Endangered spring Chinook salmon, *Oncorhynchus tshawytscha*, in the Elbow Coulee primary side channel during the first post-restoration spring channel activation event, 15 June 2009.
1. Executive Summary

In September 2008, the Elbow Coulee Floodplain Reconnection and Side Channel Restoration Project was implemented in order to: 1) re-establish a primary side channel to the Twisp River at RM 6.6; 2) increase habitat complexity and large woody debris recruitment potential; and 3) increase habitat for native fish, especially rearing-age salmonids. Specifically, a rock breach was constructed in an existing dike at the upper entrance to the primary side channel (Figure 1). The sill (breach) functions as a grade control structure and permits flow to enter the side channel. The sill was designed to activate the side channel when flows in the Twisp River (based on USGS gauge #12448998 data) reached 200-400 c.f.s., which represents a 1.5 – 2 year flow event (i.e. bankfull flow).

Post-project monitoring of the restored side channel and associated floodplain is necessary to gauge project success at meeting goals and to form the basis of adaptive management. Monitoring will consist of both quantitative and visual examinations of side channel form and function. Specifically, monitoring was conducted to assess the: 1) response of the primary side channel geomorphic configuration to restoration activities designed to create long-term habitat benefits; 2) Response of physical characteristics (primarily discharge and water temperature) and the biological community to habitat restoration and the newly re-established aquatic habitats within the primary side channel; and 3) identify steps needed to adaptively manage the project in order to maximize project success.

Key findings of the 2008-2009 monitoring effort include the following:

- The primary side channel was activated when Twisp River discharge approached 300 c.f.s., but flows in excess of 575 c.f.s. may be required for unimpeded fish passage through the breach.
- The side channel was activated on four occasions for a total of 107 days with the longest occurring during spring runoff when the channel was active for 78 consecutive days.

Figure 1. Elbow Coulee primary side channel breach with the Twisp River in the background, 7 July 2009.
- Endangered spring chinook salmon and threatened steelhead trout were observed in the side channel and some of these fish entered through the restored breach.
- Fish use, primarily rearing, of the side channel is year-round and is facilitated by groundwater flow that provides passage to the Twisp River at the downstream end of the side channel.
- Water temperature in the side channel was both warmer in winter and cooler in summer than the adjacent Twisp River. This may provide salmonids with a thermally beneficial environment.

2. 2008-2009 Monitoring Results

2.1 Physical Habitat
A stream habitat survey was conducted in the primary side channel on 20-21 November 2008. This survey used the USFS Level 2 Stream Inventory protocol (USFS 2006) to obtain channel type, substrate, large wood, and longitudinal profile data. Generally, surveys of this nature proceed in an upstream direction, but as the location of the downstream terminus of the channel is determined by discharge in the Twisp River, it was determined that beginning the survey upstream would increase repeatability of subsequent surveys.

Stream habitat in the side channel was dominated by riffles which accounted for half of the total habitat units and nearly 60% of the total side channel length (Table 1). Pools were the second most common habitat type and accounted for only slightly over 12% of the total channel length. The channel was dry in two locations (in the vicinity of construction activities upstream of groundwater influence) covering approximately one-quarter of the channel. Runs and marsh habitat combined accounted for <7% of the channel habitat.

Table 1. Units and length of Elbow Coulee Primary Side Channel habitat types based on USFS Level 2 Stream Inventory, November 2008.

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Number of units</th>
<th>Length (feet)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool</td>
<td>4</td>
<td>119</td>
<td>12.3</td>
</tr>
<tr>
<td>Riffle</td>
<td>9</td>
<td>574</td>
<td>59.6</td>
</tr>
<tr>
<td>Run</td>
<td>2</td>
<td>40</td>
<td>4.2</td>
</tr>
<tr>
<td>Marsh</td>
<td>1</td>
<td>25</td>
<td>2.6</td>
</tr>
<tr>
<td>Dry Channel</td>
<td>2</td>
<td>205</td>
<td>21.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18</td>
<td>963</td>
<td>100</td>
</tr>
</tbody>
</table>

Longitudinal profile data are presented in Figure 2. In total, 120 depth measurements were collected along the thalweg and depth generally varied between 0.3’ and 0.6’. The mean depth was 0.43’ and the deepest point measured was 1.2’ in a pool near the downstream end of the channel. During this survey (representing base flow conditions) residual depth for the pools varied between 0.5’ and 1’. Mean channel width was 6.3’ and varied between a minimum of 1.5’ and a maximum of 12.5’.
Substrate measurements were taken at 25% intervals at cross sectional transects (five at each). Substrate in the channel was dominated by small particles of silt and detritus which were present at nearly 75% of the sampling locations. These particles were commonly associated with pools and lower gradient runs and were especially prominent in the previously dry reach upstream from the groundwater source. The remaining 25% of substrate was comprised of gravels and cobbles associated with the sparse higher gradient sections and at the return drop into the Twisp River. Boulders were only encountered at the uppermost transect across the breach. During this survey, and in subsequent casual observations, it was noted that a 3-12” thick layer of fines overlaid cobble in many locations in the channel and it is noted that these could become exposed after a large flow event through the side channel.

Large wood was present in the side channel (within the bankfull channel) in over half (55%) of the habitat units (10 of 18 units). Wood was dominated by small logs (>6”-12” diameter, >20’ long) which accounted for 27 of the 30 pieces counted (90%). Medium sized wood (>12”-20” diameter, 35’ long) comprised the remaining 10%. No large logs (>20” diameter) were observed. The majority of the wood was present in the lower half of the channel downstream of the AquaRod deployment site and no wood was present in the upper 200’ of channel that was disturbed during construction.

2.2. Channel Cross Sections
Twelve channel cross sectional profiles were surveyed during 19-21 November 2009. Cross sections were spaced at equal intervals beginning at the upstream entrance sill (breach) to the side channel and moving downstream to the return to the Twisp River (Appendix A). The survey used the EMAP channel survey protocol (Peck et al. 2001) to establish transect locations. However, this survey added an extra transect in the upper section in order to gain more detail of the channel in the construction zone where the channel is not fully defined. Over the length of the channel, cross sections were spaced 88’ apart and photographs were taken at each.

The channel at the breach (XS 1) was dry at the time of the survey and is several feet higher than the channel immediately downstream. The bankfull area in the vicinity cross sections 2 and 3 is
relatively wide and the channel in this reach is not very well defined as it was subject to construction impacts. When wetted, the channel flows within a defined channel, but topographically the area is relatively flat and the channel width increases significantly, and expanding into several braided channels, with small increase in discharge. Downstream of cross section 3, the channel gains perennial groundwater and flows within a narrower, yet well defined, bankfull channel. This channel form maintains integrity downstream into the area just upstream of cross section 10, at which point the channel widens until it rejoins the Twisp River downstream of cross section 12. In this reach, the channel is broad at higher discharge, but is difficult to determine because of adjacent, and extensive, emergent vegetation and sediment through which the water flows. The narrowest bankfull channel width area is in the vicinity of cross section 5.

The wetted channel during the survey (completed during groundwater-derived base flow) generally varied from 2’-7’. The widest wetted cross section was at cross section 8 which was over 30’ wide. However, a small hummock braided the channel at this location, thus the entire channel was not wetted.

2.3 Discharge
Discharge characteristics in the primary side channel were monitored through a combination of staff gauge readings, flow estimates, water level monitoring and visual observations. Flow measurements during the first season of monitoring were focused around capturing the period when the side channel was activated by flows entering from the Twisp River. Groundwater input into the channel was assumed to be relatively constant, thus less effort was directed at obtaining flow measurements during the periods when the channel was dominated by groundwater. However, monitoring data obtained in 2009 indicates that more attention is needed to investigate baseflow regime in the side channel and this will be included in future monitoring efforts.

Ten discharge estimates were made in the side channel at the staff gauge and AquaRod deployment pool between 2 December 2008 and 16 June 2009 which led to the development of a rating curve (Figure 3). As expected, flow in the side channel increased with increased depth measured at the staff gauge. A peak discharge of 13.89 c.f.s. was recorded in the side channel on 30 May 2009 that corresponded with a Twisp River flow of 1610 c.f.s. at the downstream USGS gauge (#12448998). The spring runoff in Twisp River peaked on the same day at a flow of 1790-1830 c.f.s, so this discharge measurement in the side channel likely underestimates, to a small degree) the peak flow that actually moved through (albeit only a few hours) the side channel in 2009. Only one discharge measurement was collected at baseflow (no Twisp River input) and resulted in a flow of 0.24 c.f.s. This could be considered primarily groundwater sourced as the Twisp River flow at this point in time was flowing at 123 c.f.s. and not entering the side channel.

The relationship between discharge in the side channel and Twisp River is displayed in Figure 4. The gauge reading of 0.32’ represents the baseflow condition with no direct input of Twisp River (flowing at 123 c.f.s.) water into the side channel.
Visual observations at the breach confirmed no visible flow from the Twisp River was entering the side channel at the time and the upper 200’ of channel was dry. All other data were derived during visually confirmed hydrologic connectivity between the Twisp River and the side channel, and, based on these data, discharge in the side channel increases relatively gradually when the Twisp River is flowing between 630-900 c.f.s. Flow in the side channel increased sharply when flow in the Twisp River approached and exceeded 1000 c.f.s. Based on these data, and additional visual observations, it appears that 1000 c.f.s. flowing in the Twisp River corresponds to a bankfull flow in the existing, un-restored portion of the side channel. It is noted, however, that more data and observations are needed to fully support this assertion and more fully develop a relationship between ground and surface water flow in the side channel.
The time period of side channel activation was examined through flow patterns in the Twisp River (Figure 5), side channel water level measurements (figure 6) and visual observations. The primary side channel was engineered to activate when discharge in the Twisp River was between 200-400 c.f.s. (USBR 2008). Based on visual observations on several dates in 2009, flow began to seep through the breach when discharge in the Twisp River reached 250-275 c.f.s. and flow in the side channel became noticeable in the restored (upper) portion of the channel when flows reached about 300 c.f.s. Although at this discharge flow is moving through the breach rather than over it, 300 c.f.s. appears to be the approximate discharge required to activate the side channel.

![Figure 5. Twisp River discharge and gauge height at USGS station #12448998, 10/08-11/09. Icing of monitoring instruments occurs during winter at this station and is responsible for data gaps in December and January.](image)

On 21 May 2009, flow over the “sill rock” in the breach cut, considered to be the base elevation post-construction, was observed and measured at 1.5 mm deep. The Twisp River discharge at this point in time was 637 c.f.s., thus it is estimated that a flow of approximately 580-600 c.f.s. in the Twisp River is sufficient to crest the sill rock. This flow also appears to correspond to the point on the line in Figure 4 (between 0.92 and 1.19 side channel gauge height) where flow increases significantly in the side channel. Maximum water depth above the sill rock was measured at 1.1’ on 30 May 2009 which coincides with peak spring flow in the Twisp River in 2009.

Water level in the side channel was measured hourly at the upper staff gauge pool with an AM&C AquaRod water level monitor between 30 September 2008 and 16 November 2009 (and is currently on-going). These data indicate that four flow events in the side channel occurred during the monitoring period (figure 6). [Note: A fifth, and short duration (<8 hours), event was recorded on 22 October 2008, but it is believed that this is a result of an AquaRod recording error as the Twisp River was flowing <100 c.f.s.]. AquaRod water level data is generally supported by both USGS gauge data (for flows >300c.f.s. which activate the side channel) and visual observations. However, during the two winter flow events ice was noted as affecting the USGS gauge and thus there is some disagreement between specific discharge data from the
USGS gauge and AquaRod measurements. In these two instances, it is thought that the AquaRod was measuring water level accurately and that the rises in water level associated with side channel activation did occur.

The first side channel activation post-construction was brief and occurred between 12-13 November 2008 (Table 2) and peak Twisp River discharge during this period was 536 c.f.s. The next two events occurred during the winter and were both of longer duration and of higher discharge than the first (Table 2) with Twisp River flows of up to 650 c.f.s. recorded. Yet, during both of these events discharge in the side channel was less than 2 c.f.s. It is noted, however, that the Twisp River gauge was affected by ice during these events and may not be a fully accurate representation of flow patterns in the river.

Table 2. Flow activation schedule for Elbow Coulee Primary Side Channel, 10/08-11/09.

<table>
<thead>
<tr>
<th>Date Activated</th>
<th>Date Deactivated</th>
<th>Peak Twisp Flow</th>
<th># days active</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/12/08</td>
<td>11/13/08</td>
<td>536 c.f.s.</td>
<td>2</td>
</tr>
<tr>
<td>12/20/08</td>
<td>1/7/09</td>
<td>758 c.f.s.</td>
<td>19</td>
</tr>
<tr>
<td>1/24/09</td>
<td>1/31/09</td>
<td>642 c.f.s.</td>
<td>8</td>
</tr>
<tr>
<td>4/21/09</td>
<td>7/7/09</td>
<td>1790 c.f.s.</td>
<td>78</td>
</tr>
<tr>
<td>TOTAL</td>
<td>n/a</td>
<td>n/a</td>
<td>107</td>
</tr>
</tbody>
</table>

Overall during the monitoring period, the side channel was activated by Twisp River flow for 107 days with the spring runoff event accounting for nearly 75% of this time. Spring side channel activation was designed to coincide with the steelhead spawning window in the Twisp River and these data indicate that in 2009 it was available habitat for migrating or spawning adult steelhead. For reference purposes only, if the 2008 hydrograph is taken into consideration, the side channel would have been activated (based on a discharge of 300 c.f.s. in the Twisp River, as the side channel had not been re-connected at this time) between 5 May and 12 July, a total of 69
days. This connection is 9 days fewer than what was observed, but it still coincides with adult steelhead migration and spawning in the Twisp River.

2.4 Water Temperature
Water temperature in the primary side channel and in the Twisp River adjacent to the side channel was continuously monitored on an hourly basis from 3 December 2008 to 16 November 2009 (and is presently on-going). To ensure data accuracy, temperature loggers (both Onset Temp Pro V2 and Onset Tidbits were used) were submitted to pre- and post-deployment accuracy checks (ODEQ, 200X). Unfortunately, the temperature logger deployed in the Twisp River was lost or stolen during the summer of 2009 and thus data are unavailable for that location after 9 April 2009.

Daily maximum, minimum and average water temperature data for the primary side channel are presented in figures 7 and 8, respectively. Generally, temperatures in both locations were coldest from December through March and the Twisp River remained near 0 °C for two months between mid-December through mid-February. During this period, the side channel was warmer and fluctuated between 2-5 °C. A noticeable increase in temperature occurred in both locations beginning around early April and this increase continued into September in the side channel. The side channel had a maximum temperature of 11.87 °C on 2 September and consistently averaged around 10°C for much of July, August and September. Unfortunately, summer temperature data are missing from the Twisp River location, but it is believed that summer maximums were significantly higher than in the side channel. This is supported by data from a temperature monitoring location in the Twisp River above Buttermilk Creek (approximately 5 RM upstream of Elbow Coulee) that experienced a maximum temperature of 17.63 °C on 28 July. Additionally, a monitoring site at the USGS stream gauge approximately 4 RM downstream of Elbow Coulee had a maximum temperature of 20.62 °C on 12 August which is nearly twice the maximum temperature recorded in the side channel. Beginning around early October, the side channel temperature began its seasonal decline to wintertime lows and this trend was likely occurring in the Twisp River as well.

![Figure 7. Maximum, minimum and average water temperature from the Elbow Coulee primary side channel, 12/08 – 11/09.](image-url)
Figure 8. Maximum, minimum and average water temperature from the Twisp River adjacent to the Elbow Coulee side channel, 12/08 – 4/09.

A comparison of the 7 day average temperature between the primary side channel and adjacent Twisp River is made for the period that data was available from both locations (Figure 9). These data illustrate the difference in temperature regimes between the two locations during the cold portion of the year with the side channel commonly 2-4° C warmer than the adjacent Twisp River. As noted above, the Twisp River averaged near 0° C for nearly two months while the side channel average was consistently above 2° C during this period. Although the side channel is largely spring fed during this period of record, fluctuations in side channel average temperature were recorded and could be a response to changes in the ambient air temperature as well as flow entering the channel from the Twisp River which likely occurred on two occasions between 20 December and 31 January. These events may be responsible for the sharp decreases in average temperature observed during the first half of the run.

Figure 9. 7-day average temperature for the Elbow Coulee primary side channel and the adjacent Twisp River, 12/08-4/09.
Although data are unavailable for comparison, it is expected that beyond April the average in the Twisp River climbed to summertime highs that exceeded the side channel average by as much as 4-8° C. Additional data collection from both locations will likely confirm this occurrence on an annual basis.

2.5 Fish Surveys
A fish population survey, via electrofishing, was conducted in the primary side channel on 3 December 2008. Additional snorkel and visual surveys were conducted on four occasions in June and July 2009 when the restored upper channel reach was activated with flow from the Twisp River. The primary survey involved three-pass removal electrofishing of the entire groundwater-derived baseflow wetted channel that covers a distance of approximately 700’. A USGS crew assisted USBR in survey work and the majority of fish captured were PIT tagged for possible detection within the Methow subbasin.

In total, 41 fish representing three species were captured and identified during electrofishing (Table 2). Fish were captured along the entire length of the wetted channel and were most commonly observed in the deeper portions of the channel in pools. The species list could include a fourth member if any of the unidentified *Oncorhynchus* were *O. clarki lewisi* (cutthroat trout), yet this was not determined. When species and size (age) classes are combined, the three pass depletion lies within an estimated coefficient of variation of 25%. A more precise population estimate could have been obtained with a fourth pass, but logistical considerations during sampling prevented this from occurring.

Nearly half of the fish sampled were unidentified *Oncorhynchus* trout, most likely rainbow/steelhead trout. Including these fish with the positively identified *O. mykiss* would increase the percentage of this species to over 80% of the sample. *O. mykiss* (including unidentified trout) ranged in size from 37-150 mm in length. Based on their silver coloration and size (>140 mm), several of the *O. mykiss* were identified as steelhead smolt, so it is likely that the channel contained both resident and anadromous forms of this species. Several of these fish were PIT tagged and at least one of them moved downstream and was detected in the lower Twisp River in May 2009.

<table>
<thead>
<tr>
<th>Species</th>
<th>Pass 1</th>
<th>Pass 2</th>
<th>Pass 3</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook salmon (<em>Oncorhynchus tshawytscha</em>)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Unidentified <em>Oncorhynchus</em> (&lt;80mm)</td>
<td>11</td>
<td>5</td>
<td>2</td>
<td>18</td>
<td>43.9</td>
</tr>
<tr>
<td>Rainbow/steelhead trout (<em>Oncorhynchus mykiss</em>)</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>16</td>
<td>39.1</td>
</tr>
<tr>
<td>Brook trout (<em>Salvelinus fontinalis</em>)</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>14.6</td>
</tr>
<tr>
<td>TOTAL (N=41)</td>
<td>24</td>
<td>11</td>
<td>6</td>
<td>41</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2. Fish survey species data, Elbow Coulee Primary Side Channel, 3 December 2008.

Brook trout were the second most abundant species encountered, with six fish ranging between 105-130 mm sampled during the three passes. At least three of these were ripe males who expressed milt during handling. One juvenile Chinook salmon (*Oncorhynchus tshawytscha*, length = 72 mm) was captured during sampling and, based on the location of documented spawning areas, this fish was likely an endangered spring Chinook salmon (figure 10).
The uppermost reach of the channel (~70 meters immediately downstream of the breach) was snorkeled on 15 June 2009 to determine fish presence in the newly established portion of the side channel. During this survey, 16 young-of-the-year Chinook salmon were observed and photographed. These fish were estimated to be between 40-65 mm in length. Additionally, one 130 mm *O. mykiss* was observed along with four larval *Cottus* sp. (Figure 11). After this survey, water in this reach of the side channel became too shallow and silty to snorkel effectively.
However, five subsequent visual surveys for fish presence occurred on 23, 26, 30 June and 2 and 9 July (flow through the breach and into the channel effectively ceased around 7 July, see results in section 2.4). Between 8 and 15 young-of-the-year Chinook and *O.mykiss* combined were observed in the channel during each of these visits, although their number decreased to only 5 fish on 9 July, just prior to cessation of input flow. These fish likely became stranded in the upstream pool in the channel, but this was not verified. It is likely that at least some fish moved downstream into the perennial section of the side channel prior to upstream disconnection. Temperatures during snorkeling and visual surveys ranged between 7-13° C.

2.6 Photo Monitoring
In total, 23 photopoints were established in the side channel. These photopoints cover a variety of habitat features and include all twelve channel cross section locations. Several photopoints are located around the breach and upper section where the channel is less well defined. Photos were taken at a variety of flow levels (figures 12 and 13) and all are documented in the photo journal for the site.

3.0 Discussion
The Elbow Coulee primary side channel was designed and engineered largely to re-establish connectivity between side channel floodplain habitat and the mainstem Twisp River in order to increase habitat complexity and provide habitat for ESA listed salmonids. Monitoring results obtained in 2008 and 2009 indicate that this goal has largely been met and it is likely that this project will provide habitat for spring chinook salmon, steelhead, and possibly bull trout for years to come. Indeed, the project was completed in the fall of 2008 and soon after the side channel was activated by flow from the Twisp River for the first time in over 50 years.

Prior to the first side channel activation event, discharge monitoring and visual observations over several years (J. Molesworth, USBR, personal communication) revealed that groundwater influence into the side channel was perennial with a discharge of approximately 0.24 c.f.s. Yet, water level data also indicate that groundwater influence in the side channel is not constant and may be influenced by seasonal factors such as irrigation operations, precipitation, riparian transpiration rates, soil dynamics, etc. Furthermore, groundwater discharge may be influenced by the location within the side channel, as it appears that groundwater may be infiltrating into the side channel along a continuum rather than from a single point source. Thus, more flow may exist near the terminus of the side channel as opposed to the upper staff gauge pool where flow measurements have been concentrated. Additional discharge measurements at multiple locations during groundwater only periods are needed to fully assess the groundwater patterns in the side channel as it is possible that the average annual groundwater discharge is significantly different from the 0.24 c.f.s. measured in 2008.

Importantly, the perennial nature of the side channel groundwater provides at least 700’ of fish bearing habitat as witnessed by the collection of numerous fish, including spring Chinook salmon and steelhead, along the entire length of the baseflow wetted channel. The perennial groundwater provides year-round connectivity to the Twisp River and juvenile fish are certainly using the side channel for rearing. The side channel is dominated by shallow riffles, yet pools are providing deeper habitat throughout the wetted channel.
Figure 12. Elbow Coulee primary side channel near peak channel activation flow, 30 May 2009. Twisp River discharge at time of photo was 1720 c.f.s. Young-of-the-year Chinook salmon were observed in the pool in the middle of the photo two weeks later.

Figure 13. Elbow Coulee primary side channel nearly disconnected from the Twisp River, 7 July 2009. Twisp River discharge at time of photo was 303 c.f.s.
Brook trout were present in the side channel prior to any activation events, and it is believed that they have been using the side channel for many years. Brook trout have also been observed in the adjacent ponds which also have seasonal access to the Twisp River. Several of the brook trout captured were ripe males who were possibly attempting to spawn in the side channel. No redds were observed during the survey, but brook trout are known to spawn over the variety of substrates currently present in the side channel. The brook trout captured were large enough to be considered possible predators of young-of-the-year fish.

The side channel lies within a dense and complex riparian forest that is contributing a significant amount of wood to the stream channel. While this wood, derived primarily from willow and alder, is mostly <12” in diameter, it is responsible for the creation of several fish bearing pools and pockets and appears to be contributing to overall habitat complexity. Larger cottonwoods are present along the channel and an active beaver community has been observed working on several of these trees. It is assumed that over time some of these larger trees will make their way into the side channel where they would then have the possibility of recruitment into the Twisp River during a flood event.

Post-construction observations at the breach indicate that a Twisp River discharge of approximately 250-275 c.f.s. (measured at the USGS gauge 4 RM downstream) is sufficient to activate slight flow through the breach and flow begins to connect with the groundwater channel when flows reach approximately 300 c.f.s. All of this flow is through the breach and the exact flow where upstream connectivity becomes established for fish passage is not fully known (i.e. it is not known if fish can and will pass through the breach). Flows greater than approximately 580 c.f.s. are sufficient to crest the rock sill in the breach and fish would have uninhibited, albeit shallow, passage into the upstream end of the side channel at this flow. Once in the side channel, fish would have the ability to move downstream within the side channel and also back into the Twisp River at the terminus of the side channel. Thus, flow in excess of 600 c.f.s. should be sufficient to allow passage for all life stages of fish.

During the first year post-construction, the side channel was activated by the Twisp River on four occasions for a total of 107 days. Three of these were winter events of relatively low discharge and duration and, hence, significance related to influencing the dynamics of the side channel. Icing of instruments was, and will likely continue to be, a significant factor affecting the ability to continuously measure discharge in both the side channel and Twisp River and thus visual observation during suspected activation events is warranted. These winter events likely afforded little opportunity for fish passage.

The spring runoff activation event (based on 300 c.f.s. in the Twisp River) in 2009 lasted for 78 days and was entirely dependant (obviously) on the Twisp River hydrograph. Based on USGS gauge data, the 1790-1830 c.f.s. peak flow in 2009 was approximately a 1.5 year event (2 year event = 2,470 c.f.s.). Thus, the side channel was able to capture this flow for over 2 months. Based on USGS daily average flow since 1974, the side channel could be expected to be activated for 98 days during the “average” spring runoff period (again, based on 300 c.f.s.). While the side channel in 2009 was activated for 20 days less than this in 2009, this is not surprising given the magnitude of the hydrograph. It does not appear the flows observed in 2009 were sufficient to provide a significant amount of scouring in the side channel. If this is the case, then flows in excess of a two year event will likely be needed in order to flush the large amounts of fine sediment that have accumulated in the side channel.
Peak flow in the side channel was 13 c.f.s. during the spring runoff and discharge into the side channel increased sharply when Twisp River discharge exceeded ~575 c.f.s. As a result, habitat availability likely increased dramatically during this period, although only for a relatively short duration.

While rearing sized fish were observed in the side channel prior to re-connection, the presence of young-of-the-year fish, including ESA listed salmonids, in the uppermost pool in the side channel is strong evidence that these fish gained access to the side channel through the newly constricted breach. Although it is plausible that 40 mm salmonids could have swum up the side channel from the bottom, this explanation is untenable when considering the presence of larval sculpin that lack the swimming ability to move upstream through the side channel. Thus, it is concluded that fish, either volitionally or passively, gained access to the side channel during the first activation event post-emergence and resided in the channel until it became disconnected from the Twisp River at the upstream end. The period of this residency for these fish is estimated at several weeks to months and possibly longer for fish that select to remain in the groundwater influenced portion of the channel.

Rainbow trout/steelhead were the most numerous fish sampled in the groundwater (baseflow) channel, and although other species were present, including chinook salmon, it is likely that the restored side channel may provide the most benefits to this species. Yet, additional monitoring will be required to fully assess this.

The fate of the fish that entered the side channel is unknown. Based on numbers of fish observed at any one time (<20 from the uppermost pool) throughout channel activation during spring runoff, some likely moved downstream into the perennial portion of the channel and thus gained access to the perennial portion of the channel with access to the Twisp River. Five chinook and steelhead were observed in the uppermost pool during the period when activation was ceasing in early July and these fish likely became isolated in the top pool. Once isolated these fish probably did not survive and probably succumbed to predation, starvation or lethal high temperatures.

With the possible exception of brook trout, spawning habitat for salmonids is very limited in the side channel and it is unlikely that successful spawning will occur in the side channel in its present configuration. There is a high amount of fine silt throughout the channel, and although this material overlays potential spawning substrates (cobble and gravel) in some locations, it appears that a significant flow event would be required to transport this material off these substrates before some type of spawning potential develops in the side channel.

The temperature regime in the side channel appears to be one that would be favorable for fish use during many portions of the year. The side channel was both warmer in winter and cooler in summer when compared to the adjacent Twisp River. This difference was as much as 3-5 °C in winter and likely as much or more during summer. Juvenile fish rearing in the side channel may experience a thermal regime that favors growth, hence, survival.

Monitoring goals in this first year were focused around an initial investigation into the physical and biological aspects of the side channel through the development of a baseline dataset on which future monitoring can be based. These goals were largely met, yet additional monitoring will be necessary to develop a broad enough understanding of the functionality of the restored habitat in order to adaptively manage the project to increase functionality and overall effectiveness.
4.0 Monitoring Recommendations

1. Continue to monitor the side channel at a level similar to that in 2008-2009, including flow (discharge and water level), temperature, fish use, and photopoints. Repeat channel cross sections in five years or when a significant (>10-20 year flood) flow event occurs.

2. Investigate groundwater baseflow in the side channel through discharge measurements when the channel is not activated (summer-spring).

3. Develop a more specific sediment monitoring plan to investigate sediment dynamics. Methods could include additional pebble counts and/or scour and fill chains.

4. Check water temperature thermographs and water level monitors more frequently (i.e. every two months) to insure that they are present and functional.

5. Consider re-vegetation of primary side channel area influenced by construction activities. Although natural plant regeneration is likely, willow sprigs placed in uppermost reach of the side channel would have a high probability of survival without significant maintenance and could contribute cover and nutrient input sooner than plants germinating from other sources.

5.0 Literature Cited


APPENDIX A. PRIMARY SIDE CHANNEL CROSS SECTIONS
(Note: Cross section 1 is upstream beach and subsequent sections are downstream. Sections move from left bank to right bank and red lines demark approximate wetted channel location during survey, with the exception of cross section 1 where the red line denotes the restored breach. Variations in scale are present in both X and Y-axes.)