians deemed necessary for sufficient visibility to conduct an accurate survey. This depth was determined through professional judgement by observing the depths where spawning habitat was located. Based on wetted channel depths, minimum visibility of 1.2 m would allow for sufficient clarity to confidently identify spawning activity in potential spawning habitat. Flows were also much higher than the 10 cfs minimum instream flow and ranged from 1,388 to 4,851 cfs during the periodic checks (Table 4). The maximum flow in the Bear River near Wheatland during the survey period was 34,900 cfs in January 2017. Conditions conducive to red surveys did not return for the remainder of the 2016/2017 redd survey period, which ended on March 31, 2017.

Figure 3. Chinook salmon redd on the lower Bear River, photo taken during November 2016 redd survey.

Table 4. Secchi depth and flow conditions for the lower Bear River during the 2016/2017 redd survey.

Date	Secchi Depth, measured at Highway 65 (meters)	Daily Average Flow, reported on CDEC at Wheatland Gage (cfs)
12/20/2016	0.35	2,125
12/27/2016	0.45	1,388
1/3/2017	0.6	1,434
1/24/2017	0.25	3,183
1/30/2017	0.3	1,820
2/6/2017	0.3	3,545
2/20/2017	0.25	4,851
2/27/2017	0.2	2,249
3/8/2017	0.25	1,640
3/20/2017	0.5	1,422
3/27/2017	0.4	2,200

The four surveys conducted in 2016 resulted in documenting 23 redds, 4 adult Chinook salmon (*Oncorhynchus tshawytscha*), and 3 Chinook salmon carcasses (see associated data file labeled ReddLocations_2016_2018). SSWD did not have permits to enter the water to take physical measurements of redds in 2016, so redd dimensions were visually estimated from the bank. This was done by holding a stadia rod horizontally on the bank adjacent to the redd location for a visual reference to the redd. Pot area ranged from 0.29 to 8.75 square meters (sq m), and total redd area ranged from 1.27 to 36.73 sq m (Table 5). Pot depths were not estimated, as visual estimation of depth can be highly variable depending on water clarity, lighting conditions, and velocity. Of the 23 redds documented in 2016, none were recorded in Reach 2; 20 in Reach 3; and 3 in Reach 4 (see Table 1 for Reach identification). The 4 adult Chinook salmon identified

were observed on or adjacent to redds (Figure 4). No Chinook salmon were seen actively spawning. New redds were observed during surveys on November 7-8, November 22-23, and December 7-8, 2016.

Figure 4. Lower Bear River redd with Chinook salmon nearby, photo taken during November 2016 redd survey.

Table 5. Pot and tailspill areas for visually estimated redd dimensions, and substrate size classes in 2016.

	Area (square meters)			Pot Substrate[2]
	Pot	TailSpill	Total	
Minimum[1]	0.29	0.84	1.27	sand
Maximum[1]	8.75	29.73	36.73	cobble
Average[1]	2.76	8.71	11.35	coarse gravel

1. n = 23
2. Pot substrate was estimated by comparison to bank substrate. Tailspill substrate was not estimated.

SSWD conducted additional redd surveys from January through March 2018 to gather additional data on potential steelhead spawning. The first surveys were conducted from January 15 through 17, 2018, during a break in high winter flows. During this event, SSWD identified a total of 78 Chinook salmon redds, 4 test redds, 10 adult Chinook salmon, and 6 Chinook salmon carcasses. Out of the 78 redds identified, 35 were found in Reach 2; 23 in Reach 3; and 20 in Reach 4 (see associated data file titled ReddLocations_2016_2018 and Table 1 for Reach identification). Redd age was difficult to determine due to the late date of the spawning surveys, and the presence of periphyton that had begun to regrow on most of the redds.

Flows were increased one or two days after the initial survey was conducted, but returned to base levels early in February 2018. A second survey was conducted on February 1, 2018, at

which point flows on the lower Bear River were approximately 670 cfs. SSWD surveyed a section of Reach 2 and the entirety of Reach 3. Due to high flows the top of Reach 2 and Reach 4 were not safely accessible and did not provide reasonable put-in and take-out locations for the survey crew. No new redds were identified and no fish were encountered during this survey.

A third survey was conducted on February 14-15, 2018. No new redds were identified during this survey. Flows and turbidity were monitored bi-weekly for the remainder of February and beginning of March. During this period, flows on the lower Bear river ranged from 300 cfs to 1,300 cfs and secchi reading ranged from 0.2 m to 0.8 m. SSWD attempted a survey on March 12, 2018. Reach 2 was surveyed at approximately 340 cfs with 1.5 m of visibility. Heavy rain over the following two days increased flows to approximately 2,200 cfs and decreased visibility to less than 0.4 m. Therefore, Reaches 3 and 4 were not surveyed. No new redds were identified and no fish were encountered in Reach 2. Two weeks later on March 27, 2018 flows on the lower Bear River were approximately 1,870 cfs and visibility was 0.4 m. No steelhead or steelhead redds were observed during the January to March 2018 surveys.

Redd area ranged from 0.36 to 39.26 sq m (Table 6). Large discrepancies between minimum and maximum redd areas are due to close proximity of multiple redds and test redds at multiple locations, which precluded accurate identification and measurement of individual redds. Pot substrate was variable, ranging from sand to cobble, and tailspill substrate was typically one size class smaller than the associated pot substrate (Table 6). Salmonid redd surveys are completed as of April 1, 2018.

Table 6. Minimum, maximum, and average values for redd area, pot depth and velocity, and substrate.

	Area (square meters)			Pot Depth (meters)	Pot Velocity (meters per second)	Substrate	
	Pot	Tail Spill	Total			Pot	Tailspill
Minimum[1]	0.22	0.13	0.36	0.1	0	sand	sand
Maximum[1]	13.37	29.64	39.26	0.6	0.7	cobble	cobble
Average[1]	2.77	4.84	7.61	0.3	0.2	cobble	coarse gravel

[1] n=78

Associated Data Files:
The data files listed below are available on SSWD's public relicensing website (www.sswdrelicensing.com).

Table 1. Data files associated with Study summary.

File Name	Data Description	File Type and Size
ReddLocations_2016_2018.pdf	Map of redd locations in 2016 and 2018.	Adobe PDF
Redddata_2018_final.xlsx	Raw data for redd surveys 2016-2018	Excel workbook
GravelMapping_Final.xlsx	Primary and secondary gravel abundance, pebble count, and velocity transect data from spawning gravel mapping.	Excel workbook
CFW Permeability_2017_Final.xlsx	Gravel permeability, dissolved oxygen, temperature, and conductivity data.	Excel workbook
SpawningGravel_Protocol.docx	Description of methods used to assess abundance of spawning gravels.	Word document

Variances from Study:

There were two variances from the Study Plan. The first variance was that redd measurements were only visually estimated in 2016 because SSWD had not received the necessary scientific collecting permits to authorize the activity prior to the field season. The goal of the Study was to "supplement existing information regarding the spawning of salmonids in the Bear River downstream of the non-Project Diversion Dam". While visual estimates reduce the accuracy of field data, they do support the overall goal of the study and therefore do not affect the outcome. SSWD received the necessary permits to conduct redd measurements in March 2017 and the 2018 4(d) extension letter in January 2018, which enabled full measurements of redds to be collected for surveys completed in 2018.

The second variance was that spawning gravel mapping was not completed in 2017. Due to abnormally high flows in 2016 and into 2017, SSWD experienced a compressed 2017 field season. In addition, the mapping effort proved to be more intensive than originally thought due to the large amount of potential spawning gravel encountered. As such, the gravel mapping effort was shifted to 2018, which allowed for the surveys to be completed in a consistent manner within a single season.

Remaining Work:

The Study is complete.