Morse Creek Stream Restoration Monitoring Project 2010

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1 INTRODUCTION

This report summarizes stream channel and riparian habitat conditions in and along Morse Creek as part of the North Olympic Salmon Coalition’s (NOSC) restoration project. Pre-construction habitat and channel conditions were characterized as severely degraded. The stream was channelized, confined, and over-steepened, diked, and depleted of large woody debris (LWD). The intent of the restoration project was to restore high quality mainstem, side-channel, and off-channel habitat, as well as reconnect the stream system with its historical floodplain.

The purpose of this report is to provide long-term baseline monitoring data on pre-and post-restoration habitat conditions. This report includes three main sections:

- Introduction (Section 1)
- Methods (Section 2)
- Results (Section 3)

1.1 Monitoring Approach

Three intensive monitoring reaches were identified during the monitoring scoping phase, these included the following: abandoned channel, the new channel (and side channels), and an upstream control reach (see Figure 1). Several additional channel segments were also identified, including the following: impact reach #1, impact reach #2, overflow channel #1 and #2, overflow return #1 and #2, and the old pond.

The downstream end of impact reach #1 corresponds to a point just downstream of the restoration project boundaries, the upstream end is at the intersection of the abandoned channel and the new main channel. The downstream end of impact reach #2 corresponds to the confluence with the new main channel and the upstream boundary corresponds the upstream project limits. Table 1 includes the measured lengths for all reaches monitored.

Table 1. Morse Creek monitoring reach lengths. (lengths need to be updated)

<table>
<thead>
<tr>
<th>Reach</th>
<th>Length (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abandoned Channel</td>
<td>364</td>
</tr>
<tr>
<td>Control Reach</td>
<td>500</td>
</tr>
<tr>
<td>New Main Channel</td>
<td>471</td>
</tr>
<tr>
<td>Side Channel #1 &amp; #3</td>
<td>244</td>
</tr>
<tr>
<td>Side Channel #2</td>
<td>109</td>
</tr>
</tbody>
</table>
Figure 1. Morse Creek site map.
2 Methods

This section includes an overview of the methods used to monitor the Morse Creek Restoration project.

2.1 Channel Thalweg Survey

Measurement stations were established at distances equal to 1/100\textsuperscript{th} of the surveyed reach length. Transects (both primary and secondary) were established at distances equal to 1/20\textsuperscript{th} of the surveyed reach length. Secondary and primary transects alternated between transects with the first transect being a secondary transect and the second transect being a primary transect. Permanent reference points were established at long-term monitoring cross-sections.

For primary transects the following parameters were measured: thalweg depth (to nearest 0.01 meter), wetted width (to nearest 0.1 meter), bankfull width (to nearest 0.1 meter), bar width (to nearest 0.1 meter), thalweg soft sediment (Yes or No, sediment less than 16 mm), habitat unit ID (from habitat survey), particle size and depth at left edge of water, 25, 50, 75, and 100\% wetted width, GPS location, and a minimum of two photos (one looking downstream and one looking upstream).

Particle size was determined by measuring the b-axis of the particle. The first step in determining the length of the b-axis is to determine the length of the a-axis. The a-axis was defined as the longest axis across the particle. The b-axis was defined as the longest intermediate axis perpendicular to the a-axis.

Particle size was determined by measuring the b-axis of the particle. The first step in determining the length of the b-axis is to determine the length of the a-axis. The a-axis was defined as the longest axis across the particle. The b-axis was defined as the longest intermediate axis perpendicular to the a-axis.

Figure 2. Diagram depicting a-, b-, and c-axis for an irregularly shaped particle (from: Yuzyk and Winkler 1991 \textit{in} Brunte and Abt 2001).

Detailed pebble counts were made at each channel cross-section (see below) The methods used were adapted from Wolman (1954) and involved collecting and measuring
the b-axis of 100 streambed particles. The measurer started at the right or left bank edge of channel and took one pace along the cross-section. Facing away from the stream bottom a pointer was used to randomly select a particle for measurement. The particle was picked up and the b-axis was measured and recorded. The measurer then proceeded taking one-pace across the channel in a random, zigzag manner staying within +/- 2 meters of the cross-section center line.

Riparian condition and canopy cover data were collected at each primary transect. In-stream canopy cover was measured using a Model-A convex spherical densitometer. The instrument was held level, approximately 30 cm in front of the operator at elbow height, so that the operator’s head was just outside of the grid area. The densitometer was modified from the manufacturer, it included four equally spaced dots in each of the 24 squares. The number of dots covered by canopy were counted and summed. To find percent canopy closure the sum was multiplied by 1.04167.

The first series of measurements were taken within +/-2 meters of the center of the low flow wetted width at each primary transect. Four measurements were made from the middle of the low flow wetted width: facing upstream, toward left bank, downstream, and toward right bank. Two additional measurements were also made: one from the left edge of water facing the left bank and other from the right edge of water facing the right bank.

Riparian condition was evaluated at each primary transect. Riparian conditions were classified using the methods generally outlined in WFPB (1997). An area 15 meters upstream and downstream and 30 meters deep was assessed and classified using the criteria in Table 2.

Table 2. Summary of watershed analysis riparian habitat classification (source: WFPB 1997).

<table>
<thead>
<tr>
<th>Dominant Riparian Condition</th>
<th>First letter code used in series of three</th>
<th>Second letter code used in series of three</th>
<th>Third letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dom. Veg. Type</td>
<td>C &gt; 70%Conifer Dominated</td>
<td>D &gt; 70% Deciduous</td>
<td></td>
</tr>
<tr>
<td>Dom. Veg. Type</td>
<td>D &gt; 70% Deciduous</td>
<td>M = all other cases</td>
<td></td>
</tr>
<tr>
<td>Average tree size</td>
<td>(S) small &lt; 12 inches DBH</td>
<td>(M) medium &gt;12 in. DBH &lt; 20 in. DBH</td>
<td></td>
</tr>
<tr>
<td>Average tree size</td>
<td>(L) large &gt; 20 inches DBH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stand density</td>
<td>(D) dense &gt; two-thirds canopy closure</td>
<td>(S) Sparse &lt; two-thirds canopy closure</td>
<td></td>
</tr>
</tbody>
</table>

For secondary transects the same parameters were measured as in the primary transect except no BFW, GPS, riparian/canopy cover data were collected. Photos were also not routinely taken at secondary transects.

Non transect stations: At these stations the following parameters were measured: thalweg depth, wetted width, bar width (to nearest 0.1 meter), thalweg soft sediment (Yes or No, sediment less than 16 mm), and habitat unit ID (from habitat survey). In addition all side
channels, off-channel habitat, tributary confluences, and other features were be noted and recorded.

2.2 LWD Survey

For the abandoned channel and control reach LWD survey data were collected during the thalweg survey. Each piece of LWD was inventoried and recorded based on the thalweg distance from the start of survey. The following parameters were also measured and/or recorded: cumulative distance, piece ID, diameter at large end, diameter at small end, rootwad attached (yes/no), length, species class (conifer/deciduous/unknown), jam ID (each piece of LWD was classified as either in a jam or not in a jam, if in a jam, jam ID was recorded), channel position (e.g., LBm-left bank margin), habitat unit forming (Yes/No, and habitat unit ID), and notes.

2.3 Habitat Unit Survey

These data were collected at the same time as the thalweg survey data. The downstream end of each habitat unit was recorded based on distance from start of survey. The upstream end of each unit corresponded to the downstream end of the next upstream habitat unit. The following parameters were inventoried and recorded: cumulative distance, habitat unit ID, habitat type [plunge pool (PP); scour pool (SP); lateral scour pool (LP); dammed pool (DP); bedrock pool (BRP); step pool (STP); pools behind boulders (POB); mixed pocket water (POWC); glide (G); run (RUN); rapid (R); cascade (CS); low gradient riffle(LGR); low gradient riffle w/ pockets (LGRP); high gradient riffle (HGR)], pool forming agent (LWD, LWD jam, bed, bank, boulders, bedrock, roots, etc…), maximum depth, pocket depth 2, pocket depth 3, residual depth, unit length, and notes.

2.4 Channel Profile and Cross-Sections

A channel profile was run upstream from the start of each survey reach surveyed. The water surface and substrate elevations were measured and recorded at all primary and secondary transects. Standard survey methods were employed using an auto level, tripod, and stadia rod. Reference elevations were established at a minimum of two points at each of the permanent cross-sections.

Cross-section elevation measurements were typically measured at 1 meter intervals along each cross-section. However, these measurement intervals varied depending upon topography, in some cases measurements were made at less than or greater than 1 meter intervals. Detailed pebble counts were conducted at each cross-section following the methods outlined above for detailed pebble counts (see Section 2.1).
2.5 Post Restoration Treatment Survey

2.5.1 Thalweg and Habitat Survey

The thalweg and habitat survey was conducted using the same methods as described above in Sections 2.1 and 2.3

2.5.2 Engineered Logjam-LWD Survey

Nearly every piece of LWD placed within the bankfull width was part of an engineered logjam (ELJ). Many of these pieces were buried and therefore it was not possible to inventory all pieces of LWD placed. Each ELJ or combination of ELJs was inventoried. The following data were measured and recorded for each ELJ: jam ID (including design ID), stream reach (e.g., new channel), upstream end (distance from start of survey), downstream end, jam length, average width, average maximum height, average minimum height, channel location, and notes. A minimum of one photo was taken of each jam.

All clearly visible LWD pieces were inventoried, and subset was tagged with a unique numbered aluminum tag. Each LWD piece had the following parameters measured and recorded: approximate distance from new channel start of survey, piece number, tag number (when tagged), diameter within +/- 1 meter of tag, rootwad attached (y/n), piece size (S/M/L), species type (conifer, deciduous, unknown), jam ID, channel position, and notes. Size classes were defined based on the diameter at the mid-point of the piece. Sizes were small (10-20 cm), medium (20-50 cm), or large (>50 cm).

2.6 Snorkel Surveys

Snorkel surveys were conducted on August 16, 2010. Three stream segments were surveyed. Habitat unit boundaries were delineated in the field prior to the survey. Length and area measurements were made based on the previously conducted habitat and thalweg surveys. Three snorkelers entered each habitat unit from the downstream end, surveying in the upstream direction. Within each habitat unit each snorkeler was assigned a lane within the habitat unit to reduce potential double counting of fish. One recorder was stationed on the bank and recorded the observations called out by the snorkelers.

Juvenile salmonids were recorded based on age class, age class was based on size. Age 0+ coho were less than 70 mm length and age 1+ coho were 70-140 mm length. Age 0+ trout were less than 60 mm, age 1+ trout were 60-100 mm, and age 2+ trout were greater than 100 mm. No other juvenile salmonid species were present within the stream segments surveyed.
3 RESULTS

3.1 Abandoned Stream Reach

3.1.1 Thalweg and Habitat Survey Results

Thalweg and habitat surveys were conducted August 6 and 7, 2010 (prior to abandoning
the channel; Department of Ecology [DOE] Four Seasons stream discharge~74 cfs, site
below aqueduct ~66cfs). The total length surveyed was 364 meters (1,194 ft). Stream
gradient was measured at 17.5 meter (57 ft) intervals, a total of 20 measurements were
made. Bankfull width measurements were made at 11 observation points. Wetted width
and thalweg depth measurements were made at 105 observation points. A summary of
the results is included below in Table 3.

Table 3. Abandoned stream reach channel gradient, BFW, wetted width, and thalweg
depth summary.

<table>
<thead>
<tr>
<th>Measurement Range</th>
<th>Gradient</th>
<th>BFW (m / ft)</th>
<th>Wetted Width (m / ft)</th>
<th>Thalweg Depth (m / ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>3.9%</td>
<td>29.7m / 97ft</td>
<td>21.4m / 70ft</td>
<td>1.2m / 3.9ft</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.1%</td>
<td>18.7m / 61ft</td>
<td>6.4m / 21ft</td>
<td>0.25m / 0.8ft</td>
</tr>
<tr>
<td>Average</td>
<td>1.0%</td>
<td>23.7m / 78ft</td>
<td>13.9m / 46ft</td>
<td>0.65m / 2.1ft</td>
</tr>
</tbody>
</table>

A total of 44 thalweg canopy closure measurements were made at 11 observation points.
Average canopy closure ranged from 14 to 95 percent at the 11 observation points.
Reach level canopy closure averaged 63 percent. However, observation point one had
been disturbed by the construction of the stream channel, excluding this point reach level
canopy closure averaged 68 percent. Riparian conditions varied along the reach. The
lower (175m/575ft) left bank of the riparian area was classified as deciduous, small,
sparse. The road and road prism occupy much of the potential riparian area in this
segment. The upper 175 meters along the left bank was classified as deciduous, medium,
dense. The right bank riparian forest was classified as deciduous, small, dense.
However, 4 of 11 observations were classified as deciduous, medium, and either dense or
sparse.

A total of 15 habitat units were delineated in this stream reach. Eight different habitat
types were classified, these included: a low gradient riffle (1), low gradient riffles
w/pocket water (3), high gradient riffles (3), rapids (3), a cascade (1), a lateral scour pool
(1), and bedrock pool (1), and runs (2). These units were later grouped together into four
categories: riffles (all riffle types), rapids (including cascades), pools (all types), and runs.
Table 4 depicts the habitat unit breakdown including percentage of habitat by length and
area.

A total of only 10 pieces of LWD were identified within this reach. This resulted in 0.65
pieces per channel width. Total volume of LWD within the BFW of this segment
equaled only 6.3 m³. This equates to a volume of 1.7 m³ per 100 meters of channel or
0.0007 m³ per square meter of channel.
Table 4. Summary of habitat units in abandoned channel reach.

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Number of Units</th>
<th>Total Unit Length (Meters)</th>
<th>Percent (length)</th>
<th>Total Unit Surface Area</th>
<th>Percent (area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool</td>
<td>2</td>
<td>70</td>
<td>19%</td>
<td>758</td>
<td>15%</td>
</tr>
<tr>
<td>Rapid</td>
<td>4</td>
<td>84</td>
<td>23%</td>
<td>1,161</td>
<td>23%</td>
</tr>
<tr>
<td>Riffle</td>
<td>7</td>
<td>175</td>
<td>48%</td>
<td>2,711</td>
<td>54%</td>
</tr>
<tr>
<td>Run</td>
<td>2</td>
<td>35</td>
<td>10%</td>
<td>425</td>
<td>8%</td>
</tr>
</tbody>
</table>

Pebble counts were conducted at 21 transects, a total of 105 stream particles were measured. For reporting purposes fines were tabulated as one mm and bedrock was tabulated as 4,000 mm, one mm was added to all measurements and particle sizes are reported as cumulative percent smaller than (see Figure 3).

![Particle Size Distribution](image)

Figure 3. Abandoned channel reach particle size distribution from the 21 transects delineated during the thalweg survey.
### 3.1.2 Snorkel Survey Results

Two short stream segments were snorkel surveyed on August 16, 2010. The lower survey segment consisted of 108.5 meters of channel. There were three habitat types sampled in this segment. This reach corresponds to the lower portion of the reach which is expected to be backwatered and fed by groundwater post project. The upper survey reach was 84 meters in length and included three habitat types. Part of this reach was subsequently filled in as part of the restoration project.

A summary of the habitat units contained within the snorkel survey segments is included in Table 5. A summary of trout and salmon densities observed in snorkel surveys is included in Table 6. Note that no other juvenile salmonids other than coho and trout were observed during the snorkel surveys. Also note that only 2 of 118 juvenile coho were classified as age 1+.

**Table 5. Summary of habitat unit types and sizes contained within the snorkel survey segments.**

<table>
<thead>
<tr>
<th>Reach ID</th>
<th>Habitat Unit ID</th>
<th>Habitat Type</th>
<th>Start Distance (m)</th>
<th>Stop Distance (m)</th>
<th>Length (m)</th>
<th>Average Wetted Width (m)</th>
<th>Avg. Thalweg Depth (m)</th>
<th>Surface Area (Sq. meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-Lower 4/5 Riffle</td>
<td>45.5</td>
<td>94.5</td>
<td>49</td>
<td>17.2</td>
<td>0.5</td>
<td>844</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Lower 6 Rapid</td>
<td>94.5</td>
<td>112</td>
<td>17.5</td>
<td>16.0</td>
<td>0.6</td>
<td>281</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Lower 7 Run</td>
<td>112</td>
<td>133</td>
<td>21</td>
<td>11.1</td>
<td>0.8</td>
<td>232</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Lower 8 Rapid</td>
<td>133</td>
<td>154</td>
<td>21</td>
<td>12.9</td>
<td>0.6</td>
<td>271</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Upper 10 Pool</td>
<td>231</td>
<td>280</td>
<td>49</td>
<td>10.1</td>
<td>0.9</td>
<td>495</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Upper 11 Rapid</td>
<td>280</td>
<td>304.5</td>
<td>24.5</td>
<td>12.6</td>
<td>0.6</td>
<td>309</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Upper 12 Riffle</td>
<td>304.5</td>
<td>315</td>
<td>10.5</td>
<td>13.3</td>
<td>0.6</td>
<td>139</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 6. Summary of juvenile salmonid densities from snorkel surveys.**

<table>
<thead>
<tr>
<th>Reach ID</th>
<th>Habitat Unit ID</th>
<th>Habitat Type</th>
<th>Total Salmonids per m²</th>
<th>Coho (Age 0+ and 1+) per m²</th>
<th>Total Trout per m²</th>
<th>Age 1+ and 2+ Trout per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-Lower 4/5 Riffle</td>
<td>0.21</td>
<td>0.04</td>
<td>0.16</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Lower 6 Rapid</td>
<td>0.13</td>
<td>0.01</td>
<td>0.12</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Lower 7 Run</td>
<td>0.46</td>
<td>0.03</td>
<td>0.43</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Lower 8 Rapid</td>
<td>0.38</td>
<td>0.05</td>
<td>0.32</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Upper 10 Pool</td>
<td>0.47</td>
<td>0.08</td>
<td>0.38</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Upper 11 Rapid</td>
<td>0.33</td>
<td>0.03</td>
<td>0.30</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-Upper 12 Riffle</td>
<td>0.24</td>
<td>0.04</td>
<td>0.21</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.1.3 Profile and Cross-Section Results

A thalweg substrate and water surface elevation profile was run upstream from the downstream end of the abandoned channel reach. Water surface and substrate elevations were measured and recorded at 17.5 meter (57 ft) increments. Elevations were measured at a total of 21 stations. Between stations water surface gradients ranged from 0.1 to 3.9 percent, averaging 1.0 percent. The water surface and substrate profile for this reach is depicted in Figure 4.

![Figure 4. Abandoned channel reach water surface and substrate profile (pre-diversion). Note vertical datum was arbitrarily determined, vertical exaggeration ~86x.](image)

Three long-term monitoring cross-sections were established in this reach. Cross-section AC-XSEC 1 is located 62 meters (203 ft) upstream from the start of survey (see Figure 5). Figure 6 and Figure 7 are photos looking upstream and downstream from AC-XSEC 1. Cross-section AC-XSEC 2 is located 114 meters (374 ft) upstream from the start of survey. Figure 8 and Figure 9 are photos looking upstream and downstream from AC-XSEC 2.

Cross-section AC-XSEC 3 is located 166.5 meters (546 ft) upstream from the start of survey. Figure 10 and Figure 11 are photos looking upstream and downstream from AC-XSEC 3. Annotated cross-section plots for AC-XSEC 1 through 3 are included below in Figure 12 through Figure 14. Note that each of these figures has an inset multi-reach profile plot, the yellow highlighted cross-section label corresponds to the cross-sections location of the figure being viewed. Figure 15 depicts complete pebble counts for each of the three cross-sections described above.
Figure 5. Morse Creek cross-section location map.
Figure 6. Photo looking upstream from cross-section AC-XSEC 1.

Figure 7. Photo looking downstream from cross-section AC-XSEC 1.
Figure 8. Photo looking upstream from cross-section AC-XSEC 2.

Figure 9. Photo looking downstream from cross-section AC-XSEC2.
Figure 10. Photo looking upstream from cross-section AC-XSEC 3.

Figure 11. Photo looking downstream from cross-section AC-XSEC 3.
Figure 12. Morse Creek Abandoned Channel Cross-Section 1 located 62 meters (203 ft) upstream from start of survey.
Figure 13. Morse Creek Abandoned Channel Cross-Section 2 located 114 meters (374 ft) upstream from start of survey.
Figure 14. Morse Creek Abandoned Channel Cross-Section 3 located 166.5 meters (546 ft) upstream from start of survey.
Figure 15. Complete pebble counts from cross-sections AC-XSEC-1 through AC-XSEC-3 contrasted with thalweg survey pebble counts.
3.2 Control Reach

3.2.1 Thalweg and Habitat Survey Results

Thalweg and habitat surveys were conducted August 13, 2010 (DOE Four-Seasons stream discharge~61 cfs, site below aqueduct ~52cfs). The total length surveyed was 500 meters (1,640 ft). Stream gradient was measured at 25 meter (82 ft) intervals, a total of 20 measurements were made. Bankfull width measurements were made at 11 observation points. Wetted width and thalweg depth measurements were made at 104 and 101 observation points respectively. A summary of the results is included below in Table 7.

Table 7. Control reach channel gradient, BFW, wetted width, and thalweg depth summary.

<table>
<thead>
<tr>
<th>Measurement Range</th>
<th>Gradient</th>
<th>BFW (m / ft)</th>
<th>Wetted Width (m / ft)</th>
<th>Thalweg Depth (m / ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>5.7%</td>
<td>36.1m / 118ft</td>
<td>39.4m / 70ft</td>
<td>1.4m / 4.6ft</td>
</tr>
<tr>
<td>Minimum</td>
<td>&lt;0.1%</td>
<td>17m / 56ft</td>
<td>8.8m / 29ft</td>
<td>0.24m / 0.8ft</td>
</tr>
<tr>
<td>Average</td>
<td>0.9%</td>
<td>26.5m / 87ft</td>
<td>14.7m / 48ft</td>
<td>0.65m / 2.1ft</td>
</tr>
</tbody>
</table>

Note the 39.4 meter wetted width was measured perpendicular to stream flow but across a large transverse bar.

A total of 44 thalweg canopy closure measurements were made at 11 observation points. Average canopy closure ranged from 35 to 99 percent at the 11 observation points. Reach level canopy closure averaged 70 percent. Riparian conditions varied along the reach, riparian conditions were generally poor along the left bank where yards and structures occupied a portion of the riparian zone. The majority of the left bank riparian area was classified as deciduous, medium, sparse/medium. The right bank riparian forest contained even more variability. Riparian classifications varied from deciduous, small, sparse, to mixed, medium, dense, including: deciduous, medium, dense; deciduous small, dense; deciduous, large, sparse; and deciduous, medium, sparse.

A total of 13 primary habitat units were delineated in this stream reach. Two additional secondary habitat units were also identified. Six different habitat types were classified, these included: low gradient riffles (3), high gradient riffles (2), rapids (2), scour pool (6), a run (1) and a transverse bar (1). These units were later grouped together into four categories: riffles (all riffle types), rapids (including the transverse bar), pools (all types), and runs. Table 8 depicts the habitat unit breakdown including percentage of habitat by length and area.

A total of only 39 pieces of LWD were identified within this reach. Nearly 67 percent of pieces were classified as deciduous and 26 percent were classified as conifer, the remaining pieces were classified as unknown. The 39 pieces inventoried resulted in 2.1 pieces per channel width. Total volume of LWD within the BFW of the control reach equaled only 22.1 m³. This equates to a volume of 4.42 m³ per 100 meters of channel length or 0.0017 m³ per square meter of channel.
Table 8. Summary of habitat units in control reach.

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Number of Units</th>
<th>Total Primary Unit Length (Meters)</th>
<th>Percent (length)</th>
<th>Total Unit Surface Area</th>
<th>Percent (area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool</td>
<td>6</td>
<td>186.2</td>
<td>37%</td>
<td>2,508</td>
<td>34%</td>
</tr>
<tr>
<td>Rapid</td>
<td>3</td>
<td>45</td>
<td>9%</td>
<td>1,007</td>
<td>14%</td>
</tr>
<tr>
<td>Riffle</td>
<td>5</td>
<td>233.8</td>
<td>47%</td>
<td>3,511</td>
<td>47%</td>
</tr>
<tr>
<td>Run</td>
<td>1</td>
<td>35</td>
<td>7%</td>
<td>369</td>
<td>5%</td>
</tr>
</tbody>
</table>

Pebble counts were conducted at 21 transects, a total of 105 stream particles were measured. For reporting purposes fines were tabulated as one mm and bedrock was tabulated as 4,000 mm, one mm was added to all measurements and particle sizes are reported as cumulative percent smaller than (see Figure 16).

![Figure 16. Control reach particle size distribution from the 21 transects delineated during the thalweg survey.](image-url)
3.2.2 Snorkel Survey Results

A 127 meter stream segment was snorkel surveyed on August 16, 2010. This stream segment contained three primary habitat units and one secondary habitat unit. There were three habitat types sampled in this segment: two pools, a riffle, and a short rapid. A summary of the habitat units contained within the snorkel survey segment is included in Table 9.

A summary of juvenile trout and salmon densities observed in the snorkel survey is included in Table 10. Note that no other juvenile salmonids other than coho and trout were observed during the snorkel surveys. Also note that an adult steelhead trout was observed in habitat unit 1a and an adult pink salmon was observed unit 3.

Table 9. Summary of habitat unit types and sizes contained within the control reach snorkel survey segment.

<table>
<thead>
<tr>
<th>Reach ID</th>
<th>Habitat Unit ID</th>
<th>Habitat Type</th>
<th>Start Distance (m)</th>
<th>Stop Distance (m)</th>
<th>Length (m)</th>
<th>Average Wetted Width (m)</th>
<th>Avg. Thalweg Depth (m)</th>
<th>Surface Area (Sq. meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Reach</td>
<td>1</td>
<td>Riffle</td>
<td>0</td>
<td>65</td>
<td>65</td>
<td>15.6</td>
<td>0.5</td>
<td>913</td>
</tr>
<tr>
<td>Control Reach</td>
<td>1a</td>
<td>Pool</td>
<td>46.6</td>
<td>65</td>
<td>18.4</td>
<td>5.5</td>
<td>na</td>
<td>100</td>
</tr>
<tr>
<td>Control Reach</td>
<td>2</td>
<td>Rapid</td>
<td>65</td>
<td>78</td>
<td>13</td>
<td>12.6</td>
<td>0.6</td>
<td>164</td>
</tr>
<tr>
<td>Control Reach</td>
<td>3</td>
<td>Pool</td>
<td>78</td>
<td>127</td>
<td>49</td>
<td>11.5</td>
<td>0.8</td>
<td>565</td>
</tr>
</tbody>
</table>

Table 10. Summary of juvenile salmonid densities in the control reach snorkel survey

<table>
<thead>
<tr>
<th>Reach ID</th>
<th>Habitat Unit ID</th>
<th>Habitat Type</th>
<th>Total Juvenile Salmonids per m²</th>
<th>Coho (Age 0+ and 1+) per m²</th>
<th>Total Trout per m²</th>
<th>Age 1+ and 2+ Trout per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Reach</td>
<td>1</td>
<td>Riffle</td>
<td>0.25</td>
<td>0.03</td>
<td>0.22</td>
<td>0.04</td>
</tr>
<tr>
<td>Control Reach</td>
<td>1a</td>
<td>Pool</td>
<td>0.92</td>
<td>0.44</td>
<td>0.47</td>
<td>0.11</td>
</tr>
<tr>
<td>Control Reach</td>
<td>2</td>
<td>Rapid</td>
<td>0.12</td>
<td>0.00</td>
<td>0.12</td>
<td>0.04</td>
</tr>
<tr>
<td>Control Reach</td>
<td>3</td>
<td>Pool</td>
<td>0.48</td>
<td>0.14</td>
<td>0.34</td>
<td>0.05</td>
</tr>
</tbody>
</table>

3.2.3 Profile and Cross-Section Results

A thalweg substrate and water surface elevation profile was run upstream from a point 124.5 meters upstream from the upstream end of the abandoned channel reach. Water surface and substrate elevations were measured and recorded at 25 meter (82 ft) intervals. Elevations were measured at a total of 21 stations. Between stations water surface gradients ranged from less than 0.1 to 5.7 percent, averaging 0.9 percent. The water surface and substrate profile for this reach is depicted in Figure 17.
Figure 17. Control reach water surface and substrate thalweg profile.

Four long-term monitoring cross-sections were established in this reach. Cross-section CR-XSEC 1 is located 488.5 meters (1,603 ft) upstream from the start of survey\(^1\) (see Figure 5). Figure 18 and Figure 19 are photos looking upstream and downstream from AC-XSEC 1. Cross-section CR-XSEC 2 is located 557.5 meters (1,829 ft) upstream from the start of survey. Figure 20 and Figure 21 are photos looking upstream and downstream from CR-XSEC 2. Cross-section CR-XSEC 3 is located 663 meters (2,175 ft) upstream from the start of survey. Figure 22 and Figure 23 are photos looking upstream and downstream from CR-XSEC 3. Cross-section CR-XSEC 4 is located 837.5 meters (2,747 ft) upstream from the start of survey. Figure 24 and Figure 25 are photos looking upstream and downstream from CR-XSEC 4.

Annotated cross-section plots for CR-XSEC 1 through 4 are included below in Figure 26 through Figure 29. Note that each of these figures has an inset multi-reach profile plot, the yellow highlighted cross-section label corresponds to the cross-section location. Figure 15 depicts complete pebble counts for each of the four cross-sections described above.

\(^1\) Distance is from the downstream end of the abandoned channel reach start of survey.
Figure 18. Photo looking upstream from cross-section CR-XSEC 1.

Figure 19. Photo looking downstream from cross-section CR-XSEC 1.
Figure 20. Photo looking upstream from cross-section CR-XSEC 2.

Figure 21. Photo looking downstream from cross-section CR-XSEC 2.
Figure 22. Photo looking upstream from cross-section CR-XSEC 3.

Figure 23. Photo looking downstream from cross-section CR-XSEC 3.
Figure 24. Photo looking upstream from cross-section CR-XSEC 4.

Figure 25. Photo looking downstream from cross-section CR-XSEC 4.
Figure 26. Morse Creek Control Reach Cross-Section 1 located 488.5 meters (1,603 ft) upstream from start of survey.
Figure 27. Morse Creek Control Reach Cross-Section 2 located 557.5 meters (1,829 ft) upstream from start of survey.
Figure 28. Morse Creek Control Reach Cross-Section 3 located 663 meters (2,175 ft) upstream from start of survey.
Figure 29. Morse Creek Control Reach Cross-Section 4 located 837.5 meters (2,747 ft) upstream from start of survey.
Figure 30. Complete pebble counts from cross-sections CR-XSEC-1 through CR-XSEC-4.
3.3 New Channel Reach

3.3.1 Thalweg and Habitat Survey Results

Based on an estimated total length of 500 meters, stations were established 5 meter intervals. Primary transects were established at 50 meter intervals and secondary transects were established at 25 meter intervals. Thalweg and habitat surveys were conducted September 17, 2010 (DOE Four-Season stream discharge~39 cfs, site below aqueduct ~32cfs). The total length surveyed was 471 meters (1,545 ft). Stream gradient was measured at 15 to 30 meter intervals, a total of 22 measurements were made. Bankfull width measurements were made at 10 observation points. However, bankfull width was undefined at three of these observation points. Wetted width and thalweg depth measurements were made at 95 observation points. A summary of the results is included below in Table 11.

Table 11. New stream reach channel gradient, BFW, wetted width, and thalweg depth summary.

<table>
<thead>
<tr>
<th>Measurement Range</th>
<th>Gradient</th>
<th>BFW (m / ft)</th>
<th>Wetted Width (m / ft)</th>
<th>Thalweg Depth (m / ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>1.7%</td>
<td>45.3m / 149ft</td>
<td>33m / 108ft</td>
<td>0.8m / 2.6ft</td>
</tr>
<tr>
<td>Minimum</td>
<td>&lt;0.1%</td>
<td>25m / 82ft</td>
<td>8.8m / 29ft</td>
<td>0.17m / 0.6ft</td>
</tr>
<tr>
<td>Average</td>
<td>0.87%</td>
<td>36.1m / 119ft</td>
<td>17.1m / 56ft</td>
<td>0.29m / 2.1ft</td>
</tr>
</tbody>
</table>

A total of 44 thalweg canopy closure measurements were made at 11 observation points. Average canopy closure ranged from 5 to 77 percent at the 11 observation points. Reach level canopy closure averaged 37 percent. Observation point one had been highly disturbed by the construction of the stream channel, excluding this point reach level canopy closure averaged 40 percent. Riparian conditions varied along the reach from none (station 1 right bank) to deciduous, large, dense (primary station 10 left bank). Overall riparian conditions averaged deciduous, medium, dense. Only three habitat units were delineated in this stream reach. Three different habitat types were classified, these included: a low gradient riffle, a shallow glide, and a low gradient riffle w/pockets. Four small pool sub-units were also identified. A summary of habitat units is included below in Table 12.

Table 12. Summary of new channel habitat units.

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Number of Units</th>
<th>Total Length</th>
<th>Percent (Length)</th>
<th>Area (sq M)</th>
<th>Percent (area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low gradient riffle</td>
<td>1</td>
<td>35</td>
<td>7%</td>
<td>458</td>
<td>5%</td>
</tr>
<tr>
<td>Glide</td>
<td>1</td>
<td>65</td>
<td>14%</td>
<td>1664</td>
<td>20%</td>
</tr>
<tr>
<td>Low gradient riffle w/pockets</td>
<td>1</td>
<td>371</td>
<td>79%</td>
<td>6,155</td>
<td>73%</td>
</tr>
<tr>
<td>Pool sub-units</td>
<td>4</td>
<td>na</td>
<td>na</td>
<td>158</td>
<td>2%</td>
</tr>
<tr>
<td>Primary Totals</td>
<td>3</td>
<td>471</td>
<td>na</td>
<td>8,435</td>
<td>-</td>
</tr>
</tbody>
</table>
Pebble counts were conducted at 20 transects, a total of 99 stream particles were measured (one point fell on LWD). For reporting purposes fines were tabulated as one mm and one mm was added to all measurements. Particle sizes are reported as cumulative percent smaller than (see Figure 31).

![Figure 31. New Channel particle size distribution from the 20 transects delineated during the thalweg survey.](image)

### 3.3.2 Engineered Logjams and LWD Inventory Results

A detailed LWD and logjam inventory was conducted on September 22, 2010. A total of 675 pieces of LWD were inventoried. Additional pieces of LWD were identified but not inventoried. The LWD pieces not inventoried were outside the channel’s bankfull width (and not part of an ELJ structure). Most of these uninventoried pieces were part of the erosion control plan for construction access routes. Of the 675 pieces inventoried 91-percent (614) were part of the 20 ELJs inventoried. The remaining 9-percent (61 pieces) were located in over-flow and side channels.

The vast majority (73%) of pieces inventoried were classified as medium size (20-50 cm diameter). Only 11 percent of the pieces were greater than 50 cm diameter, no key pieces were identified within the project area. The remaining 16 percent of pieces were classified as small (10-20cm). Species type (conifer versus deciduous) was determined for 600 pieces (75 pieces classified as unknown). Conifer type LWD made up approximately 70 percent the LWD contained within the project area.
Five basic ELJ types were used for the Morse Creek restoration project. Several of the ELJs were designed using a combination of these 5 ELJ types. Figure 32 depicts ELJ types and their location within the Morse Creek restoration project. There is only one jam type 3+, it is a combination of one type 3 ELJ, one type 5 ELJ, and one type 4 ELJ. A summary of ELJ attributes is included in Table 13 (note that the number of LWD pieces is based on the total number of pieces inventoried, additional pieces may be entirely buried and not included in the inventory).

Table 13. Summary of engineered logjam attributes (note all measurements in meters).

<table>
<thead>
<tr>
<th>Jam ID</th>
<th>Herrera ID 1</th>
<th>Herrera ID 2</th>
<th>Herrera ID 3</th>
<th>Reach</th>
<th>Downstream End Position</th>
<th>No. of LWD Pieces</th>
<th>Length</th>
<th>Avg Width</th>
<th>Max Height</th>
<th>Min Height</th>
<th>Channel Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ELJ 2-2</td>
<td>ELJ 4-12</td>
<td>na</td>
<td>IR1</td>
<td>86</td>
<td>68</td>
<td>34</td>
<td>10</td>
<td>3.6</td>
<td>1</td>
<td>Floodplain</td>
</tr>
<tr>
<td>2</td>
<td>ELJ 5-1</td>
<td>ELJ 5-2</td>
<td>ELJ 5-3</td>
<td>IR1</td>
<td>70</td>
<td>9</td>
<td>17</td>
<td>7.5</td>
<td>1.2</td>
<td>0</td>
<td>Floodplain</td>
</tr>
<tr>
<td>3</td>
<td>ELJ 3-4</td>
<td>na</td>
<td>na</td>
<td>IR1</td>
<td>220</td>
<td>25</td>
<td>44</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Bank/FP</td>
</tr>
<tr>
<td>4</td>
<td>ELJ 2-1</td>
<td>ELJ 4-11</td>
<td>na</td>
<td>IR1/AC</td>
<td>230</td>
<td>63</td>
<td>31.5</td>
<td>10</td>
<td>4.75</td>
<td>3.5</td>
<td>Bank/Terrace</td>
</tr>
<tr>
<td>5</td>
<td>ELJ 3-3</td>
<td>ELJ 5-4</td>
<td>ELJ 4-14</td>
<td>NC</td>
<td>28</td>
<td>57</td>
<td>40</td>
<td>9</td>
<td>-</td>
<td>0</td>
<td>In-channel, bank, and overflow channel</td>
</tr>
<tr>
<td>6</td>
<td>ELJ 5-5</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>44</td>
<td>3</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Overflow channel</td>
</tr>
<tr>
<td>7</td>
<td>ELJ 5-6</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>58</td>
<td>3</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Overflow channel</td>
</tr>
<tr>
<td>8</td>
<td>ELJ 4-9</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>118</td>
<td>19</td>
<td>20</td>
<td>9</td>
<td>3.7</td>
<td>1.2</td>
<td>Right Bank to mid-channel</td>
</tr>
<tr>
<td>9</td>
<td>ELJ 4-8</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>128</td>
<td>25</td>
<td>29</td>
<td>8</td>
<td>3.7</td>
<td>0.8</td>
<td>LB to Mid-Channel</td>
</tr>
<tr>
<td>10</td>
<td>ELJ 4-7</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>186</td>
<td>19</td>
<td>23</td>
<td>8.5</td>
<td>3.8</td>
<td>1.2</td>
<td>Right Bank to mid-channel</td>
</tr>
<tr>
<td>11</td>
<td>ELJ 3-2</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>231</td>
<td>26</td>
<td>10</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>Across channel</td>
</tr>
<tr>
<td>12</td>
<td>ELJ 4-6</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>290</td>
<td>22</td>
<td>19</td>
<td>9.2</td>
<td>3.2</td>
<td>0</td>
<td>Right Bank</td>
</tr>
<tr>
<td>13</td>
<td>ELJ 4-5</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>316</td>
<td>21</td>
<td>15</td>
<td>8</td>
<td>3.5</td>
<td>0</td>
<td>Right Bank</td>
</tr>
<tr>
<td>14</td>
<td>ELJ 4-4</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>347</td>
<td>35</td>
<td>23.5</td>
<td>8</td>
<td>3.2</td>
<td>1</td>
<td>Mid-Channel</td>
</tr>
<tr>
<td>15</td>
<td>ELJ 4-3</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>390</td>
<td>25</td>
<td>23</td>
<td>9.4</td>
<td>2.8</td>
<td>0</td>
<td>LB to Mid-Channel</td>
</tr>
<tr>
<td>16</td>
<td>ELJ 3-1</td>
<td>na</td>
<td>na</td>
<td>NC/IR2</td>
<td>471</td>
<td>24</td>
<td>23</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>Overflow channel</td>
</tr>
<tr>
<td>17</td>
<td>ELJ 4-2</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>-</td>
<td>29</td>
<td>14</td>
<td>10</td>
<td>4.5</td>
<td>0</td>
<td>Overflow/Floodplain</td>
</tr>
<tr>
<td>18</td>
<td>ELJ 4-1</td>
<td>na</td>
<td>na</td>
<td>IR2</td>
<td>-</td>
<td>35</td>
<td>12</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>Bank/Floodplain</td>
</tr>
<tr>
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<td>ELJ 1-1</td>
<td>na</td>
<td>na</td>
<td>NC</td>
<td>-</td>
<td>72</td>
<td>62</td>
<td>24.3</td>
<td>5.2</td>
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<tr>
<td>20</td>
<td>ELJ 4-10</td>
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<td>na</td>
<td>NC</td>
<td>-</td>
<td>34</td>
<td>20</td>
<td>8.5</td>
<td>3.4</td>
<td>0</td>
<td>Overflow channel</td>
</tr>
</tbody>
</table>

The inventory identified one type 1 ELJ, two type 2 ELJs, four type 3 ELJs (note Jam 5 is classified as a type 3+ ELJ in Figure 32 and included a type 4 and a type 5 ELJ), ten type 4 ELJs (note that two additional type 4 ELJs are part of the type 2 ELJs), and three type 5 ELJs (note Jam 2 is made up of three type 5 ELJs). Figure 33 through Figure 39 include as-built photos of the different ELJ types.
Figure 32. As-built map of Morse Creek ELJs with jam IDs.
Figure 33. Photo looking downstream at the only type 1 ELJ (note this is the primary plug separating the new channel system from the abandoned channel).
Figure 34. Photo looking downstream at Jam 4. This ELJ is composed of one type 2 ELJ (upstream portion) and one type 4 ELJ constructed at the downstream end.

Figure 35. Photo looking downstream at Jam 11 (Jam 10 in background). This is an example of a typical type 3 ELJ.
Figure 36. Photo looking at Jam 5. This type 3+ ELJ is made up of a type 3, 4, and 5 ELJ. Note that the type 5 ELJ (middle of photo) has additional racking pieces added.

Figure 37. Photo looking downstream at Jam 8. It is an example of a type 4 ELJ.
Figure 38. Photo looking towards right bank at Jam 10. Side view of a type 4 ELJ.

Figure 39. Photo looking at Jam 6, typical type 5 ELJ.
3.3.3 Profile and Cross-Section Results

A thalweg substrate and water surface elevation profile was run upstream from the downstream end of the new channel to the upstream end of the new channel. Water surface and substrate elevations were measured and recorded at 15 to 30 meter intervals. Elevations were measured at a total of 22 stations. Between stations water surface gradients ranged from less than 0.1 percent to 1.7 percent, averaging 0.87 percent. The water surface and substrate profile for this reach is depicted in Figure 40.

Figure 40. New channel water surface and substrate thalweg profile.

Five long-term monitoring cross-sections were established in the new channel reach. Cross-section NC-XSEC 1 is located 61 meters (200 ft) upstream from the start of survey (see Figure 5). Figure 41 and Figure 42 are photos looking upstream and downstream from NC-XSEC 1. Cross-section NC-XSEC 2 is located 123 meters (404 ft) upstream from the start of survey. Figure 43 and Figure 44 are photos looking upstream and downstream from NC-XSEC 2. Cross-section NC-XSEC 3 is located 229 meters (751 ft) upstream from the start of survey. Figure 45 and Figure 46 are photos looking upstream and downstream from NC-XSEC 3. Cross-section NC-XSEC 4 is located 316 meters (1,037 ft) upstream from the start of survey. Figure 47 and Figure 48 are photos looking upstream and downstream from NC-XSEC 4. Cross-section NC-XSEC 4 is located 390 meters (1,280 ft) upstream from the start of survey. Figure 49 and Figure 50 are photos looking upstream and downstream from NC-XSEC 5.
Figure 41. Photo looking upstream from cross-section NC-XSEC 1.

Figure 42. Photo looking downstream from cross-section NC-XSEC 1
Figure 43. Photo looking upstream from cross-section NC-XSEC 2.

Figure 44. Photo looking downstream from cross-section NC-XSEC 2.
Figure 45. Photo looking upstream from cross-section NC-XSEC 3.

Figure 46. Photo looking downstream from cross-section NC-XSEC 3.
Figure 47. Photo looking upstream from cross-section NC-XSEC 4.

Figure 48. Photo looking downstream from cross-section NC-XSEC 4.
Figure 49. Photo looking upstream from cross-section NC-XSEC 5.

Figure 50. Photo looking downstream from cross-section NC-XSEC 5.
The results from the complete pebble counts at NC-XSEC 2 through 5 are included below in Figure 51. Annotated cross-section plots for NC-XSEC 1 through 5 are included below in Figure 52 through Figure 56. Figure 57 includes a comparison between pre- and post-construction water surface and substrate thalweg profiles. The figure shows that the new channel configuration is longer than the old channel system but that elevating the WSE at the entrance to the new channel effectively diminished the net reduction in water surface gradient between the old and new channel systems to only 0.1 percent.

Figure 51. Complete pebble counts from cross-sections NC-XSEC-2 through NC-XSEC-5.
Figure 52. Morse Creek New Channel Cross-Section 1 located 61 meters (200 ft) upstream from start of survey.
Figure 53. Morse Creek New Channel Cross-Section 2 located 123 meters (404 ft) upstream from start of survey.
Figure 54. Morse Creek New Channel Cross-Section 3 located 229 meters (751 ft) upstream from start of survey.
Figure 55. Morse Creek New Channel Cross-Section 4 located 316 meters (1,037 ft) upstream from start of survey.
Figure 56. Morse Creek New Channel Cross-Section 5 located 390 meters (1,280 ft) upstream from start of survey.
Figure 57. Comparison between pre- and post-construction water surface and substrate thalweg profiles.
3.4 Impact Reach #1 and #2

All ELJ and LWD inventory data for impact reach 1 (IR1) and 2 (IR2) are included above in Table 13 and Figure 32. Stream profile data collected for IR2 is included above in Sections 3.1 and 3.2. No thalweg or riparian survey data were collected in IR1 or IR2.

A thalweg substrate and water surface elevation profile was run upstream from the downstream end of impact reach 1 to the downstream end of the new channel. Water surface and substrate elevations were measured at a maximum interval of 27 meters. Elevations were measured at a total of 13 stations. Between station water surface gradients ranged from less than 0.2 percent to 4.3 percent, averaging 1.3 percent. The water surface and substrate profile for this reach is depicted in Figure 58.

A thalweg substrate elevation profile was run upstream from the downstream end of overflow return channel 1 (this is in impact reach 1), to the upstream end of overflow channel 1 (this is in the new channel reach). Substrate elevations were measured at a maximum interval of 86 meters. Elevations were measured at a total of 14 stations. The substrate profile for overflow channel 1 is included below in Figure 59.

Two long-term monitoring cross-sections were established in impact reach 1. Cross-section IR1-XSEC 1 and IR1-XSEC 2 are located 14 meters (46 ft) and 146 meters (479 ft) upstream from the start of survey respectively (see Figure 5). Annotated cross-section plots for IR1-XSEC 1 and 2 are included below in Figure 60 and Figure 61. Figure 62 and Figure 63 are photos looking upstream and downstream from IR1-XSEC1. Figure 64 and Figure 65 are photos looking upstream and downstream from IR1-XSEC2.
Figure 58. Impact reach 1 water surface and substrate thalweg profile.
Figure 59. Overflow channel 2 profile from impact reach 1 to new channel overflow inlet. Figure includes an inset map depicting thalweg survey location.
Figure 60. Morse Creek Impact Reach 1 Cross-Section 1 located 14 meters (46 ft) upstream from start of survey.
Figure 61. Morse Creek Impact Reach 1 Cross-Section 2 located 146 meters (479 ft) upstream from start of survey.
Figure 62. Photo looking upstream from cross-section IR1-XSEC 1.

Figure 63. Photo looking downstream from cross-section IR1-XSEC 1.
Figure 64. Photo looking upstream from cross-section IR1-XSEC 2.

Figure 65. Photo looking downstream from cross-section IR1-XSEC 2.
4 CITATIONS


