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# Restoration Monitoring on the McKenzie River, Oregon

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## ABSTRACT

In the spring of 2012, we, the Stream Stewardship Team from the University of Oregon's Environmental Leadership Program (ELP), conducted post-monitoring surveys at a side channel of the Middle McKenzie River (side channel 4) to compare with baseline monitoring data collected by the 2011 ELP Restoration Stewardship Team. The goal of this restoration project was to enhance juvenile spring Chinook salmon (*Oncorhynchus tshawytscha*) rearing habitat within the channel. In 2011 the U.S. Forest Service placed large woody debris (LWD) in five sections of the channel after baseline monitoring to increase the complexity of the streambed within the channel and to create a distribution of sediment optimal for salmon spawning habitat. We conducted pebble counts, cross-channel surveys, and a longitudinal profile of the stream to observe changes since the addition of LWD. Median pebble size decreased downstream of the LWD placements at gravel count 1 and increased upstream at gravel count 2. The percent of embedded sediment decreased at both gravel count sites. We also detected noticeable changes in the stream morphology at four of the five cross-sectional surveys as well as along the longitudinal profile. Sediment size distribution and the formation of pools at the downstream end of the channel showed an initial change in stream morphology since 2011, but further monitoring is warranted in order to fully assess the effects of LWD on streambed complexity and salmon spawning habitat.

## 1. INTRODUCTION

The McKenzie River Watershed consists of 857,364 acres of diverse ecosystems that are culturally and ecologically indispensable to the Willamette Valley (Runyon 2000). Additionally, the McKenzie River provides drinking water to over 200,000 Eugene area residents (McKenzie Watershed Council 2002). The McKenzie River also supplies abundant habitat for numerous

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plant and animal species, including threatened species such as spring Chinook salmon and Oregon chub (*Oregonichtys crameri*) (McKenzie River Trust 2012). The river and its banks also offer recreational opportunities such as fishing, camping, rafting and kayaking. Its numerous recreational uses and ecological attributes make the McKenzie River an integral part of the Willamette Valley.

Many changes in the McKenzie River have occurred over the past 50 years due to human development, such as altered water flows as a result of damming and reduced stream channel stability caused by bank erosion. Increasing development along the lower reaches of the river has confined the river's natural meandering state. A naturally meandering river is characterized by braided sided channels, which create gravel bars and ponds, as well as slow peak flows during high water events. Side channels are a valuable component of salmon-bearing rivers such as the McKenzie. They provide gentle flows, which are an essential element of spawning habitat for many salmonid species in this region. Slower water velocity enables the proper sized sediment and debris for salmon spawning ground to remain in the streambed, rather than peak flow events sweeping them away (United States Forest Service 2010). Even though channelization, damming, and other anthropogenic activities have degraded much of the original McKenzie River habitat, the McKenzie Watershed Council has concluded that the McKenzie River still contains some of the most pristine water on earth (McKenzie Watershed Council 2002).

The health of McKenzie River side channels is critical for water quality and habitat complexity; however, development along the channels has reduced the input of essential ecosystem components such as large woody debris (LWD). The removal of large trees for development on the riparian banks reduces shade and litter fall and prevents logs from naturally entering the river. These logs, which are essential to the river's ecosystem functions, are also being removed due to an increased need for safe boating recreation (Runyon 2000). The presence of LWD in a stream channel can exert beneficial significant controls on the physical characteristics of streams. These controls influence channel type, sediment storage, and bed-form roughness (Naiman et al. 2000). LWD enhances instream habitat by creating pools, scouring pockets that provide hiding cover, and producing other shelter formations for aquatic species to spawn and rest. LWD increases habitat complexity by trapping smaller wood, branches, leaves and other organic materials that add to instream diversity (Gurnell 2002). This diversity provides algal food sources for aquatic biota, which in turn furnish a food source for aquatic invertebrates. In summary, aquatic species rely heavily on the maintenance of healthy habitats that contain LWD (Roni and Quinn 2001).

In October of 2011, the U.S. Forest Service and the McKenzie Watershed Council placed LWD at five different sites in the Middle McKenzie to enhance channel diversity and improve salmon spawning habitat. In May of 2011, the ELP's 2011 Restoration Stewardship Team (2011 ELP Team) collected baseline data by conducting stream surveys and Wolman pebble counts in McKenzie side channel 4 (Figure 1, Bonanno et al. 2011). We used the same procedures at Middle McKenzie side channel 4 along transects established in 2011. We then compared the baseline data with data collected this year to assess the effects of LWD placement on stream morphology. These data may be used in future restoration efforts to enhance stream habitats for aquatic species.

## 2. STUDY AREA

The study area is located off McKenzie Highway 126 in the Willamette National Forest on the north bank of the McKenzie River at the McKenzie River Campground (approximately 60 kilometers east of Springfield, Oregon). The surrounding area is characterized as temperate rainforest, which receives high rainfall and is heavily vegetated by native herbs, shrubs and conifers. Herb species include: oxalis (*Oxalis oregana*), western coltsfoot (*Petasites frigidus*), waterleaf (*Hydrophyllum capitatum*), and cow parsnip (*Heracleum maximum*). The shrub layer is mainly comprised of vine maple (*Acer circinatum*), osoberry (*Oemleria cerasiformis*), alder (*Alnus glutinosa*), and elderberry (*Sambucus nigra*). The tree layer consists of western red cedar (*Thuja plicata)*, Douglas-fir (*Pseudotsuga menziesii*), and big leaf maple *(Acer macrophyllum)* (Washington Native Plant Society 2002).

The side channel itself is approximately 400 meters long and 20 to 30 meters wide. It includes of a mixture of riffles, pools, and glides. The U.S. Forest Service placed five log jams throughout the side channel (Figure 1, Bonanno et al. 2011). The side channel section remains around 6 degrees Celsius for most of the year and can increase to 16 degrees Celsius during summer months, making it optimal spawning ground and rearing habitat for spring Chinook salmon, bull trout (*Salvelinus confluentus)*, and many other aquatic species and wildlife native to the watershed (Risley et al. 2010).

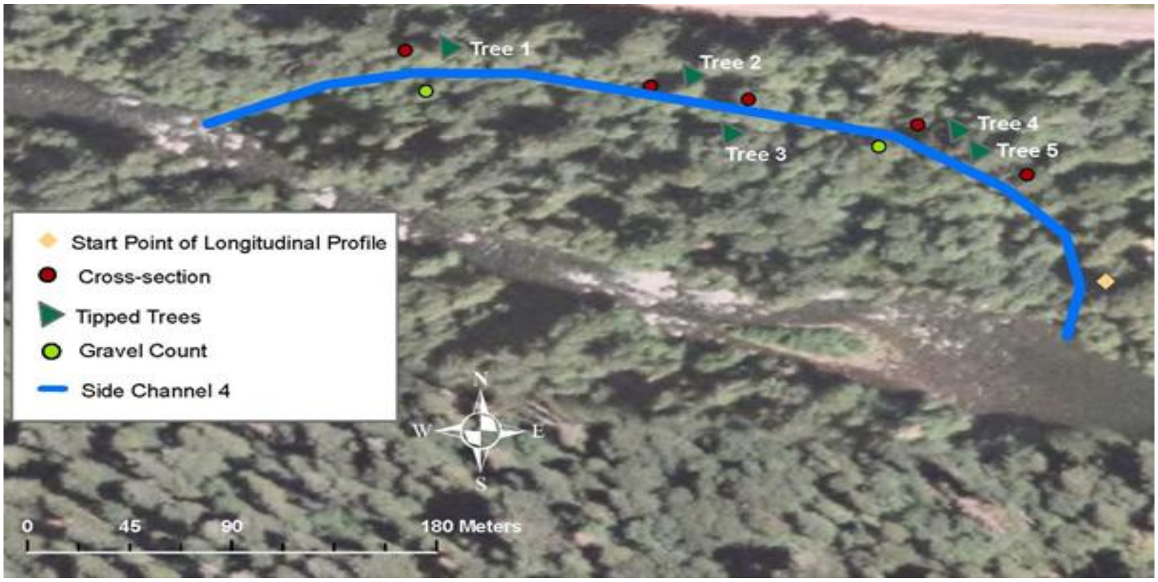

Figure 1. Map of Middle McKenzie side channel 4 including the locations of LWD placement, right bank cross section monuments, gravel count locations, and the longitudinal profile monument which were established in 2011 (Figure modified from Bonnano et al. 2011).

# 3. METHODS

The 2011 ELP Team conducted baseline monitoring at Middle McKenzie side channel 4 and established permanent rebar monuments along the right and left bank of the channel at all of their survey locations (Bonnano et al. 2011). In May of 2012, we used a Global Positioning System (GPS) to locate these monuments in order to conduct five cross-channel surveys, a longitudinal channel profile, and two Wolman pebble counts along the same transects used in 2011. To ensure data collection consistency, we used the same surveying methods used in 2011 (Bonnano et al. 2011).

## 3.1 PEBBLE COUNT

We conducted Wolman pebble counts at both an upstream and a downstream location. Gravel count 1 was located upstream of cross section 5 and gravel count 2 was located downstream of cross section 2 (Figure 1). We set up three transects at each gravel count and took two particle samples at every half-meter distance along the transect for a minimum sample size of 100 particles. Using blind sampling, we selected particles from the stream and measured the b-axis size class of each particle using a gravelometer (Bunte and Abt 2001). We also noted whether the particles were embedded or not embedded. We defined an embedded particle as one that is lodged or partially lodged within the streambed and has finer sediment attached to it.

## 3.2 CROSS SECTION SURVEYS

We conducted cross-channel surveys by lying transects between right bank and left bank monuments and taking measurements along each transect at every major observable change in elevation (Harrelson et al. 1994). We were unable to locate the left bank monument at cross section 1, so we made an estimation based on the right bank monument and length of the 2011 transect. For all cross-channel surveys, we used a surveyor's auto-level and a metric elevation rod to measure distance from the bank, water depth, and the elevation relative to the right bank monument at each point along the transect (Harrelson et al. 1994). By applying our measurements to the known elevations of the monuments, we calculated the actual elevation along the streambed.

## 3.3 LONGITUDINAL PROFILE

We used the same surveying methods as mentioned above when conducting the longitudinal profile. We began our transect at an upstream monument established in 2011 and placed it 241.1 meters downstream, along the edge of the channel bank. We used a surveyor's auto-level and a metric elevation rod to measure the streambed elevation and water depth systematically within the thalweg (the deepest part of the stream) (Harrelson et al. 1994). To capture the entire length of the channel, we set up multiple surveying stations and used multiple benchmarks to calculate actual elevation using the same calculations as those for the cross-channel surveys (Harrelson et al. 1994). We did not collect data near the log jams due to safety concerns.

### 3.4 DATA ANALYSIS

We used the same surveying methods as mentioned above when conducting the longitudinal profile. We began our transect at an upstream monument established in 2011 and placed it 241.1 meters downstream, along the edge of the channel bank. We used a surveyor's auto-level and a metric elevation rod to measure the streambed elevation and water depth systematically within the thalweg (the deepest part of the stream) (Harrelson et al. 1994). To capture the entire length of the channel, we set up multiple surveying stations and used multiple benchmarks to calculate actual elevation using the same calculations as those for the cross-channel surveys (Harrelson et al. 1994). We did not collect data near the log jams due to safety concerns.

## 4. RESULTS

### 4.1 PEBBLE COUNTS

The percent of embedded sediment in both gravel count 1 and count 2 decreased from 2011 to 2012 after the placement of LWD. The total embedded sediment decreased from 33.3% to 26.6% in gravel count 1 and from 27.6% to 23% in gravel count 2.

As compared to 2011, the 2012 sediment size distribution in Middle McKenzie side channel 4 shifted toward a smaller median pebble size with an increase in $D_{84}$ in count 1, while median pebble size increased with no detectable change in $D_{84}$ values for count 2 (Figure 2). For count 1, the $D_{50}$ size class decreased from 45-64 mm to a size class of 32-45 mm and the $D_{84}$ size class increased from 91-128 mm to 128-181 mm. For count 2, the $D_{50}$ size class increased from 32-45 mm to 45-64 mm and the $D_{84}$ size class was recorded at 91-128 mm both years.

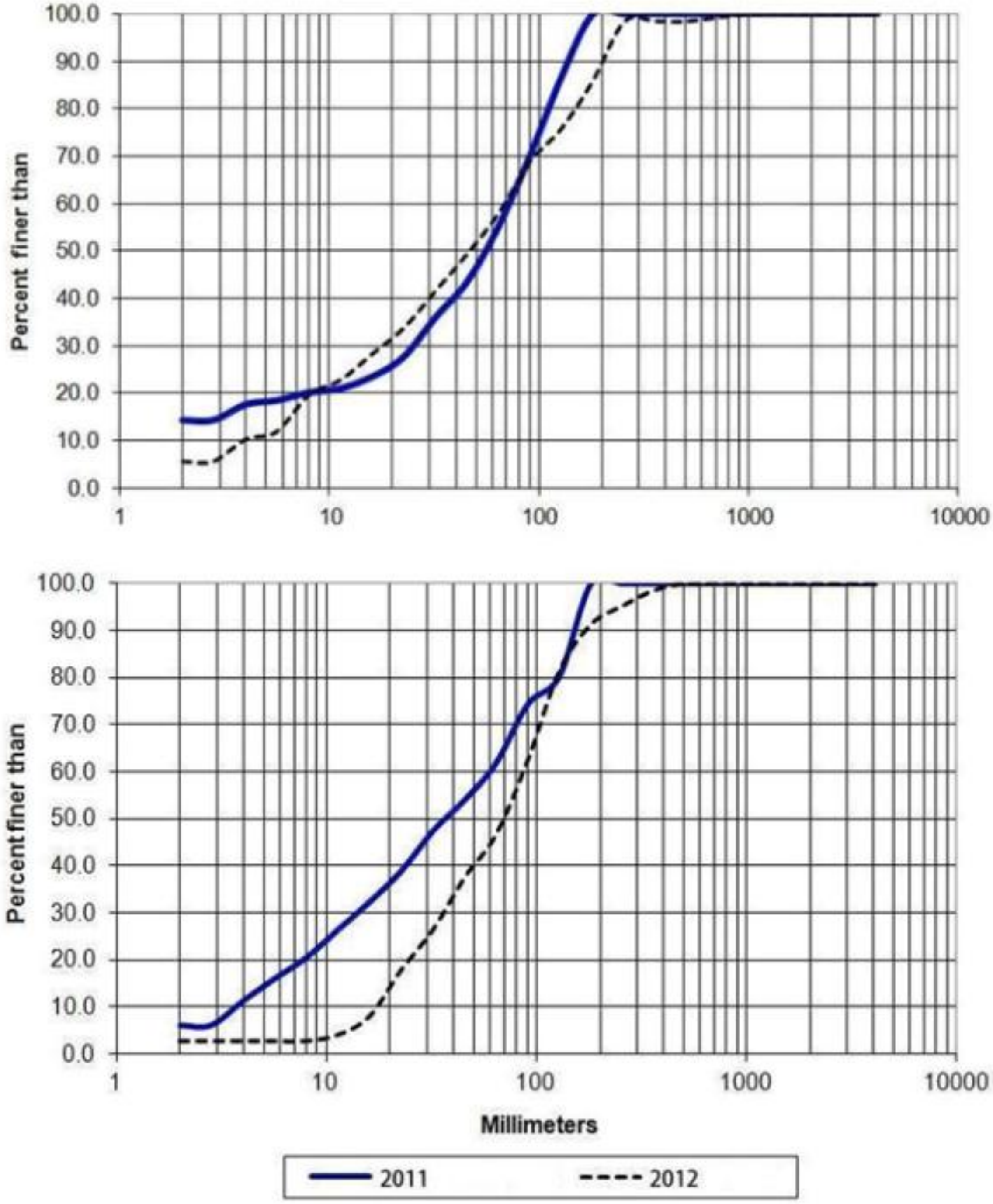

Figure 2. Comparison of cumulative sediment size distribution of gravel count 1 (top), and gravel count 2 (bottom) in McKenzie side channel 4 from 2011 to 2012.

## 4.2 CROSS SECTION SURVEYS

There were changes in the streambed topography at four out of the five cross sections in Middle McKenzie side channel 4 from 2011 to 2012 (Figure 3). We observed channel degradation and a decrease in streamed elevation due to scouring and erosion at both cross section 1 and cross section 2 between 2011 and 2012 (Keefer et al. 1980). The streambed lowered in the right side of the channel at cross section 1 and in the left side of the channel at cross section 2. At cross section 3, the channel deepened by approximately one-half meter but maintained the same general morphology. We did not observe any major changes in the channel topography at cross section 4. There was minor erosion along the left bank at cross section 5 but only minor changes in streambed morphology.

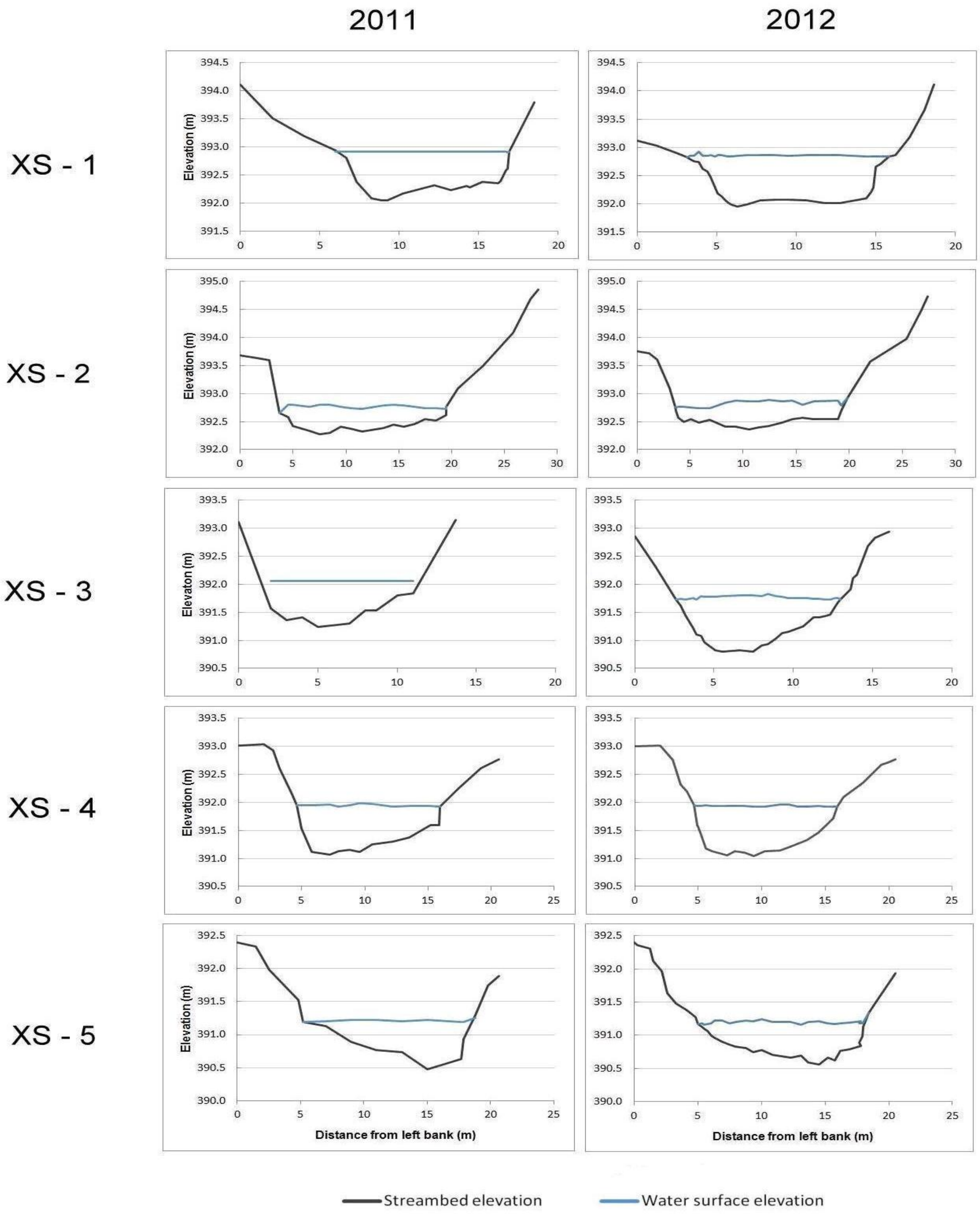

Figure 3. Comparison of channel morphology at cross section surveys (XS) 1 through 5 in Middle McKenzie side channel 4 from 2011 to 2012.

## 4.3 LONGITUDINAL PROFILE

We observed an increase in the complexity of the streambed elevation along the entire transect from 2011 to 2012 (Figure 4). The profile degraded due to scouring immediately downstream of the first LWD placement at 32.4 m along the transect (downstream from the permanent monument). There were aggradations of deposited sediment downstream of the last three LWD placements at 105 m, 136.6 m, and 201.5 m along the transect. The first noticeable pool formations occurred at 156.1 m near cross section 4 and before the last LWD placement at 201.5 m on the transect.

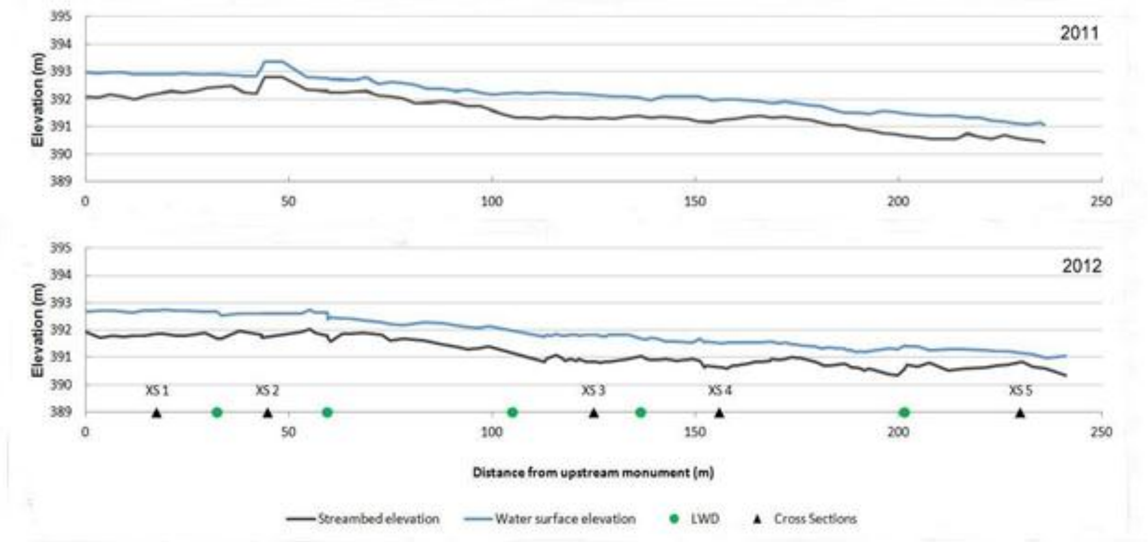

Figure 4. Comparison of streambed elevation and water surface elevation in a 241.4 m longitudinal profile of McKenzie side channel 4 from 2011 (top) to 2012 (bottom). LWD markers represent the locations of large woody debris along the length of the profile. Cross section markers represent the locations of each cross section along the length of the profile.

## 5. DISCUSSION

We observed changes in the sediment size distribution as well as the morphology of the streambed of the channel from 2011 to 2012 after the placement of LWD. Median pebble size decreased downstream of the LWD placements at gravel count 1 and increased upstream at gravel count 2. The percent of embedded sediment decreased at both sites. Also, we detected noticeable changes in the stream morphology at four of our five cross-sectional surveys as well as along the longitudinal profile.

Optimal median pebble size for salmon spawning habitat is within the size class of 32-45 mm (Bonanno et al. 2011). After the placement of LWD in 2011, the distribution in gravel count 1 shifted to the 32-45 mm size class while the size class in count 2 shifted to a larger size class. The percent of embedded sediment decreased from 2011 to 2012 in both gravel counts. A decrease in embedded pebbles promotes spawning habitat for salmon and other fish species that use the loose gravel to create spawning beds (Bevenger and King 1995).

The changes in sediment distribution could be due to a changing energy gradient as the result of LWD placement in which upstream scouring of the streambed transports smaller sediment downstream. This would result in less sediment being embedded and a larger median sediment size upstream. However, the changes could also be the result of annual variation in the flow regime of the channel. We observed that many of the LWD placements were bridged over the channel and did not have much contact with the water, which minimally affect changes in sediment distribution.

We also observed a trend in sediment moving downstream in our cross-channel surveys and longitudinal profile (Figures 3 and 4), which likely resulted from the LWD placement rather than annual variation in flow regime.. According to our longitudinal profile, scouring was more frequent upstream while deposition occurred mostly downstream between 2011 and 2012. The proximity of these changes to the placements of LWD suggests that the LWD affects the streambed morphology.

Roni and Quinn (2001) recorded an increase in juvenile Coho salmon population density after the placement of LWD in 30 streams in the Pacific Northwest. After a single season of winter flows, we have detected the formation of pools and an improvement in sediment size for salmon spawning habitat in the downstream portion of our longitudinal profile. As the LWD sinks down over time and gains more contact with the channel, even more changes in the streambed can be expected. We did not have any control treatment for this experiment and thus can assert no definite causal conclusions regarding the effects of LWD. We did, however, find changes in the channel conducive to salmon spawning habitat since the addition of LWD in October of 2011.

Multiple sources of error and observer bias could account for discrepancies in our data. Observer bias most likely occurred in our gravel counts since we had twelve different people conducting them. During the longitudinal and cross-channel surveys, we had to shout some of the measurements across lengths of the channel and consequently may have recorded some incorrectly. Additionally, while conducting the longitudinal profile we could not always stand in the thalweg due to safety concerns and this slightly affected the accuracy of our data. Safety concerns for working adjacent to the LWD placements prevented us from taking measurements at several points along the transect of the longitudinal profile. Considering that our data were consistent with the data from the 2011 ELP team, these sources of error and bias had a minimal effect on our results. However, measures should be taken to address these sources of bias and further monitoring is warranted.

## 6. RECOMMENDATIONS AND MANAGEMENT IMPLICATIONS

We recommend three actions for post monitoring of LWD placement in the Middle McKenzie side channel 4. First, LWD should be monitored annually for subsequent years to observe noticeable changes in stream morphology. We recommend that future observations last for at least three years post-project (preferably longer) (Roni and Quinn, 2001). Second, elevation and orientation of the LWD should be considered in future data analysis. We noticed that much of the LWD was barely submerged in the stream, thereby putting into question the overall effects it has on stream morphology. Lastly, previously placed LWD should be evaluated to assess which sites were most effective in positively altering streambed morphology to inform future designs for LWD placement projects.

In addition, we recommend having a single survey crew for all Wolman pebble counts conducted year to year to reduce observer bias in the field and maintain consistency. However, considering the challenge of keeping the same surveyors, strict protocols to reduce observer bias should be implemented. Stream surveyors should collect data when the water levels are low (during late spring or summer) to ensure the consistent collection of data within the thalweg. Most importantly, surveyors should collect data annually at a consistent time to ensure accurate data comparison.

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