APPENDIX H

FISH HABITAT ASSESSMENT
POWDER RIVER IMMEDIATELY BELOW MASON DAM
-Technical Memorandum-

MASON DAM PROJECT
BAKER COUNTY, OREGON
Project Number P-12686-001

Prepared for

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April 2011

Stream Report for the Powder River
ODFW PROTOCOL COVER PAGE

STREAM: Powder River

BASIN: Powder River

DATES: February 2-3, and March 15, 2011

SURVEY CREW: Jim Lawrence and Jackie Dougan

SURVEY REPORT PREPARED BY: Jackie Dougan

TECHNICAL REPORT PREPARED BY: Jackie Dougan and Leslie Gecy

STREAM ORDER: 1 BASIN AREA: 1,750 miles square

USGS MAP: Bowen Valley

HUC NUMBER: 170502 03 LLID: 3515

1.0 SURVEY OVERVIEW

The Powder River flows 144 miles from its source in the Blue Mountains to the Snake River. The Powder River begins near Sumpter, Oregon (River Mile 144), where the McCully Fork, Cracker Creek and several smaller tributaries join, and flows east-southeast through the tailings of past dredge-mining into Phillips Lake (RM136). The river exits Phillips Lake at Mason Dam at RM 131. The river continues east through Bowen Valley and Baker City, Oregon (RM 113). The river winds through the Baker Valley where many tributaries join the Powder River including the North Powder River at RM 82. The Powder River turns southeast and flows through Thief Valley Reservoir (RM 71), through the lower Powder Valley and enters the Snake River through the Powder River Arm of Brownlee Reservoir (RM 10) near Richland, Oregon (Nowak 2004). Eleven dams on the Columbia and Snake River separate the Powder River from the Pacific Ocean. The Snake River dams have no passage for anadromous fish and they prevent any passage into the Powder River.

The Powder River Subbasin encompasses an area of about 1,750 m^2 in Northeastern Oregon. The subbasin is almost entirely encompassed within Baker County but does include a small portion of Union County. The elevation at the start of the Powder River (RM 144) is 4,388 feet above Mean Sea Level (MSL) and flows into the Snake River near 1,650 feet above MSL.

The entire Powder River is designated for use by redband trout (*Oncorhynchus mykiss gibbsii*). Dissolved oxygen standards in the Powder River below Mason Dam are 11.0 ppm or 95% saturation during the redband trout spawning period of January 1 through May 15, and 6.5 ppm the remainder of the year. Baker County has proposed to meet the seasonal 11 ppm or 95% saturation compliance point from the Mason Dam stilling basin at a point 0.16 miles downstream at the stream gaging station. According to the Oregon Department of Fish and Wildlife (ODFW), this could potentially affect redband trout, as they may rear in the stilling basin with spawning habitat thought to occur immediately downstream of the stilling basin (Fagan 2010).

The purposes of this survey were to:

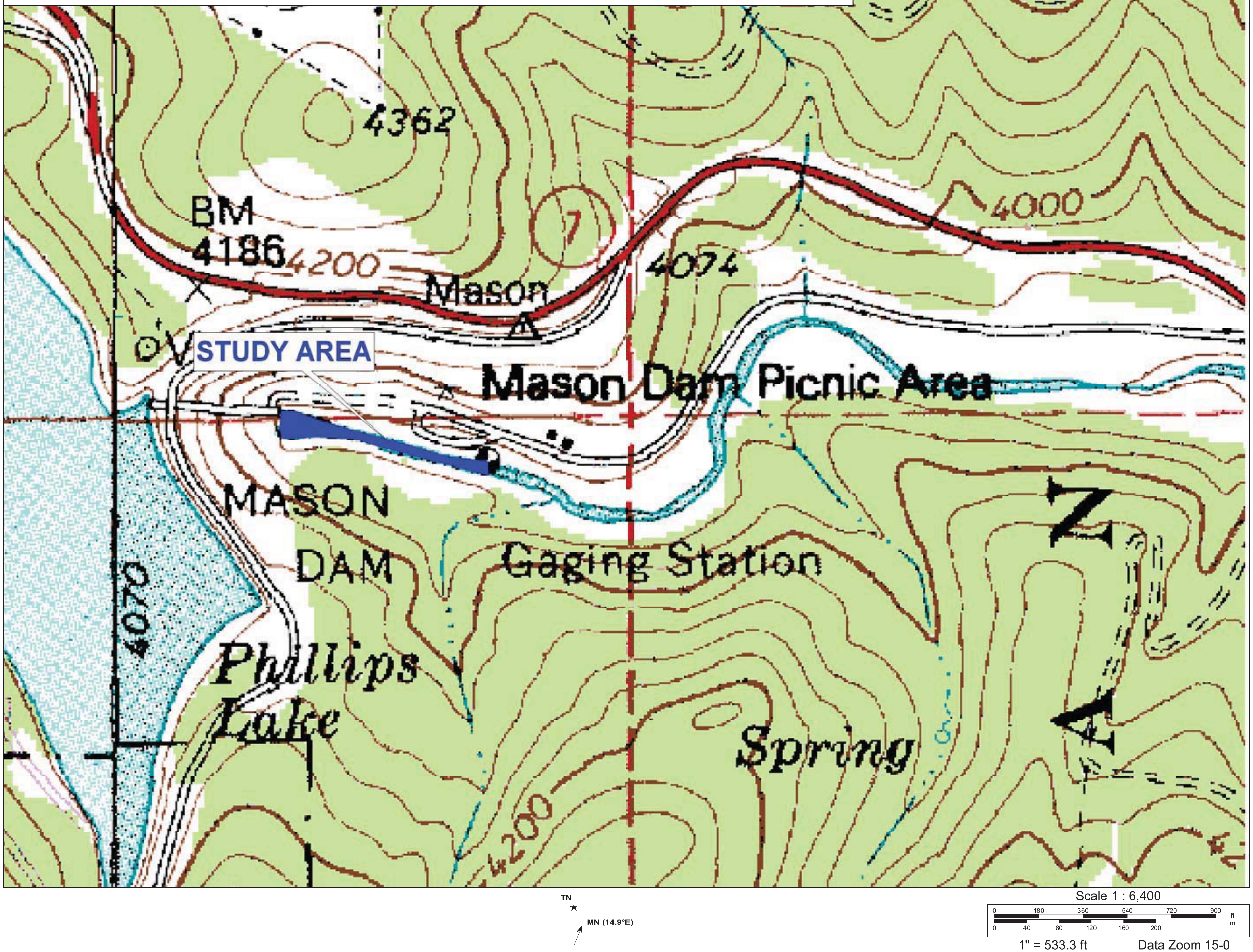
- Collect quantitative data on the parameters affecting fish habitat between Mason Dam and the gaging station (see Figure 1 for the location of the study area), and

- Provide an interpretation of the quality of the habitat for redband trout spawning, incubation and rearing by a fishery biologist.

2.0 SURVEY PROTOCOLS

The ODFW Oregon Aquatic Inventories Project: Methods for Stream Habitat Surveys (Moore et al. 2010) were used to characterize the habitat within the 0.16 mile area of interest. Survey data were collected on each of the channel units within the study area, which is greater than the normal survey sample sizes recommended in the ODFW protocols (i.e., 10% subsample of channel units). The

Figure 1. Location of the Mason Dam Fish Habitat Study Area.



higher survey intensity was used to more precisely characterize all of the habitats in the study area. In addition, detailed particle size analyses were conducted along three transects perpendicular to the river and water column velocity measurements were made within each channel unit.

Particles sizes were estimated ocularly as described in Moore et al. (2010) for each channel unit. Particle sizes were also measured quantitatively on transects across the downstream end of the stilling basin, across a channel unit characterized as a riffle with pocket pools, and at the gaging station according to standard quantitative particle size analysis protocols (see for example, Bunte and Abt 2001). On the quantitative transects, particles sizes were measured at even intervals of 1 foot (where large boulders were absent), increasing the intervals to 1.5 feet where boulders were frequent to avoid counting the same "particle" twice. Measurements were collected at 100 points per transect and tallied according to the Wentworth scale, as modified by Rosgen (Wentworth 1922, Rosgen 1996). Where the stream width was less than 100 feet, a second transect was placed adjacent to the first transect so that it traversed the same unit type but was offset slightly to avoid sampling the same particles. A cumulative particle size distribution was plotted for each transect and the D_{50} and D_{84} (median and 84^{th} percentile values) calculated. For the analysis, fine particles were defined as any particles less than 2 mm in size.

Velocity measurements were made by the Oregon Water Resources Department, Eastern Region and the Baker County Watermasters Office using a digital meter. Measurements were made across the channel at 20 to 30 subsections of the overall stream cross section. If the water depth was less than 1.5 feet, then a single measurement was taken at a depth of 60% of the total water column. Where water depths exceeded 1.5 feet, velocity measurements were taken at 20 and 80% of the water column. Stream temperatures and discharge were calculated at each transect. Details on the meter and depths sampled are on file with Baker County. All other field data was collected and analyzed by an EcoWest fisheries biologist.

A general habitat and channel unit characterization was made February 2-3, 2011 at a flow of approximately 17 cfs. Additional data were collected on March 15 at releases of approximately 100 and 200 cfs (actual discharge in the study area was measured at 106-109 cfs during the 100 cfs release and 199-204 cfs during the 200 cfs release). Data collection was made over this series of flows to (1) allow data collection at a low flow where characteristics such as bankfull width and percent riparian shade could be most easily measured, and (2) collect data over the range of flows typically occurring during redband trout spawning. During the potential spawning period of January 1 to May 15 (as defined by the Oregon water quality standards), flows range from very low to slightly over 100 cfs through April (except in high flow years). Flows are generally greater than 200 cfs during the peak redband trout May spawning period.

The general reach description provided below in sections 3.1 and 3.2 summarizes the data collected at the low flow stage. Section 3.3 provides a summary of the changes in channel unit type, water depths and velocities with increasing flows. Habitat data summaries are provided in Appendix A. Appendix B provides a photograph comparison of each channel unit under the three different flows. Appendix C provides the Wentworth and modified Wentworth particle size scales. Habitat data sheets and velocity and flow data are on file with Baker County.

3.0 RESULTS

3.1 General Study Area Description

The Powder River stream habitat survey extended from the pool directly below Mason Dam downstream to the gaging station, a distance of 0.16 miles (888.8 feet or 271.0 meters[m]; see Figure 1). The channel contained 100% flow from the river with no incoming tributaries in this section. The channel is constrained by multiple terraces and hillslopes. A parking lot and road to the parking area exists on the first upper terrace for the full length of the survey area on the north side of the river. There is a small picnic area on the south side of the river. The survey reach occurs within second growth ponderosa pine (south side of the river) and grass/sagebrush communities on the north side of the river. Some sedges, rushes, willows, alder and aspen line the edge of the river where it is not dominated by gravels and boulders. Several noxious weed plants (knapweeds and teasel) were visible adjacent to the river on river left (going downstream) in the survey area (see EcoWest 2009 for detailed descriptions of the riparian vegetation in the study area).

There is only one reach in the study area, as identified by valley and channel morphology, gradient and lack of tributary junctions. Five channel units were identified in the reach at low flow (see Figure 2). All five channel units were examined in detail. Land use adjacent to the first channel unit is primarily related to existing Mason Dam facility access and management. Land use adjacent to the rest of the reach is recreation parking, fishing and picnicking (see Baker County 2009 for additional information about recreational use of the area).

The average reach gradient was 1.56%. Riffles with pocket pools (56%) and scour pools (39%) were the dominant stream habitats at low flow. Five percent of the area included breaks or areas in which the units were only partially hydrologically connected. Bank erosion was 2% of the entire reach length. Large wood volume was low with 3 pieces, with no key pieces (>10m by 0.6 m). The average residual pool depth was 1.75 feet (0.53 m). The only pool with a depth greater than 1 meter at low flow was the pool immediately below the dam, the "stilling basin". There are no complex pools. The trees most frequently identified in the riparian zone were hardwoods (alder, 3-5 cm.) and conifers (ponderosa pine 3-30 cm). The average shade for the right bank (going downstream) is 55.2 % and average shade for the left bank is 35.6%. There were 582 boulders protruding above the water surface at low flow. Water temperatures were approximately 38 degrees F (3.3 degrees C) during the low flow survey.

3.2 Channel Unit Descriptions

Channel Unit 1: Scour Pool
GPS Coordinates: NAD 83 11T 042851/4947097 to 11T0420907/4947079

Channel unit 1 is the scour pool directly below the spillway (also known as the stilling basin). It is much wider than the normal stream channel and appears to reflect both scour from dam releases and some man-made modifications. Even at low flow the pool is approximately 15 feet (4.57 m) deep. The unit gradient is 1.0. The scour pool was 161.6 feet (49.11 m) long and 58.05 feet (17.70 m)

Figure 2. Location of Mason Dam Study Reach Channel Units at Low Flow.

Figure 3. Cumulative Particle Size Distribution-Mason Dam Study Area Transect #1

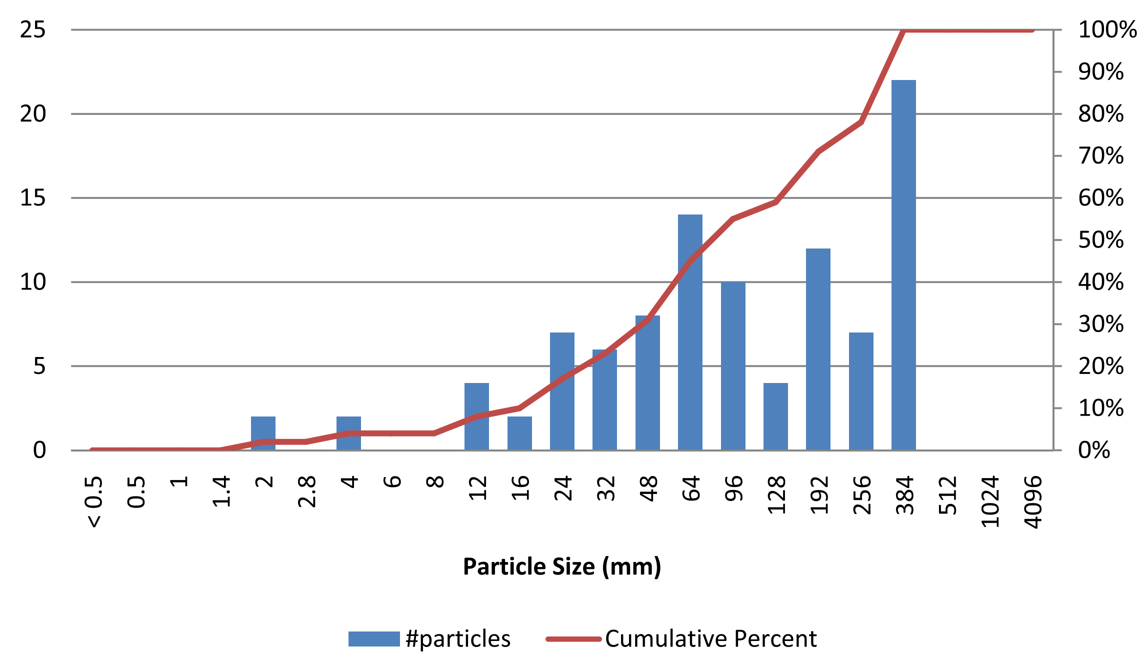
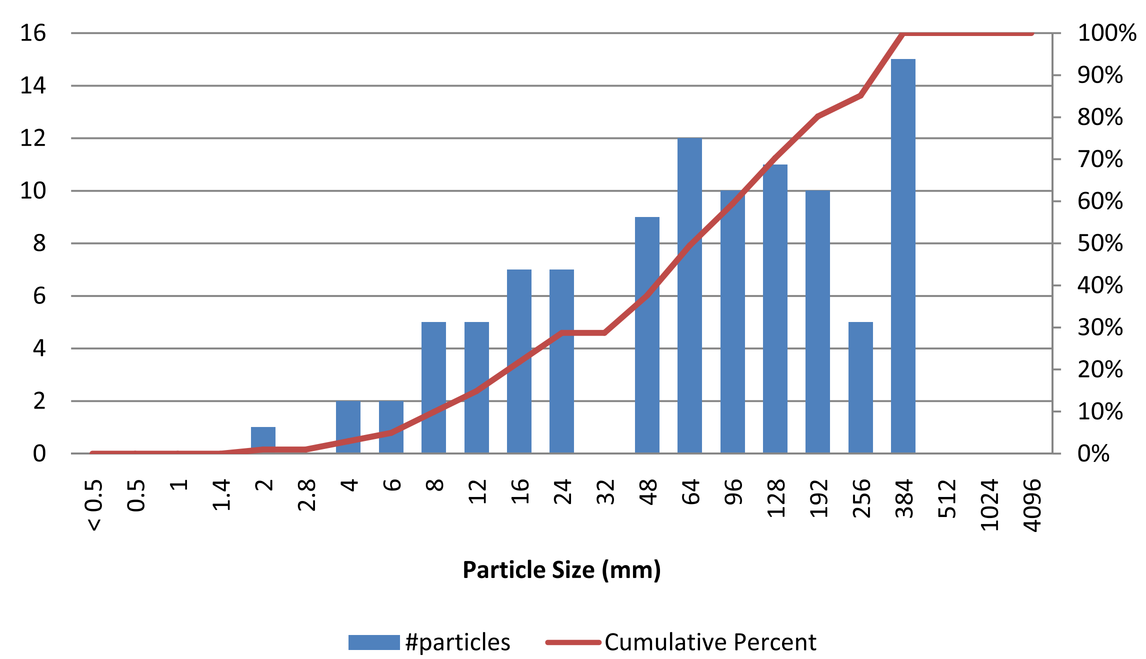


Figure 4. Cumulative Particle Size Distribution-Mason Dam Study Area Transect #3



wide at pool tail-out. Based on an ocular examination of the entire unit, cobble (45%) and gravel (45%) were the primary stream substrates within the pool, with large boulders dominating the pool along the low flow edge. There are 52 large boulders in the unit. Bank erosion was 10% in this unit occurring along the right bank below the dam. There is no large wood in or adjacent to this pool. There is almost no vegetation along the edge of this pool. It is dominated almost entirely by cobble and boulder. The average shade for the right bank (going downstream) is 44.0% and average shade for the left bank is 39.0%.

Velocity, discharge, and detailed particle measurements were made at the downstream end of the pool or "pool tail-out". The discharge was 17.26 cfs during the low flow survey. Velocities ranged from 0.02 to 1.52 ft/sec across the transect, with a mean velocity of 0.55 ft/sec (16 cm/sec).

At low flow and 100 cfs, there were no particles less than 4 mm within the wetted perimeter at the pool tail-out. At 200 cfs, two 2mm particles fell within the wetted perimeter, at very shallow depths. The D_{50} and D_{84} varied little among flows, with a D_{50} of 80 mm (small cobble) and a D_{84} of 291 mm (boulder size) at 200 cfs (Figure 3). More than fifty percent of the substrate consists of cobble (34%) and boulders (22%). Four percent of the substrate consists of coarse sands and fine gravels.

Channel Unit 2: Scour Pool
GPS Coordinates: NAD 83 11T 0420907/4947079 to 11T 0420937/4947068

Channel unit 2 is also a scour pool that is differentiated from the first unit by a substantial change in width (from almost 18 to 10 meters, or 58 to 34 feet), which is close to the average width of the stream reach. The average pool depth is 1.4 feet (0.43 m). The unit gradient was 1.5%. The scour pool was 121.6 feet (37.07 m) long and 34.10 feet (10.40 m) wide at pool tail out. Gravel (50%) and cobble (30%) were the primary stream substrates based on an ocular examination of the pool, with 67 large boulders. There was no bank erosion. There is no large wood in or adjacent to this pool. There is some aquatic vegetation along the edge of this pool but it still has a high component of cobble and boulder in the primary floodplain. The average shade for the right bank (going downstream) is 54% and average shade for the left bank is 38%.

Discharge at a transect across the downstream end of the channel unit was 17.23 cfs. Velocities ranged from 0.18 to 0.96 ft/sec across the transect, with a mean velocity of 0.59 ft/sec (18.09 cm/sec). Detailed particle size data was not collected along the transect.

Table 1. Comparison of Channel Unit Characteristics within the Mason Dam Fish Habitat Study Reach.						
Habitat Type	**Channel Unit #**	**Total Length**	**Wetted Width**	**Bankfull Width**	**Average Depth**	**Large Boulders**
SP/SB	1	161.6 ft (49.1 m)	58.0 ft (17.7 m)	111.7 ft (34.0 m)	15.0 ft* (4.6 m)	52
SP	2	121.6 ft (37.1 m)	34.1 ft (10.4 m)	69.7 ft (21.2 m)	1.4 ft (0.4 m)	67
RP	3	172.5 ft (52.6 m)	26.2 ft (8.0 m)	48.8 (14.9 m)	2.5 ft (0.8 m)	116
RP	4	349.6 ft (106.6 m)	30.1 ft (9.2 m)	47.2 (14.4 m)	2.4 ft (0.7 m)	288
SP	5	83.5 ft (25.4 m)	54.9 ft (16.7 m)	67.8 ft (20.7 m)	2.1 ft (0.6 m)	61
Reach Averages			40.7 ft (12.4 m)	69.0 ft (21.0 m)	1.75 ft * (0.53 m)	Total=584

SP/SB=Scour Pool/Stilling Basin
SP= Scour Pool
RP=Riffle with Pocket Pools
* Stilling Basin pool not included in average as it is partially man-made

Channel Unit 3: Riffle with Pocket Pools
GPS Coordinates: NAD 83 11T 0420937/4947068 to 11T 0420986/4947035

Channel unit 3 is classified as a "riffle with pocket pools," with the pocket pools created by the boulders in the channel (116 large boulders in the channel unit). The average riffle depth is 2.5 feet (0.76 m). The unit gradient was 2.1%. The riffle was 172.5 feet (52.59 m) long and 26.2 feet (7.98 m) wide at pool tail out. Cobble (60%) and gravel (25%) were the primary stream substrates based on an ocular survey. There was no bank erosion. There is no large wood in or adjacent to the pool. There is some aquatic vegetation along the edge of the pool, but it still has a high component of cobble and boulder in the primary floodplain. The average shade for the right bank (going downstream) is 70% and average shade for the left bank is 30%.

Discharge at a transect near the downstream end of the channel unit was 17.12 cfs. Velocities ranged from 0.61 to 1.34 ft/sec across the transect, with a mean velocity of 0.93 ft/sec (28.47 cm/sec).

At low flow, there were no particles less than 4 mm within the wetted perimeter. At 100 and 200 cfs, 1% of the particles within the wetted perimeter were smaller than 2 mm in size. The D_{50} and

D_{84} varied little among flows, with a D_{50} of 65.6 mm (size of small cobble) and a D_{84} of 241 mm (very large cobble) at flows above 100 cfs (Figure 4). The substrate is comprised primarily of cobble (38%), boulders (15%) and coarse gravel (27%). Ten percent of the substrate consists of coarse sands and fine gravels.

Channel Unit 4: Riffle with Pocket Pools
GPS Coordinates: NAD 83 11T 0420986/4947035 to 11T 0421089/4947025

Channel unit 4 is classified as a "riffle with pocket pools" with the pools associated with the boulders in the channel (288 large boulders in the channel unit). The average riffle depth is 2.4 feet (0.73 m). The unit gradient was 3.0. The riffle was 349.6 feet (106.58 m) long and 30.1 feet (9.18 m) wide at pool tail out. Cobble (55%) and boulder (25%) were the primary stream substrates. There was no bank erosion. There were two pieces of wood in this section, with one pine 28.0 feet long and one alder 14 feet long. There is some aquatic vegetation along the edge of this pool but it still has a high component of cobble and boulder in the primary floodplain. The average shade for the right bank (going downstream) is 58% and average shade for the left bank is 42%.

Discharge at a transect across the downstream end of the channel unit was 21.11 cfs. Velocities ranged from 0.27 to 3.16 ft/sec along the transect. Mean velocity was 1.17 ft/sec (52.64 cm/sec), although the accuracy of the mean was affected by the large number of the boulders along the transect. Detailed particle size data was not collected along the transect.

Channel Unit 5: Scour Pool
GPS Coordinates: NAD 83 11T 0421089/4947025 to 11T 0421115/4947023

Channel unit 5 is a scour pool located just above the gaging station and ending at the station. The average pool depth is 2.1 feet (0.64 m). The unit gradient was 0.20. The pool was 83.5 feet (25.45 m) long and 54.9 feet (16.73 m) wide at pool tail out. Gravel (50%) and cobble (35%) were the primary stream substrates, with 61 large boulders. There was no bank erosion. There was one piece of wood in this section, an alder 12 feet long. There is some aquatic vegetation along the edge of this pool but there still is a high component of cobble and boulder in the primary floodplain. The average shade for the right bank (going downstream) is 50% and average shade for the left bank is 29%.

Discharge at a transect near the downstream end of the channel unit was 16.68 cfs. Velocities ranged from 0.01 to 0.91 feet/sec across the transect, with a mean velocity of 0.48 ft/sec (14.01 cm/sec).

Channel unit 5 differed from the other channel units as 16% of the particles were less than 4 mm. The D_{50} and D_{84} varied little among flows, with a D_{50} of 31.4 mm (coarse gravel) and a D_{84} of 96 mm (small cobble) (Figure 5). The substrate is comprised primarily of very coarse sand (16%), cobble (24%) and gravel (53%).

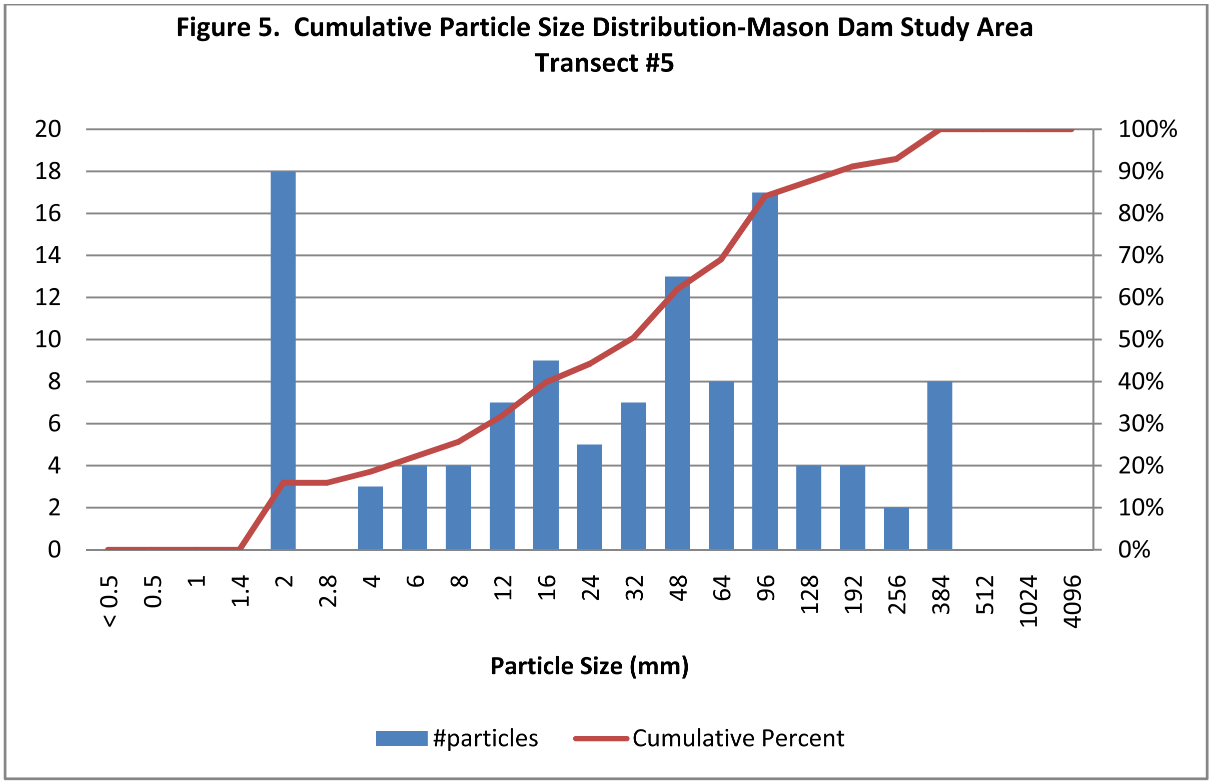


Figure 5. Cumulative Particle Size Distribution-Mason Dam Study Area
Transect #5
20
18
16
14
12
10
8
6
4
2
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
< 0.5
0.5
1
1.4
2
2.8
4
6
8
12
16
24
32
48
64
96
128
192
256
384
512
1024
4096
Particle Size (mm)
#particles
Cumulative Percent

3.3 CHANNEL UNIT CHANGES WITH INCREASING FLOWS

The five individual low flow channel units consolidated into just two channel units at flows greater than 100 cfs, without any hydrologic breaks between units. Channel unit 1 expanded in extent to form one large scour pool 303.6 feet long (92.6 m). The remainder of the channel formed one continuous riffle with pocket pools. The scour pool comprised 34% of the wetted area length and the riffle 66%.

Mean depths at the higher flows were measured primarily along the velocity measurement transects. In general, there was an increase in mean depth over low flow conditions of approximately 9 to 12 inches at 100 cfs releases (see Appendix A), except near the gaging station where the mean depth increased by approximately 4 inches. The change in mean depth between low flow and flows of slightly over 200 cfs were 16-18 inches, except near the gaging station where the depth increased approximately 8 inches.

Stream widths increased with the increased flows, with widths close to bankfull at 200 cfs. At 200 cfs, the stream was in contact with the adjacent riparian vegetation in the riffle unit, providing increased vegetation cover over the low flow condition.

The particle size distribution showed almost no change among flows, with the size distribution as reported in section 3.2. The number of boulders protruding above the water surface decreased with increasing flows from 584 at 17 cfs to 466 (at 100 cfs release) and to 332 (at 200 cfs release).

Velocities ranged from 14.0 to 35.6 cm/sec under low flow conditions (Table 2). Velocities increased along all transects at a 100 cfs release to between 30.72 to 68.64 cm/sec. Velocities increased again along transects 1, 2 and 5 to between 34.2 to 62.3 cm/sec with releases of 200 cfs. The survey crew was unable to safely collect velocity data along transects 3 and 4 at 200 cfs, as velocities were too high to stand. Velocities along these transects were estimated at substantially greater than 68 cm/sec, the flow along transect 4 at 100 cfs that was able to be safely collected earlier in the day by the same crew.

Table 2. Mean Velocities along Each of the Transects at Differing Flows.

Transect #	Low Flow- 17 cfs		100 cfs Release		200 cfs Release	
	ft/sec	cm/sec	ft/sec	cm/sec	ft/sec	cm/sec
1	0.55	16.0	1.00	30.72	1.12	34.23
2	0.59	18.1	1.09	33.33	1.42	43.27
3	0.93	28.5	1.56	47.49	> 2.25	>68
4	1.17	35.6	2.25	68.64	>2.25	>68
5	0.48	14.0	1.43	43.66	2.04	62.30

4.0 HABITAT SUITABILITY DISCUSSION

4.1 Overview

No overall habitat suitability model has been developed for redband trout, but the FWS rainbow trout habitat suitability model ([HSI], Raleigh et al. 1984) has been used as a base for assessing habitat conditions for *O. mykiss* and subspecies. The rainbow trout HSI addresses four life history stages (adult, juvenile, fry and embryo), with an "other" component that includes additional variables not specific to a single life history stage. Eighteen variables are included in the HSI, with key physical variables for spawning, incubation (embryo stage) and fry emergence including:

- **Substrate Size and Distribution**: Predominant substrate type, substrate size class distribution, mean gravel size, percent fines in riffles.

- **Mean Velocity**

The HSI presents a range of parameters that can be adapted for regional conditions or subspecies life history specifics. In addition to the substrate parameters listed in the HSI, the ability of the fish to move the substrate (or the size of the fish in relation to the substrate) is of critical importance in spawning.

Key factors for rearing include the **percent and quality of pool habitat/cover**.

Each of these key physical variables are discussed individually below.

4.2 Substrate Size and Distribution

4.2.1 Spawning Requirements

The size of spawning substrate material is important as it may be too coarse for a fish to move, or the percentage of fine material may clog the interstitial pores of gravels allowing spawning, but poor success in egg incubation and fry emergence. The suitability of stream substrate for spawning depends mostly on fish size, but the range of substrate suited for rainbow trout species is 1.3 to 10.2 cm (13 mm -102 mm) (Raleigh et al. 1984, Bjornn and Reiser 1991). Other general substrate characteristics include less than 10-12% fines (material < 2 mm), and an ability to move material so that eggs can be deposited within the substrate. In order for spawning redds to be constructed, most of the substrate must be moveable, which effectively sets an upper limit to the size of suitable spawning substrate.

During spawning, female trout select a redd in a riffle or at the downstream end or "tail-out" section of a pool. The female then excavates a small pit that is typically longer than her body length and deeper than the deepest body depth. In general, spawning fish can move substrate particles with a median diameter or D_{50} up to 10% of her length (Kondolf and Piegay 2003). Fish surveys in the Powder River watershed have documented redband trout of up to 10 inches or 254 mm (Powder

River Watershed Council 2004). Surveys in larger rivers within the area have documented redband trout sizes of just less than 500 mm (Chandler et al. 2003). Adult redband trout sizes in other systems range between 156 to 300 mm (see for example, Muhlfeld 2002). A redband trout with a length between 254 mm (as documented in the Powder River watershed) or up to 500 mm (as documented within the nearby Hell's Canyon complex), requires a median particle size or D_{50} between 25.4 to 50 mm (or less) to be moveable.

Muhlfeld (2002) found that Columbia River redband trout redds in Montana were dominated by small gravel (2–6 mm), with no substrate particle sizes larger than 75 mm. Adult red-band trout in the Hell's Canyon complex used a wide variety of substrate sizes, and were often observed within boulder and bedrock substrates (Chandler et al. 2003). However, these substrates were not used for spawning which occurs in smaller tributaries. Other studies throughout the western US have indicated that the D_{50} for rainbow trout spawning ranges from 15-70 mm, with a D_{90} up to 110 mm (Kondolf 2000, Kondolf and Piegay 2003). In a comparison of 27 studies of substrate size within *O. mykiss* redds (western rainbow trout and steelhead), Kondolf and Wolman (1993) found a range of 10.5-40 mm, with a D_{50} of 22.3 mm.

4.2.2 Egg Incubation/Fry emergence Requirements

Substrate size is also critical for egg incubation and fry emergence (Raleigh et al. 1984). The permeability of the substrate is critical in allowing dissolved oxygen to reach the developing embryos. An excess of fine material smothers the eggs and prevents alevin emergence. A number of metrics have been developed as to how much fine sediment is too much and these generally range up to a of maximum 10-12% of the substrate (Kondolf 2000).

After hatching, alevins live in intra-gravels and then migrate through the gravels to the surface. The availability of small gravels within the redd is critical for the fry to hide in after emergence.

4.2.3 Comparison to Mason Dam Habitat

Both general rainbow trout and redband trout specific surveys have identified a maximum range of spawning substrate size of up to 110 mm, with median particles sizes no more than 70 mm, or where fish are smaller, no more than 10% of the female trout body length. Using a redband trout length between 254 mm (as documented in the Powder River watershed) or up to 500 mm (as documented within the nearby Hell's Canyon complex) means that the median particle size would need to be between 25.4 to 50 mm or less to be moveable.

Particles sizes in the Mason Dam study reach range from 2 to 384 mm, with no fines. The median particles sizes within the reach are 96 mm at the stilling basin pool tail-out, 66 mm through the riffles and only reach a potentially moveable size at the gaging station (D_{50} of 31 mm). However, the range of substrate sizes throughout the reach vastly exceeds maximum reported spawning substrate sizes from hundreds of studies, with D_{84} values of 241-290 mm throughout most of the reach and D_{90} values of 190 mm at the gaging station.

There is no fine material (less than 2 mm) in the reach. There is also a distinct lack of small gravels (2-10 mm). Four percent of the substrate at the stilling basin pool tail-out consists of small gravels, with up to 10% of the substrate small gravels within the mid to lower reach riffle. Gravel does not become a major substrate component until the gaging station, where 25% of the substrate contains small gravels.

Substrate coarsening has been reported below many reservoirs as sediment is trapped and clear water (free of sediment) is released downstream (Kondolf 1997). The released water has the energy to move sediment, but since it carries no sediment, erodes the bed and streambanks for a period after dam construction until the bed material can not longer be moved. This process is referred to as armoring and results in the substrate being too large for spawning salmonids to move. A similar process appears to have occurred on the Powder River below Mason Dam as the median particle size is almost one-third the size of the redband trout observed in the watershed and much too large for the fish to move. The lack of small gravels also indicates that even if spawning did occur, that there would be no habitat for emerging fry.

The overall substrate particle size distribution, lack of small gravels, and high D_{50} and D_{84} values support the observations made by the fishery biologist during the field surveys (see Appendix A):

> "The pebble count however does not reveal the cemented-in substrate. Almost none of the substrate was moveable. Most of the gravels, cobble and boulders are well cemented into the substrate. There was very little loose gravel. Almost all of the cobble and boulders are covered with aquatic mosses. This area would not make good spawning habitat (not enough oxygen in substrate)."

4.3 Mean Velocity

4.3.1 Habitat Requirements

Raleigh et al. (1984) identified the optimal water velocity above rainbow trout redds during egg incubation to be between 30 and 70 cm/sec. Velocities less than 10 cm/sec or greater than 90 cm/sec were deemed to have zero suitability for egg incubation and fry emergence. Other rainbow trout studies (as summarized in Kondolf and Wolman [1993]) have identified that rainbow trout 300 mm in size can spawn at velocities up to 50 to 60 cm/sec.

Studies looking specifically at redband trout have identified that redds were constructed where velocities ranged from 23 to 69 cm/sec, with maximum suitability between 15-60 cm/sec (Mulhfeld 2002). Adult redband trout in the Hell's Canyon complex were found preferentially at velocities between 15 to 60 cm/sec, with use substantially reduced at velocities greater than 60 cm/sec, and zero use of habitats where velocities exceeded 85 cm/sec (Chandler et al. 2003). The average mean water column velocity for adult use in the Hells Canyon complex was 39 to 48 cm/sec. These velocities are slightly different from the overall rainbow trout HSI, but fall within the velocity ranges documented for other inland salmonids (as summarized in Muhlfeld [2000]).

Redband trout remain in the gravel for about 2 weeks after hatching (Behnke 1992) and emerge 45 to 75 days after egg fertilization. Fry residing in streams prefer slower velocities than do other 1ife stages of stream trout, using areas with velocities less than 30 cm/sec and preferring areas with velocities less than 8 to 10 cm/sec (Raleigh et al. 1984, Muhlfeld 2000).

In spite of local and species variability, optimal velocities suitable for spawning are generally exceeded at 60-70 cm/sec, with fry emergence where velocities are 30 cm/sec or less.

4.3.2 Comparison to Mason Dam Habitat

Redband trout spawn in the spring, with spawning in the Powder River basin occurring during April and May (Nowak 2004), but with peak spawning occurring in May (Tim Bailey, pers comm). Egg incubation generally takes between 4 to 6 weeks, with fry emergence in June and July, depending on the spawning time and temperature. Flows in April typically range between 50 to 100 cfs. Flows during the May peak spawning period through the June-July egg incubation and fry emergence period exceed 200 cfs and generally range between 200 to 300 cfs.

Velocities at 200 cfs (typical of flows during the Powder River May peak spawning period) range between 34 to 43 cm/sec within the single large scour pool (see Table 2), which is within the range of suitable spawning velocities. However, the substrate in this upper portion of the stream reach is much too coarse for spawning. Velocities are not suitable in the riffles for spawning at flows of 200 cfs or above.

Velocities would generally fall within a suitable spawning range during flows typical of April, but the substrate would still not be suitable. In addition, the flows during the June and July fry emergence period would be well above their tolerances, especially with the lack of small gravels for cover.

4.4 Pool Habitat and Cover

4.4.1 Habitat Requirements

There is less quantitative data and more within-data variability on juvenile rainbow trout and subspecies' rearing habitat requirements than for spawning habitat requirements. Raleigh et al (1984) identified that optimal rearing habitat required an equal mix of pools and riffles, but that rearing habitat would be considered good quality with pools comprising 37 to 67% of the stream habitat during late growing season, low flow conditions. Habitat quality decreases with both increased and decreased pool percentages.

Pool quality and cover is also important. For the highest quality habitat, large, deep pools (> 2 m deep and 5 m wide) or pools with more than 30% of the bottom obscured by vegetation, debris, large cobbles and boulders or surface turbulence should comprise more than 30% of the habitat (Raleigh et al. 1984). Moderate rearing habitat can be provided by either (a) large, deep pools providing between 10 to 30% of the reach, or (b) 30% of the habitat comprised of smaller pools with 5-30%

of the bottom obscured.

An additional requirement is the need for an adequate invertebrate food source, which is often inferred by the substrate type or other qualitative observations.

4.4.2 Comparison to Mason Dam Habitat

Because low flow and late season growing conditions differ within the Mason Dam study reach, measurements for both conditions are provided. The percent of habitat consisting of pools is 34% during late season (highest flow period) and 41% during low flows. In general, these ratios would provide good, but not optimal rearing habitat.

At both low and late season flows, 18% of the habitat consists of deep, wide pools, with additional habitat provided within the "riffle with pocket pool" habitat as flows increase. According to the Raleigh et al (1984) criteria, pool habitat quality would be rated as moderate.

During the field surveys, the fishery biologist identified that there was likely a very good invertebrate food source associated with the aquatic vegetation.

Overall, the Mason Dam study reach could provide moderate quality redband trout rearing habitat.

4.5 Conclusions

The substrate within the Mason Dam study reach has been armored and is too coarse to provide either redband trout spawning habitat or adequate habitat for egg incubation and fry emergence. Gravel does not become a major substrate component until the gaging station, where the overall bed framework may still be too large for redband trout to construct a redd. Riffle velocities exceed suitable spawning ranges at the 200 cfs flows that generally occur during the peak May spawning period. Pool velocities at 200 cfs vary between 34 to 43 cm/sec, which is within the range of suitable spawning velocities. However, the substrate in this upper portion of the stream reach is much too coarse for spawning.

Velocities during flows typical of April (50 to 100 cfs) would be suitable for spawning in some portions of the reach, but the coarse substrate would still prevent spawning. Even if spawning could occur, egg incubation/fry emergence would be limited by the lack of gravels and the very high velocities during the June-July fry emergence period.

The Mason Dam study reach could provide moderate quality juvenile and adult habitat.

Although not examined in this study, both the substrate and habitat complexity change substantially below the gaging station (EcoWest 2009), potentially providing spawning habitat downstream of the study reach.

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APPENDIX A

HABITAT DATA SUMMARY ACCORDING TO ODFW PROTOCOLS

Stream Report for the Powder River

STREAM: Powder River

BASIN: Powder River

DATES: February 2-3, and March 15, 2011

SURVEY CREW: Jim Lawrence and Jackie Dougan

REPORT PREPARED BY: Jackie Dougan

STREAM ORDER: 1 BASIN AREA: 1,750 miles square

USGS MAP: Bowen Valley

HUC NUMBER: 170502 03 LLID: 3515

LOW FLOW HABITAT SUMMARY

Valley and Channel Characteristics Summarized

Channel Morphology (Percent Reach Length)

- Narrow Valley Floor: Moderate V Shape- 100% for five units
- Constrained by Hillslope – 100%
- VWI = 1.45 (average valley floor width (59.28)/average channel width(40.67)

Channel Characteristics

- Type - Primary – 888.8 ft. (0.16 mile) (270.97 M.)

Channel Dimensions

- Active Wetted Width Average is 40.67 feet (12.39 M.)
- Bankfull Width Average 69.04 feet (21.04 M.)
- Average Depth (unit 2-5) 2.1 feet (0.64 M.)
- Stream Flow Type is LF = Low Flow - Discharge is 17 cfs.
- Average Gradient:1.56
- W:D ratio = 11.6 (14.87 M/1.28 M.)

Water Temperature 2-2-11 39.0-40.0 F. (3.8-4.4 C.)
2-3-11 37.6-37.97 F. (3.11 – 3.31 C)

Riparian, Bank and Wood Summary

- Land Use: Primary ST (Second Growth Timber) Secondary ST
- Riparian Vegetation – Dominate -C (Coniferous Forest)15-30
  Sub- Dominate S (Shrubs)
- Banks Actively Eroding – 4% Undercut Banks – 2%
- Reach Average Shade - Left side – 35.6%; right side 55.2% (going downstream)
- Large wood – 2 pieces (>=3 M. x 0.15m.) 1 for volume with no key pieces.
- Total/100m. primary channel = 0.20; and 0.10 for volume.

Habitat Detail – Reach 1

Habitat Type	Number Units	Total Length	Wetted Width	Bankfull Width	Average Depth	Large Boulders
SP (Stilling Basin)	1	161.6 ft. (49.11 M.)	58.05 ft. (17.70 M.)	111.70 ft. (34.05 M.)	(15.0 ft.)* (4.57 M.)	52
SP	2	121.6 ft. (37.07M.)	34.1 ft. (10.40 M.)	69.7 ft. (21.25 M.)	1.4 ft. (0.43 M.)	67
RP	3	172.5 ft. (52.59 M.)	26.2 ft. (7.98 M.)	48.8 ft. (14.87 M.)	2.5 ft. (0.76 M.)	116
RP	4	349.6 ft. (106.58 M.)	30.1 ft. (9.17 M.)	47.2 ft. (14.39 M.)	2.4 ft. (0.73 M.)	288
SP	5	83.5 ft (25.45 M.).	54.9 ft. (16.73 M.)	67.8 ft. (20.67 M.)	2.1 ft. (0.64 M.)	61
		Total Length 888.8 ft. (270.97 M.)	Ave. Width 40.67 ft. (12.39 M.)	Ave.Bankfull width. 69.04 ft. (21.05 M.)	Ave. Depth 1.75ft.(0.53M) (* not part of average)	Total Boulders 584

Substrate – Percent Wetted Area-Based on Channel Unit Ocular Estimates

Unit Number	S/O	Snd	Grvl	Cbl	Bldr	Bdrk
Unit 1	5	5	45	45	--	--
Unit 2	--	10	50	30	10	--
Unit 3	--	--	25	60	15	--
Unit 4	--	--	20	55	25	--
Unit 5	--	5	50	35	10	--
Total	1%	4%	38%	45%	12%	0

Habitat Summary

Habitat Group	Number Units	Total Length	Avg. Width	Avg. Depth	Wetted Area Percent*
SP Stilling Basin	1	161.1 (49.11 M.)	58.05 (17.69 M.)	15.0 (4.57 M.)	18%
SP	2	205.1 (93.01 M.)	44.5 (13.56 M.)	1.75 (0.53 M.)	23%
RP	2	522.1 (159.17M.)	28.15 (8.58 M.)	2.45 (0.75 M.)	59%
*Does not include a 2% break between units 2 and 3 and a 3% break between units 3 and 4.					

Pool Summary

- Only 1 pool >= 1 meter deep. This is the pool below the spillway.
- There are no complex pools
- All Pools are 41% of the total area surveyed (39% accounting for unit breaks)
- Residual pool depth of scour pools outside of the stilling basin is 1.75 ft. (0.53 M.)

Riparian Zone Vegetation Summary

Average Number of Trees in a 5 meter band
Zone 1 – Floodplain 2 conifers; 1 3-15 cm, 1 15-30 cm.; 14 willow < 3 cm.
Zone 2 – High Terrace 1 conifer 3-15 cm.
Zone 3 – High Terrace 5 conifers 3-15 cm.; 39 young alder < 3cm.

Canopy Closure
Zone 1 – 45%
Zone 2 – 10%
Zone 3 – 60%

Shrub and Grass/Forb Cover
Zone 1 – Shrub, 70% and grass/forb cover 30%
Zone 2 – Shrub, 10% and grass/forb cover 90%
Zone 3 – Shrub, 40% and grass/forb cover 60%

Predominant landform in each Zone
Zone 1 – Floodplain 100%
Zone 2 – High Terrace – 100%
Zone 3 – High Terrace – 100%

Surface Slope
Zone 1 – 44%
Zone 2 – 8%
Zone 3 – 3%

Average Number of Trees in a 5 – M. wide band
7 conifers between 3-30 cm., 14 willow and 39 young alder all <3 cm.

Field Observations/Comments

The pebble count however does not reveal the cemented in substrate. Almost none of the substrate was moveable. Most of the gravels, cobble and boulders are well cemented into the substrate. There was very little loose gravel. Almost all of the cobble and boulders are covered with aquatic mosses. This area would not make good spawning habitat (not enough oxygen in substrate) but it is good rearing habitat, due to the many deeper pockets in the pools and riffles that make good hiding cover. The invertebrate population is usually good in this area due to the filter feeding attachments available in the mosses and rocks.

There is old evidence of one beaver dam in the 4th unit. There was a heron along the river when we arrived on February 3, 2011. There is a good osprey nest directly north of the survey site, above the highway.

Powder River Channel Habitat Changes at Different Flows

On 3/15/11 releases at Mason Dam were increased to over 100 cfs., to look at the 5 habitat units on 0.16 mile of the Powder River below the dam. On that same day releases were also increased to over 200 cfs. During the two releases information and measurements were taken on: channel habitat, width and depths at transects, substrate, water quality, boulder number and pictures.

Habitat Data at 100 cfs release.
Channel Habitat: The five habitat units (1 Deep Scour Pool, 2 other Scour Pools and 2 Riffle with Pocket Pools) changed to one scour pool and one riffle/with pocket pools with no breaks between units

Channel Habitat Units at 17 cfs

Habitat Group	Number Units	Total Length	Wetted Area Percent
SP Stilling Basin	1	161.1 (49.11 M.)	18%
SP	2	205.1 (93.01 M.)	23%
RP	2	522.1 (159.17M.)	59%

Channel Habitat Units at 100 cfs.

Habitat Group	Number Units	Total Length	Wetted Area Percent
SP	1	303.6 (92.56 m.)	34%
RP	1	585.2 (178.4 m.)	66%

Length and Depth of Measured Riffle/Pool Transect #3
At 17 cfs transect #3 was 26.20 ft. (7.98 M.) wide.
Average Depth was 2.5 Ft. (0.76 M.)

At 100 cfs. Transect #3 was 38.8 ft. (11.83 M.) wide
Average Depth was 3.30 Ft. (1.00 M.)

Substrate Changes: There was no visible movement of any substrate. There were no changes in any unit of the original substrate analysis.

Water Quality: There was almost no plume visible of sediment. There was very little visible sediment seen with the rise from approximately 20 cfs. to over 100 cfs. Water appeared very clear within minutes of the full flow of over 100cfs. being accomplished.

Boulder Counts: The number of boulders protruding above the water surface at this flow was 466.

Units	Large Boulders at 17 cfs	Large Boulders at 100 cfs
Unit 1	52	43
Unit2	67	51
Unit3	116	84
Unit4	288	231
Unit5	61	57
Total Boulders	584	466

Habitat Data at 200 cfs.

Channel Habitat: The five habitat units (1 Deep Scour Pool, 2 other Scour Pools and 2 Riffle with Pocket pools) changed to one scour pool and one riffle/with pocket pools, with no breaks between units. There was no change in habitat units from 100-200 cfs.

Channel Habitat Units at 17 cfs

Habitat Group	Number Units	Total Length	Wetted Area Percent
SP Stilling Basin	1	161.1 (49.11 M.)	18%
SP	2	205.1 (93.01 M.)	23%
RP	2	522.1 (159.17M.)	59%

Channel Habitat Units at 200 cfs.

Habitat Group	Number Units	Total Length	Wetted Area Percent
SP	1	303.6 (92.56 m.)	34%
RP	1	585.2 (178.4 m.)	66%

Length and Depth of Measured Riffle/Pool Transect #3

At 17 cfs transect #3 was 26.20 ft. (7.98 M.) wide.
Average Depth was 2.5 Ft. (0.76 M.)

At 100 cfs. Transect #3 was 38.8 ft. (11.83 M.) wide
Average Depth was 3.30 Ft. (1.00 M.)

At 200 cfs. Transect #3 was 44.1 ft. (13.45 M.) wide
Average Depth (not measured)

Substrate Changes: There was no visible movement of any substrate. There were no changes in any unit of the original substrate analysis.

Water Quality: There was almost no plume visible of sediment. There was very little visible sediment seen with the rise from approximately 100-200 cfs. Water appeared very clear within minutes of the full flow of over 200cfs. being accomplished.

Boulder Counts: The number of boulders protruding above the water surface at this flow was 332.

Units	Large Boulders at 17 cfs	Large Boulders at 200 cfs
Unit 1	52	52*
Unit2	67	42
Unit3	116	58
Unit4	288	139
Unit5	61	41
Total Boulders	584	332

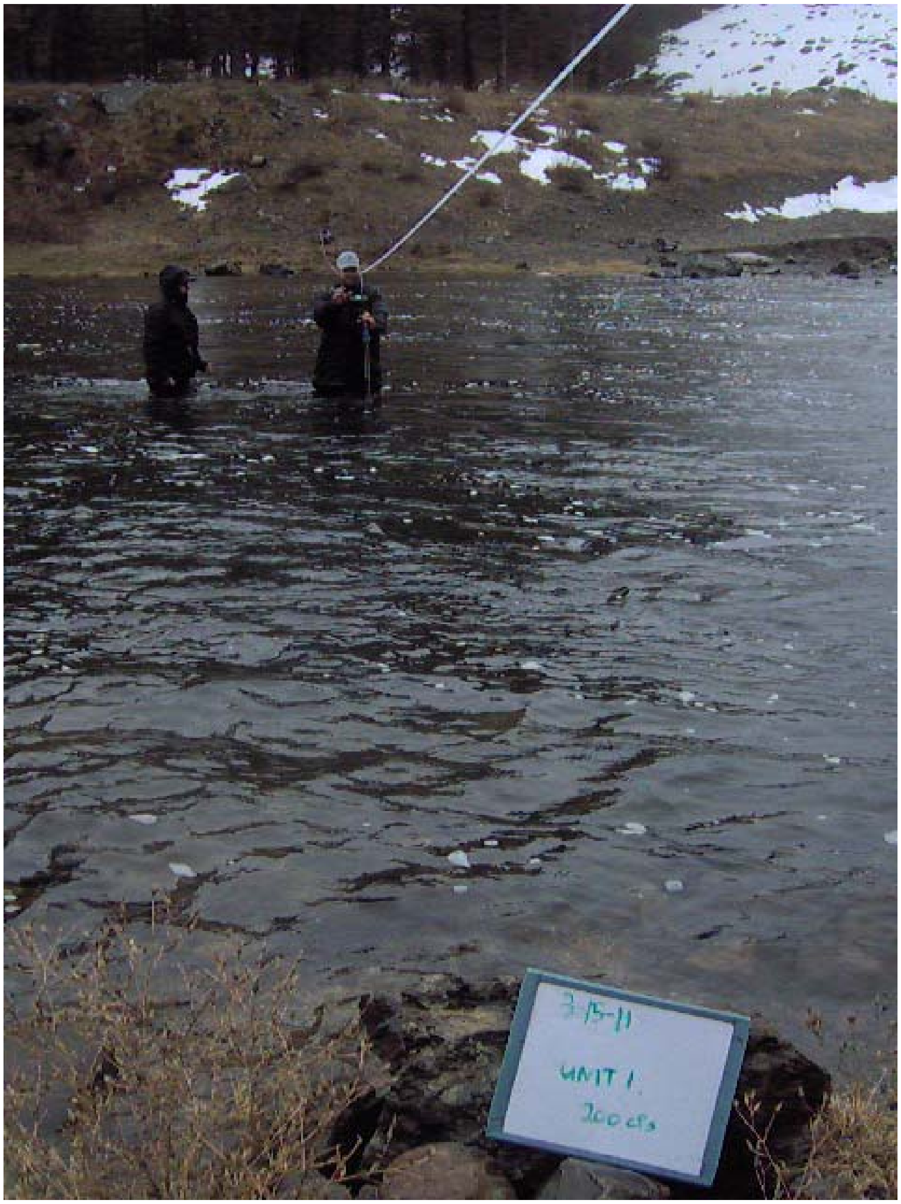
- The only reason this number was the same as in the original survey were more boulders were touched by the higher flow in the pool. This is due to the heavy armoring on this pool , just below the dam.

APPENDIX B

CHANNEL UNIT PHOTOGRAPHS AT LOW FLOW AND RELEASES OF 100 CFS AND 200 CFS

Unit 1 – Across channel at Low Flow

Unit 1 at 100 cfs



Unit 1 at 200 cfs

Unit 2, upper end looking across channel-Low Flow

Unit 2 at 100 cfs

Unit 2 at 200 cfs

Unit 3 looking across channel-Low Flow


Unit 3 at 100 cfs

Unit 3 at 200 cfs

Unit 4 – looking across channel-Low Flow


Unit 4 at 100 cfs

Unit 4 at 200 cfs


Unit 5 at Gaging Station-Low Flow

Unit 5 at 100 cfs.

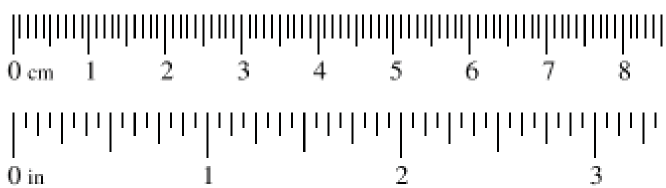
Unit 5 at 200 cfs.

APPENDIX C

WENTWORTH AND REVISED WENTWORTH PARTICLE SIZE SCALES

Wentworth Size Classes

Inches (in)		Millimeters (mm)	Wentworth size class	
			Boulder	Gravel
	10.08	256		
			Cobble	
	2.56	64		
			Pebble	
	0.157	4		
			Granule	
	0.079	2.00		
			Very coarse sand	Sand
	0.039	1.00		
			Coarse sand	
	0.020	0.50		
			Medium sand	
1/2	0.0098	0.25		
			Fine sand	
1/4	0.005	0.125		
			Very fine sand	
1/8	0.0025	0.0625		
			Coarse silt	Silt
1/16	0.0012	0.031		
			Medium silt	
1/32	0.00061	0.0156		
			Fine silt	
1/64	0.00031	0.0078		
			Very fine silt	
1/128	0.00015	0.0039		
			Clay	Mud



Particle Description	Intermediate Axis of Particle (mm)	Substrate Type	Particle Count Tally	Particle Count Results		
				Total#	Item %	Cumulative %
Silt/Clay	<.062	Silt/Clay				
Very Fine	.062-.125	Sand				
Fine	>.125-.25					
Medium	>.25-.5					
Coarse	>.5-1.					
Very Coarse	>1-2					
Very Fine	>2-4	Gravel				
Fine	>4-6					
Fine	>6-8					
Medium	>8-11					
Medium	>11-16					
Coarse	>16-23					
Coarse	>23-32					
Very Coarse	>32-45					
Very Coarse	>45-64					
Small	>64-90	Cobble				
Small	>90-128					
Large	>128-180					
Large	>180-256					
Small	>256-362	Boulder				
Small	>362-512					
Medium	>512-1024					
Large-Very Large	>1024					
Bedrock		Bedrock				
Sample Size:		**Totals:**				