Hansen Creek Alluvial Fan and Wetland Restoration Project Report

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Contents

Figures

Maps

Tables

Executive Summary

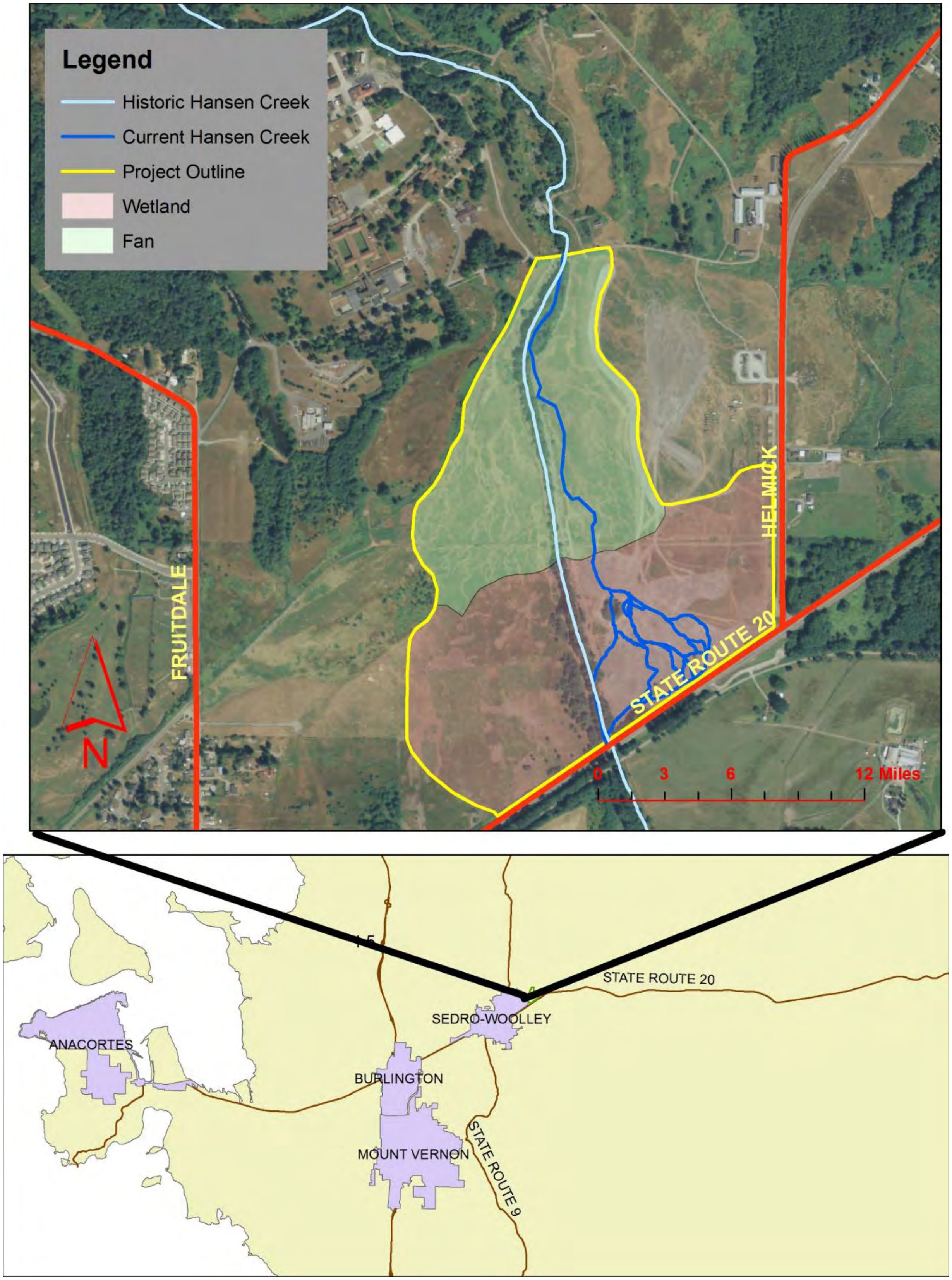
The Hansen Creek Alluvial Fan and Wetland Restoration Project is located just east of Sedro-Woolley in Skagit County, WA (Map 1). This project has reconnected a significant portion of the historic floodplain alluvial fan and riverine wetland to the main stem channel encompassing 140 acres of Skagit County Park land. This project is unique in its size of freshwater floodplain restoration. Its location within a natural resource park created the ideal opportunity to undertake a cornerstone watershed process restoration. The floodplain restoration goals incorporated the restoration of natural hydro-geomorphic processes to support fishery restoration, water quality restoration and flood reduction to downstream agriculture. It further supports the re-establishment of native floodplain habitat that will support a wide array of wildlife, an increase in groundwater recharge in a water-limited basin, and improve flow contributions to the stream in the dry season. Lessons from this project can advance freshwater floodplain restoration throughout the Puget Sound region, where WDFW estimates up to 90% of the lowland freshwater riparian systems have been lost to development (WDFW 2005).

Final design called for large woody debris (LWD) grade control structures in the main stem channel to facilitate sediment deposition in the upper project reach main stem, constructed side channels to facilitate flow in the floodplain, a significant number of LWD structures for side channel, alluvial fan and wetland habitat initiation, hummock islands to add complexity, and a diverse planting plan to institute habitat forming structure. The dikes that confined the main channel were notched open where historic side channels existed in the upper alluvial fan habitat, and notched open again in the lower riverine wetland habitat to support return flow, while the mid project section supported lowering of the dikes due to the almost exclusive invasion of Himalayan blackberry. The existing dikes were left in place where riparian canopy was established. The design allowed for low banks and opened notches to distribute high flows across the broad floodplain, creating floodwater holding capacity in the wetland and allowing sediment to settle across the fan and wetland.

The first major rain event of 2009 sent water flowing through the new side channels and carving additional channels. The first two wet seasons ultimately dropped approximately 30,000 cubic yards (CY) of material through the historic main stem channel and project site. The 2010 wet season continued to see new channel formation, flood water retention and sediment capture. The historic main stem channel has filled with sediment and in the lower wetland reach the main stem was abandoned in 2009 while in the upper fan reach the historic channel was abandoned

in 2010, moving the main stem into the east fan and wetland floodplain. The overall stream length through the project has significantly increased as a result of multiple braided channel formations. Downstream agricultural flooding reduction has been achieved with flood water detention and sediment capture within the project. Holding capacity of the newly restored wetland is effectively lowering downstream flood height, duration and frequency. Fish habitat was greatly increased with scouring of pools around many of the LWD structures, gravel sorting initiation and an establishing macroinvertebrate food web. Although canopy formation has not yet had time to occur, vegetation that was added was composed of native species and planted in a complex planting plan that mimicked natural vegetative communities (Figure 1).

Figure 1. Live stake black cottonwood next to a planted rose along the bank of Hansen Creek where gravel transportation has resulted in sorting of intermediate gravels.



Map 1. Vicinity map showing location of Hansen Creek restoration project relative to Skagit County.

1.0 Introduction

Dredging became normal practice on Hansen Creek after being initiated in response to late 1940 landslide debris removal. Dredging had become a routine HPA request on as frequent a basis as every year to three years between the 1970's and 1990s. Dredging applications were submitted for reaches above the present project site, within the project site and below the project site. Dredging impacts are well documented including bed disturbances, turbidity, channel confinement, and ecosystem fragmentation, salmon and other aquatic losses. In 1998, in response to a dredging application, Washington Department of Fish and Wildlife required the development of a plan to recover salmon habitat and ultimately halt the dredging practices that were a frequent occurrence on Hansen Creek. The outcome of the planning effort was the Hansen Creek Watershed Management Plan, 2002 (The Plan). The cornerstone project identified by the Plan to restore watershed and ecosystem processes was the reconnection of floodplain with the main stem in the project site. Connection of the main stem with the alluvial fan (the upper project reach) and re-establishment of the riverine wetland (the lower project reach) are essential to establishing and sustaining complex riparian habitat, the hydro-geomorphic processes essential for salmon productivity and restoring watershed health.

Hansen Creek supports two ESA species, Chinook and Steelhead, in addition to Coho, Chum and Pinks. The Hansen Watershed is primarily a Coho and Steelhead production watershed and has sustained losses in each of the 5 evaluated reaches between 85 to 98%, of which the project reaches are estimated to have lost 98% of the historic production (The Plan). Hansen Creek is an impaired 303d listed waterbody for fish habitat, temperature, fecal coliform and dissolved oxygen. Restoration in the project site will address fish habitat, temperature, sediment transport, and flood flows.

Project design targeted the essential elements to jumpstart floodplain reconnection and reactivation of the alluvial fan and a flow-through riparian wetland through dredge spoil dike notching and lowering, strategic placement of wood structures and aggressive revegetation (Figure 2). These actions jumpstart the reactivation and reconnection of the alluvial fan and wetland area to:

- Maximize in-stream and floodplain habitat quantity, complexity and accessibility

- Restore hydrologic and hydraulic connectivity between the channel, alluvial fan and wetlands
- Encourage interaction between the main channel and side channels
- Enable hydraulic flows and bedload movement to avulse into the alluvial fan
- Maximize the frequency of floodplain and off-channel habitat utilization to transport sediment
- Encourage gravel sorting and retention, increasing and enhancing salmonid spawning and rearing habitat
- Increase the overall channel length, stream channel area, side channel habitats, edge and pool-riffle habitats for juvenile salmonid rearing
- Increase water storage necessary to support salmon spawning, rearing, and migration in both high and low flow seasons
- Provide substrate to support forested wetland vegetation
- Restore sufficient wood and riparian cover to the project zone to provide refuge, shade, and forage material
- Restore floodplain holding capacity to support reduction in flood frequency, height, and duration in downstream reaches

Figure 2. Hansen Creek alluvial fan and wetland restoration vegetation design. Figure from Conceptual Restoration Report, Herrera Environmental Consultants, Inc. Hummock islands were eliminated from final design due to cost.

Hard engineering was not incorporated except to establish the project boundary berms. The project's floodplain boundary was the mid-size alluvial fan alternative presented in The Plan and incorporated by consensus in the Northern State Recreation Area Master Plan Update of 2002.

2.0 Statement of Need

Hansen Creek has been on the Washington State 303d list of impaired waterbodies for fecal coliform and fish habitat since 1998, temperature impairment was added on the 2004 Washington State 303d list and the 2008 Washington State 303d list of impaired waterbodies for dissolved oxygen. Land use includes rural residential (small hobby farms) and prime agricultural properties in the lower watershed. The Northern State Recreation Area (NSRA), which contains 726 acres of Skagit County park land and also the area of the project, is located in the middle watershed. Private and public forest lands dominate the upper reaches of the watershed.

Hansen Creek (HUC171100070107) had become incised in the alluvial fan (sediment deposition reach) and aggraded in the wetland reach and below. Before project initiation, sediment moved through the straightened, channelized and levied main stem reach of the alluvial fan depositing sediments farther downstream rather than depositing in the fan reach. The artificially raised creek bed downstream of the alluvial fan increased flooding on private properties and buried, damaged, or destroyed salmon redds, while both dredging and channeled sediment deposition destroyed habitat. Floodwaters constrained by the dikes passed rapidly downstream, rather than spreading out as they did historically, further increasing flood threats and habitat losses.

The historic practices of dredging, diking and straightening activities that had occurred since 1948 had 'de-activated' the floodplain alluvial fan and riverine, flow through wetlands. The consequence had been substantial loss of side channels, forested floodplain and productive aquatic habitat. The primary issue facing the Hansen Creek Watershed was the disruption of historic sediment transport patterns. As a result the natural watershed ecological and habitat processes had nearly been annihilated. Floodwater storage, water quality, fishery resources, and stream channel stabilization, habitat and function were extremely impaired.

The project reaches consisted of a single hydromodified channel bounded by dredge spoil dikes, lacking channel roughness elements, and with minimal riparian vegetation. Sediments and flood waters transported downstream, impacting lower reaches and disrupting groundwater recharge resulting in the creek tending to run low and/or become intermittently sub-surface during summer months. The alluvial fan alternative was designed to re-activate the historical fan and capture sediment in the area where deposition historically occurred and restore riverine wetland flood storage. Re-activation of the fan allows larger sized sediments to deposit on the alluvial fan, reducing the size and amount of sediment transported and deposited downstream, eliminating a progressively worsening flooding problem and the need for associated maintenance dredging. The design provides riverine wetland re-connection and habitat regeneration with initiated LWD and native plants. LWD and native plants increase gravel retention and sorting, form canopy and recruit LWD to restore natural processes.

3.0 Project Description

Reconnection of the floodplain with the main channel is essential to move sediment transport into the floodplain, reduce artificial scour, burial or siltation of salmon redds, improve sediment and gravel sorting, and improve channel morphology for salmon spawning and rearing habitat. Reconnection of the floodplain is also essential to flood flow storage that increases riverine wetland habitat and function, refugia accessibility for salmon, and reduction of flood frequency, height and duration to downstream properties. In addition, project wood and native plant restoration will reintroduce natural functions and features to Hansen Creek that bring about increased stream sinuosity, food production, and stabilized habitat, resulting in reduced stream temperatures and moderated stream flows.

Long-term dredging of sediments channelized the main stem and cut off sediment and flow distribution and storage of the main stem with its floodplain as dredge spoils were embanked along the channel. Sediment and flows were pushed through the channelized main stem farther downstream than natural processes would support. The constrictive channel and sediment aggradation increased downstream flooding and starved the upper reaches of the creek of sediment by preventing deposition in the alluvial fan. Because of these processes, the riparian, side channel and essential floodplain habitat was reduced significantly.

4.0 Project Goals, Objectives, and Activities

4.1 Planned and Actual Milestones, Products, and Completion Dates

The planned and actual milestones, products, and completion dates are summarized in Table 1.

Table 1. Milestones

Milestone	Target Date	Actual Date	Comments/Description
Project Start	06/01/2007	06/01/2007	Project scope work began
Engineering RFP for Design, Permit Assistance, Construction	7/24/2007	8/22/2007	Advertisement, review and assessment of RFP proposals
Engineering Awarded	8/22/2007	8/22/2007	Notice of Award
Conceptual Design & Community Outreach	9/13/2007	12/26/2007	Community Meeting, Charette
Funding Applications	10/30/2007	07/01/2009	Completed funding for implementation
Applied for Permits	02/01/2009	02/11 to 02/18/2009	Permits applicable to this project include: COE – NW27, HPA and Unanticipated Discoveries Streamlined JARPA, NEPA
A&E Plans Submitted	02/01/2009	03/05/2009	Final draft submitted for review/no comments received
RFP for Construction	04/01/2009	05/11/2009	Advertised 06/01 and 06/08/2009
Construction Awarded	06/30/2009	07/02/2009 07/15/2009	Notice of Award Notice to Proceed
Construction Started	06/30/2009	07/20/2009	Mobilization began
Construction Complete	10/31/2009	10/31/2009 majority 10/31/2010	Wet weather began October 1st, and flood event occurrences began October 16th and continued through November requiring earthwork to be unfinished for the western boundary berm, the re-grading of the staging area, and final grading of a portion of west wetland. Plantings and seeding carried into spring and fall 2010 for these restricted areas.
			2010 Additional work to protect highway culvert and highway road embankment from main stem flow that had avulsed into east floodplain.
Project Complete Record Drawings	12/31/2009	12/31/2010	Based on weather conditions in 2009, in 2010 there was spring and summer work by the earth contractor to complete and spring and fall planting by the planting contractor to complete for the earthwork areas.
Monitoring	Summer 2010	Summer 2010	Monitoring support is cobbled together from a variety of fund sources for baseline information. Not all desired data collection is funded to track early establishment functions.

4.2 Evaluation of Goal Achievement, and Relationship to Management Plan

Goals in the completion of the project were to increase the quantity and quality of salmonid habitat, stream length, native plant diversity, surface roughness of the stream, sediment metering capabilities, wetland holding capacity, and riparian cover. Also important was the reduction of downstream flooding in neighboring agricultural lands and protecting the upland use recreation area as well as increasing trail lengths within the park to provide patrons with greater opportunities. While all of these goals have been met thus far, the project is still young and the Tribe expects the benefits to increase over time.

Fish habitat increases encompass multiple factors that were included in the project goals. The increase in stream length, native plant diversity, surface roughness, sediment metering, holding capacity, and riparian cover all aid in the enhancement of fish habitat. The opening of the fan area has allowed the stream to take its own course, metering sediment and carving new channels. Installation of logs has provided surface stream roughness and also provides scour pools that are utilized by juveniles and adults. The native plant diversity and riparian cover increase the nutrient input to the stream and provide shade that provides a more stable water temperature. Each factor also contributes to the growth and stabilization of the macroinvertebrate community, providing food for juvenile and adult fish.

Because the project is located in a county park, the recreational value was an important factor. Trail lengths were increased by over 1.5 miles with the addition of the boundary berms and the berms themselves are barriers to keep flood waters from invading the upland recreational use areas that have been outlined in the NSRA Management Plan for development into high use recreation areas. Public interaction on the site was a regular occurrence during construction and park patrons are often eager to learn about the site.

Downstream agricultural land was flooded on an annual basis before the project. Dredging practices had changed the sediment metering and the dike systems that were used had severely impacted the natural hydrology of the creek. A major rain event halted construction in October and though flows increased significantly during this event and

large events to follow, the downstream flooding was reduced due to the holding capacity of both sediment and flood waters in the project site. While some flooding was still expected to take place, the reduction in flood waters was noticeable and the sediment that was transported into Reach 5 was reduced. The concept plan identified that aggraded sediments in the lower project reach may require future dredging if deposited in the agricultural reach during the initial 5-8 years of project establishment with the ultimate goal to eliminate dredging in the system. The result of the main stem avulsion into the floodplain and the significant reduction in sediment transport to that reach has eliminated any foreseeable dredging. Restoration of the system in the agricultural reach is currently being pursued to further advance the watershed and ecological system process of Hansen Creek. Reduced dredging improves fish habitat, as the dredging practices often eliminate ideal spawning and rearing habitat and increase turbidity on the creek.

4.3 Supplemental Information

In 2009, the Tribe partnered with Skagit County Parks and Recreation, Skagit Fisheries Enhancement Group, Starbucks, and smaller groups to host the first annual Earth Day Celebration at NSRA. The event enlisted the help of volunteers to remove blackberries and plant trees. In 2010, the second annual Earth Day Celebration was held at NSRA. About 100 volunteers helped to plant over 16,000 wetland plugs on a rainy day and completed the task in an hour. In 2011 Skagit Fisheries Enhancement Group hosted a planting event in the downstream agricultural reach. Plans are being made to continue the work of the partners in hosting an event each year to bring additional visitors and allow them to experience the park and the project site. The berm that surrounds the project was implemented with a dual purpose; to secure upland recreation areas and to add over 1.5 miles of new trails within the park.

During construction and after completion of the project, various groups have toured the Hansen Creek restoration site. Groups that have toured include Congressman Rick Larsen, Skagit County Commissioners, Skagit Valley College groups, University of Washington, Skagit Watershed Masters, Envision Skagit County Committee, and funding agencies including NOAA, Washington State Department of Ecology, Department of Natural Resources, and Northwest Indian Fisheries Commission. The Tribe developed with Skagit County Parks Department interpretive displays that have

been placed along the boundary trail explaining the project and benefits, as well as what park visitors should expect to see over time.

The Skagit Audubon Society also takes a role in the project by surveying the site for bird species. These bird inventories are used to see what types of birds are utilizing the site at various times of year and the changes over time of the migratory and Pacific Northwest lowland and coniferous species utilization. Many migrating birds use the site, as well as local populations that stay year-round.

The project implemented many BMPs throughout the project. Standard procedures included using only Clarity biodegradable oil certified equipment in the dewatered channel, high visibility construction fencing to demark the project work area, erosion control silt fencing, sterile straw for erosion control, dust control through site watering, street sweeping, adherence to construction entrance protocol, implementation of a Storm Water Pollution Prevention Plan, and standard turbidity testing during high flows and construction. All water that had been rerouted or drawn from the creek in dewatering practices was discharged through energy dispersion devices and/or onto vegetated areas. The BMPs that were used allowed the project to proceed without violations.

5.0 Monitoring Results

The project site consisted of 128 acres of disturbed area, of which 40 acres was used in recent years as income for the park by way of haying grasses. Eighty-seven acres of wetland, which includes 12 acres of riparian growth along the historic main stem, were primarily depressional wetlands infested with reed canarygrass. In the fan area, riparian areas were heavily infested with Himalayan blackberry, which was up to 60 feet wide on each side. There are roughly 3.4 acres of boundary berm that were constructed, meeting ADA standards for multiuse. The construction staging area was 28 acres and was not included in the restoration acreage of the project, though it was graded and seeded with a native low-growing “Elk seed” grass mix.

The monitoring results reported are based on data collected according to the Quality Assurance Project Plan (QAPP) for the Hansen Creek Floodplain Restoration Project. There are several components to the monitoring, including:

- Physical and chemical water quality parameters, including use of continuous temperature dataloggers

- Creek discharge
- TFW Habitat Unit Surveys to determine the availability of salmonid habitat
- Stream lengths and GPS layers of channels to monitor the progression of channels over time
- TFW LWD surveys to determine the abundance and distribution of LWD in the project
- Sediment analysis to determine the sediment composition within the project
- Vegetation transects to determine the composition of the plant community
- Photo points to show the progress of the project site over time
- Inundation mapping and groundwater ports to measure holding capacity of the site
- Spawner surveys to determine the abundance of returning adult salmon in the creek

Initial baseline data collection has been completed by the University of Washington's (UW) Wetland Ecosystems Team in the School of Aquatic and Fishery Sciences for the following:

- Benthic macroinvertebrate index
- Juvenile salmon diet composition

Initial baseline data collection has been completed by the Watershed Master volunteers for:

- Amphibian composition, abundance, and habitat use

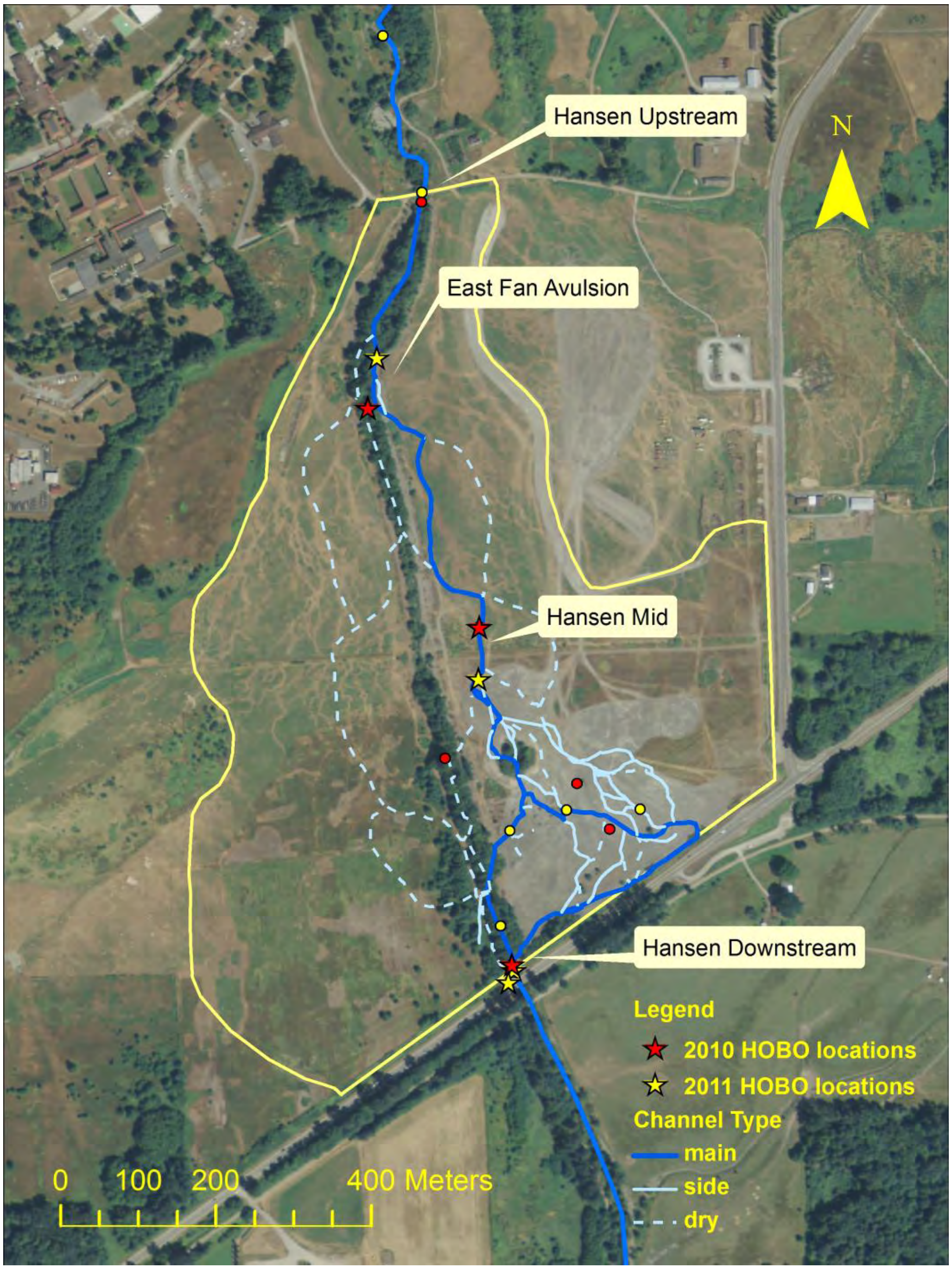
Regular and ongoing bird surveys are completed by a Skagit Audubon volunteer for:

- Bird species abundance and site utilization. Two years of data have been collected thus far.

5.1 Water Quality

Ambient monitoring of water quality parameters was executed weekly on the project site. Monitoring is done at upstream, mid, and downstream sites within the project reach (Map 2). Monitoring for dissolved oxygen, temperature, pH, and specific conductivity are conducted using a YSI 650 multiprobe and grab samples. Turbidity samples are collected at each site and triplicate measurements are run through a Hach benchtop turbidimeter. Flow is calculated using a Pygmy flow meter and a Rickly Hydrological Company Current Meter Digitizer. In addition to the weekly monitoring, HOBO temperature dataloggers are also deployed during the summer months. All results are

entered into an Excel spreadsheet and imported to an Access Database on the USIT network.



Map 2. Map showing location of Hansen Creek upstream, mid, and downstream water quality monitoring sites. The 2010 locations of the HOBO temperature dataloggers are indicated in red and the 2011 locations in yellow. The HOBO data from sites marked by a star are represented in Figure 5. Stream channels are based on 2011 channel locations (all HOBOs were deployed in channels that were active at the time).

5.1.1 Dissolved Oxygen

The dissolved oxygen levels on Hansen Creek were above the minimum state standard of 9.5 mg/L for all except one week in August 2010 (Figure 3). These oxygen levels support Core Summer Salmonid Habitat. The dissolved oxygen levels were quite similar among the three sites, though there were a few occasions during the summer months where the downstream sites had slightly elevated dissolved oxygen levels, which are assumed to be caused by natural conditions associated with the growth of periphyton on the substrates.

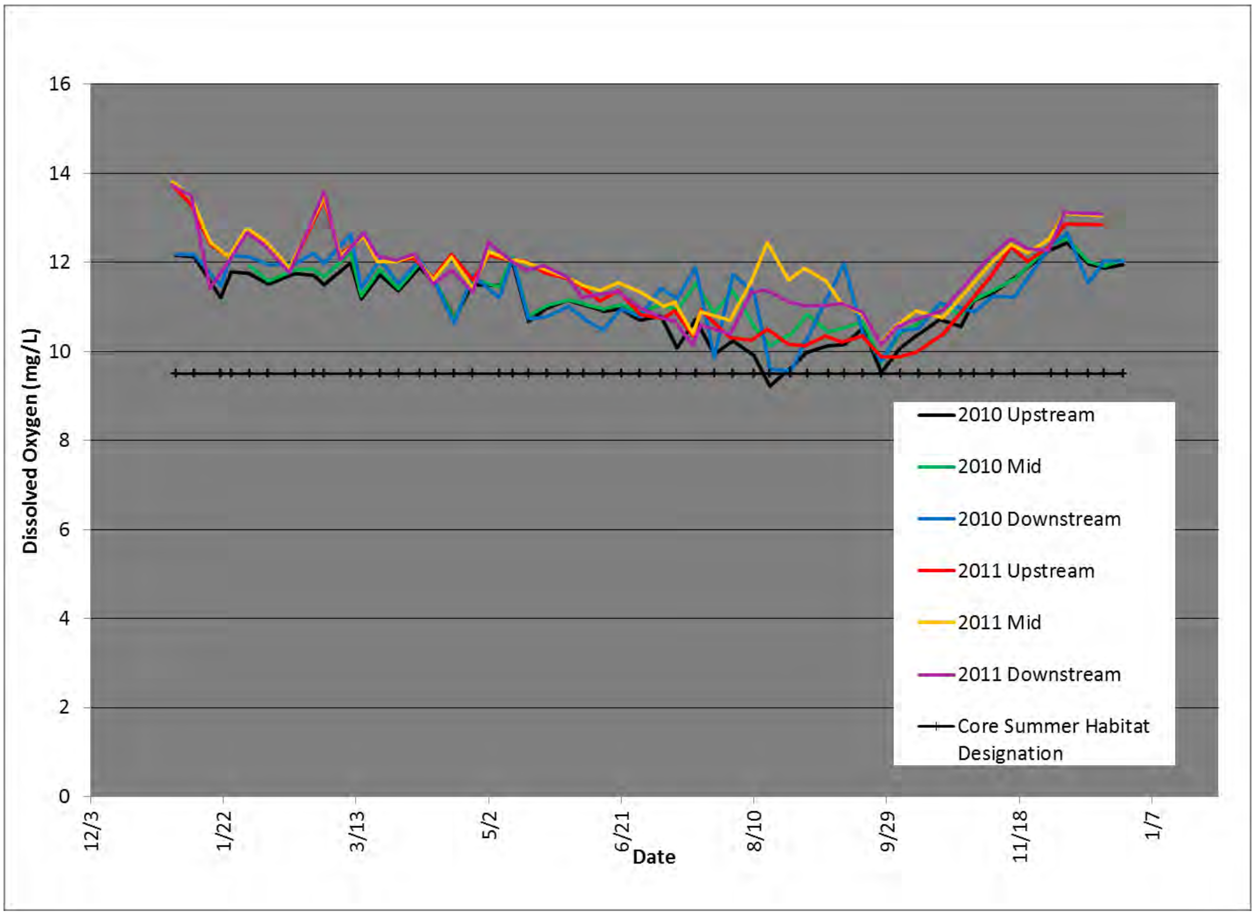


Figure 3. Graph showing dissolved oxygen levels in Hansen Creek during 2010 and 2011. The state standard of 9.5 mg/L for Core Summer Habitat is shown as a hashed line.

5.1.2 Temperature

Temperature data was collected during weekly water quality site visits using a YSI handheld datalogger (Figure 4). In addition, HOBO continuous temperature dataloggers were deployed at multiple locations within the project site (Map 2). The HOBOs were deployed in the spring and collected in late summer or early

fall, depending on when the channels dried up. Unfortunately, one HOBO has been lost each season due to sediment deposition from high flow events. Due to the loss of the Hansen Upstream HOBO in 2010, temperatures from the East Fan Avulsion site were compared instead of the Hansen Upstream site (Figure 5). The East Fan Avulsion, Hansen Mid, and Hansen Downstream sites were chosen for comparison since they were the most consistent in location between the two years. Since the HOBO data was continuous and the YSI data represented isolated data points, the 7-day average of the daily maximum (7-DADMax) was calculated for the HOBO data only.

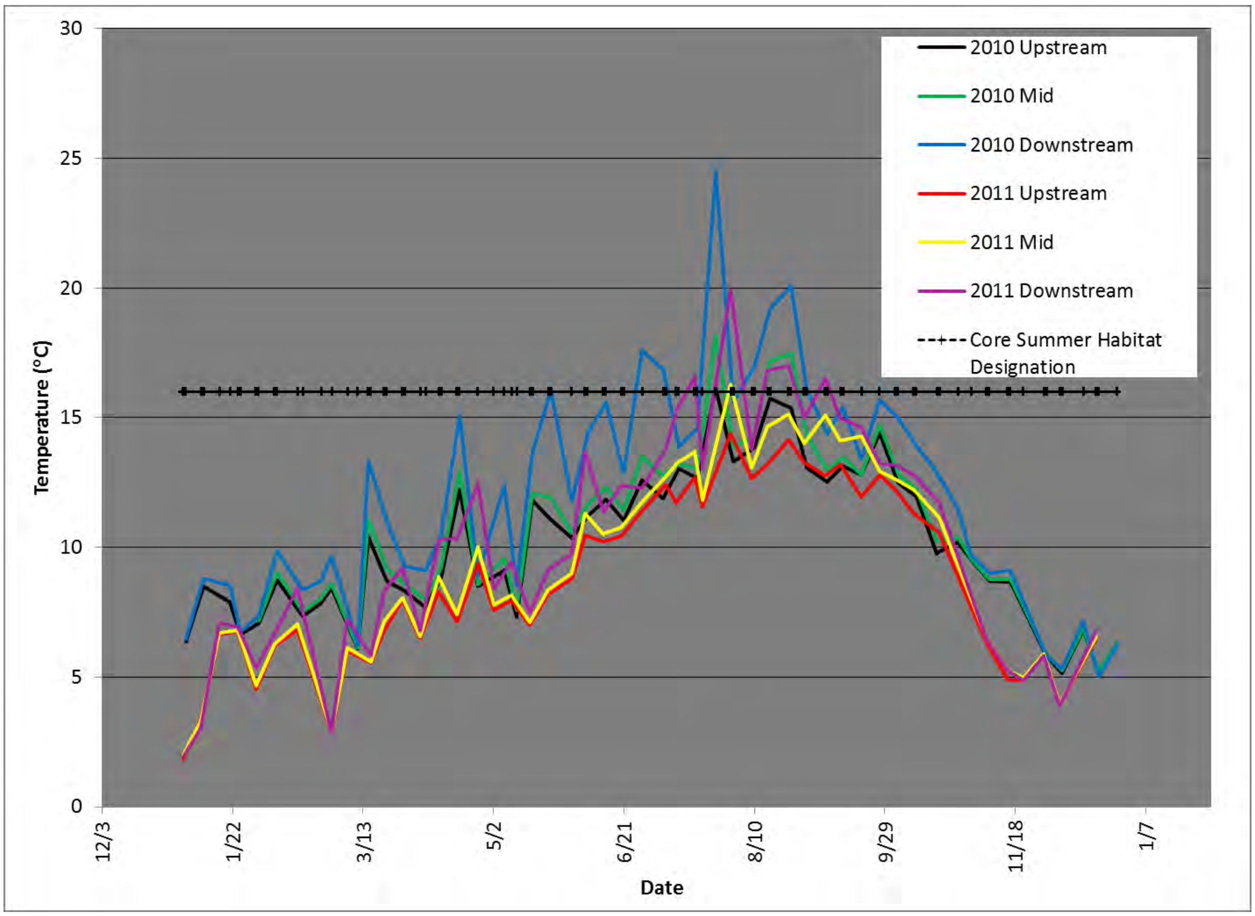


Figure 4. Graph showing weekly water temperatures in Hansen Creek during 2010 and 2011. The state standard of 16°C 7-DADMax for Core Summer Habitat is shown as a hashed line. The other data series are not a 7-DADMax.

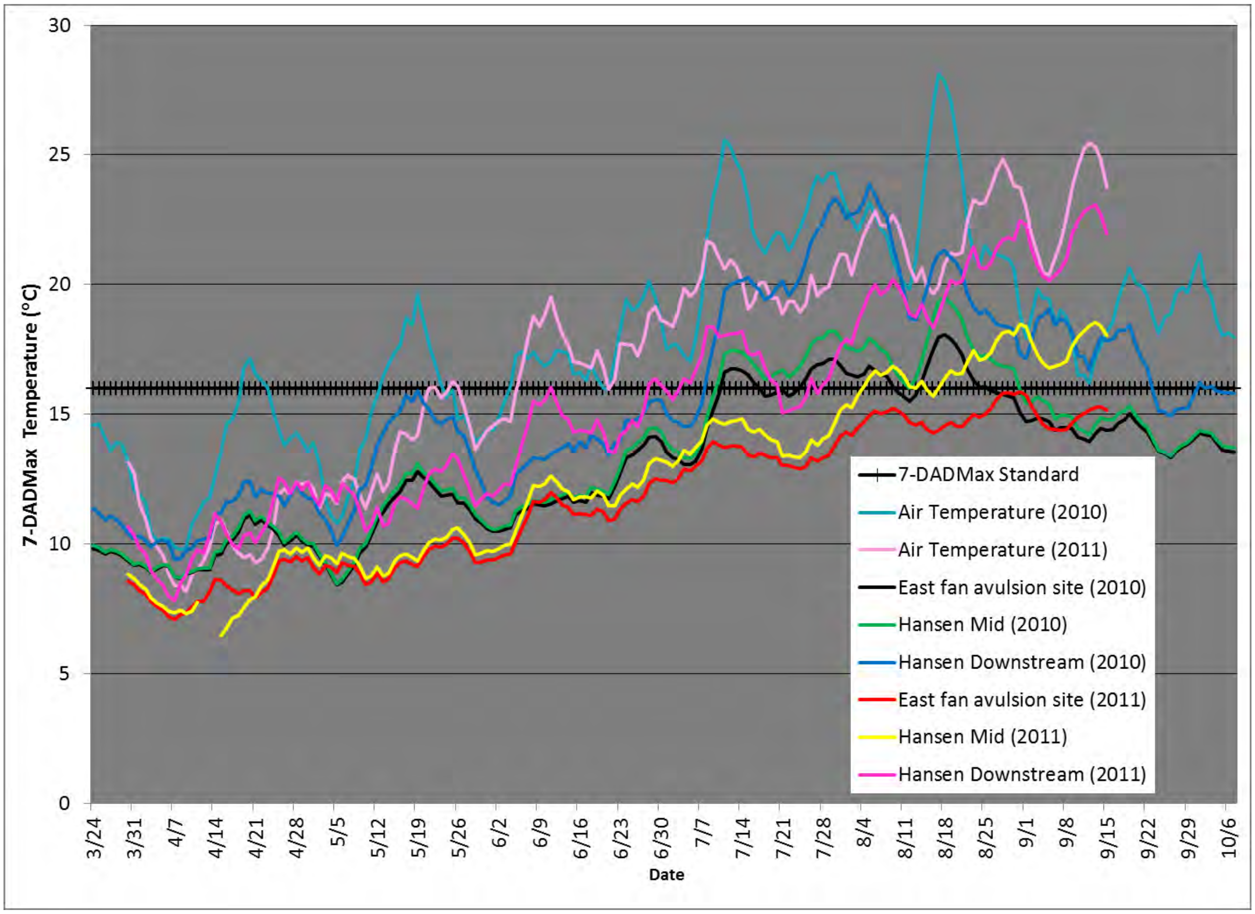


Figure 5. Graph showing 7-DADMax of HOBO water temperatures. The locations correspond to the starred HOBO locations in Map 2. In 2010 the Hansen Upstream HOBO was lost during a high flow event, so the East Fan Avulsion site was used for comparison instead. The state standard of 16°C 7-DADMax is shown as a hashed line.

The water temperatures in Hansen Creek were as expected; higher in the summer low flow season and lower in the winter. Additionally, in 2011 the temperatures peaked later in the season due to the later arrival of typical summer weather. During the summer low flow season, there were several weeks when the temperatures exceeded the 7-DADMax state standards. However, this is not unexpected due to the high air temperatures, long summer days, shallow flow through the wetland, and lack of riparian cover establishment in the new floodplain. As the project matures and vegetation cover develops, these high summer temperatures should decrease. HOBO temperature loggers will be placed each year at the most comparable locations to these data collection areas in wetted channels as funding allows.

Temperature is an impairment that existed prior to the project undertaking as registered in the TMDL listings maintained by Washington State Department of Ecology. Achieving temperature water quality goals takes significant time and is dependent on the maturation of the restoration native riparian vegetation plantings.

5.1.3 pH

pH data was collected using the YSI datalogger. Except for a single sample in 2011, all the samples were within the 6.5-8.5 pH range of the state standard (Figure 6).

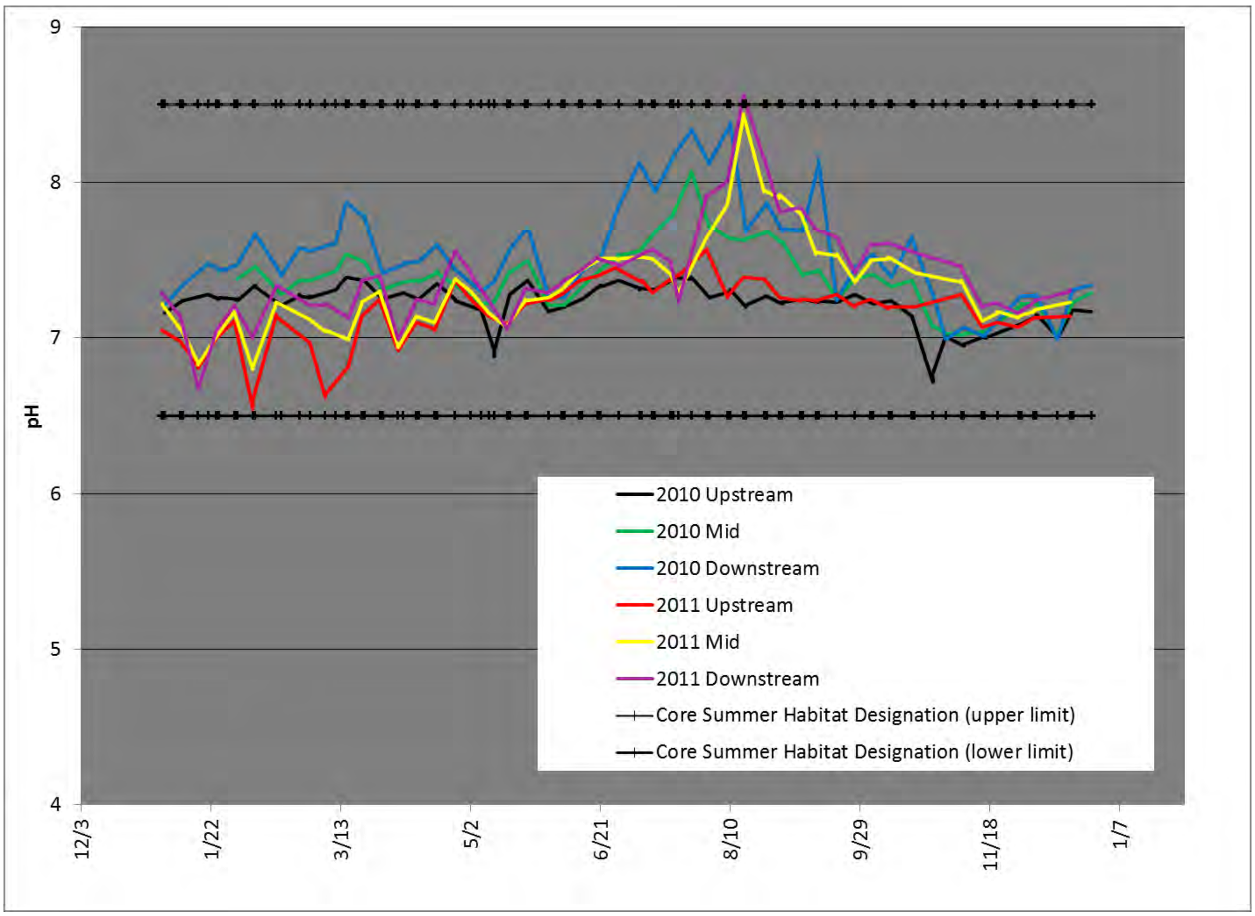


Figure 6. Graphs showing pH values of water in Hansen Creek during 2010 and 2011. The state standard of pH 6.5 and pH 8.5 for Core Summer Habitat are shown as hashed lines.

5.1.4 Specific Conductivity

The specific conductivity among the three sites (Upstream, Mid, and Downstream) for a given week was consistently similar, though it fluctuated over

the course of the year (Figure 7). It was highest in the late summer and lowest in the winter. This is interpreted as a reflection of the flow conditions, with the highest conductivity during the low flow months when the dissolved solutes are more concentrated. Again, the later arrival of low-flow conditions in 2011 is reflected by the later peak in specific conductivity.

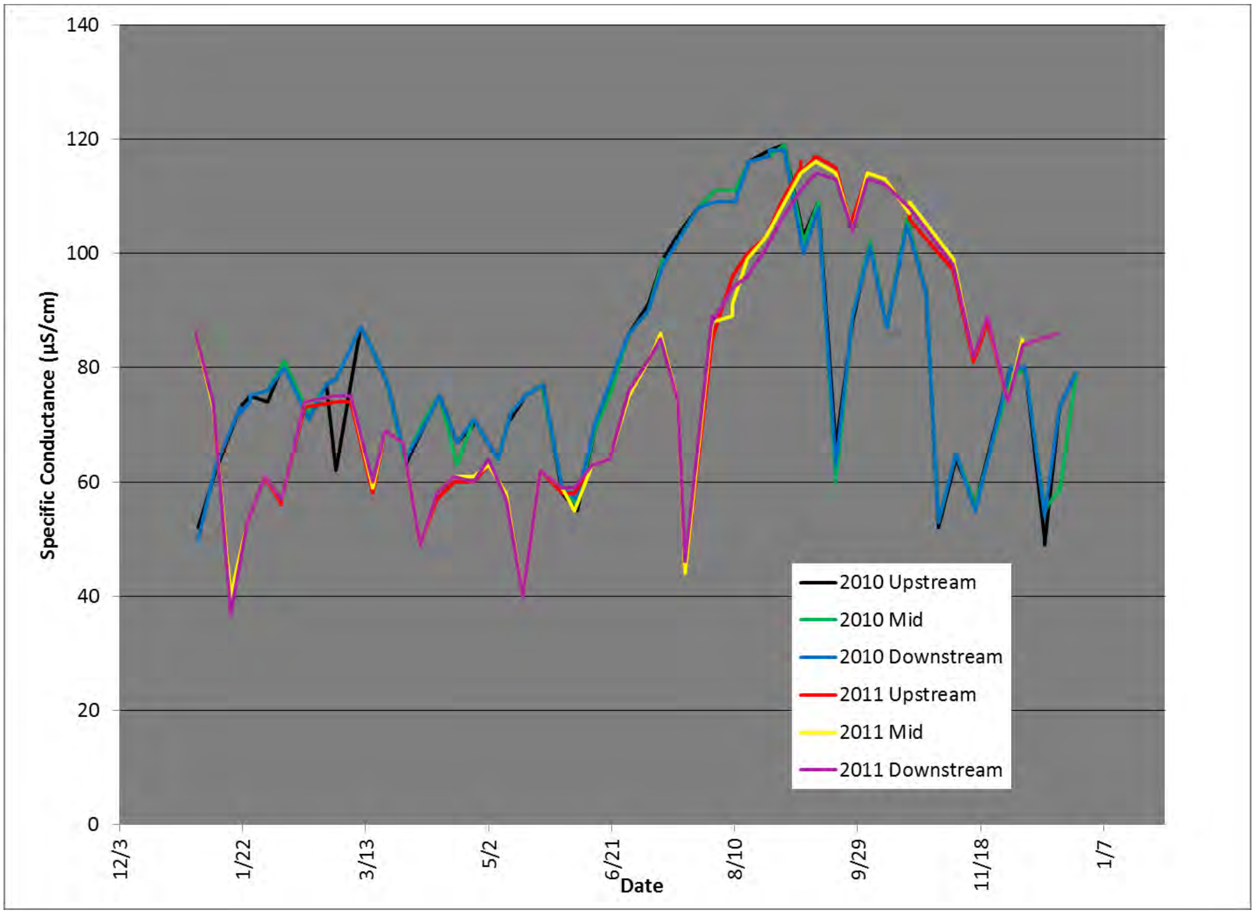


Figure 7. Graph showing specific conductivity in Hansen Creek in 2010 and 2011.

5.1.5 Turbidity

The turbidity on Hansen Creek reflected the flow conditions. During high flow events there was a spike in turbidity (Figure 8). When the flow receded, the turbidity dropped as well. However, this pattern was different between the spring and the fall of 2010. In the fall of 2010, the creek avulsed into the east fan and began scouring away sediment. Thus, under similar flow conditions, the turbidity was higher in fall 2010 –spring 2011 than it was in spring 2010. The new east fan channel has since begun to stabilize and the downstream turbidities remained low during high flow events in the fall of 2011. Additionally, due to several large

sediment transport events, the Ecology flow gage experienced dramatic changes in the channel bed morphology, affecting the accuracy of the flow gage. According to Ecology staff, the flows were underrepresented due to an inaccurate rating curve. Despite the inaccuracy of the flow gage, it was possible to estimate the flows; the discharge was 5-10 cfs in the dry season and 20-40 cfs in the wet season, with rain events bringing flows even higher. The higher turbidities are attributable to the natural process of channel avulsion and side channel development in the early restoration site as the channels and vegetation mature.

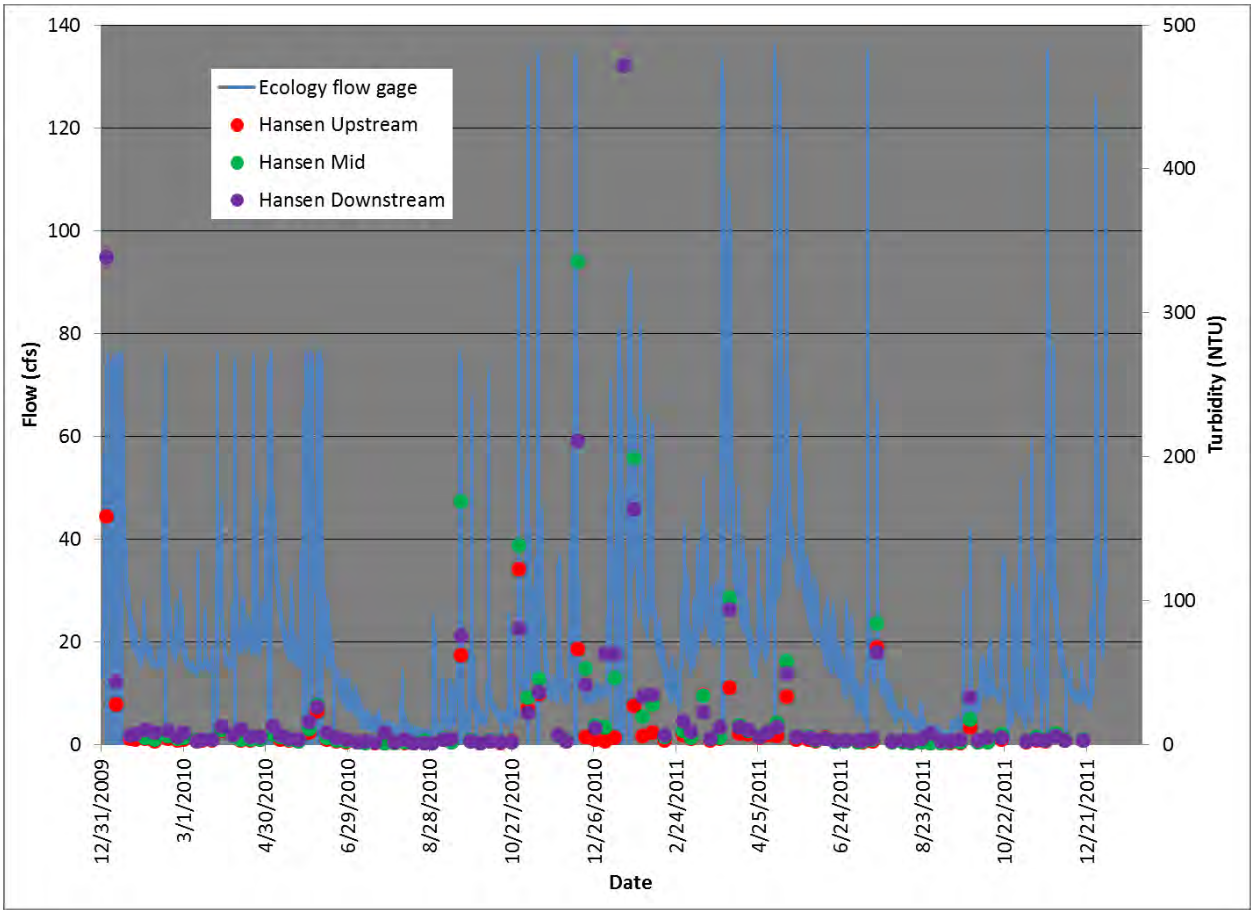


Figure 8. Graph comparing turbidity with flow data from the Ecology flow gage. Left vertical axis shows flow and right vertical axis shows turbidity. 2010 and 2011 data are included as a single data series.

The natural processes of floodplain sediment deposition and storage were immediately realized. In 2009 and again in 2010 mobilization of sediment in the system was on the order of 30,000 cubic yards. A more accurate estimate of

sediment mobilization and site productivity cannot be calculated due to the lack of supportive funding. Financial support in future monitoring would allow for a meaningful estimation of sediment deposition. The re-establishment of the floodplain and the early stage of restoration of stream geomorphology within the site may result in periodic starvation of channel sediments in the downstream reaches below the project site. Within the project site channel gravel sorting occurred immediately and will continue to advance in the anabranching stems through the wetland floodplain.

Sediment deposition measurements have been estimated by the design team, Herrera Environmental Consultants using the Syvitski Analysis. The project has been successful thus far in sediment holding after two wet seasons of receiving near the upper estimated event year sediment load. Sediment transport was estimated for the project between 300 and 33,000 cubic yards, with an annual input average of 3,000 cubic yards. In the alluvial fan where the stream avulsed, sediment sorting began and new layers of light silt can be seen in channels that were activated (Figure 9). The duning effects of water movement and fast deposition can be seen throughout the site and are most notable in areas where the stream topped the banks, spilling into the floodplain (Figure 10).

Figure 9. Almost 20 cm of sediment deposition in a wetland channel.

Figure 10. Sediment deposition in the wetland due to channel overflowing during flood events.

Sediment deposited in the wetland as well, leaving up to 8 inches (20 cm) of fine silt in many areas. In addition, both the constructed and naturally carved channels allowed for consolidation of channel bottoms via sorting. Larger pebbles now fill the channels and the substrate is approaching an ideal compaction and sediment size (Figure 11 and Figure 16).

Figure 11. Several feet of sediment were deposited in the historic main stem when the channel avulsed into the east fan design channel.

Figure 12. East fan design channel before the Hansen Creek main stem avulsed into this channel (facing upstream).

Figure 13. East fan design channel after Hansen Creek main stem avulsed into this channel (facing upstream). Meanders and gravel bars have developed.

Figure 14. East fan design channel before Hansen Creek main stem avulsed into this channel (facing downstream)

Figure 15.East fan design channel after Hansen Creek main stem avulsed into this channel (facing downstream). Extensive gravel bars have developed and additional LWD is being recruited.

Figure 16. East fan design channel after a year of channel activation. The meanders and gravel bars have developed even further.

5.1.6 Flow

The flow on Hansen creek is quite flashy; the discharge increases rapidly during rain events and drops off quickly when the rain ends (Figure 17). Washington State Department of Ecology has a flow gage on Hansen Creek at the upstream end of the project reach and the flow data is made available online. The flow gage has several shortcomings, however. In high flow events the rating curve is inaccurate so the gage goes offline. Additionally, several rain events in the fall of 2010 caused dramatic changes in the channel bed morphology, so the rating curve underestimated the flow significantly. Due to the dynamic nature of the creek, the field checks performed by Ecology staff are outdated almost immediately. To help compensate for this shortcoming, discharge is also measured in the field using a wading rod and a Pygmy flow meter. While this has the advantage of being more up-to-date and accurate than the Ecology flow gage, the equipment was subject to a malfunction in spring 2011 and was out for repairs for several months. A high flow event in April 2011 destroyed the Ecology staff gage, making it difficult to directly compare USIT flow measurements with the equivalent Ecology gage measurements.

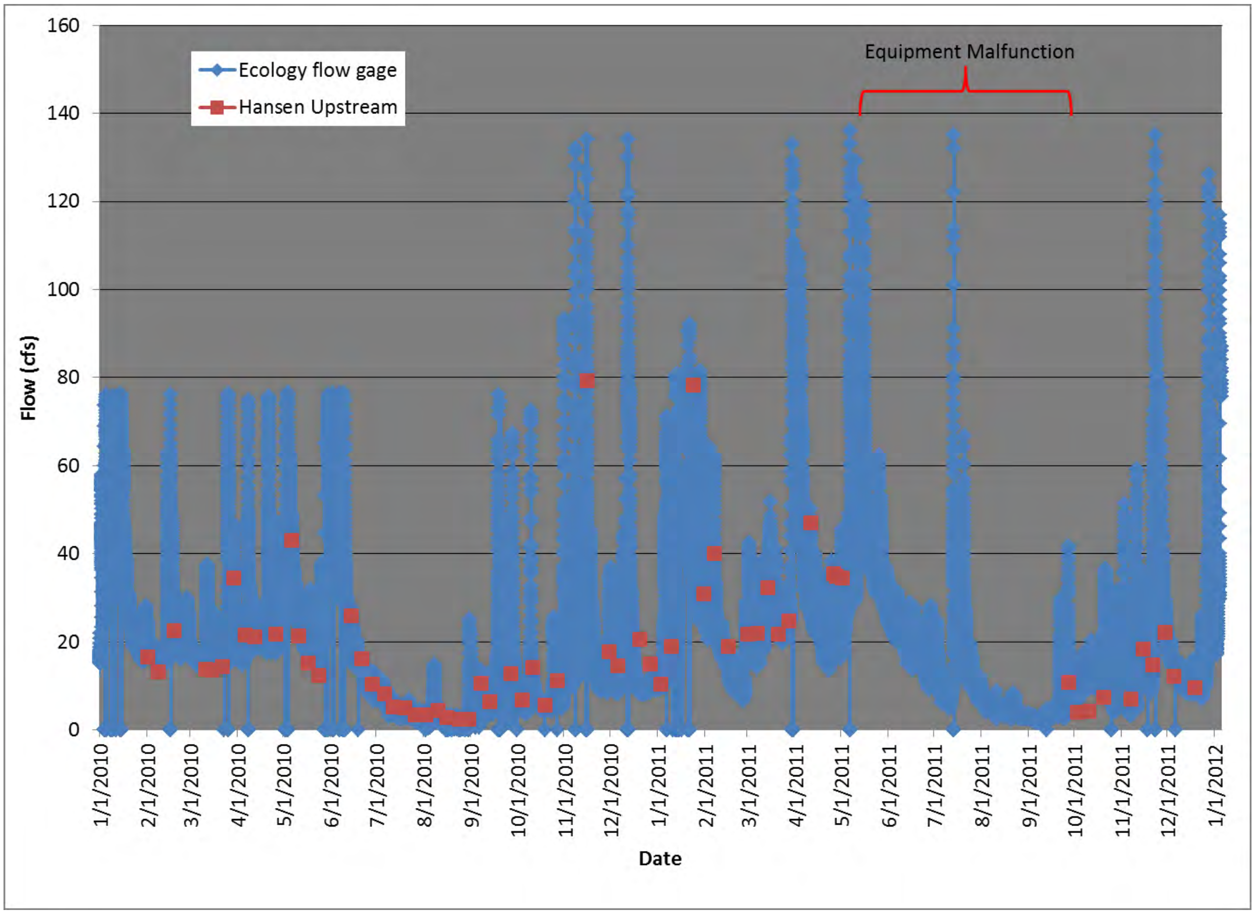


Figure 17. Graph comparing USIT flow measurements and Ecology flow gage measurements. The series in red shows the USIT flow measurement at the Hansen US site adjacent to the Ecology flow gage. The series in blue shows the continuous Ecology flow gage data for 2010-2011. Due to equipment malfunction there was no USIT flow data between 5/2/11 and 9/27/11.

Holding capacity of the site has decreased downstream sediment transport and flooding (Map 11). Downstream residents have confirmed the reduction in height, duration and frequency of flooding. Skagit County and the design team of Herrera Environmental Consultants have confirmed a lowering of the channel elevation downstream of the project site from pre to post project surveys.

5.2 Habitat Unit Surveys

After review of applicable habitat assessments, the TFW Habitat Unit Survey (HUS) was chosen as the method to be used to monitor change over time in Hansen Creek. This method measures the lengths and widths of pools and riffles in the system, as well as the pool forming functions (Figure 18). Analysis of these habitat assessments can reveal if the creek has a reasonable number of pools and riffles or if the system is unbalanced.

In this process the overall stream length is measured and can be divided by lengths of pools and riffles in the surveyed reaches. The first HUS module was completed in early fall 2010. However, shortly after the survey was completed, the main stem avulsed into the east fan, abandoning the old channel. Thus, many of the pools identified in the fan portion of the survey were no longer in an active channel in 2011. Due to the dynamic nature of the system, these surveys and future surveys may not be directly comparable.

Figure 18. Example of a riffle section of a pool-riffle sequence.

The HUS module details procedures and provides data sheets for both field work and cataloging of the data. These protocols were followed as described in the module. Only the project reaches, 3 and 4, were measured, although the last riffle sequence overlapped slightly into reach 2. Each length was measured and width measurements were taken at specified intervals listed in the module. For pools, the maximum depth and the outfall depth were also measured and the difference in depths (residual pool depth)

determined if the segment was a pool or not. Also listed with pool measurements were the associated pool forming factors as they impacted the pool. Some pools had more than one factor and these were listed in the order of their impacts on the pool. Once the reaches were completed and the data brought back to the office, length measurements were added to achieve unit total length. Width measurements were averaged together to obtain the average unit width. All data was input into an Excel spread sheet and all forms and data entry were checked by a different staff member.

The data were analyzed separately for the fan and the wetland (Table 2 and Table 3). In the fan, the number of habitat units decreased from 2010 to 2011, though the area remained similar. The fan had over 8 channel widths per pool in 2010 and almost 11 channel widths per pool in 2011, well above the <2 channels widths per pool recommended by DNR's Forest Practices Watershed Analysis Manual. It is important to note that the main stem of Hansen Creek avulsed into the east fan design channel after the 2010 survey so the fan channel in 2011 consisted of recently-formed channel. As the project matures it can be expected to develop more pools and pool-riffle sequences.

Table 2. Summary of Habitat Unit Survey data within the fan (Reach 3), broken down by pool and riffle habitat.

	Pools		Riffles		Total	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**
Total number	23	17	23	19	46	36
Percentage of total	50.00%	47.22%	50.00%	52.78%	100.00%	100.00%
Total surface area (m^2)	777.4	642.4	2399.4	2464.53	3176.8	3106.92
Percentage of surface area	24.47%	20.68%	75.53%	79.32%	100.00%	100.00%
Habitat Units/km	57.17	47.85				
Habitat Units/bfw	0.2257	0.1976				
Pools/km	28.586	22.594				
bfw/pool	8.8601	10.718				

In the wetland, the amount of pool area increased from 5.91% in 2010 to 9.51% in 2011 (Table 3). However, the 13-16 channel widths per pool in the wetland are still above the recommendations of the DNR Manual. As the site matures, the vegetation grows, and channels become established, these numbers should improve.

Table 3. Summary of Habitat Unit Survey data within the wetland (Reach 4), broken down by pool and riffle habitat.

	Pools		Riffles		Total	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**
Total number	16	17	20	25	36	43*
Percentage of total	44.44%	39.53%	55.56%	58.14%	100.00%	100.00%*
Total surface area (m^2)	277.554	415.566	4420.53946	3952.697	4698.09	4368.26
Percentage of surface area	5.91%	9.51%	94.09%	90.49%	100.00%	100.00%
Habitat Units/km	36.41882	38.283				
Habitat Units/bfw	0.17309	0.1524				
Pools/km	16.18614	15.495				
bfw/pool	12.99905	16.208				

*includes 1 unit of wetland core unit type (length = 30 m)

The majority of the fan habitat was primary channel (Table 4), with only 1 unit of side channel habitat in both 2010 and 2011. Since the distributary channels in the fan are activated only during high flow events and the habitat unit surveys were conducted during moderately low flows, most of the side channels in the fan were not included because they were not active.

Table 4. Breakdown of primary and side channel habitat within the fan (Reach 3)

	Primary		Side Channel		Total	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**
Number of habitat units	45	35	1	1	46	36
Total lengths of units (m)	783.4	726.8	21.2	25.6	804.6	752.4

The highly braided wetland had much more side channel habitat than the fan (Table 5). In 2010 there were 25 units of side channel habitat but only 6 units in 2011. This is likely due to the channels becoming more established, with fewer branching side channels and less surface sheet flow (though the wetland still has extensive side channel habitat).

Table 5. Breakdown of primary and side channel habitat within the wetland (Reach 4)

	Primary		Side channel		Total	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**
Number of habitat units	11	37	25	6	36	43
Total lengths of units (m)	619.8	974	368.7	123.1	988.5	1097.1

The pools in the fan were primarily formed by LWD of some form (Table **6**). Though standing trees, boulders, scour-resistant banks, and artificial banks (rip rap) all contributed to pool formation, most of the pools were caused by LWD. As more wood is added to the system from natural recruitment, the number of pools in the fan will likely increase.

In 2010 the primary pool forming factor in the wetland (by area) was channel bedform (Table 7). The wetland channels were extremely low gradient and variations in the channel bedform were sufficient to form pools. However, in 2011 the pool area almost doubled and none of them were caused by channel bedform. Rather, the main pool forming factor in the wetland was scour-resistant bank. As the vegetation matures it will stabilize the channel banks, the channels will become established, and the amount of pool habitat should increase. This is already beginning to occur.

Table 6. Factors contributing to pool function within the fan (Reach 3).

	LWD Log		**LWD Rootwad**		**LWD Jam**		**Roots of standing tree/stump**		**Boulders**		**Scour-resistant bank**		**Artificial bank**		**TOTAL**	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
Total number of pool units identified as primary PFF	5	4	5	6	3	1	3	0	2	0	4	5	1	1	23	17
Percent pool units (%)	21.7	23.5	21.7	35.3	13.04	5.9	13.04	0.00	8.70	0.00	17.4	29.4	4.35	5.88	100	100
Surface area (m^2)	130.8	115.8	136.7	254.6	118.8	61.4	113.1	0	73.49	0	173.9	171.51	30.6	38.99	777.4	642.4
Percent pool surface area (%)	16.8	18.0	17.6	39.6	15.3	9.6	14.55	0.00	9.45	0.00	22.4	26.70	3.94	6.07	100	100

Table 7. Factors contributing to pool function within the wetland (Reach 4).

	LWD log		LWD rootwad		LWD jam		Roots of standing tree/stumps		Channel bedform		Scour-resistant bank		TOTAL	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Total number of pool units	3	2	6	5	1	1	2	1	2	0	2	8	16	17
Percent pool units (%)	18.8	11.8	37.5	29.4	6.3	5.9	12.5	5.9	12.50	0.00	12.5	47.0	100	100
Surface area (m^2)	48.1	49.5	52.67	82.8	23.7	63.5	8.5	16.1	123.53	0	21.1	203.7	277.6	415.6
Percent pool surface area (%)	17.3	11.9	19.0	19.9	8.6	15.3	3.1	3.9	44.51	0.00	7.6	49.0	100	100

Most of the pools in the fan had a residual pool depth (difference between maximum depth and outflow) of 25-49 cm (Table 8). In 2011 the number of pools in the 50-74 cm size class increased. Since the historic main stem was highly channelized and much of Reach 3 was within the historic main stem, the pools had similar sizes. Now that the main channel is carving a new path through the east fan, the pool depths may show even more variability in future surveys.

The wetland showed an increase in pool habitat from 2010 to 2011, with most of the increase occurring in the 0.25-0.49 m size class (Table 9). This increase in pool size and depth indicates that the wetland pools are becoming more established as the project matures.

Table 8. Residual pool depths within the fan (Reach 3).

	0-0.24 m		0.25-0.49 m		0.5-0.74 m		0.75-0.99 m		TOTAL	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Number of pools	1	0	15	11	5	6	2	0	23	17
Percent of total	4.35%	0.00%	65.22%	64.71%	21.74%	35.29%	8.70%	0.00%	100.0%	100.0%
Surface area (m^2)	14.12	0	479.23	341.62	233.61	300.77	50.45	0	777.40	642.39
Percent surface area	1.82%	0.00%	61.64%	53.18%	30.05%	46.82%	6.49%	0.00%	100.0%	100.0%

Table 9. Residual pool depths within the wetland (Reach 4).

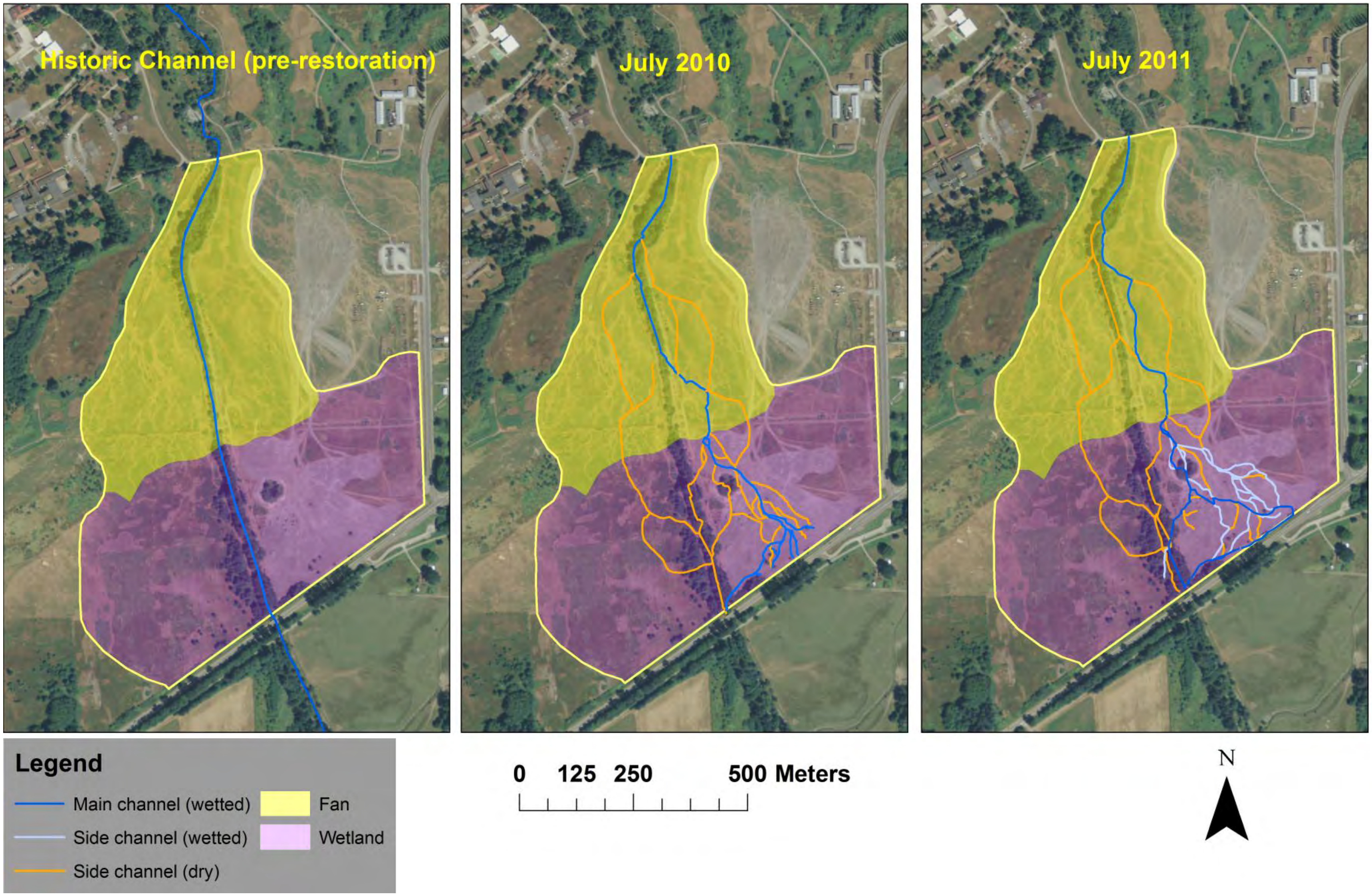
	0-0.24 m		0.25-0.49 m		0.5-0.74 m		0.75-0.99 m		TOTAL	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Number of pools	8	6	5	9	3	2	0	0	16	17
Percent of total	50.00%	35.29%	31.25%	52.94%	18.75%	11.76%	0.00%	0.00%	100.0%	100.0%
Surface area (m^2)	65.2	82.1	65.1	228.2	147.3	105.3	0	0	277.6	415.6
Percent surface area	23.49%	19.75%	23.45%	54.92%	53.06%	25.33%	0.0%	0.0%	100%	100%

5.3 Stream Lengths

Stream channels are monitored over time and are recorded when the stream changes course in the channels (Map 3). Stream lengths were measured during summer 2010 and 2011 using a string box. All channels were logged in a GPS and all were noted as dry or wet at an approximate flow of 10 cfs. This captured which channels provided summer low-flow habitat (wetted channels) and which provided off-channel habitat and high flow refugia for juvenile fish (dry channels). In 2011 the survey protocol was modified so that wetted channels were subdivided into “main” or “side” categories in order to provide a more accurate picture of the site. The original channel length before the project began was 1052 meters, but with the removal of the dikes and the addition of constructed channels, the stream was allowed to move into the floodplain, often creating its own channels. In the periods between field data collection of stream lengths any channel length changes were derived by GIS map interpolation. The creek avulsed from the main stem in October 2009, forming a new main stem channel through the wetland. It avulsed again in December 2010, moving out of the main stem into the east fan design channel. Additionally, the wetland has developed extensive braids. The total channel length (wetted + dry side channels) has increased over 500% from the historic pre-restoration stream length. The project has already surpassed the 10-year goals for stream length in the wetland (Table 10). The site conditions will vary significantly as the site matures and stabilizes. Under more mature site conditions the lengths may drop, but side and off-channel habitat will be more measurable.

Table 10. Comparison of historic conditions, current conditions, and project 10-year goals for stream lengths. All measurements were derived from GPS shapefiles except for the total channel lengths shown in bold and underlined which were based on string box measurements. The stream length measurements taken March 2011 did not have an associated string box length. Minor interim stream length changes based solely on GIS estimates are not shown.

		Historic (pre-restoration) (m)	July 2010 (m)	March 2011 (m)	July 2011 (m)	Project 10 Year Goal (m) (Herrera, Inc. Concept Plan)
Fan (Reach 3)	Main channel (wetted)	654	730	691	710	695
	Side channel (dry)	NA	1296	1345	1335	2218
Wetland (Reach 4)	Main channel (wetted)	398	942	1924	1084	393
	Side channel (wetted)	NA	NA	NA	1390	661
	Side channel (dry)	NA	2319	1720	1687	
TOTAL	Main channel (wetted) **(string box length)**	1052	1672 **(1575)**	2615	1794 **(1484)**	1088
	Side channel (wetted) **(string box length)**	NA	NA	NA	1390 **(1048)**	2879
	Side channel (dry) **(string box length)**	NA	3615 **(3577)**	3065	3022 **(2768)**	
GRAND TOTAL	All channels	1052	5287 **(5152)**	5680	6206 **(5300)**	3967

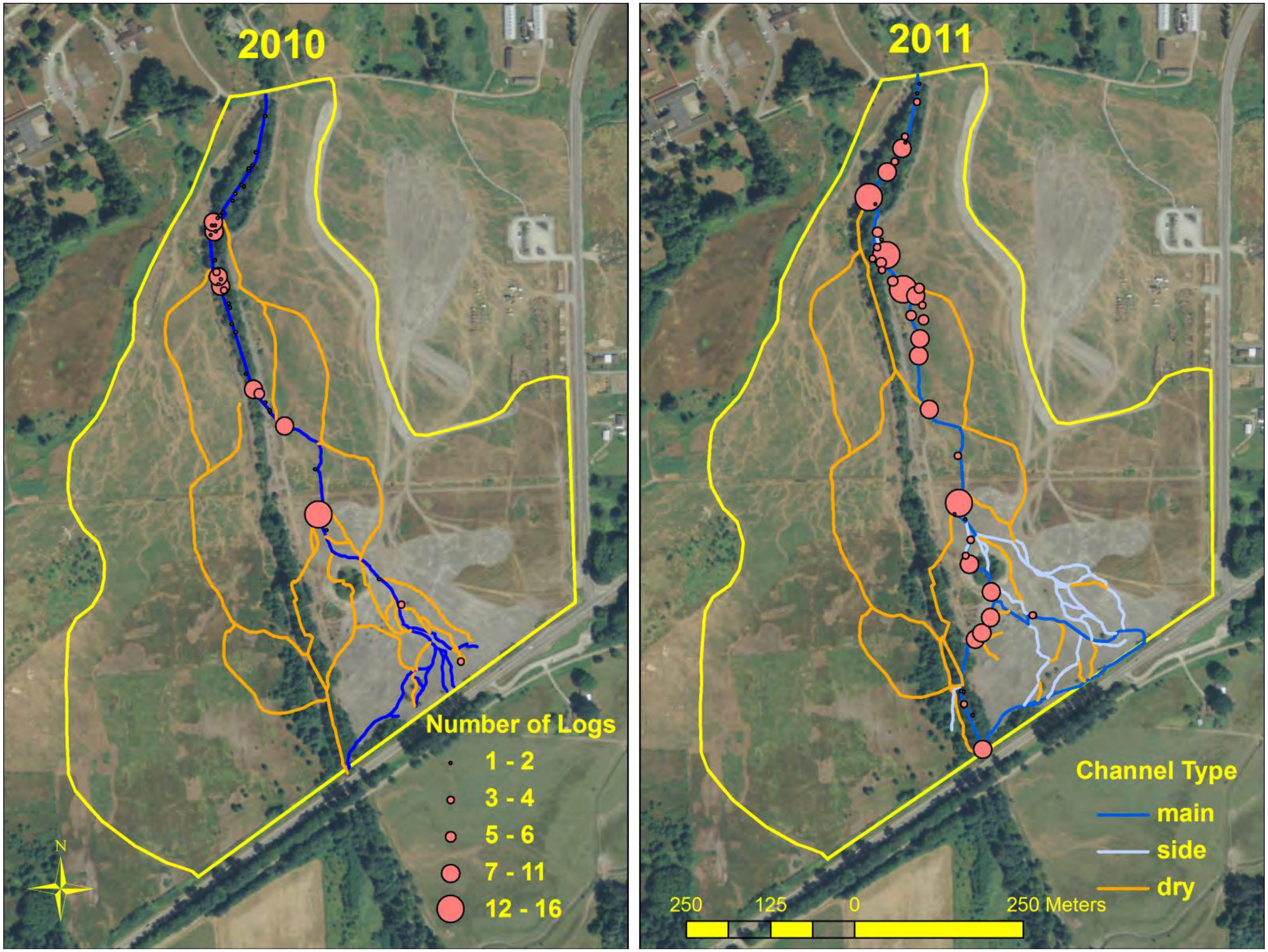


Map 3. Map showing the increase in channel lengths and braiding. The channel length classification was divided into "wetted" and "dry" in 2010. In 2011 the wetted channels were further sub-divided into "main" and "side" channels.

5.4 LWD

LWD was monitored based on the TFW module for LWD (Map 4). The module was followed for the LWD Level 1 and log jams. All visible logs in constructed log structures have been tagged and any untagged logs encountered during LWD surveys were marked as such (Figure 19). These included naturally recruited wood that had fallen into the stream, logs from jams that released above the project, and logs that had naturally recruited from higher in the system. Only the main channels were surveyed and due to the dynamic nature of Hansen Creek, the channel locations (and thus LWD distribution) will likely change as the site matures.

Figure 19. Over 1200 pieces of LWD were installed, including these in-stream grade control structures.



Map 4. Map showing the location and abundance of LWD found in the LWD survey. The size of the circle is proportional to the number of LWD pieces at that location.

Due to the large amount of LWD installed during the restoration project, the amount of LWD in 2010 and 2011 was much greater than in 2008. In 2011 the fan had almost 10 times more LWD per km than in 2008 (Table 11). Due to the movement of the Hansen Creek main stem into new, LWD-rich channels in 2011, the amount of LWD in the active channels also increased dramatically from 2010 to 2011. The LWD per km more than doubled in the wetland, from 39 pieces/km to 73 pieces/km (Table 12). This LWD will help stabilize and establish these channels as well as provide habitat for juvenile fish in the wetland.

The distribution of LWD was biased toward the fan; there was three times as much LWD per channel width in the fan as in the wetland in 2011 (Table 11 and Table 12). However, despite the dramatic increases in LWD density, both the fan and wetland reaches had LWD levels that were well below the 2 pieces/channel width recommended by DNR's Manual. There were no key pieces in the wetland and only one key piece in the fan in 2010. Most of the LWD pieces were in the 20-50 cm size class, especially in the fan. This is likely because most of the LWD in the system was installed as part of the restoration project. As the project matures, more natural recruitment of LWD should lead to a greater diversity of LWD sizes and an increase in the LWD abundance.

Table 11. Breakdown of LWD pieces in the fan (Reach 3). There were no key pieces in 2010 or 2011.

FAN (segment 3)	Rootwads		10-20 cm		20-50 cm		>50 cm		Total		
	2010	2011	2010	2011	2010	2011	2010	2011	2008*	2010	2011
Total number of pieces	3	10	13	22	75	125	14	4	15	105	161
Percent of total pieces	2.86%	6.21%	12.38%	13.66%	71.43%	77.64%	13.33%	2.48%		100.0%	100.0%
LWD per channel width	0.015	0.055	0.064	0.121	0.368	0.686	0.069	0.022		0.515	0.884
LWD per km	3.729	13.291	16.157	29.240	93.214	166.135	17.400	5.316	22.9	130.500	213.982

*2008 data was derived from historic stream lengths and pre-project LWD in the fan.

Table 12. Breakdown of LWD pieces in the wetland (Reach 4). There were no key pieces in 2011.

WETLAND (segment 4)	Rootwads		10-20 cm		20-50 cm		>50 cm		Total		
	2010	2011	2010	2011	2010	2011	2010	2011	2008*	2010	2011
Total number of pieces	0	16	5	3	15	27	5	34	11	25	80
Percent of total pieces	0.00%	20.0%	20.0%	3.75%	60.0%	33.75%	20.0%	42.5%		100.0%	100.0%
LWD per channel width	0.000	0.058	0.051	0.011	0.152	0.098	0.051	0.123		0.253	0.290
LWD per km	0.000	14.584	7.870	2.734	23.611	24.610	7.870	30.991	27.6	39.351	72.920
Number of key pieces (subset)	NA	NA	NA	NA	NA	NA	1.000	NA		1.000	NA
Key pieces per channel width	NA	NA	NA	NA	NA	NA	0.010	NA		0.010	NA
Key pieces per km	NA	NA	NA	NA	NA	NA	1.574	NA		1.574	NA

*2008 data was derived from historic stream lengths and pre-project LWD in the wetland.

In 2011 there were 5 LWD jams in the fan and 1 in the wetland (Table 13). Most of these jams were part of installed LWD structures, though the LWD jams in the fan included some naturally recruited LWD from Reach 2. One of the fan jams was comprised completely of naturally recruited LWD and the number of these types of jams should increase as the project matures.

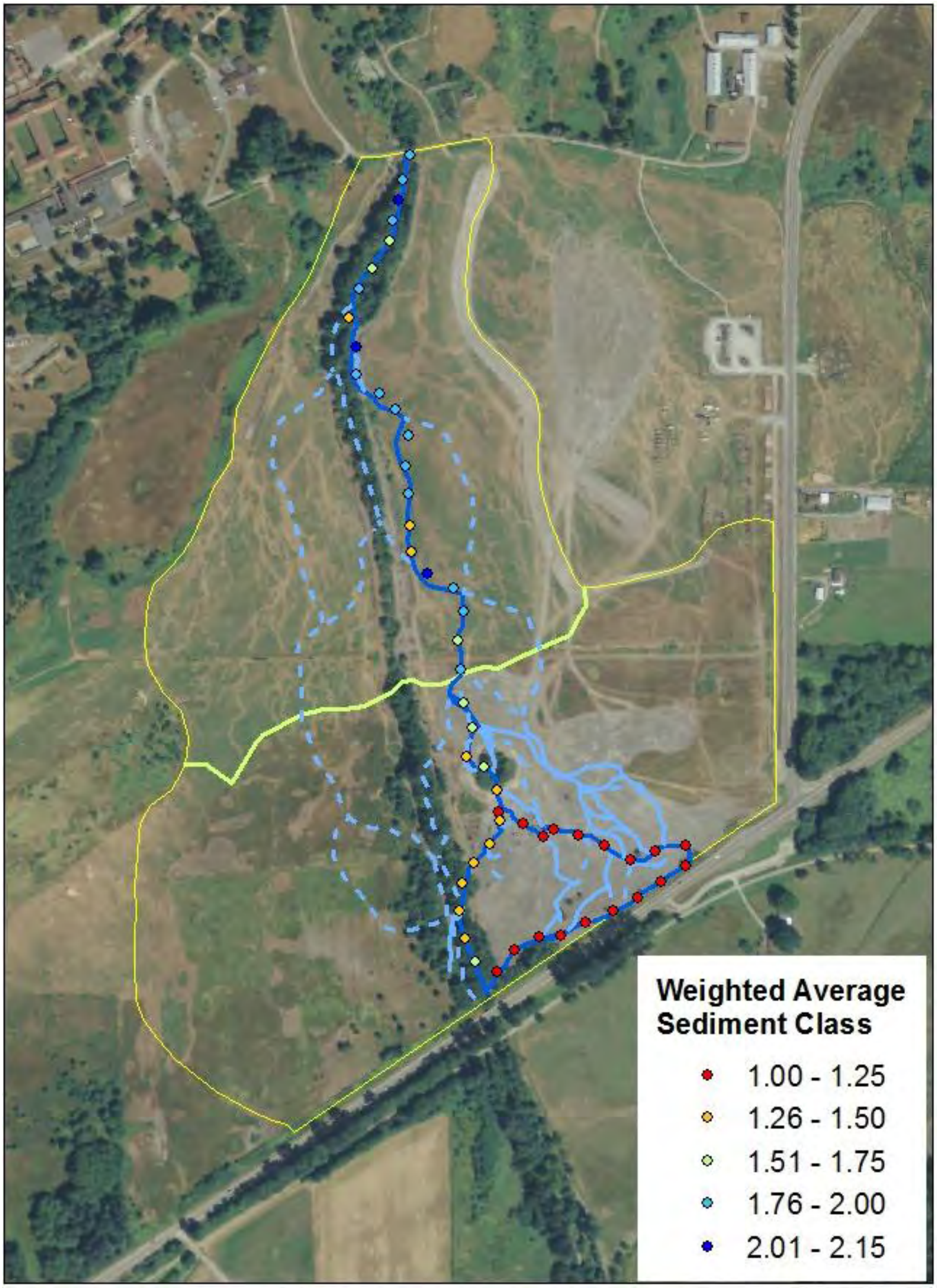
Table 13. Comparison of LWD jams in the fan and the wetland.

	WETLAND (Reach 4)		FAN (Reach 3)	
	2010	2011	2010	2011
# Debris jams	1	1	4	5
Debris jams/km	1.57	0.911	4.97	6.65
# Rootwads	0	3	2	5
# Logs 10-20 cm	5	1	0	11
# Logs 20-50 cm	4	4	29	46
# Logs > 50 cm	5	4	11	2
# Total pieces	15	12	42	64
# Key pieces	1	0	0	0
% Key pieces	6.67%	0.00%	0.00%	0.00%

5.5 Sediment Classification

In order to classify sediment size and distribution in the project, in 2010 pebble counts were conducted in the main channel, as determined by the channel with the greatest proportion of flow. Every 100 m, bank-full-width (BFW) was measured and a cross-channel transect established. At every 40 cm along the cross-channel transect, the pebble sizes were recorded. While this was supposed to help characterize the sediment size suitable for salmonid spawning, it did not give a clear picture.

To overcome these shortcomings, in 2011 the sediment classification was based on a modified procedure. Every 25-pace-long interval of the Hansen Creek main stem was assessed for sediment size class, according to the particle size class criteria and codes used in the TFW module for Salmon Habitat Availability. Each interval was broken down by percentages (e.g. 70% class 1, 25% class 2, and 5% class 3). At the upstream end of each interval a GPS point was recorded. For every interval the weighted average sediment size class was calculated and represented graphically in GIS (Map 5).



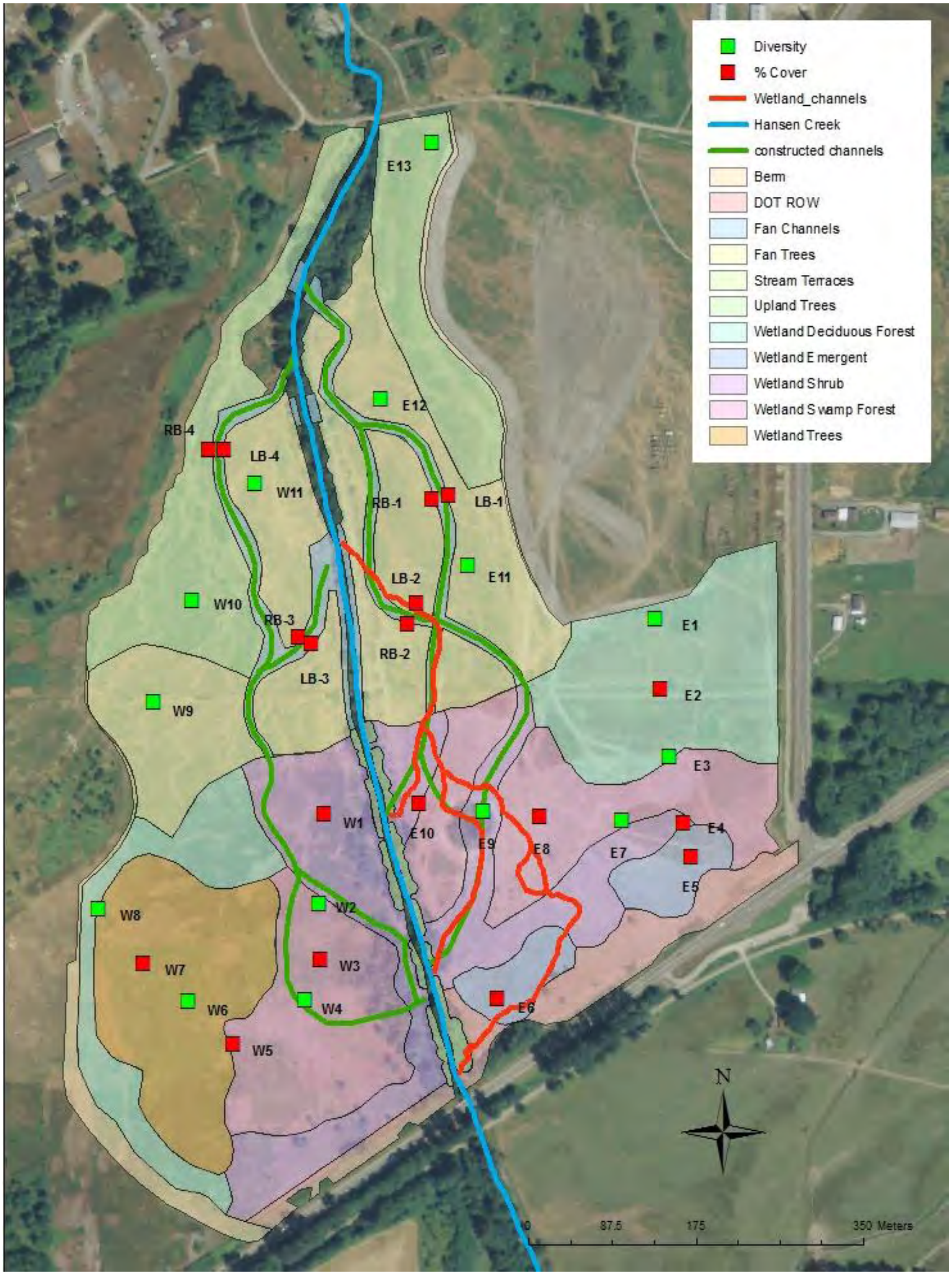
Map 5. Sediment size classification of Hansen Creek from survey conducted summer 2011.

The wetland (Reach 4) consisted of mostly fine sediments. While these fine particles do not support salmon spawning habitat, they are consistent with the project design goals of sediment storage in the wetland (Figure 9 and Figure 10). The sediments in the fan are coarser and support salmon spawning habitat, as demonstrated by Pink and Coho salmon observed spawning within the project fan reach (Figure 50; Map 13 and Map 14). The fan is also functioning for sediment storage as evidenced by the several feet of coarse sediments trapped by the grade control structures in Reach 3 (Figure 11).

5.6 Vegetation

One component of the habitat restoration project was invasive plant removal and native plant revegetation. Up to 8 inches of ground was scraped off in the wetland reed canarygrass–infested areas and Himalayan blackberry was removed from the dredge spoil levies by mechanical digging (Figure 20). The project was planted according to a detailed planting plan developed by Herrera Environmental Consulting, Inc. According to this plan, the fan and wetland regions were subdivided into planting zones which were planted with a mix of native plant species (as live plants, live stakes, and seeds) that are suited to the different habitats (Map 6).

Figure 20. The dredge spoil levies were covered in Himalayan blackberry and reed canarygrass prior to the project.



Map 6. Map showing planting plan with vegetation zones and stream channels. The vegetation survey plots are shown as green (diversity) and red (% cover) boxes. In 2011 plots E11-E13 and W9-W11 were converted to % cover plots.

As the plant community matures, cover should develop over the stream channels and the diversity of the community should begin to reflect a native habitat (Figure 21). Herrera Environmental Consulting, Inc. developed vegetation goals for the project concept plan, which are summarized in Table 14. The project has already achieved the year 1 goals, as will be shown in the following section.

Table 14. Vegetation goals for the Hansen Creek Restoration Project (from Hansen Creek Conceptual Report, Herrera Environmental Consultants, Inc.)

Goal	Monitoring Year
Emergent vegetation communities will have 50% cover by the end of year 3 and 80% cover by the end of year 5.	3,5
Shrub and forest vegetation communities will have 25% cover by the end of year 3 and 50% cover by the end of year 5.	3,5
Forest vegetation communities will have 40% canopy cover by end of year 7 and 60% canopy cover by the end of year 10.	7,10
Within emergent, shrub, and forest vegetation communities, a minimum of 66% of planted species will make up the overall composition.	1,3,5,7,10
Non-native invasives, including, but not limited to, reed canarygrass, Himalayan blackberry, Japanese knotweed, English ivy, purple loosestrife, Scot's broom, thistles, and other species identified during monitoring will not cover more than 15% of the site.	1,3,5,7,10

Figure 21. The native vegetation has already begun to establish cover over the project site. USIT intern Dan Donnelly is hidden by these naturally recruited willows in the wetland.

5.6.1 Transect plots (diversity and % cover)

During the summers of 2010 and 2011 vegetation surveys were conducted according to the procedures in the Hansen Creek Floodplain Restoration Project QAPP. Vegetation transects were established through the wetland and fan with

permanent plots for percentage cover and species richness distributed along these transects. Additional plots were established in the emergent zone of the east wetland and along the fan channels. Each plot was evaluated for species composition in one of two ways: a) for percentage cover by each species within each plant layer (herb, shrub or tree) or b) for species richness in the shrub and tree layers. A total of 32 plots were evaluated (18 for percent cover and 14 for species richness). In 2011, 6 of the species richness plots were converted to percent cover plots to better capture the vegetation herb layer in the fan. Though this data represents only the first two years of the project, some simple patterns can be observed. The herb layer of the vegetation community has shown dramatic improvements (Figure 22-25).

Figure 22. Plot E6 in 2010.

Figure 23. Plot E6 in 2011. Note the growth of emergent sedges and rushes.

Figure 244. Plot W4 in 2010

Figure 25. Plot W4 in 2011. Note the growth of the herb layer.

Despite the extensive disturbance of the site, there was high species richness within the wetland (Figure 25). Between the two years of survey, over 60 species of plants were found in the wetland herb layer. In the wetland, the predominant component of the herb layer was naturally recruited non-invasive species (>50%; Figure 33). The planted species also made up almost 30% of the herb layer, while invasive species were less than 5% cover. This is well within the project design goal of <15% invasive species. Over 85% of the herb layer was vegetated with only a small percentage bare ground or open water. This also exceeds the project goal of 50% cover for the emergent communities by year 3. Though the shrub and tree layers in the wetland are developing more slowly than the herb layer, they still show good growth and can be expected to increase their percent cover as the project matures (Figure 26 and Figure 27). It is expected that the project will meet the 7- and 10-year goals for tree % cover. The channel plots, located adjacent to side channels in the fan, showed similar trends to the wetland plots. They had a diverse, extensive herb layer with few invasive species and less-developed shrub and tree layers (Figure 28, Figure 29, and Figure 30).

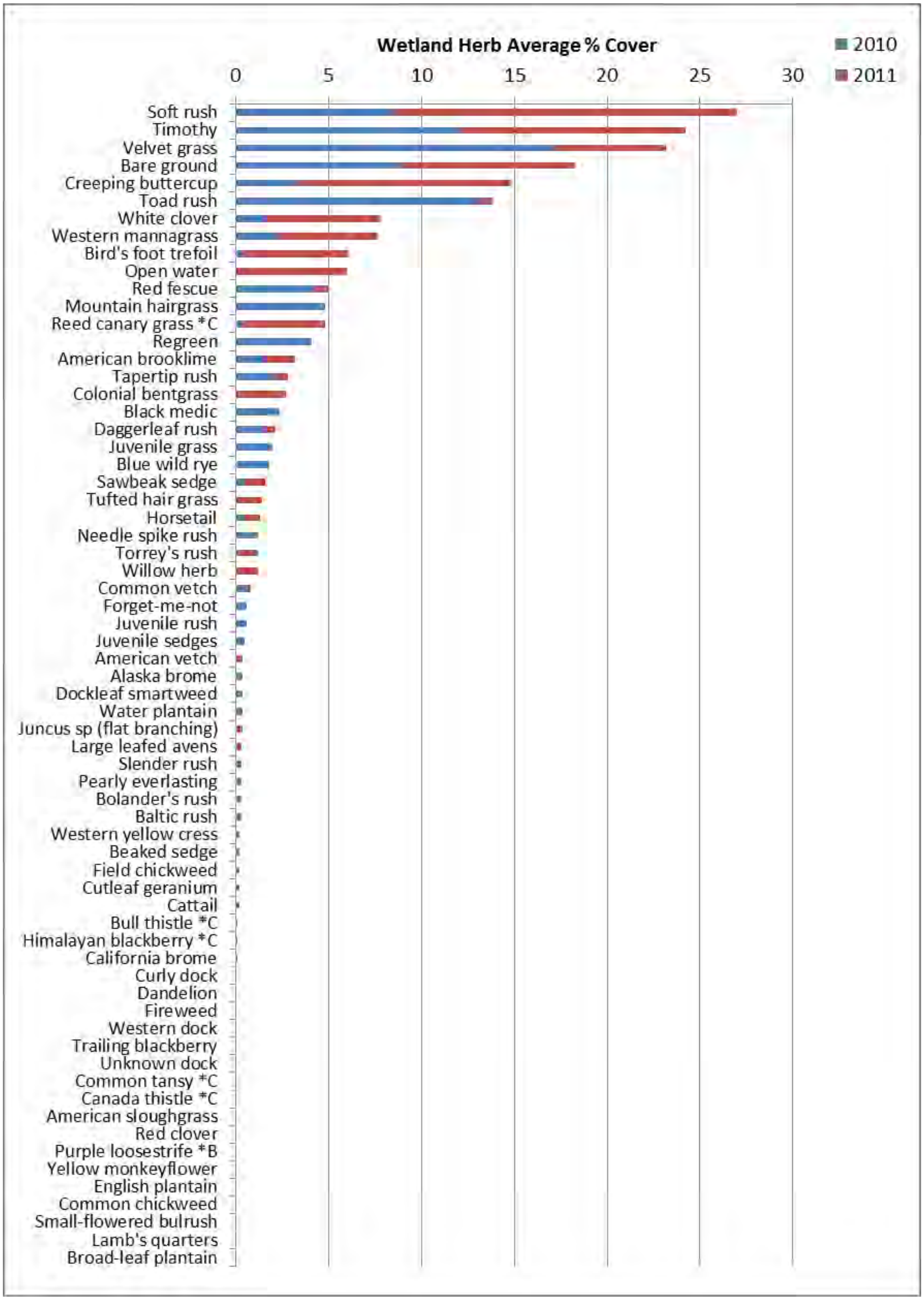


Figure 25. Average percent cover of the herb layer within the wetland vegetation plots (N=10). Invasive species are indicated by an asterisk (*) and a letter indicating their State Noxious Weed Board classification.

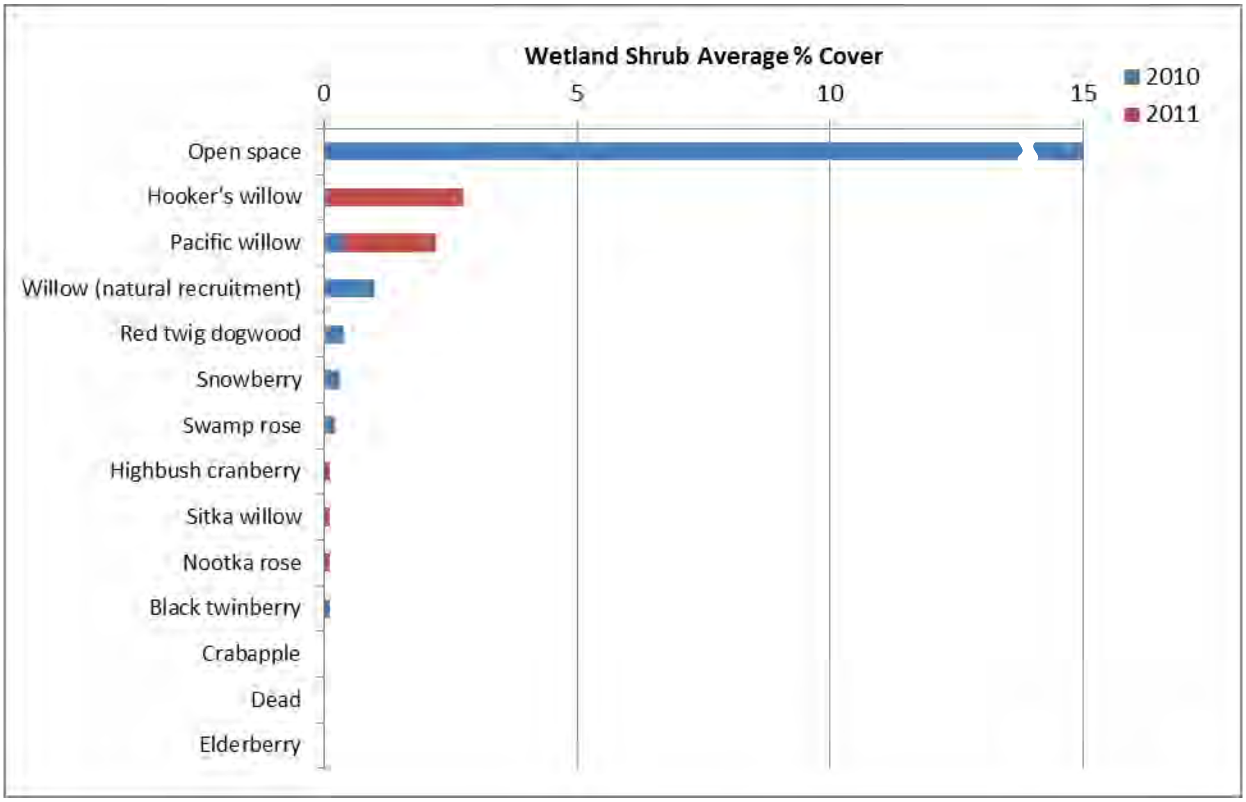


Figure 26. Average percent cover of the shrub layer within the wetland vegetation plots (N=10). The bar for "Open space" has been cut because it exceeds 90%. There were no invasive species in the shrub layer.

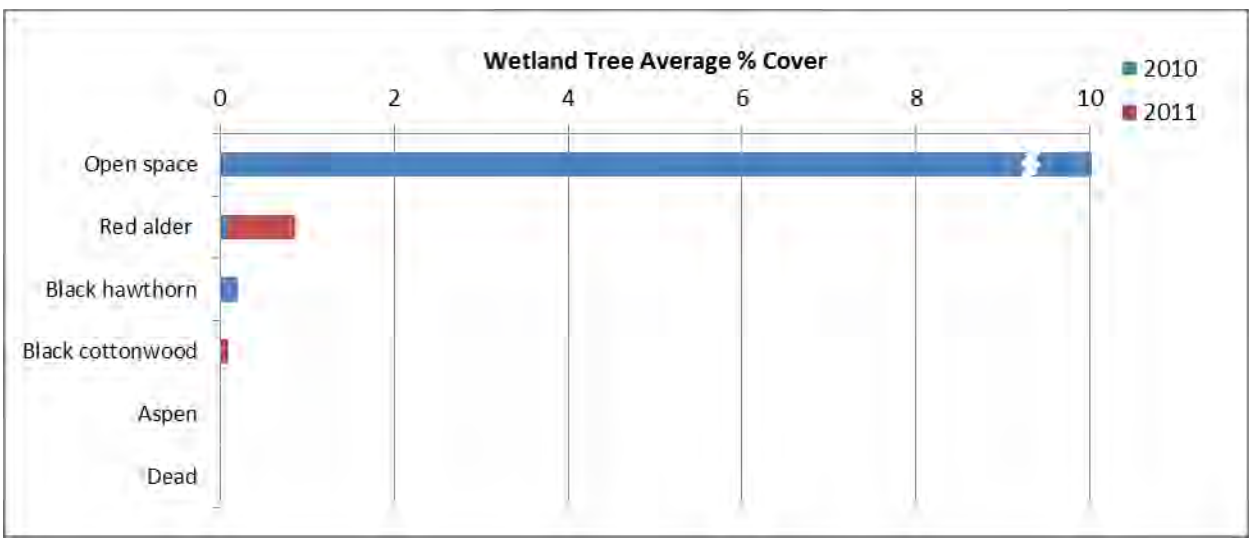


Figure 27. Average percent cover of the tree layer within the wetland vegetation plots (N=10). The bar for "Open space" has been cut because it exceeds 90%. There were no invasive species in the tree layer.

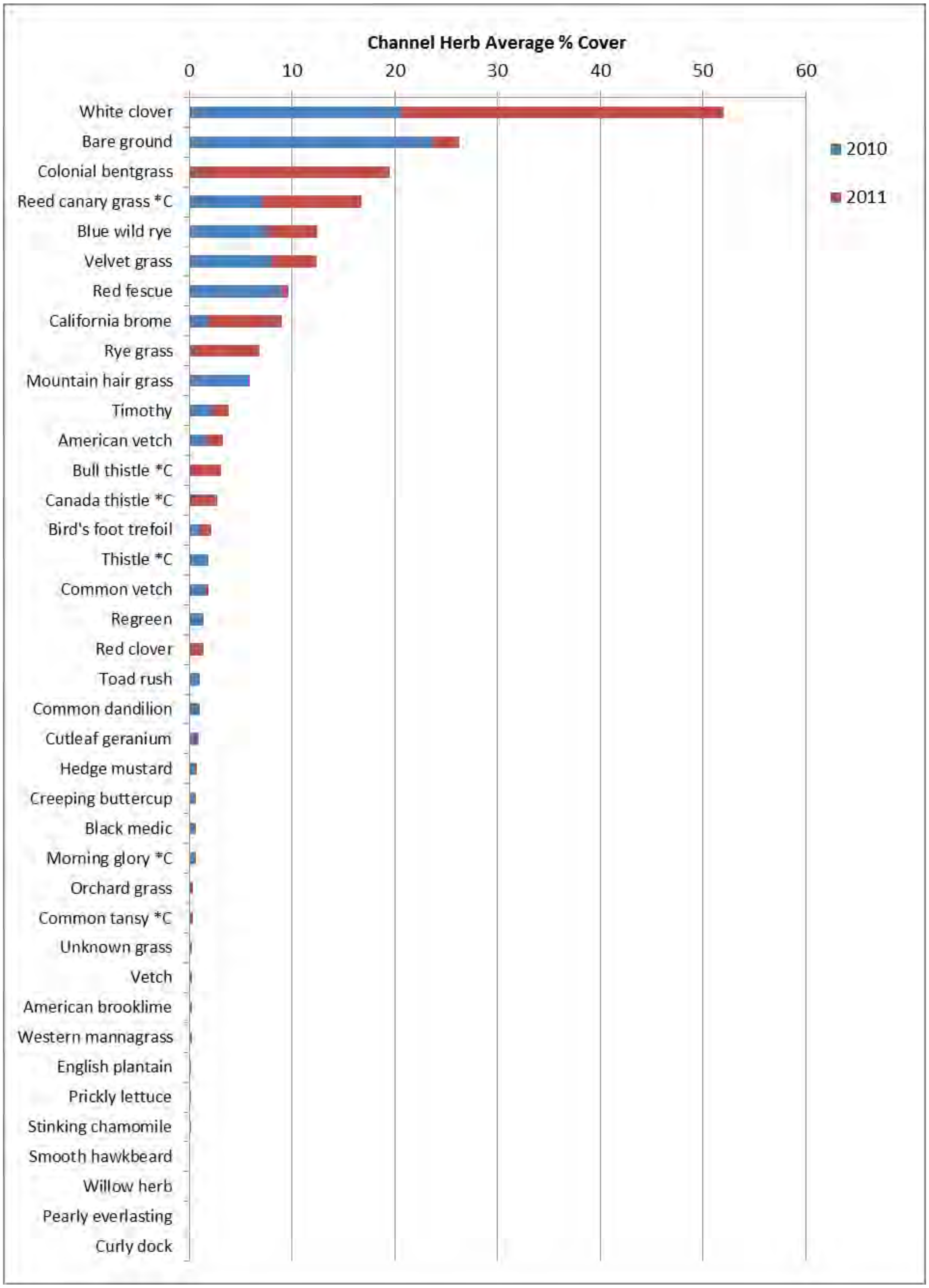


Figure 28. Average percent cover of the herb layer within the channel vegetation plots (N=8). Invasive species are indicated by an asterisk (*) and a letter indicating their State Noxious Weed Board classification.

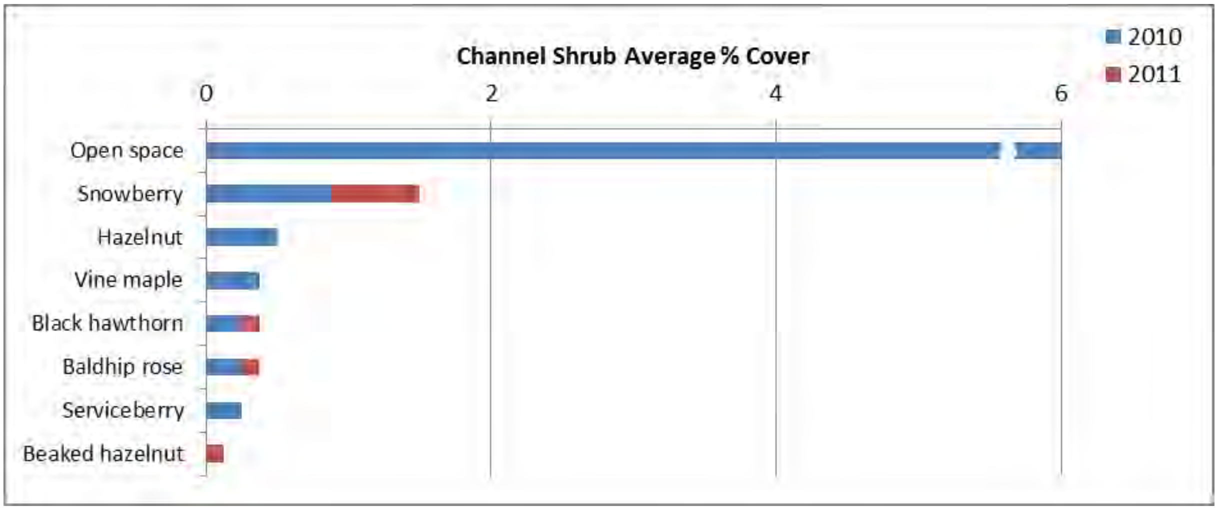


Figure 29. Average percent cover of the shrub layer within the channel vegetation plots (N=8). The bar for "Open space" has been cut because it exceeds 90%. There were no invasive species in the shrub layer.

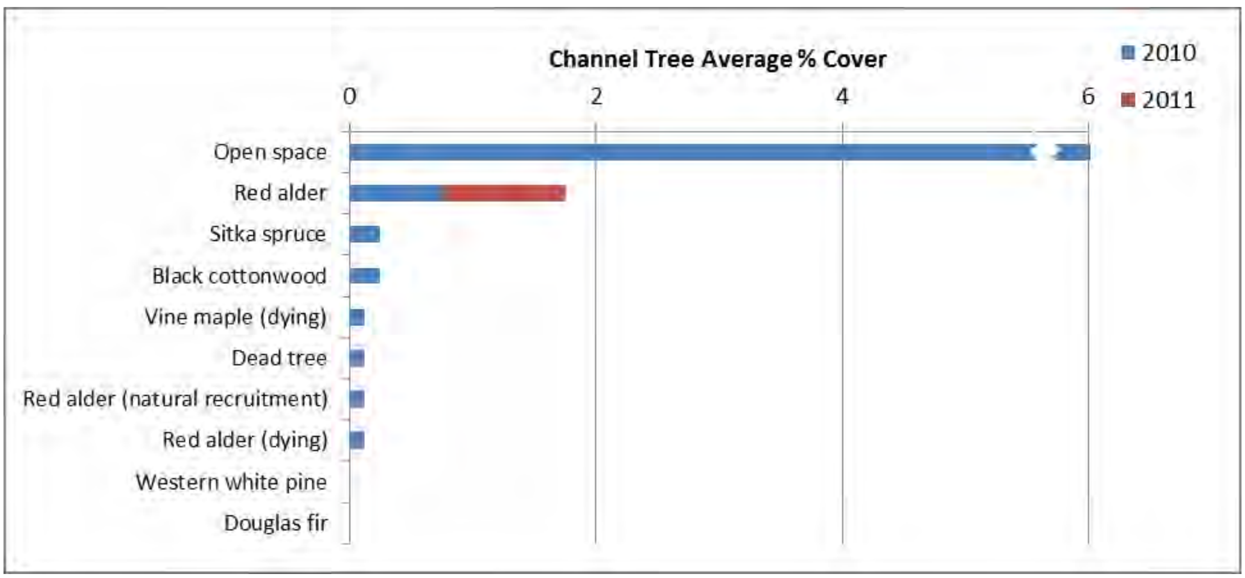


Figure 30. Average percent cover of the tree layer within the channel vegetation plots (N=8). The bar for "Open space" has been cut because it exceeds 90%. There were no invasive species in the tree layer.

In 2010 the fan vegetation plots were only evaluated for species richness. Since this method did not capture the changes in the herb layer, in 2011 survey procedures were modified and the fan plots were changed to percent cover plots in order to more accurately capture the herb layer changes. As with the wetland and channel plot herb layers, the herb layer in the fan had over 90% cover and

few invasive species (Figure 31). The tree layer in the fan is still maturing and no shrubs were captured in the fan surveys (Figure 32).

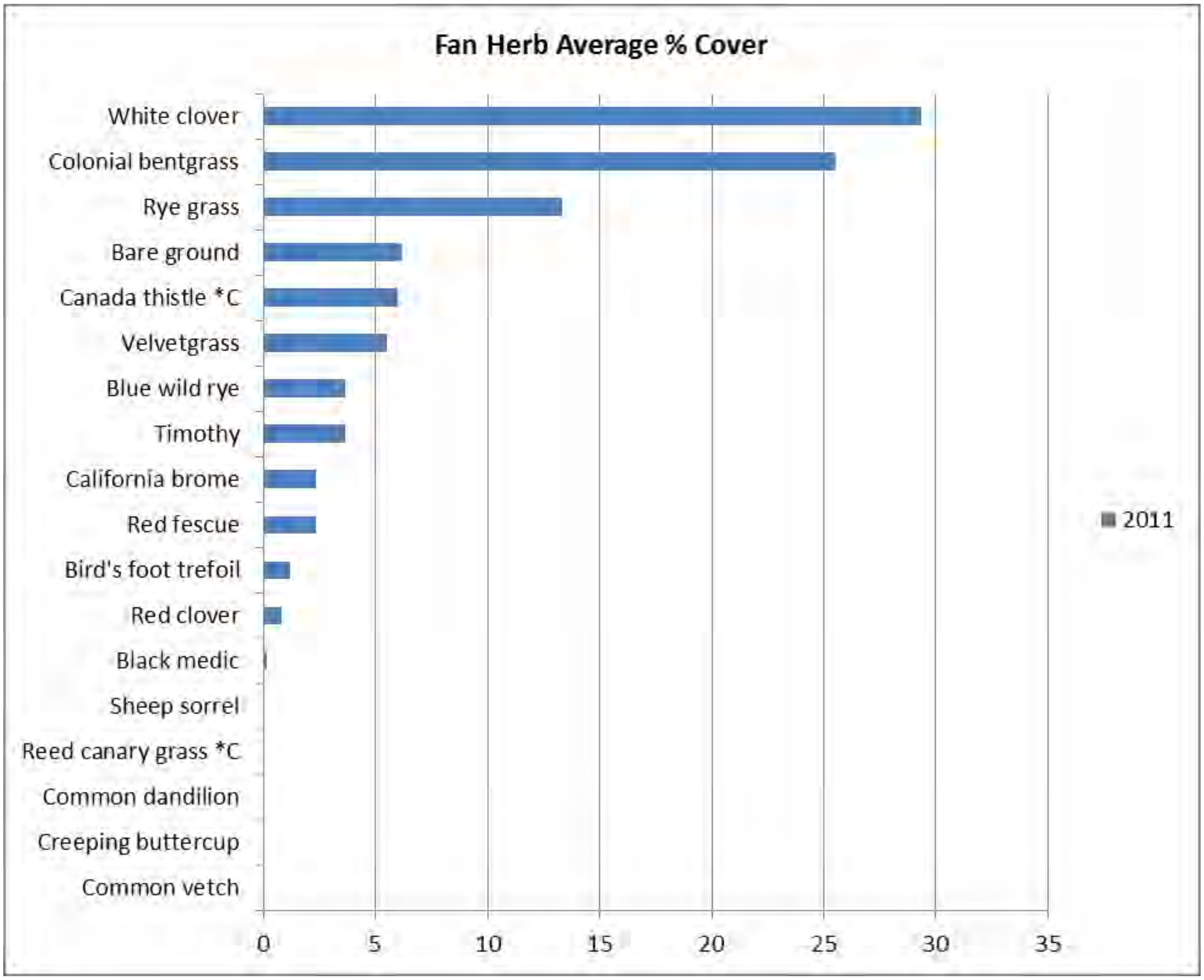


Figure 31. Average percent cover of the herb layer within the fan vegetation plots (N=6). Invasive species are indicated by an asterisk (*) and a letter indicating their State Noxious Weed Board classification.

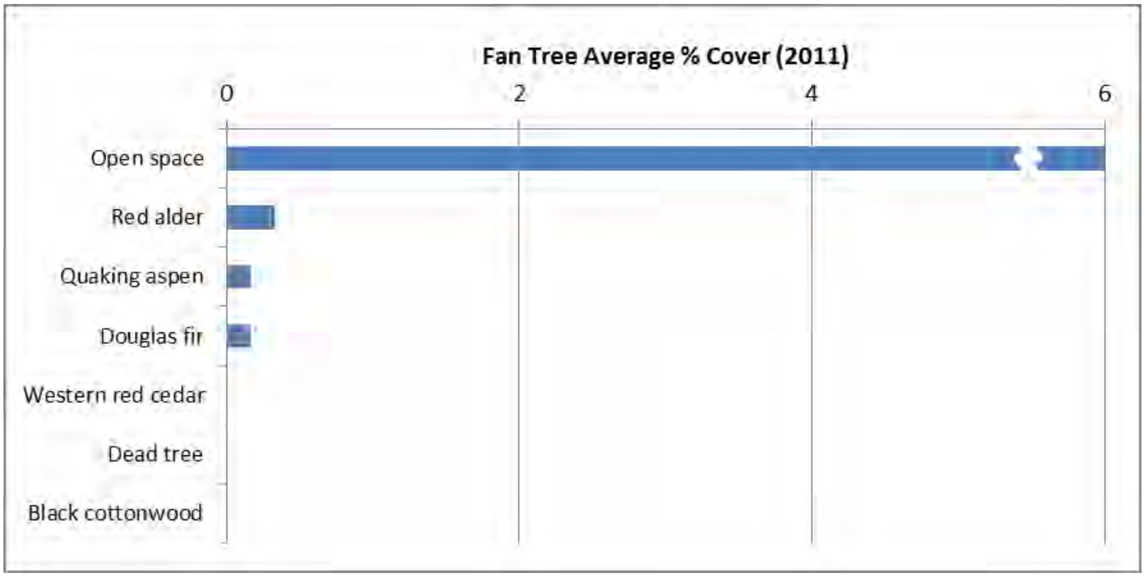


Figure 32. Average percent cover of the tree layer within the fan vegetation plots (N=6). The bar for "Open space" has been cut because it exceeds 90%. There were no invasive species in the tree layer. There was no shrub layer in the fan % cover plots.

Forty-four species of plants were planted in the wetland, of which 30 species were captured in the vegetation surveys. An additional 36 species of naturally recruited non-invasive plants were observed in the vegetation surveys, indicating an excellent level of natural recruitment. It is likely that within the project there are more species of naturally recruited native plants than planted. The shrub and tree layers still need to develop cover, which they can be expected to accomplish as the site matures.

Not surprisingly, some of the invasive plant species that were present before the project reappeared in the vegetation surveys. Five species of invasives were observed in the vegetation plots: reed canarygrass, Himalayan blackberry, thistle, purple loosestrife and common tansy. Fortunately, these invasive species were a minor component of the vegetation layers' plants (Figure 33, Figure 34, and Figure 35). The most prevalent species, reed canarygrass, was only 4% cover in the wetland and 7% cover in the fan. The invasive species are well below the goal of <15% cover. As the site matures, the invasive species may have to be managed to maintain this goal.

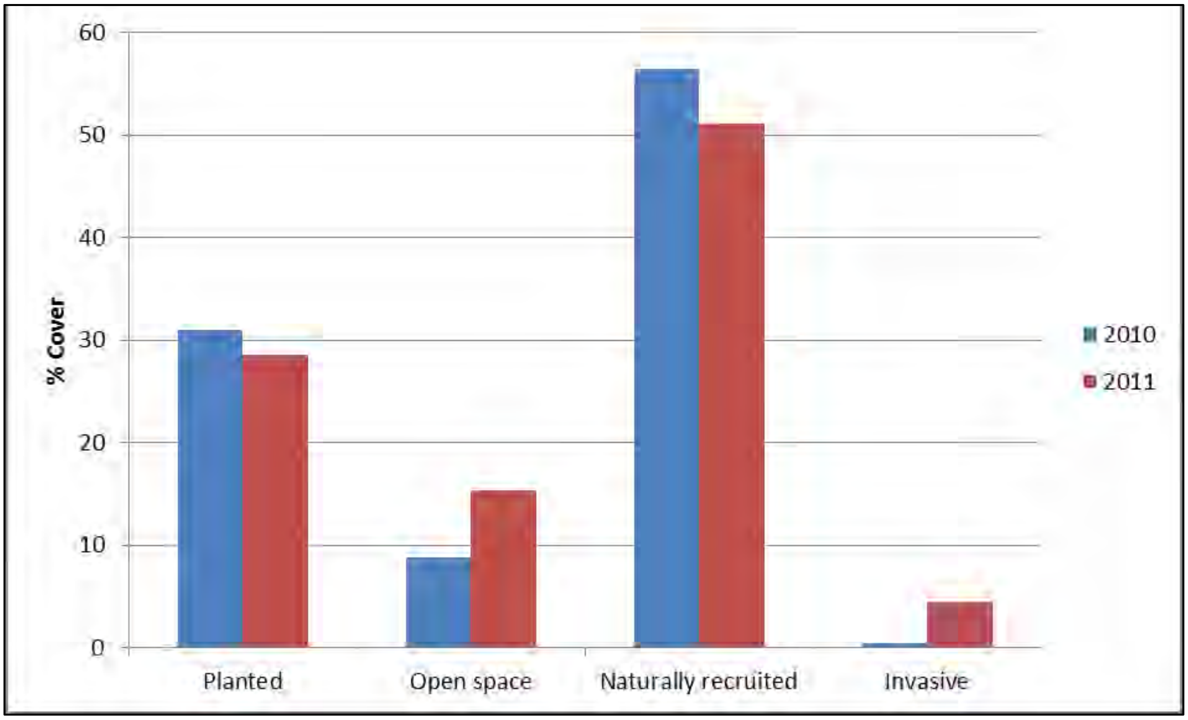


Figure 33. Breakdown of the wetland herb layer based on type of species (planted, naturally recruited, invasive, or open space).

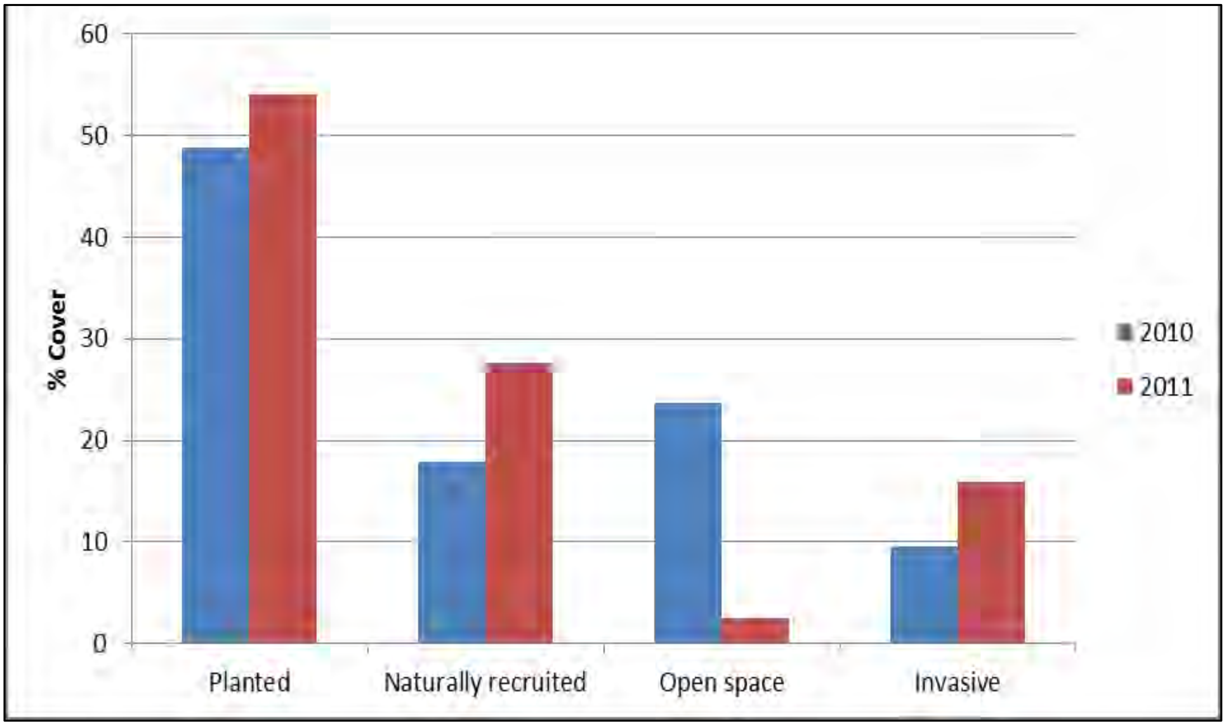


Figure 34. Breakdown of the channel herb layer based on type of species (planted, naturally recruited, invasive, or open space).

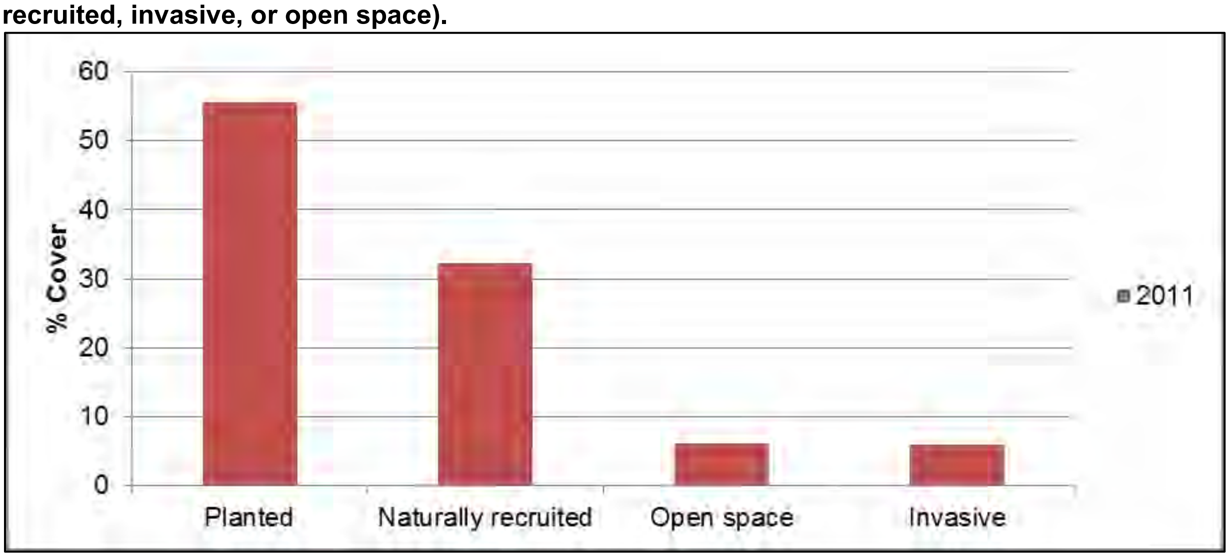
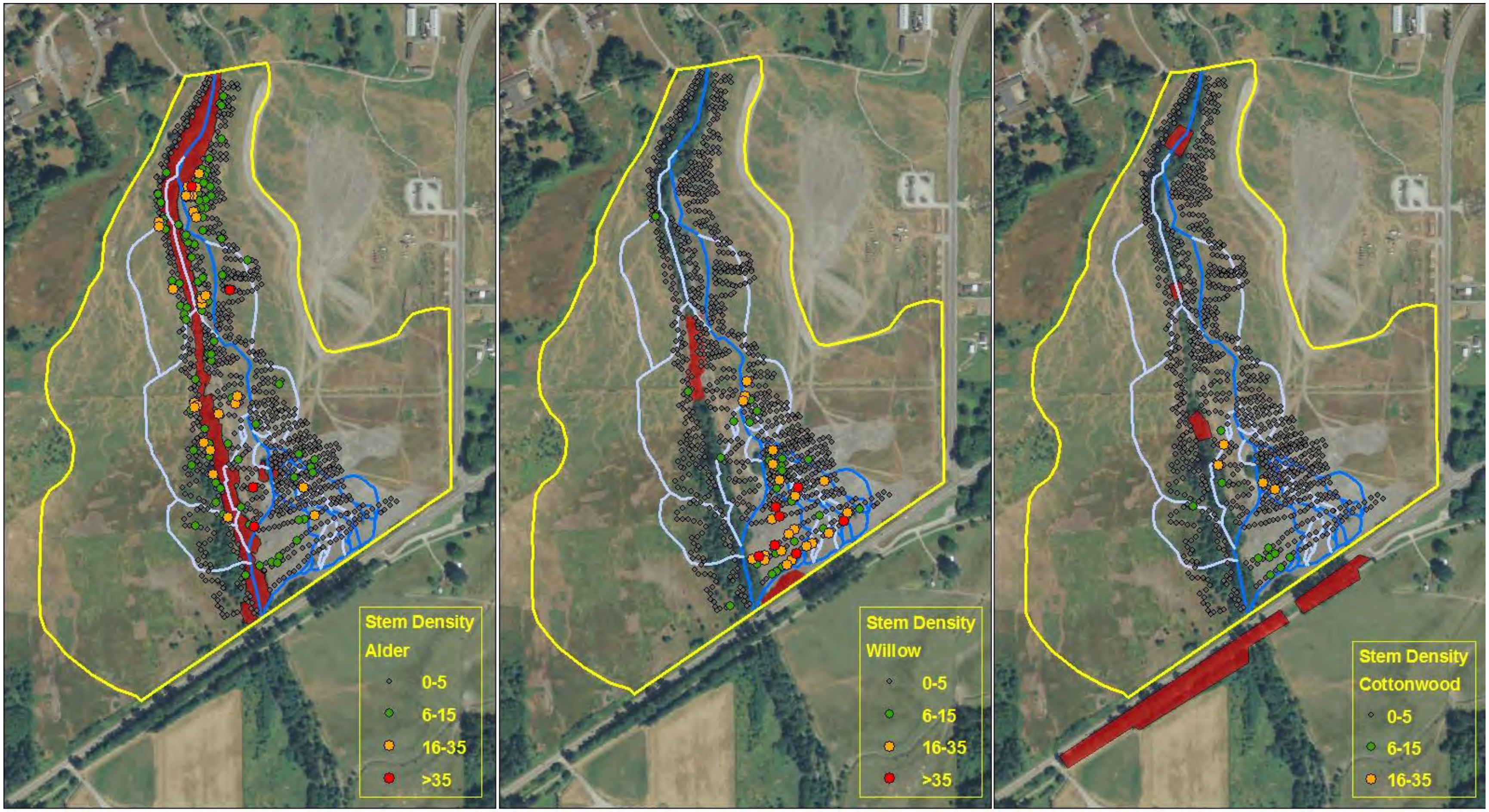


Figure 35. Breakdown of the fan herb layer based on type of species (planted, naturally recruited, invasive, or open space).

General observations were also listed during surveys. While the exact amount of plant survival cannot be calculated without significant time and effort, it can be estimated based on observation. Over 90,500 live plants were planted within the project, and of those still remaining (that have not been removed by channel

movement), a survival rate of over 90% is estimated. This meets the goals of 90% survival initially determined by Herrera Environmental Inc. for year 1.

It has also been observed that there are a high number of naturally recruited seedlings of red alder, willow, and black cottonwood on the site from the natural seed bank. In order to quantify these naturally recruited species, stem density surveys were conducted in June 2011. 882 1m x 1m plots were evaluated for the stem density of three naturally recruited species: red alder, willow, and black cottonwood (Map 7). There were abundant numbers of naturally recruited trees and these may need to be thinned over time. Alder seedlings were found throughout the fan and wetland but they had the highest stem densities near the historic main stem, in proximity to the seed bank of mature alder trees. Willows were found mostly in the wetland, downstream from their seed bank. This suggests that the willow seeds are transported from their seed bank by water and are deposited in the wetland. They also flourish best in the damp fine sediments in the lower wetland rather than the coarse sediments of upper wetland and fan. Black cottonwood seedlings were not as dense as the red alder and willow seedlings. Since their seeds are spread by wind, they are also concentrated in areas near their seed banks.



Map 7. Natural recruitment of native tree species. Stem densities are number of stems/m^2. Natural seed banks are shown in red.

5.6.2 Riparian Dripline

The established riparian dripline along the historic Hansen Creek main stem was evaluated in 2010 (Map 8). Since this assessment is only completed every 5 years it was not conducted in 2011. A Trimble model GeoXT GPS was used to document the perimeter of the dripline to create a polygon showing the extent of the tree canopy. Over the course of many years, this canopy should expand to include the riparian plantings along the stream side channels throughout the floodplain.

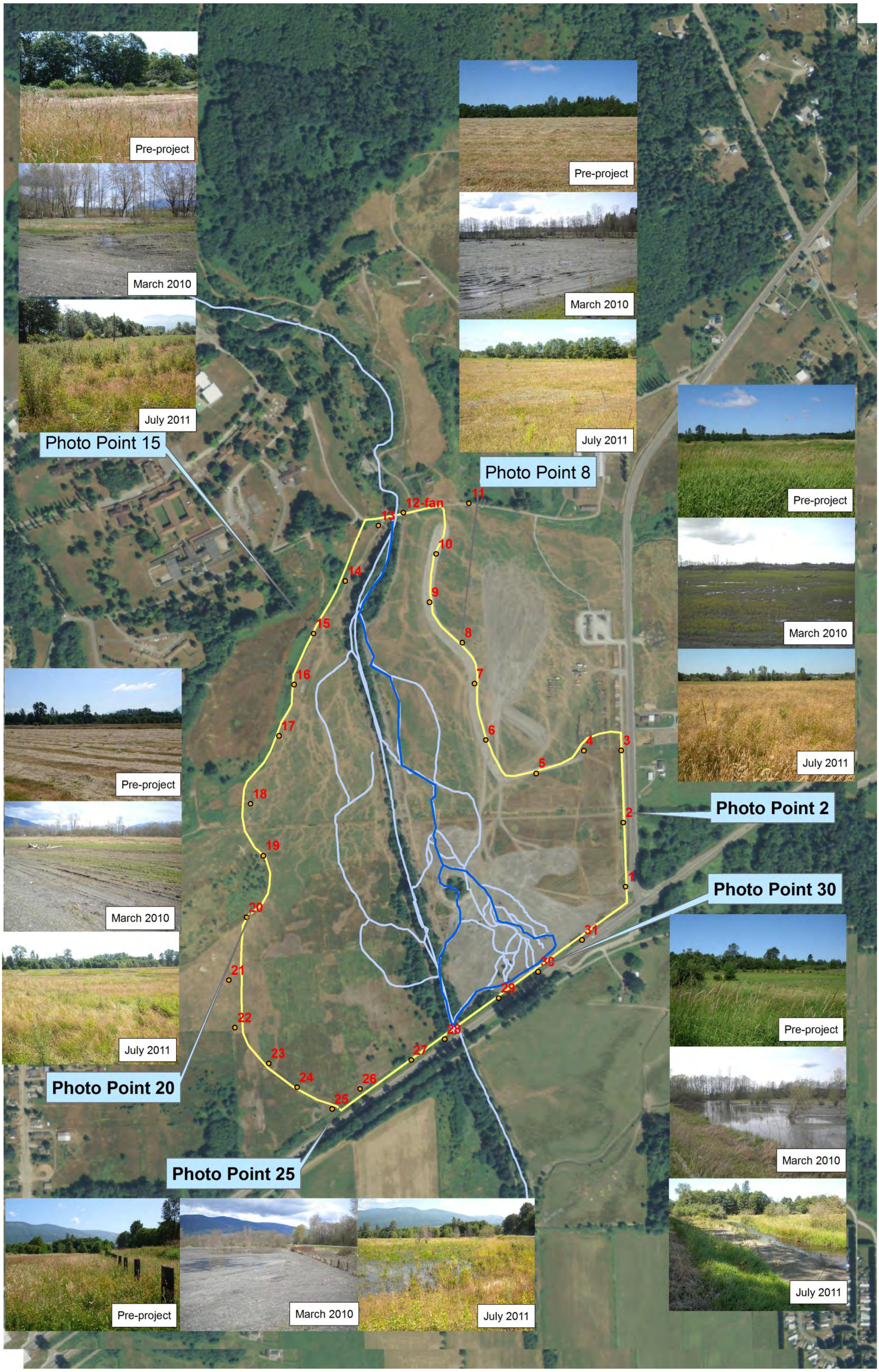
The mid-section of the historic main stem buffer within the project site was nearly all Himalayan blackberry and was removed during site restoration. In the 2009 main stem avulsion into the east floodplain the channel moved away from this opened habitat. Additionally, this existing riparian buffer is nearly entirely composed of deciduous shrub and tree species and was under planted with coniferous species. With the avulsion of the main stem into the east fan channel in 2010, the main stem is expected to temporarily experience less riparian cover until the planted and naturally recruited tree species develop more fully.

Map 8. Map showing 2010 extent of riparian dripline of Hansen Creek.

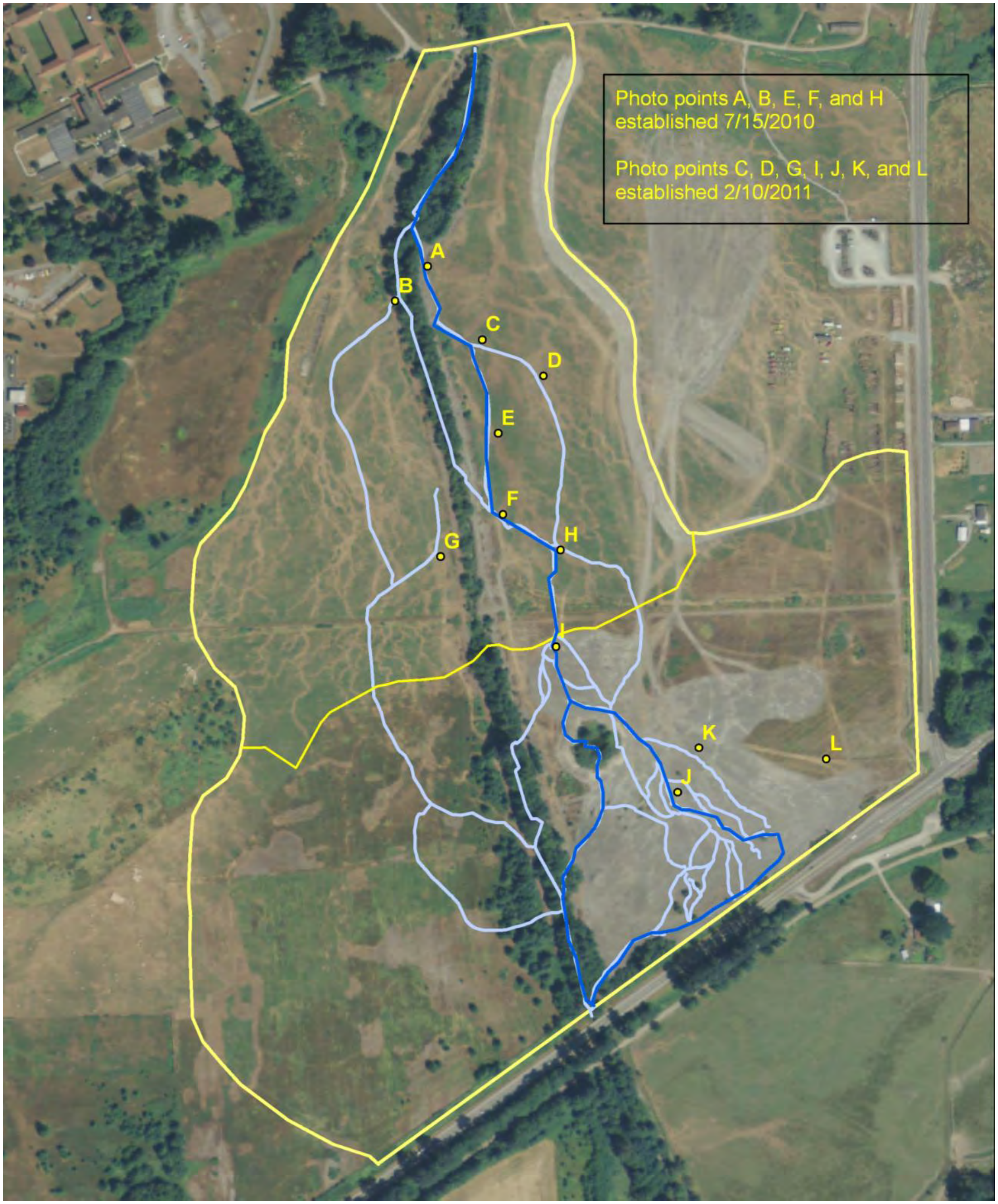
5.6.3 Project Photo Points

Another method of assessing the project vegetation is photo points. Photo points have been established at 31 sites along the project boundary berm, facing into the project site. These photo points will document the succession of vegetation in the project. In the first two years there is a dramatic change from a reed canarygrass-filled field to rush-filled wetland (Map 9).

Photo documentation also serves to illustrate the change in the channels over time. The channels changed dramatically within the first year, with the main stem channel avulsing twice and the wetland developing extensive braiding. The creek now flows almost entirely through the project design channels rather than the historic main stem. Photo points have also been established within the project area and are used to compare changes over time (Map 10). All photo points have been documented with a GPS unit and the interior points are located adjacent to log structures. These changes are evident in the following photos (Figures 37 – 45).



Map 9. Map of berm photo points with selected photos



Map 10. Map showing photo points in the restoration project interior.

Figure 36. Photo Point A on 7/15/2010. The shallow design channel can be seen.

Figure 37. Photo Point A on 2/10/2011. The creek has avulsed into this east fan channel and abandoned the historic main stem.

Figure 38. Photo Point A during a high flow event on 3/31/2011. The creek has scoured a wider channel and has begun to recruit natural LWD.

Figure 39. Photo Point A on 7/29/2011. The naturally-recruited alders have begun to obscure the view of the upper channel from this photo point.

Figure 40. Photo Point E on 7/15/2010. The shallow design channel can be seen.

Figure 41. Photo Point E on 2/10/2011. The creek avulsed into this east fan design channel and now the main stem of the creek flows through this channel.

Figure 42. Photo Point E on 7/29/2011. The creek has developed gravel bars and meanders throughout this reach.

Figure 43. Photo Point F on 7/15/2010. The historic main stem can be seen on the left with the dry east fan design channel on the right.

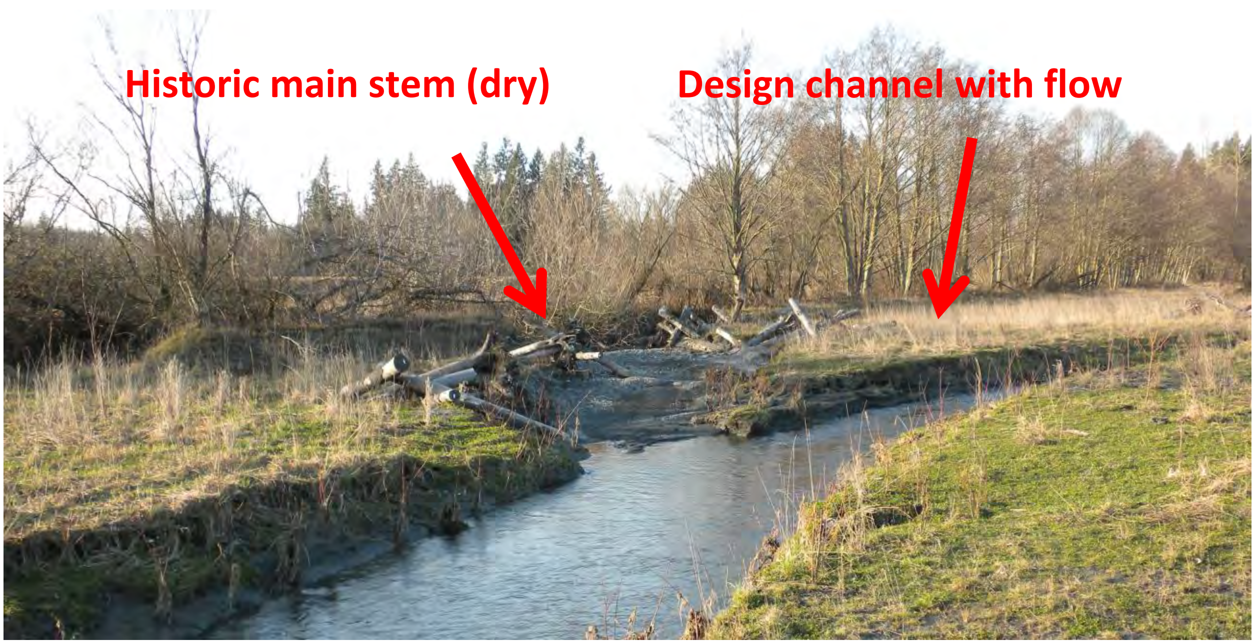


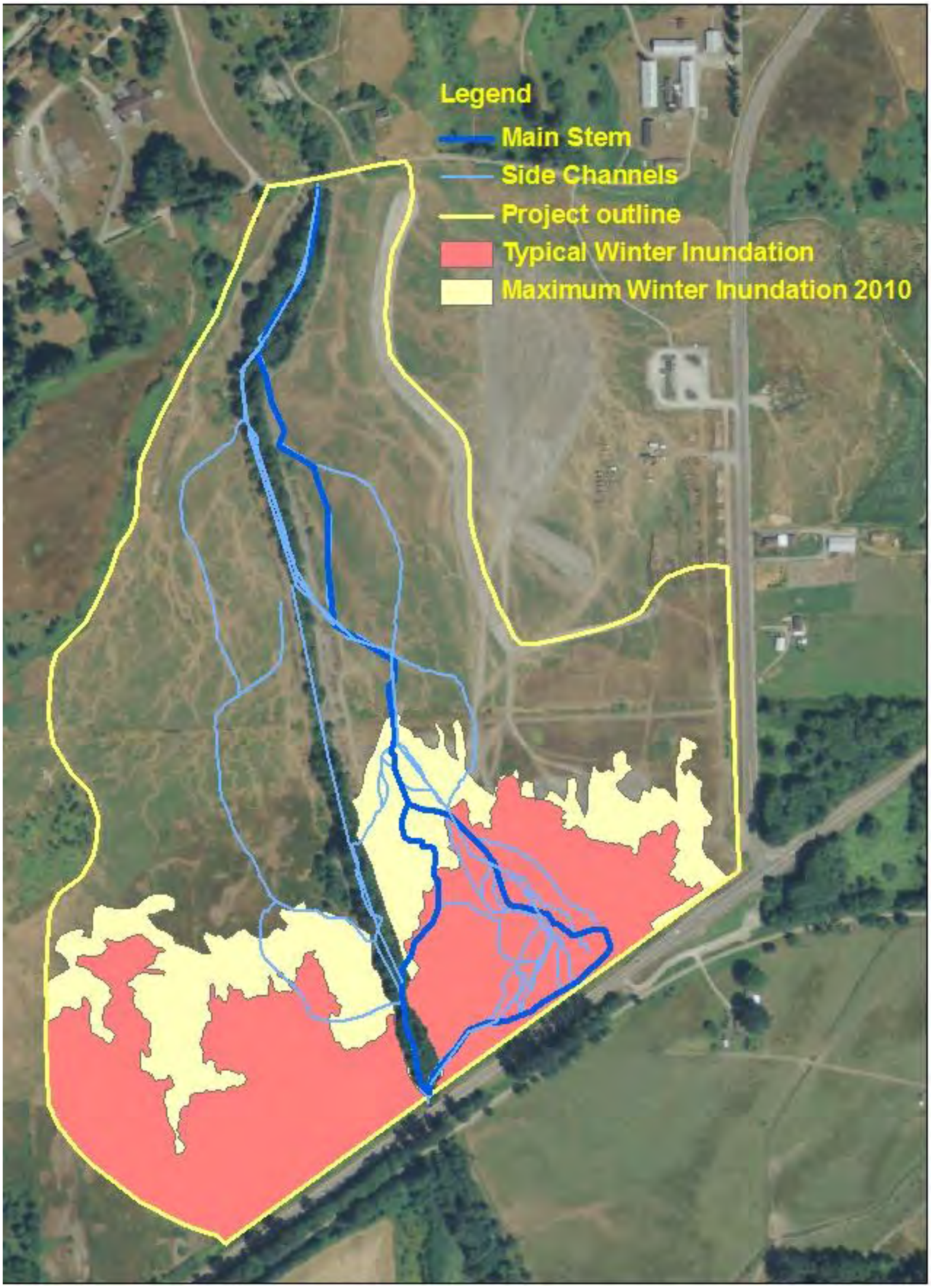
Figure 44. Photo Point F on 2/10/2011. The historic main stem has been abandoned and all the flow now passes through the east fan design channel.

Future photo points will be established in the wetted channels that form to document habitat condition development.

5.7 Holding Capacity

5.7.1 Inundation

Inundation is an important indicator of the holding capacity and consequent reduction of flooding on downstream agricultural fields. Through the wet season, inundation was measured periodically to determine the maximum inundation. This was done when the water was expected to be the highest due to rain fall and/or seasonal snow melt. A Trimble GeoXT GPS unit was used to map the extent of the inundated zone, not including ponded rainwater. This line was brought into ArcGIS and turned into a polygon so that the area of the land could be measured (Map 11). Holding capacity has been estimated at approximately 89 acre feet and ranges from 5 cm to 1 m deep. Capacity was estimated based on elevation and depth within each elevation zone and analyzed in ArcGIS.

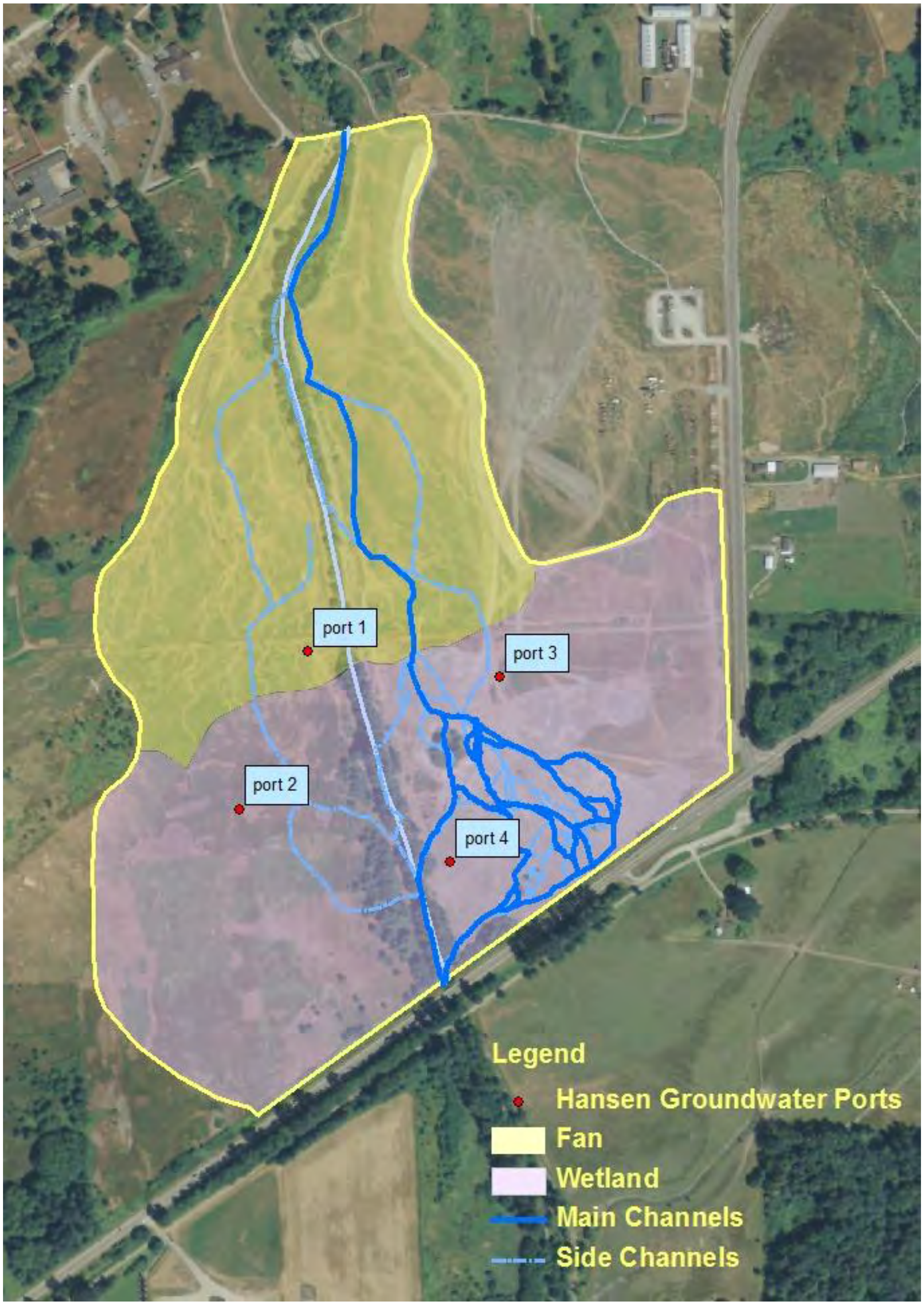


Map 11. Typical and maximum inundation in the project site during 2010.

5.7.2 Groundwater ports

Groundwater ports were installed before project construction began and were monitored for 21 months (Figure 45, Map 12). They were removed during construction and reinstalled after construction, and have been monitored since. The ground elevations of the ports changed slightly due to site grading during construction, with the greatest change being an increase in elevation of 0.32 feet at port #4. The groundwater levels reflect seasonal rainfall levels (Figures 47-50). The groundwater levels increase during winter and decrease during summer. The groundwater elevation in the east wetland (ports #3 and #4) is similar to or slightly higher than it was before restoration project. The groundwater elevation on the west side is lower than before the restoration project, especially at port #1. These changes are understandable given that the creek main stem has avulsed to the east, towards ports #3 and #4 and away from port #1.

Figure 45. Groundwater monitoring port.



Map 12. Location of groundwater monitoring ports relative to the wetland and fan and active channel locations as of March 2011.

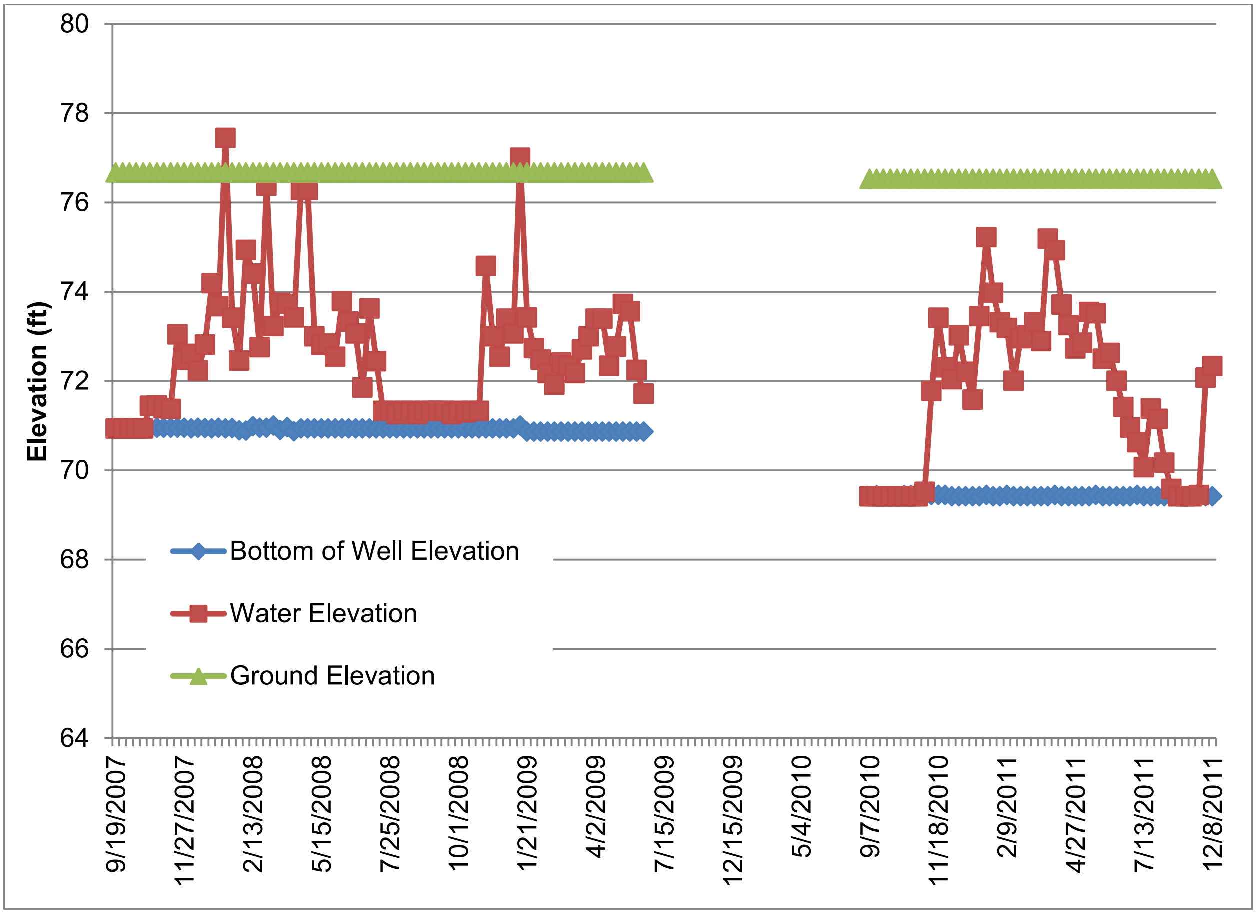


Figure 46. Graph of groundwater elevation in port #1 before and after project construction. The port number corresponds to the port location in Map 12.

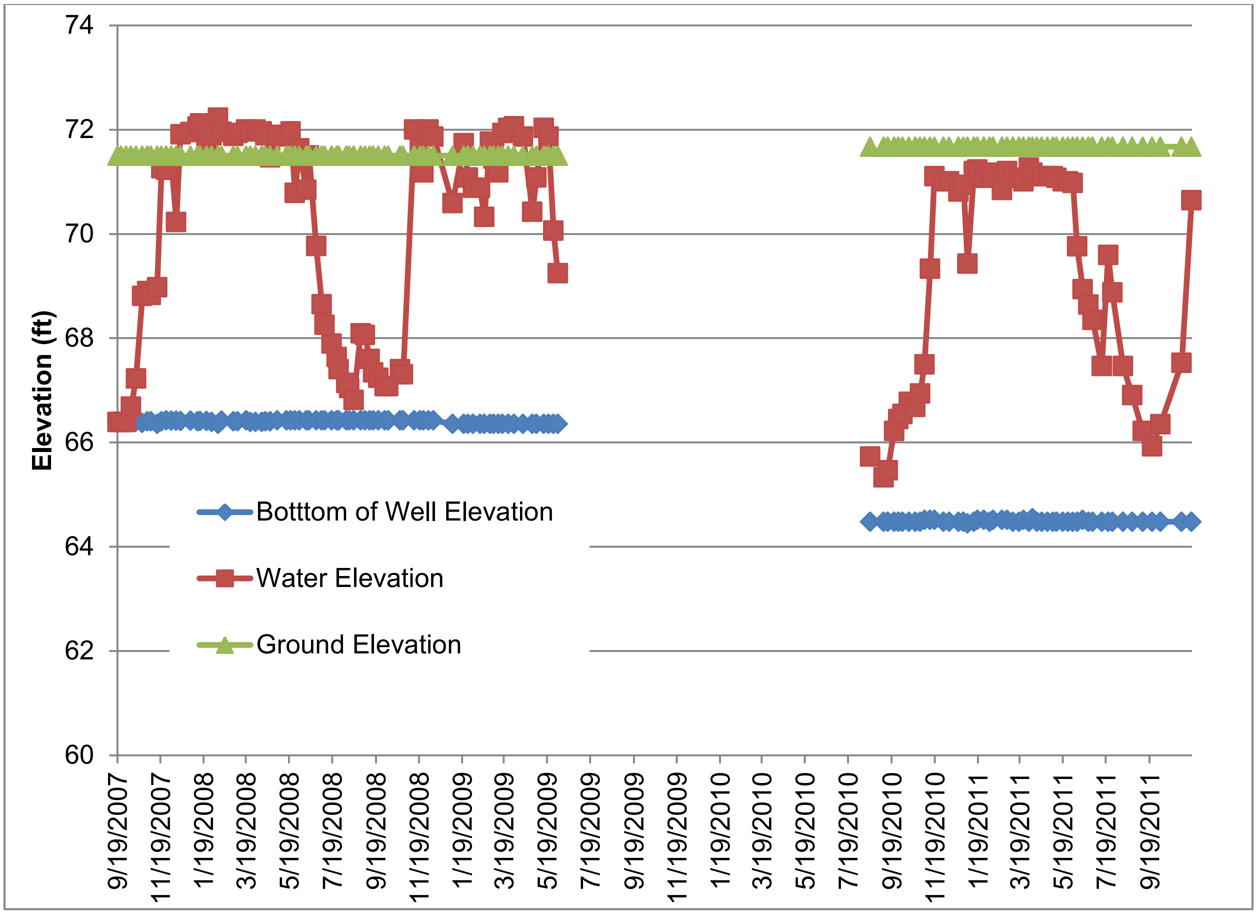


Figure 47. Graph of groundwater elevation in port #2 before and after project construction. The port number corresponds to the port location in Map 12.

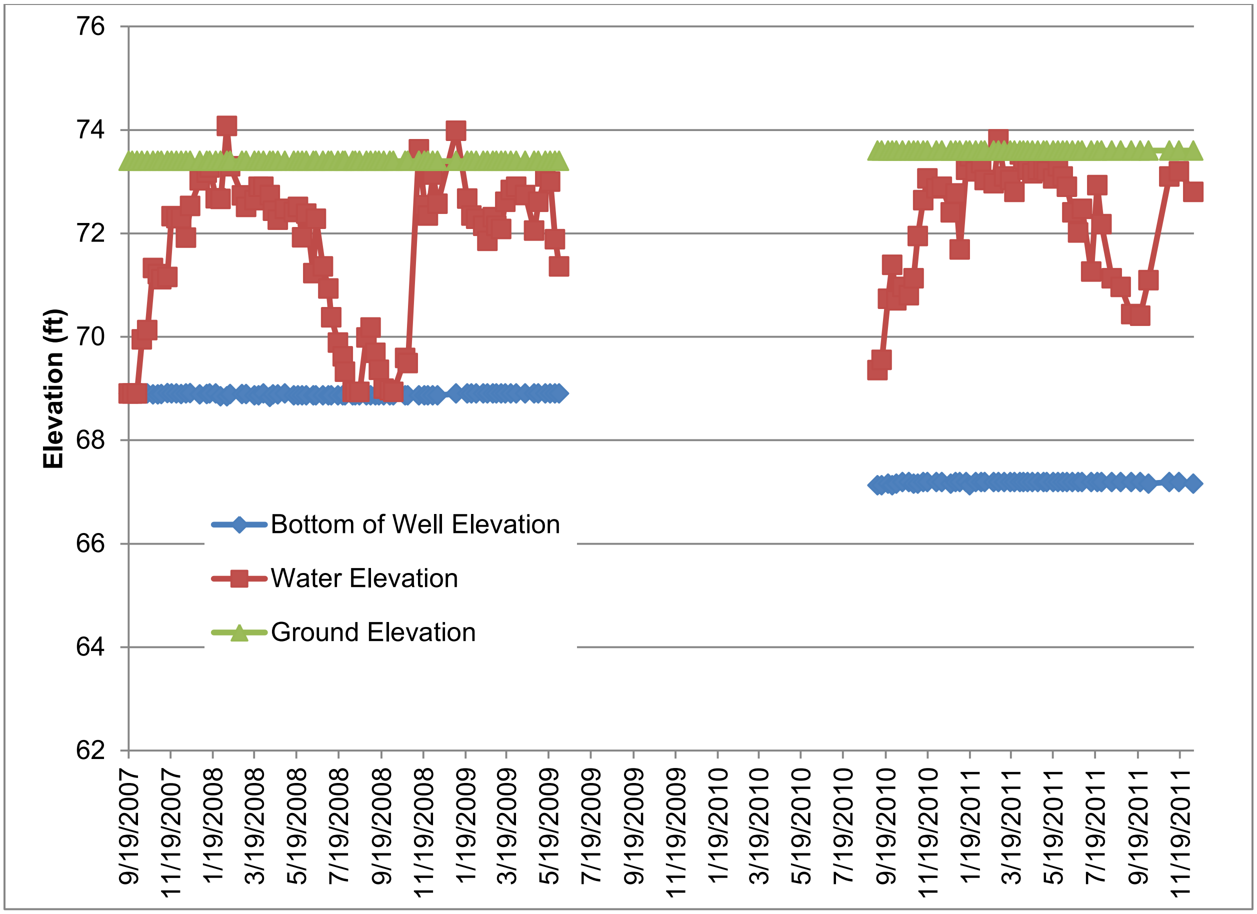


Figure 48. Graph of groundwater elevation in port #3 before and after project construction. The port number corresponds to the port location in Map 12.

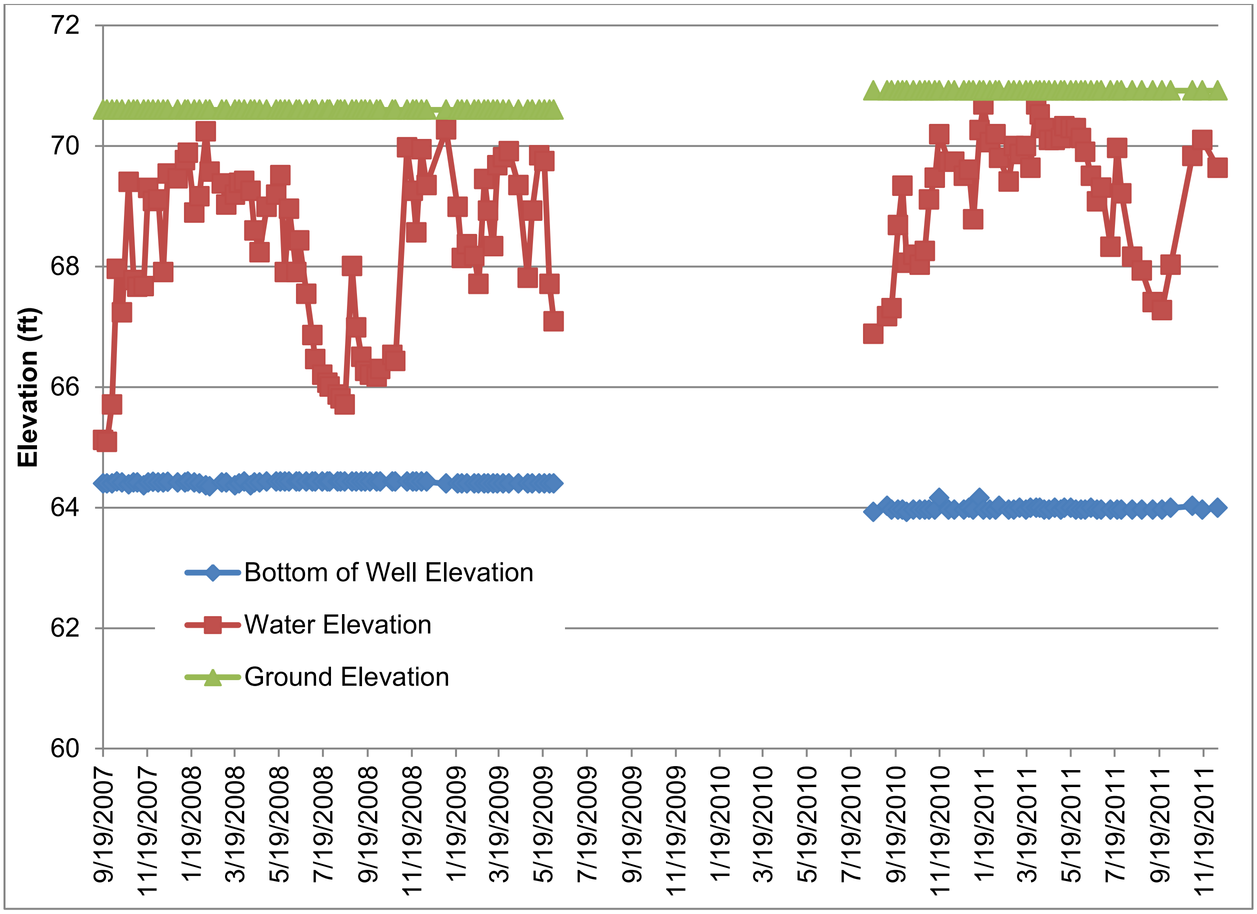


Figure 49. Graph of groundwater elevation in port #4 before and after project construction. The port number corresponds to the port location in Map 12.

Over time, the groundwater port dataset is expected to show an increase in groundwater levels as the site matures. Continuous seasonal flooding in conjunction with a riparian forested floodplain canopy is expected to improve groundwater discharge contributions in the low flow season.

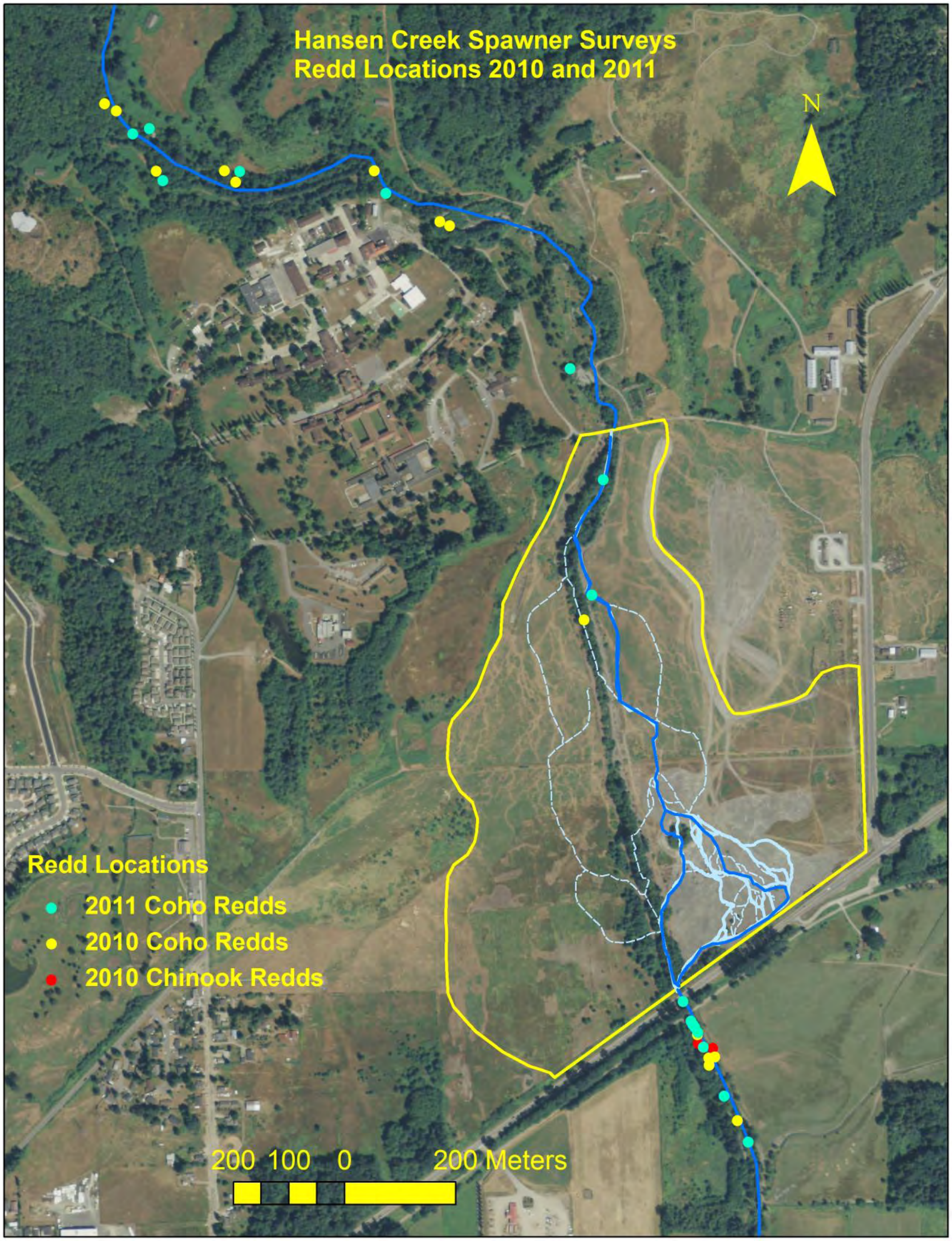
5.8 Salmon

5.8.1 Spawner Surveys

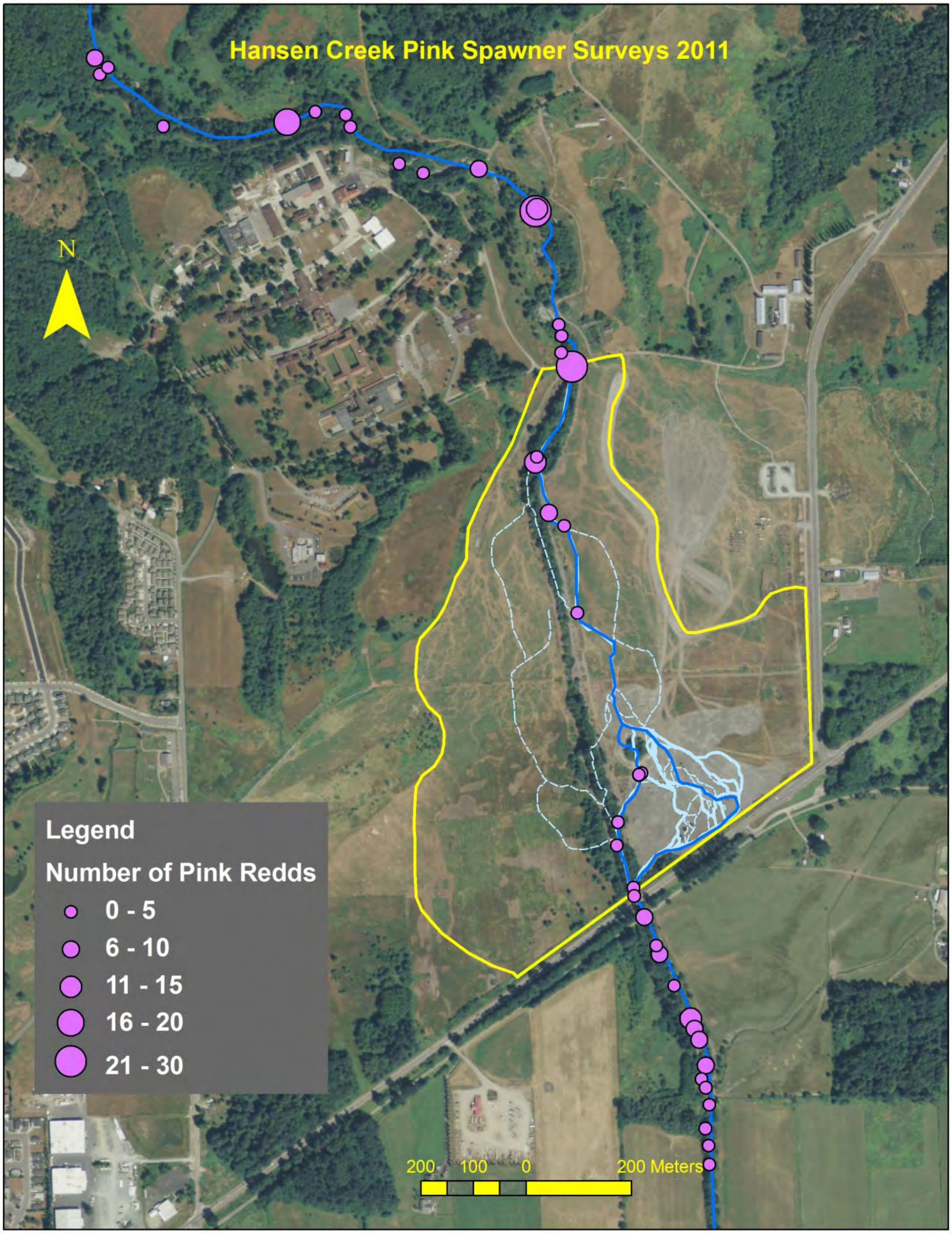
Since 1998 adult salmonid spawner surveys have been conducted on Hansen Creek in the fall and winter months. These surveys are conducted every 7-10 days, weather permitting, to determine if salmon are utilizing the site. From 1998-2009, 1.6 river miles were walked. In 2010 surveys were begun farther downstream, adding an additional 0.5 river miles. The surveys are conducted by counting live fish, dead fish, and redds observed. In addition, all dead fish are

marked (tail removed) to avoid recounting. Redds are also logged using a GPS and can be mapped for productivity (Map 13 and Map 14). Fall months generally show runs of Pinks, Coho, Chum, and Chinook. In the 2010 season, Chinook adults and redds were observed just downstream of the project reaches and may have entered the system. An adult Chinook was also observed upstream of the project site in 2011.

Figure 50. Coho salmon are just one of the salmonid species utilizing Hansen Creek.



Map 13. Map of Coho and Chinook redds observed during 2010-2011 spawner surveys.



Map 14. Map of Pink redds observed during 2011 spawner surveys (2010 was not a Pink year).

The numbers of Chinook and Chum salmon have fluctuated from year to year, with a peak approximately every 4 years (Figure 51 and Figure 52). Since 2007 (prior to project inception), Chum numbers have declined dramatically with only one individual seen in 2011. The Coho numbers had a peak in 2003-2004 but have declined since then (Figure 53). Pinks return in alternate years. In 2009 the Pink run was very strong (Figure 54). Despite 2011 being a Pink year, the observed numbers of live fish were lower than expected. Indeed, 2011 was a very poor return year for all species.

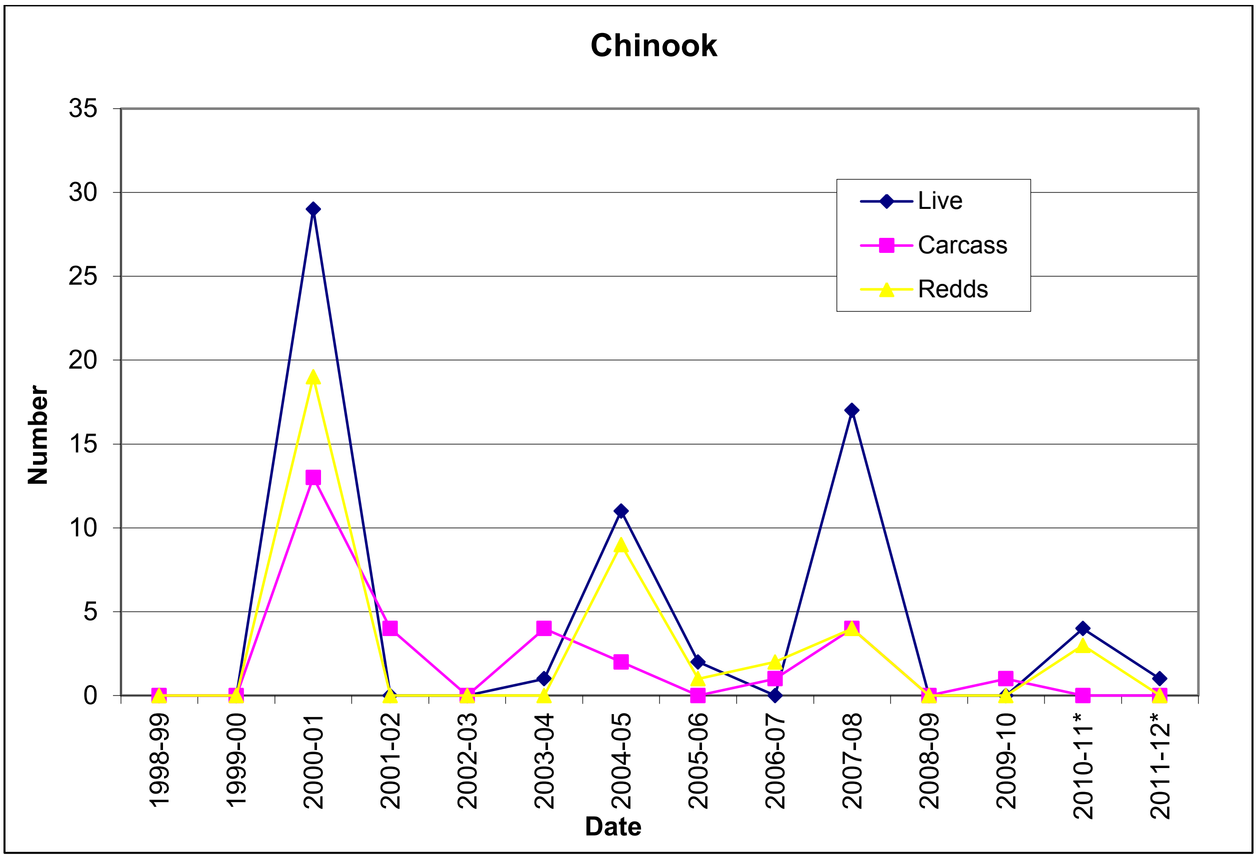


Figure 51. Comparison of Chinook salmon productivity in Hansen Creek from 1998-2011. *Includes Reach 5.

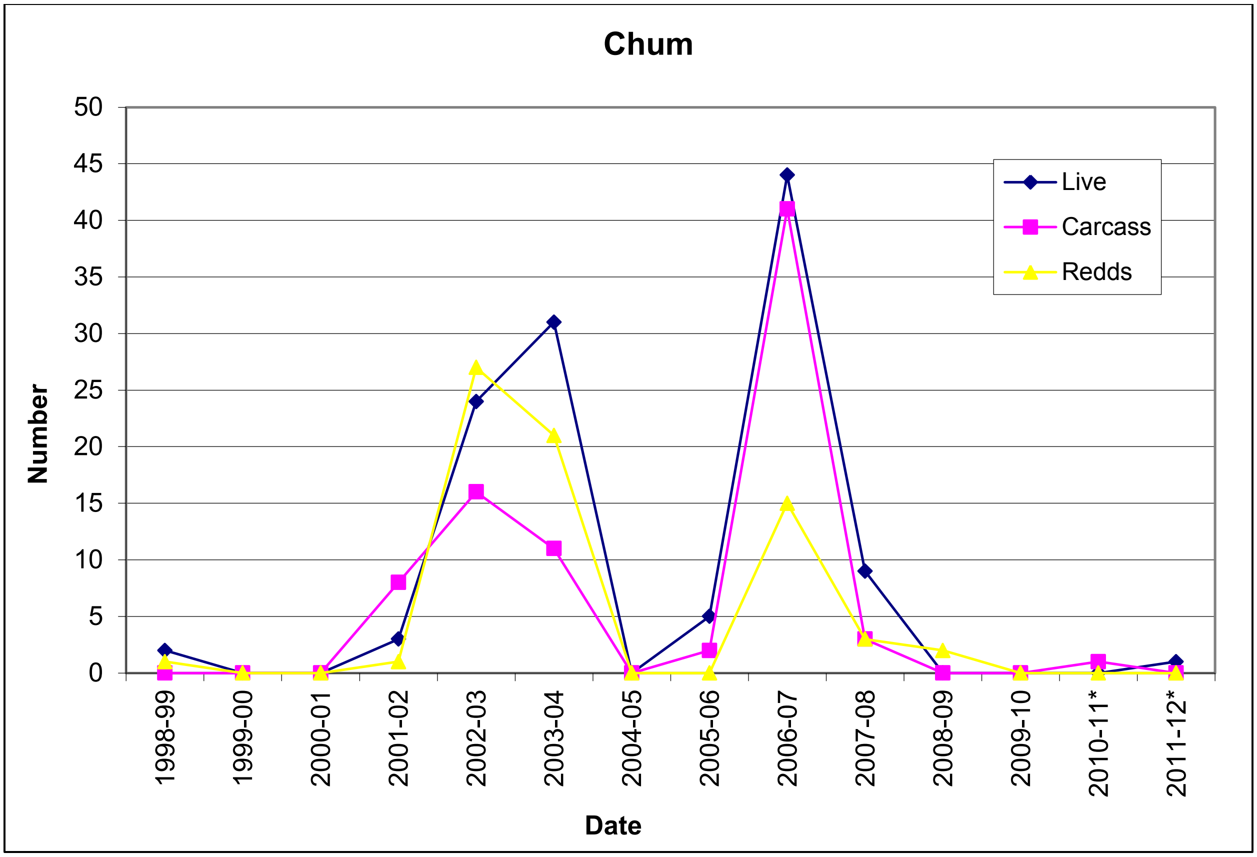


Figure 52. Comparison of Chum salmon productivity in Hansen Creek from 1998-2011. *Includes Reach 5.

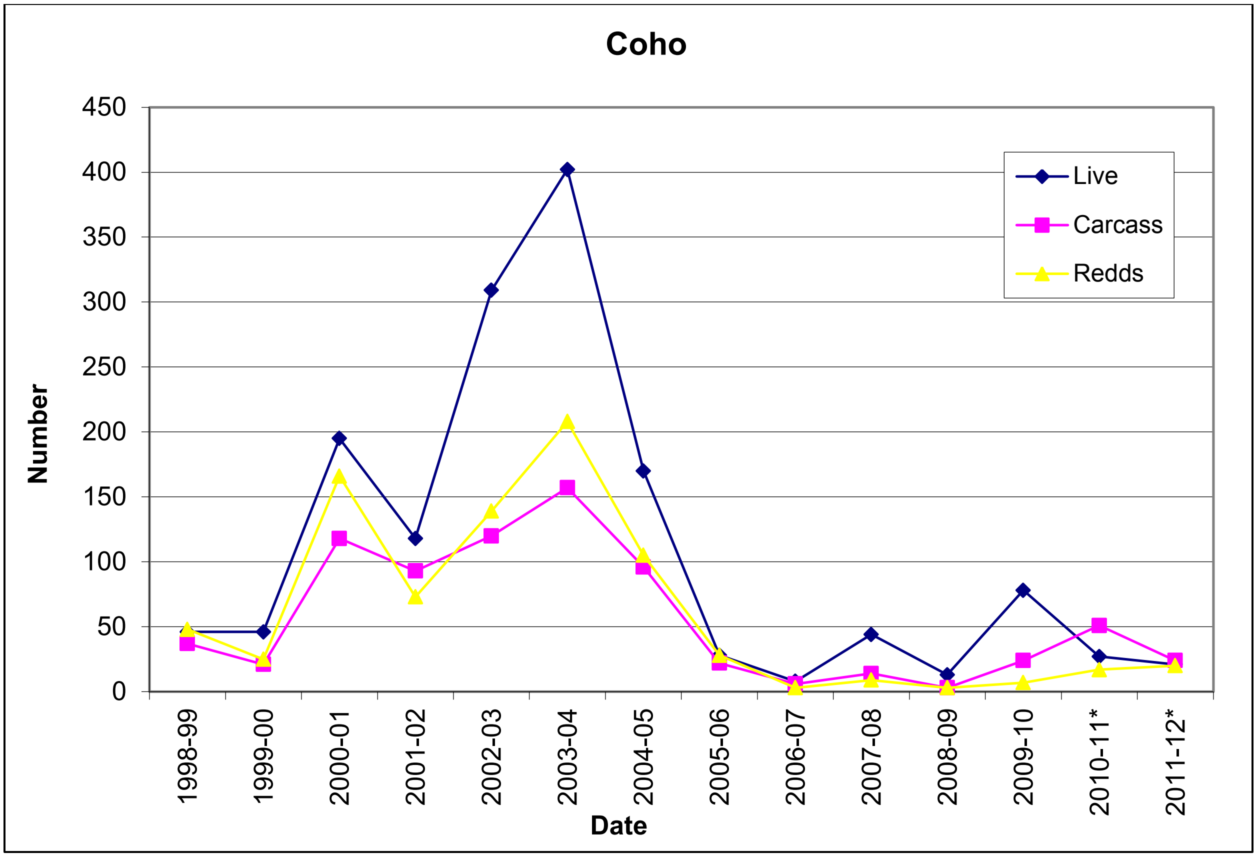


Figure 53. Comparison of Coho salmon productivity in Hansen Creek from 1998-2011. *Includes Reach 5.

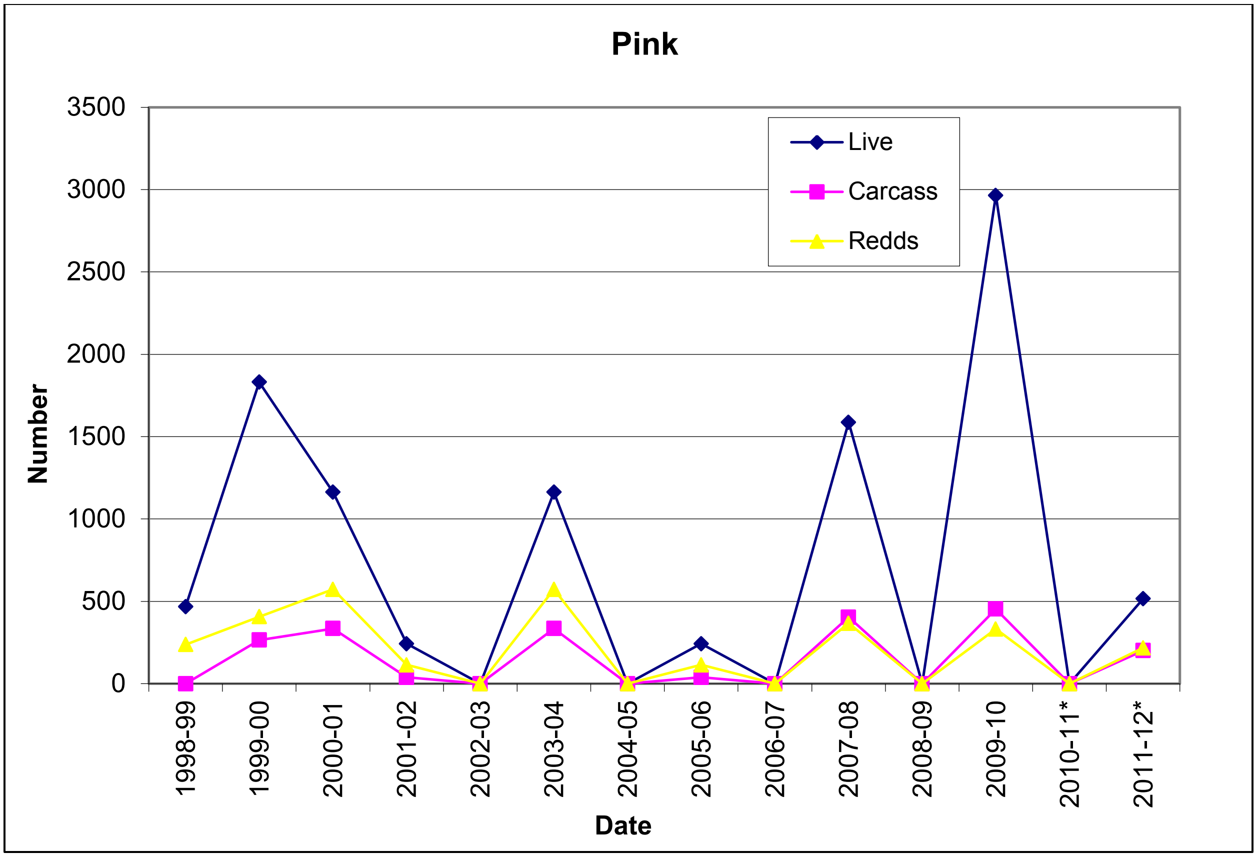


Figure 54. Comparison of Pink salmon productivity in Hansen Creek from 1998-2011. *Includes Reach 5.

In the spring, similar surveys occur for steelhead. Hansen Creek is an index stream for Steelhead and has been monitored since 1985 by WDFW. The numbers of Steelhead in Hansen Creek fluctuated from year to year. Only 3 redds were observed during the 2010 season (Figure 55).

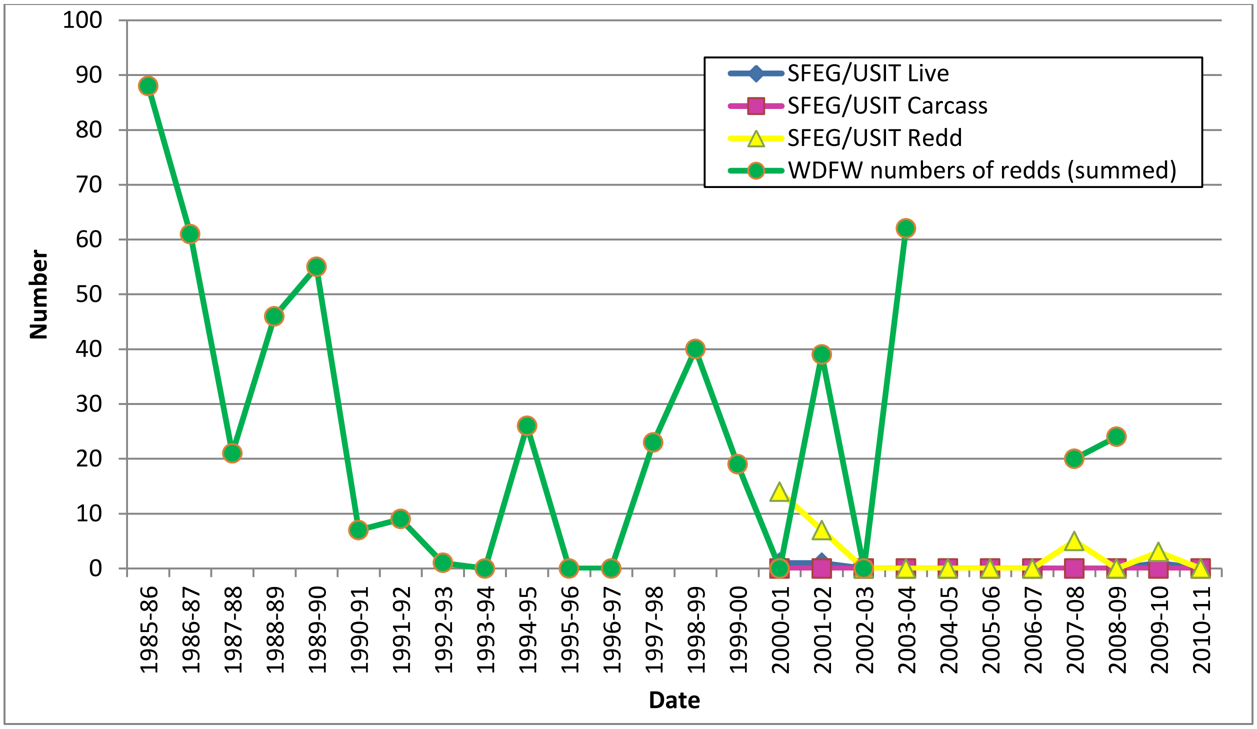


Figure 55. Comparison of Steelhead productivity in Hansen Creek from 1985-2010. WDFW redd numbers were taken from the WDFW steelhead spreadsheet. No WDFW or SFEG steelhead data was available for 2005-2007.

Fish productivity estimates can be made given proper data. A smolt trap study for outmigrating juvenile salmonids was not funded. However, the Tribe was able to engage the services of the University of Washington's (UW) Wetland Ecosystems Team in the School of Aquatic and Fishery Sciences to assist in developing information on fish utilization of the site in 2011. Several new lessons are identified for establishing floodplain restoration metrics as a result of the UW study. Future funding is essential to support multiple year sampling to identify interannual habitat and biota variations in early floodplain formation and incorporate a broader spatial scale sampling in several watersheds and the main stem Skagit River to understand source population timing, assemblage structure and fish population ecology within tributary and Skagit floodplain habitats.

A separate report produced by UW's Wetland Ecosystems Team accompanies this report. Key information from the UW report is presented here.

5.8.2 UW—Juvenile Habitat Utilization

The Tribe contracted the UW to conduct snorkel surveys and wetland nettings to determine the species utilization of areas in the fan and wetland (Figure 56). Netting occurred in the project reaches and the reference reach (upstream of the project) February through August 2011. Snorkel surveys were attempted January through May 2011 but were not completed due to visibility issues associated with high flow and turbidity in the creek. However, data were collected in June, July, and August. June and July data were comparable to netting data in regards to fish densities.

Various netting techniques were attempted, but many were difficult due to the uneven areas associated with channels that had vegetation present and those areas that were near log jams or in pools. Trout were less abundant than Coho on all sampling days and this was also true in snorkeling, with the exception of Reach 2 in July (Cordell, et. al. 2012)

Figure 56. Snorkel surveys help researchers assess juvenile salmonid habitat use.

5.8.3 UW—Diet Sampling

University of Washington conducted diet sampling of juvenile fish on the site (Figure 57). Diets were collected in one of two ways, depending on the size of the fish: non-lethal gastric lavage was performed on fish over 55 mm long and smaller fish were preserved whole for later evaluation. Gastric lavage consisted of flushing the contents from the stomach of a fish using a modified syringe or garden sprayer with a correctly sized fitting according to fish size. On 55 mm+ Coho, highest instantaneous rations were found in the inundation zone in April. There were no statistically significant differences in the instantaneous rations of Steelhead trout.

The diets were also analyzed for composition. Juvenile Coho in the smaller size class preyed mainly on larval and emergent adult insects, but the composition of main prey categories was variable among sites and time of year. Chironomids and other dipteran flies were the only prey types that were consistently abundant in the diets. While larger Coho fed mainly on insects and consistently on chironomids and other dipteran flies, their diets tended to have more annelid worms and a variety of other kinds of insects. While trout had similar diets to Coho, larger fish tended to have a more diverse diet.

Figure 57. Juvenile Coho salmon are among the species sampled for gastric lavage.

5.9 UW—Fallout Traps

University of Washington set out fallout traps across the site and found that densities of organisms in the traps were 3-4 times higher in the floodplain than other sites. Fallout organisms were more abundant July-September as compared to March-June. September yielded the highest numbers of the year. Reach 2 (reference reach above the project) and project Reach 3 had similar composition of organisms with 40-50% chironomids and other dipteran flies. Reach 4 organisms were comparable, but more than 60% of organisms were chironomids and other dipteran flies. Floodplain results showed a different composition of organisms, with almost 25% comprised of mites and chironomids and dipterans only accounting for approximately 37%.

5.10 UW—Neuston

University of Washington used neuston nets to supplement prey resource data. In June, the main channel habitats were dominated by chironomid pupae and larvae. The remainder consisted primarily of other insects. Samples taken in April differed between the east and west sides of the project. The west side yielded a population dominated by planktonic cyclopoid copepods. The east side was composed of a more evenly distributed range of organisms, including chironomids, other insects, and oligochaete and nematode worms. Organisms were much more abundant on the west side.

5.11 UW—B-IBI

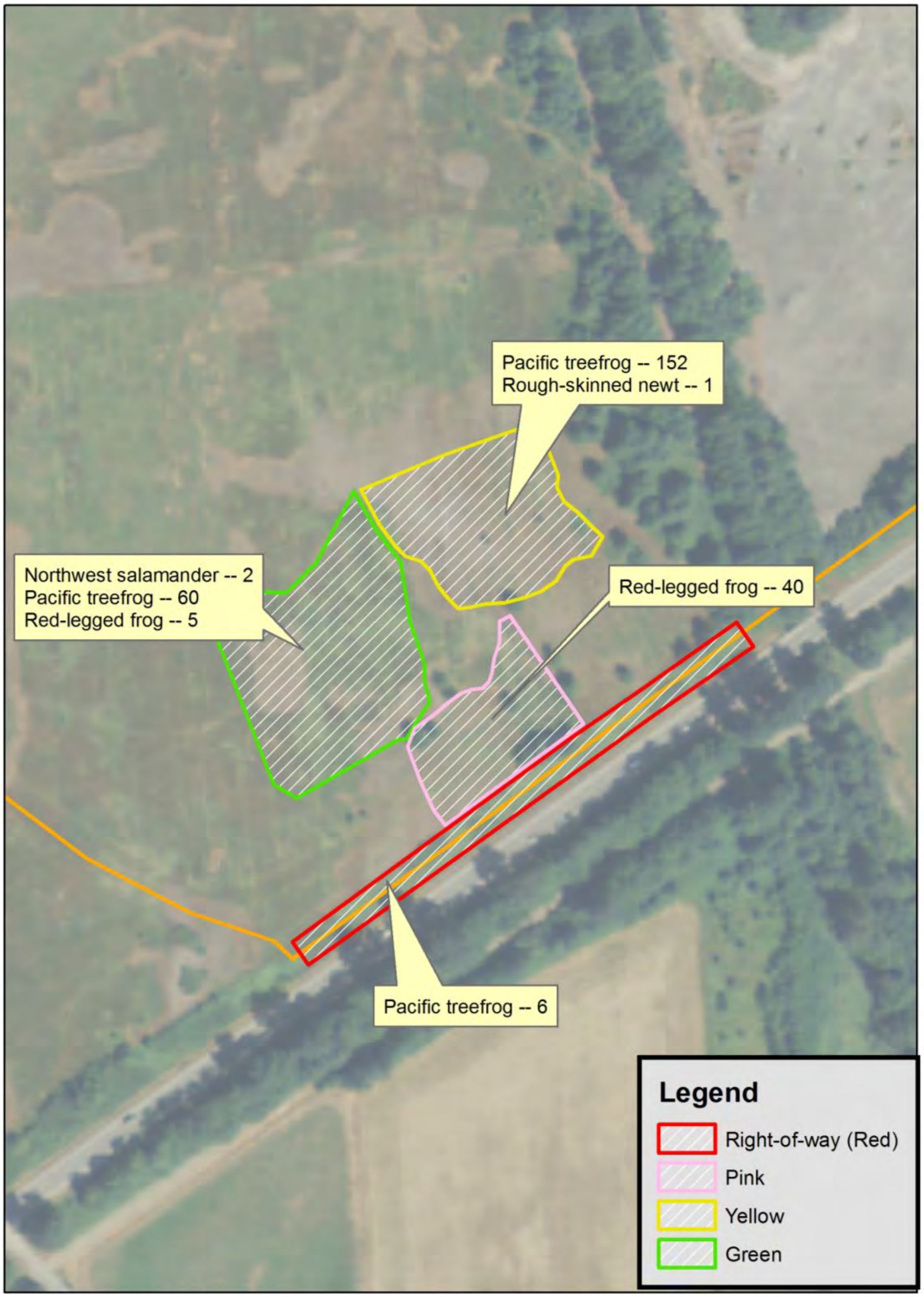
The University of Washington team also conducted B-IBI analysis on Hansen Creek by collecting benthic macroinvertebrate samples in each reach and upstream of the project site (Figure 58). All three reaches, Reach 2, 3, and 4, scored in the fair range in 2010 and 2011, except for Reach 3 which scored in the good range in 2010. However, the score for Reach 3 dropped to fair in 2011.

All University of Washington methods, results and recommendations can be found documented in the report "*Initial Biological Responses at a Restored Floodplain Habitat, Hansen Creek, Washington*," by Cordell, J.R., et.al. January 2012. The team's goal was to provide an evaluation of the biological attributes of the site in its early stages of development.

Figure 58. USIT staff and University of Washington researchers collected IBI samples in Hansen Creek.

5.12 Amphibians

2011 was the first year that amphibians were monitored at the Hansen Creek site. Before this time, observations had been made of adult amphibians, but the egg masses had not been located or tracked. In 2011, 10 volunteers from the Skagit Watershed Master's program were given the task of monitoring for amphibians in selected wetland areas of the project area. The survey plots were located in the southwest corner of the project, in the wetland between SR 20 and the historic main stem (Map 15). Adults observed in the area included Red-legged frogs, Pacific tree frogs, and Northwestern salamanders (Figure 59). Egg masses for all these species, plus Rough-skinned newt, were observed during the surveys.



Map 15. Map showing 2011 location of amphibian monitoring plots. The species and number of egg masses observed at each plot is indicated by the text box.

Figure 59. Red legged frogs are a sensitive amphibian species. The restoration site will provide habitat for this species, among others.

5.13 Birds

The Hansen Creek restoration project also supports a diverse collection of birds and wildlife (Figure 60 and Figure 61). Since February 2010, an Audubon Society volunteer has conducted 19 bird surveys within the project site, observing over 3,000 birds and almost 80 species (Table 15). Some of these are migratory species that use the restoration site for feeding during their migrations while others are residents that utilize the site year-round.

Many of the birds, such as Greater Yellowlegs, had never utilized the site before due to the poor wetland habitat. Birds such as Green Winged Teal and Northern Pintail also illustrate the importance of migratory support habitat, which for many includes open water areas. Many birds that were seen before the project was started have increased in numbers and frequency of visits, such as the Bald Eagle and Northern Harrier, suggesting an increase in various food supplies for raptors.

Table 15. Summary of bird species observed within the Hansen Creek restoration project by Audubon Society volunteer during 2010 and 2011

Species	2010	2011	Species	2010	2011
Great Blue Heron	7	6	Greater Yellowlegs	9	0
Green Heron	1	0	Solitary Sandpiper	1	0
Turkey Vulture	1	2	Spotted Sandpiper	5	4
Canada Goose	10	2	Least Sandpiper	27	0
Green Winged Teal	114	262	Wilson's Snipe	5	1
Mallard	133	155	Glaucous-winged Gull	1	0
Northern Pintail	9	254	gull sp	0	1
American Widgeon	0	5	Ruby-crowned Kinglet	2	6
Common Merganser	0	2	Swainson's Thrush	5	3
Rock Pigeon	1	4	American Robin	103	71
Vaux's Swift	2	15	Varied Thrush	1	0
Rufous Hummingbird	6	1	Cedar Waxwing	10	2
Belted Kingfisher	2	4	European Starling	239	37
Downy Woodpecker	6	1	Warbling Vireo	1	1
Northern Flicker	2	4	Orange-crowned Warbler	9	1
Western Wood-Pewee	1	1	Nashville Warbler	2	1
Willow Flycatcher	3	6	Yellow Warbler	5	1
Hammond's Flycatcher	2	0	Yellow-rumped Warbler	21	0
Tree Swallow	19	34	Myrtle Warbler	0	4
V-green Swallow	12	11	Audubon's Warbler	12	20
N Rough-winged Swallow	3	10	Common Yellowthroat	11	5
Cliff Swallow	15	12	Black-headed Grosbeak	4	3
Barn Swallow	13	11	Lazuli Bunting	2	3
Steller's Jay	2	0	Spotted Towhee	10	7
American Crow	89	53	Savannah Sparrow	120	49
Common Raven	6	5	Fox Sparrow	10	4
Black-capped Chickadee	46	36	Song Sparrow	60	52
Bushtit	0	5	Lincoln's Sparrow	7	0
Bewick's Wren	1	4	Golden-crowned Sparrow	17	11
Winter (Pacific) Wren	1	1	White-crowned Sparrow	11	2
Golden-crowned Kinglet	6	7	Dark-eyed Junco	91	64
Osprey	1	0	Red-winged Blackbird	3	267
Bald Eagle	8	7	Western Meadowlark	10	4
Northern Harrier	4	7	Brewer's Blackbird	0	3
accipiter sp	0	1	Brown-headed Cowbird	23	0
Red-tailed Hawk	9	15	House Finch	1	0
American Kestrel	2	4	Pine Siskin	21	20
Peregrine Falcon	1	0	American Goldfinch	25	66
Sora	0	3	Empidonax flycatcher--unidentified	1	4
Killdeer	44	16	Swallows--unidentified	31	0
GRAND TOTAL	**1499**	**1683**	Northern Shrike	1	0

Figure 60. Bald eagles are frequently sighted looking for fish within the project.

Figure 61. The project wetlands provide feeding habitat for migratory shorebirds as well. This Greater Yellowlegs was observed in the project on 8/5/2010.

5.14 Other Animals

Beaver activity has also been observed within the project (Figure 62 and Figure 63). Beaver-chewed sticks and branches have been seen throughout Reach 3. The presence of beaver is desirable since the construction of beaver dams will help disperse the stream flow and fulfill the project design. Beavers will also impact the plant community through selective clearing. Damming may also cause damage to plants, as the flooding creek often results in erosive damage for roots and/or plant uprooting.

Figure 62. Beaver activity observed within Hansen Creek restoration site on 10/13/2010.

Figure 63. Beaver observed on 9/7/2011 within the Hansen Creek project.

Elk are an important species and we are engaged in recovering their numbers. They have been sighted on the project area and tracks are frequently observed (Figure 64). While elk are an important large mammal, they have potential to damage young trees and shrubs within the project site. Plant damage will be monitored and survival noted for elk, vole, and other biological impacts (Figure 65). Signs of other wildlife have been observed in or near the project, including deer, coyote, raccoon, black bear, and bobcat (Figure 66). In 2011, a motion sensor game camera was installed to capture movement and numbers of animals in the project area. Elk, deer, and raccoons have been recorded with this equipment (Figure 67 and Figure 68).

Figure 64. Elk track observed within Hansen Creek restoration project on 12/1/2010.

Figure 65. Elk-damaged tree within the project site.

Figure 66. Raccoon track observed 10/7/2010.

Figure 67. Elk cow and calf in the Hansen Creek project. Image captured by game camera on 8-8-2011.

Figure 68. Elk within the Hansen Creek project. Image captured by game camera on 8-8-2011.

6.0 Public Involvement and Coordination

The project was first identified as a cornerstone project for contributing to the restoration of the watershed in the Plan. The Plan involved a wide variety of public and private interests. Stakeholders lead by Skagit County and WDFW included area tribes, contracted scientific specialists, the Hansen Sub-flood Control Zone District, the former industrial forest landowner Crown Pacific, area residents, and the Northern State Task Force. The Northern State Recreation Area Master Development Plan that adopted the restoration recommendations from the Plan also involved public and private partnerships through on-site open house events, a design charette, newsletters and public meetings held throughout Skagit County before its adoption. Both of these Plans engaged the community locally and throughout the Skagit Valley before each were approved and adopted by the Skagit County Board of County Commissioners in 2002.

These Plans described and mapped the project boundaries for the Floodplain Restoration Project. Final concept design was presented to the community at a community meeting, was submitted for review to entities including Skagit County Public Works, Parks and Recreation and their committees/foundation, the Skagit Watershed Council, and individuals at NOAA and NMFS. The concept design was refined and developed for review at 30, 60 and 90% design to funders in addition to the Skagit County partners. Funding entities included the federal agencies of NOAA – Habitat Restoration Center, EPA, an EPA-NWIFC-PSP source, and a NOAA-NACo-Coastal County Restoration Initiative source. State contributions came from the Department of Ecology CCWF, the Recreation and Conservation Office SRFB and tree donations from the Department of Natural Resources. Skagit County contributed in-kind services and cash contribution.

Figure 69. Earth Day 2010 planting event had over 100 volunteers

Prior to the start of the project construction the Burlington-Edison High School program came out to learn about the project undertaking and contribute to invasive species removal and native plant revegetation. The Tribe, County Park and Recreation, its Foundation and the Skagit Fisheries Enhancement Group collaborated for two years of Earth Day activities

at the project involving over 200 volunteers (Figure 70). The Skagit Valley College Environmental Certificate Program has engaged with site tours and data collection and sharing. Students of the Certificate Program have volunteered through an internship program with the Tribe to assist the Environmental staff with project implementation and data collection. The Skagit Watershed Masters Program toured the project site and eight volunteers from the Watershed Program monitored amphibian utilization in a portion of the restored site.

6.1 Other Park Users

The park is used by more visitors than raccoons and elk. Northern State Recreation Area attracts a broad range of visitors which include trail walkers, dog walkers, Frisbee golf players, and equestrians. The large parking lot allows for many visitors at a time and the park also serves as a venue for cross-country track meets. The park meets ADA standards allowing easy accessibility for patrons with disabilities. There is also a group of model airplane enthusiasts that utilize the open upland recreation area, as they need ample space to take off and land planes as well as set up repair and maintenance vehicles. Many visitors approach data collectors on the site to ask questions and are often excited to hear the results of the restoration thus far.

7.0 Lessons Learned

As projects progress through stages from design to implementation and monitoring, significant learning takes place, mistakes are made, and fortunate happenstances transpire. In projects of similar scope, the following Lessons Learned may prove to be useful and enlightening.

- Multi-year funding is essential to successful development of large site restorations for a number of reasons that include: pre-construction biological site assessments, advance acquisition and growing of native plants, advance acquisition of wood and multi-season implementation (Figure 71).

Figure 70. LWD acquisition and storage requires pre-project funding.

- It would be extremely helpful if funding agency RFP's and awards could be timed to allow prime recipients to bid projects early enough to ensure full season implementations.

- It was our experience that all funders have project officers that are flexible, willing and able to assist the prime recipient in achieving the project goals when timelines or other unforeseen contingencies develop. It is very important and helpful to have these project officers understand real-world, on-the-ground project development and construction in addition to their institutional policies to craft solutions that meet contractual agreements and site goals.

- The construction industry, like other fields develops specialized experience niches, from infrastructure construction, residential development construction to restoration construction. There is an experience factor when it comes to large wood structure

installation and stream rerouting and dewatering. General experience in working in or adjacent to sensitive areas is not necessarily enough for all restoration work.

- Although expensive, adequate initial site survey is essential and reliance on past survey, aerial and LiDAR technologies is not presently accurate enough for small scale and intricate work. Further, construction survey needs to be retained by the owner/engineer to ensure design needs are being met. The experience level of the construction contractor's surveying technique and abilities should be vetted carefully to reduce the possibility of additional work if they conduct the surveys during construction and for final acceptance.

Figure 71. The rotary expandable stinger greatly assisted with the vegetation planting.

- Appropriate equipment is always important and such equipment as the rotary expandable stinger contributes significantly to development goals including timelines and financial efficiency (Figure 71).

- Risk analysis during design can be expected to contribute greatly to final design. Issues can arise from people, including contractors, and inaccurate or missing data. Mother Nature is an unpredictable factor that should be considered and preparations should be made to the best of your ability in order to reduce the shock that can be eminent with unanticipated conditions.

- Project success requires pre- and post-project commitments to monitoring. Everyone wants and needs to know what works and what may not, and yet funding is virtually non-existent for almost all entities other than research arms of agencies or universities. Appropriate metrics can be better developed with a commitment to monitoring beyond these entities. This project here in the Puget Sound is one of a kind and key to freshwater indicator development for the Puget Sound Action Agenda, yet no agency has stepped up to support this restoration monitoring.

- Results monitoring requires a commitment to time and people on the ground both pre-project and post-project for up to ten years. This is a lesson most know but have not financially committed to. Monitoring can show the successes of a project, but only if monitoring can be done. Funding this portion can be just as important as the project itself so that others can learn from the project. This same is true of early project maintenance funding which often allow projects to progress more quickly.

- The saying “build it and they will come” applies now as “restore it and they will come.”

8.0 Future Activity Recommendations

The project was instituted with the expectation that nature would simply “take its course.” So far this goal is proving to have worked. The maintenance of the site will be very minimal, with the first 10 years mostly focused on invasive plant removal and conifer under planting in the wetland. The lifespan of the site is in-perpetuity; however it can be expected that after many years of sediment deposition (40-80 years), the site will need to have sediment removed so that function can continue. Skagit County is responsible for the sediment maintenance of the site.

Monitoring efforts will continue in order to gather baseline data for the project as long as possible. It is very important for this data to be collected and without additional monitoring funding, the monitoring program will need to be reduced. Looking toward the future, all funding should be sought for monitoring and research on the site. This site is an important example of stream floodplain restoration, but without data supporting the usefulness and productivity

increases, the benefits may not be known by other entities attempting to accomplish the same goals. It is the recommendation of the Tribe that monitoring continues for at least the first 10 years and at intervals thereafter. This data will prove to be very valuable for mirrored projects and for seeking funding for such projects and their monitoring costs.

According to the technical report from the University of Washington, long term monitoring will add to the comprehensive monitoring of the site and identify sources and effects of biological variation such as interannual differences in fish abundances and the effect of juvenile Pink salmon that are present in alternate years. The report recommended that sampling occur again in 2013. Long term monitoring will also aid in creating a more complete picture of general watershed health and may be used to compare Hansen Creek to other streams either in or out of the area.

There continue to be extra efforts in the watershed with investigations on Reach 5 restoration. Skagit County and the Skagit River System Cooperative have taken the lead to ensure that Hansen Creek continue to be returned to a more natural state. While modeling has been conducted to date, a clear solution has not come to light and more land acquisition is needed in order to add the sinuosity and LWD that would be present in a natural setting.

It is necessary to reach out to community planning groups and to involve floodplain restoration in watershed plans throughout the upriver valley. Participation by other groups can be acquired by stressing such projects as a win-win-win solution that reduces flooding of lowland areas including agricultural fields; provides alternate means of flood management costs; and improves local and overall Puget Sound health for water quality, sediment transport, and fish and wildlife.

Figure 72. USIT Environmental Staff left to right: Lauren Rich, Lisa Hainey, Aegis, and Chris Gourley.

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