# Evaluating Stream Restoration Projects in the Sprague River Basin

***Prepared for:***

Klamath Watershed Partnership, in conjunction with the Klamath Tribes, the U.S. Fish and Wildlife Service, the Klamath Basin Rangeland Trust, Sustainable Northwest, and The Nature Conservancy

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# Executive Summary

## Background and Purpose

Aquatic ecosystems in the Sprague River Basin in southern Oregon have been degraded by historical and current land uses including logging, dam construction, cattle grazing, and agriculture. Since the mid-1990’s, projects have been funded to improve watershed conditions in the Sprague River Basin for affected fish species, including Lost River sucker, shortnose sucker, and redband trout, channel stability, riparian habitat, and water quality. Continuation and potential future expansion of stream restoration projects in the Sprague River Basin warrant a basinwide review of the benefits of previous restoration projects. The purpose of this project was to evaluate the performance of a variety of completed restoration projects in the basin and identify key lessons learned. These lessons will be used to help implement meaningful adaptive management of the basin’s aquatic resources and to guide future project prioritization, planning, and design.

## Post Project Appraisal Framework

We developed a post-project appraisal (PPA) framework to guide our analysis and conceptual models to further our understanding of the Sprague River Basin. Development of the framework was a joint effort between the NewFields Team and agency and local stakeholders that combined a diverse set of site-specific and basinwide knowledge regarding stream restoration in the Sprague River Basin with extensive experience on the development and implementation of PPAs. We developed the framework by starting with a comprehensive review of stream restoration projects in the basin. We determined that nearly all of the previously completed projects fit into one of four categories consisting of Instream, Riparian, Floodplain, and Spring. We summarized project goals into a single goal statement for projects in a given class (category). Next, we linked the goals and objectives by identifying the natural processes that each project action could potentially affect. Finally, we identified metrics and assessment methods appropriate for each affected natural process.

The framework is illustrated in a Table 3.1-1 in Section 3 of this report and provides stream restoration practitioners and stakeholders in the Sprague River Basin a useful and convenient tool to guide monitoring and adaptive management of existing stream restoration projects and to plan, design, implement, and monitor new projects. To further our understanding critical processes and linkages in the Sprague River Basin responsible for the current condition and potential future evolution, we developed conceptual models (Section 3.2 of this report). The models provide a description of the physical and ecological system and interactions of its various components. These conceptual models can serve as the basis for developing restoration strategies and predict the likely outcomes of stream restoration actions. We developed conceptual models for meander bend cutoff, corridor confinement, channel simplification, grazing, diversions, springs, and wetlands (Section 3.2).

## Data Collection and Analysis

To evaluate stream restoration projects in the Sprague River Basin we adapted widely accepted stream restoration PPA methods (Section 4 of this report). PPAs provide a framework from which to learn from past project successes and failures, and provide performance feedbacks that allow adaptive management of environmental resources. Our PPAs of projects in the Sprague River Basin followed the framework established by Kondolf and Downs (2002) using the following eight components:

1. Success criteria
2. Baseline surveys / data collection
3. Design rationale
4. Design drawings
5. As-built surveys
6. Post-project periodic and event driven monitoring surveys
7. Supplementary historical data
8. Secondary analytical procedures

We performed additional geomorphic and vegetation monitoring on selected projects in the Sprague River Basin to supplement the pre- and post-project monitoring, including cross section and longitudinal profile surveys, photographic monitoring points, bank erosion assessments, “greenline” surveys, aerial photograph comparisons, hydrologic analyses, and instream structure assessments. We also characterized each project for its “level of investment” (as described in Downs and Kondolf 2002). For each case study we reviewed, we categorized level of investment based on our review of available monitoring data and documentation on project planning, design, and implementation.

We developed and implemented a Spatial Post Project Appraisal Management System (SPPAMS) to guide and organize our selection of projects for PPA and to provide a tool for future adaptive management and implementation of stream restoration projects in the basin (Section 5 of this report). We added relevant spatial data layers to the SPPAMS and organized the information in the SPPAMS according to the Project Organization Framework (Table 3.1-1). This allowed us to attribute all of the projects in the master list with the appropriate combination of instream, riparian, floodplain, and spring project classes. Drawing on the information contained in the SPPAMs, we began to identify potential projects for PPAs from the comprehensive set of projects. We completed final selection of projects iteratively with input from agencies and stakeholders. Our final set of ten PPAs includes representative projects from the Sycan Marsh and the upper, middle, and lower Sprague River Basin. We evaluated fencing, wetland creation, floodplain reconnection, levee breaching, meander bend cutoff plugging, riparian planting, channel realignment, fish screen, spring reconnection, and wetland connection project types.

## Post Project Appraisal Case Studies

We selected 10 projects for Post Project Appraisal (PPA) summarized in Table 1 below. Each case study follows the same format and we rate each project's level of investment and list the project class and actions from our PPA Framework (Section 6 of this report). Next, we provide a summary, description of site conditions, success criteria, timeline, and relevant conceptual models for each project, in addition to our PPA methods and results. Lastly, we conclude each case study with description and a table that summarizes the lesson learned.

*Table 1: List of the projects selected post-project appraisal for the Sprague River Basin.*

| Project Name | Stream | Location in the Watershed | Project Class | Project Type |
|---|---|---|---|---|
| South Fork Sprague River | S. Fork Sprague River | Upper | Riparian | Management |
| Five Mile Creek | Five Mile Creek | Upper | Riparian | Management |
| | | | Instream | Habitat Creation |
| | | | | Fish Passage Improvement |
| Bailey Flat | North Fork Sprague River | Upper | Instream | Channel Manipulation |
| | | | | Habitat Creation |
| | | | Riparian | Management |
| Long Creek | Long Creek | Sycan Marsh | Riparian | Management |
| Sycan River | Sycan River | Sycan | Riparian | Management |
| Whisky Creek | Sprague River | Middle | Riparian | Management |
| | | | Instream | Fish Passage Improvement |
| | | | Spring | Reconnection |
| | | | | Management |
| Nimrod River Park | Sprague River | Middle | Riparian | Management |
| | | | Instream | Channel Manipulation |
| | | | Floodplain | Reconnection |
| | | | | Modification |
| Beatty Station | Sprague River | Middle | Instream | Channel Manipulation |
| Nine Mile Road | Sprague River | Lower | Riparian | Management |
| | | | Instream | Channel Manipulation |
| Southside Levee Breach | Sprague River | Lower | Riparian | Management |
| | | | | Expansion |
| | | | Floodplain | Reconnection |
| | | | | Management |

## Implications for Future Stream Restoration Projects

Throughout this effort, we were impressed by the professionalism and integrity of the stream restoration community in the Sprague River Basin. We hope that stream restoration practitioners in the basin will use this document to inform their ongoing and future work. In Section 7 of this report, we summarize our assessments of each of the ten PPAs and provide a grade for each project with respect to its stated success criteria. Our primary overall conclusion and recommendation is that a systematic approach to all phases of the stream restoration project life cycle is needed to guide and prioritize all of the stream restoration work that is being and will continue to be implemented in the basin. Section 7 also documents a range of more specific lessons learned for each project type and offers guidance on using this report to improve future stream restoration efforts in the basin.

# 1 Introduction

## 1.1 Purpose

The primary purpose of this project is to synthesize, evaluate, and refine basin-wide goals, classify completed projects, and select specific projects for a detailed evaluation. The detailed evaluations of the selected projects will address two questions about stream restoration projects in the Sprague River Basin:

1) Are stream restoration projects in the basin meeting their success criteria?
2) Are stream restoration projects in the basin collectively supporting achievement of basin-wide stream restoration goals?

We implemented systematic post-project appraisals (PPAs) of representative stream restoration projects in the Sprague River Basin to address these questions, and in so doing, we learned a wide range of lessons about their planning, design, implementation, and monitoring. This report summarizes the context, methods, results, and conclusions of ten PPAs conducted on a range of stream restoration project types to address the primary purpose of this project and provides information intended to guide ongoing adaptive management of existing projects in the basin and implementation of future stream restoration projects.

This secondary project purpose will likely grow increasingly important as watershed-scale restoration planning remains a dominant theme in the Basin to help balance water resource-related needs. Indeed, we realized early on in this project that the diversity of stream restoration projects in the Sprague River Basin and the lack of systematic monitoring program for most of these projects would make definitive answers to the two primary questions posed for this project difficult, if not impossible. Therefore, we put significant effort into using the case studies to develop and test a stream restoration project implementation and evaluation framework that could facilitate establishment of appropriate goals and objectives for the refinement of existing projects and planning of new projects, and to establish standard monitoring metrics for stream restoration projects in the basin that are explicitly tied to the goals and relevant natural processes that likely govern the performance of stream restoration actions.

While the results of the case studies we completed for this project are interesting and valuable unto themselves, they should not be considered the primary output from this project. Rather, this entire report should be used as a guidance document that provides practical guidance for stream restoration practitioners and policy-makers working in the Sprague River Basin. Considered in this context, the case studies in this document provide a snapshot in time of the performance of a range of projects in the basin, a repository for historical and newly collected baseline data that can be used to support future monitoring and adaptive management of these projects, and a demonstration of how the stream restoration planning and implementation framework we developed to support these case studies should be applied to new projects in the basin.

# 2 Project Setting

## 2.1 Location

Stream restoration projects in the Sprague River Basin vary with the diverse conditions that characterize different parts of the system. The basin (Figure 2.1-1) encompasses approximately 1,610 square miles of south central Oregon and is a principal tributary of the Williamson River, which provides nearly half of the inflow to Upper Klamath Lake. The Sprague drains an arid volcanic plateau region east of the Cascade Range in the watershed of the Klamath River.

The Sprague River begins at the confluence of its north and south forks in eastern Klamath County, approximately 35 miles east-northeast of Klamath Falls. The North Fork Sprague River rises in southwestern Lake County in the Fremont National Forest near Gearhart Mountain and flows southwest. The South Fork Sprague River rises northeast of Quartz Mountain Pass and flows west-northwest. From the confluence of the two forks the river flows west through the broad Sprague Valley, past the small communities of Bly, Beatty, and Sprague River. It is joined by the Sycan River from the north at Beatty. The Williamson joins the Sprague River from the north at Chiloquin, about 10 miles north of the mouth of the Williamson on Upper Klamath Lake.

The Sprague River Basin drains a varied landscape, from steep-sloped, highly-dissected headwaters to low-gradient floodplains that support a variety of aquatic features including perennial, intermittent, and ephemeral streams, constructed ditches, lakes, and marshes. The lower reaches of the North Fork and South Fork Sprague River, the Sycan River, and the 86 miles (139 kilometers) of the mainstem Sprague River meander through broad alluvial valleys that have historically supported agricultural crops and livestock grazing. The Sprague River near Chiloquin is at an elevation of 4,210 feet, and the headwaters originate at an elevation of about 8,000 feet. The average watershed slope and elevation are 5.6% and 5,250 feet, respectively (GMA 2006).

Approximately 56% of the land area in the Sprague River Basin is in public ownership. The remainder is privately owned forestlands (24%), rangeland (11%), irrigated lands (6%), and urban / unclassified (3%) (NRCS 2005). Historically, the main land uses in the basin have been livestock grazing and timber harvest. Both of these activities began in the late 19$^{th}$ century, and have continued with varying intensity. Presently, agriculture, raising livestock, and timber management remain as the primary land uses in the basin, although at diminished levels in comparison to their peak during the mid-20$^{th}$ century. Forest management is now more focused on improving forest health. Agriculture occurs primarily within the wide alluvial basins and is almost all pasture and hay fields, supporting ongoing livestock operations.

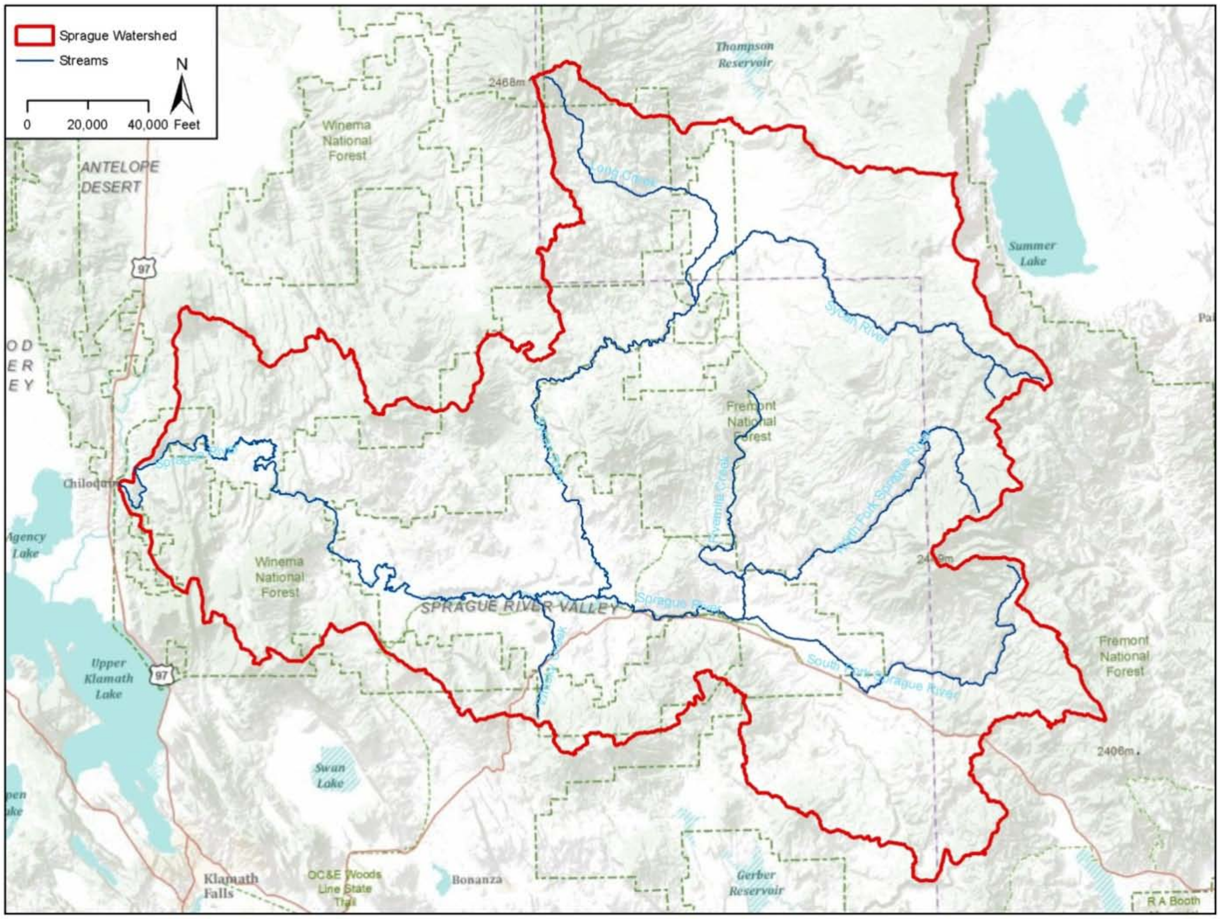



*Figure 2.1-1: Map of the Sprague River Basin*

## 2.2 Geology

The Sprague River Basin is situated within the northernmost extent of the Basin and Range physiographic province, and it also includes the eastern edge of Oregon's southern Cascade Mountains. It is characterized by multiple uplifted mountain chains separated by fault bounded valleys. Additionally, the development of the Cascade Mountains has resulted in multiple volcanic centers in the Klamath Basin; the Sprague River Basin is heavily influenced by periodic inputs of volcanic materials (O'Connor et al, unpublished).

The geology of the Sprague River Basin is chiefly defined by late Tertiary and Quaternary volcanic and sedimentary strata. Faulting occurs in the north- to northwest direction. Upland areas are composed of volcanic rocks, including upper Miocene and Pliocene basalt and basaltic andesite lava flows, as well as older siliceous lava flows and domes. The Sycan River valley is the location of more recent volcanic activity, including basalt flows that partly filled the valley approximately three million years ago (O'Connor et al, unpublished). Valley and basin geology is characterized by alluvial formations bounded by block-faulted uplifts or lava flows. River valleys and lake basins are excavated into weakly consolidated Miocene and Pliocene diatomites, mudstones, sandstones, conglomerates and tuffs (O'Connor et al, unpublished).

The eruption of Mount Mazama formed the Crater Lake caldera approximately 7400-7700 years ago, and tephra from this eruption deposited throughout the Sprague River Basin. Fallout tephra thicknesses exceeded 1 m in the northwestern part of the Sprague River Basin but diminish to less than 1 cm in the southern and eastern parts of the basin (O'Connor et al, unpublished).

## 2.3 Hydrology

The upper Klamath Basin is a semiarid region. Precipitation in the Sprague River Basin is highly seasonal and spatially variable, with about 90% falling between October and April (GMA 2006). A large portion of the annual precipitation falls as snow at higher elevations in the upper basin; approximately thirty to fifty percent of total precipitation occurs as snowfall during the winter months. A small portion of the annual precipitation occurs in the summer months during thunderstorms.

The average annual precipitation measured in Klamath Falls from 1902-2005 is 13.4 inches. The average annual precipitation measured in Crater Lake from 1931-2005 is 68 inches. Isohyetal maps for the watershed indicate that annual precipitation generally increases with elevation along the north and north-east portion of the basin. The average annual precipitation increases about 55 inches per year from the lower reaches, near the town of Chiloquin, to the higher areas near the watershed divide (GMA 2006).

Previous surface and groundwater investigations in the Sprague River Basin have concluded that groundwater – surface water interactions play an important role in hydrological processes, especially in the reaches with broad alluvial valleys and high channel sinuosity. Leonard and Harris (1974) concluded that:

- The lower valley of the Sprague River is a major groundwater discharge area, and groundwater flow generally follows the surface topography that trends south in the upper basin and west in the lower basin;
- Snowmelt in the headwaters to the north and east is the main source of groundwater recharge;
- Groundwater discharge along the Sprague River Basin is the source of seasonal baseflow; and
- Limited groundwater recharge or discharge occurs in the steep entrenched channel reaches downstream of Beatty, Oregon.

The USGS completed a study of historical hydrology in the Sprague River Basin that demonstrated a major increase in mean runoff after 1951. Because climate data did not show a statistical difference between pre- and post- 1951 time periods, it is likely that this increase in runoff is at least partially attributable to anthropogenic causes. One possible explanation is that the runoff time of concentration for precipitation in the basin has decreased in the lower Sprague River due to extensive channelization and drainage for irrigation and agricultural conversion of marsh land (USGS 1999).

Graham Matthews and Associates (GMA) produced a draft hydrologic analysis of the Sprague River Basin in 2006 as part of an ongoing geomorphic assessment of the basin. The key findings of this analysis include:

- The magnitude of monthly streamflow in the Sprague River is dominated by snowmelt, rainfall-runoff, and rain-on-snow events from December to February and by snowmelt from March to June.
- Daily and monthly baseflow occurs from late June to mid October.
- The largest flood measured in the Sprague River (near Chiloquin – USGS Gage 11501000) over the 90 year period of record occurred in December 1964, when flow peaked at 14,900 cfs (a 100- to 150- year flow event). The flood lasted about 11 days. The second largest recorded flood peaked at 10,800 cfs (a 50-year flow event) in January 1997 and lasted about 12 days. These two large flood peaks resulted from regional rain-on-snow events.
- Flow duration analysis results show that lower Sprague River near Chiloquin exceeds 1,500 cfs 10% of the time, or 36 days per year on average, while 50% of the time flows are below 400 cfs.

We updated the flood frequency analysis initiated in the GMA 2006 investigation using the Hydrologic Engineering Center Statistical Software Package (HEC-SSP). This software facilitates statistical analyses of hydrologic data. We conducted our updated flood frequency analysis based on Bulletin 17B, "Guidelines for Determining Flood Flow Frequency" (USGS 1982), a generalized frequency analysis for watersheds that have recorded peak streamflow data. We used USGS annual peak streamflow data for gauged streams in the Sprague River Basin to compute the 1-year, 2-year, 5-year, 10-year, 20-year, 50-year, and 100-year flood frequencies for key locations in the basin (Table 2.3-1). Flood frequency statistics from the North Fork and South Fork Sprague Rivers, as well as Deming Creek (GMA 2006) are also included in this table.

*Table 2.3-1: Sprague River flood frequency statistics (Source: USGS, 2012 http://waterdata.usgs.gov/nwis; GMA 2006)*

| Site Name | USGS Gage Number | Drainage Area at Gage (mi²) | Peak Flow Reporting Years | Flood Frequency Recurrence Interval | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1-Year Flow (cfs) | 2-Year Flow (cfs) | 5-Year Flow (cfs) | 10-Year Flow (cfs) | 20-Year Flow (cfs) | 50-Year Flow (cfs) | 100-Year Flow (cfs) |
| Sprague River near Chiloquin | 11501000 | 1,565 | 1921 – 2010 | 349 | 2,037 | 3,932 | 5,568 | 7,437 | 10,325 | 12,866 |
| Sycan River near Beatty | 11499100 | 568 | 1980 – 1991 | 89 | 1,032 | 2,480 | 3,913 | 5,695 | 8,678 | 11,483 |
| Sprague River near Beatty | 11497500 | 513 | 1914 – 1991 | 250 | 1,265 | 2,267 | 3,074 | 3,952 | 5,242 | 6,326 |
| NF Sprague River at Power Plant | 11495800 | 78 | 1994 - 2010 | 80 | 583 | 876 | 1,026 | 1,140 | 1,253 | 1,318 |
| SF Sprague River at Brownsworth | | 62 | | | 294 | | | | | 2,160 |
| NF Sprague River at Sandhill | | 35 | | | 261 | | | | | 996 |
| Deming Creek | | 4 | | | 38 | | | | | 157 |

**Error! Reference source not found.** shows annual peak flows for the Sprague River at Chiloquin (USGS Gage 11501000). We were especially interested in peak flow hydrology over the past ten to fifteen years as all of the stream restoration projects we evaluated were completed during this period and influenced by the hydrology of the time. In general, compared to previous decades, the last decade has experienced lower magnitude peak flows. The three largest peak flows in the last decade include 3,590 cfs (on Jan 5th, 2006), 2,660 cfs (on May 23rd, 2005), and 2,520 cfs (on April 23rd, 2000). In contrast, the decades beginning in 1970, 1980, and 1990 each had at least three years where flows exceeded 4,000 cfs (USGS 2012).

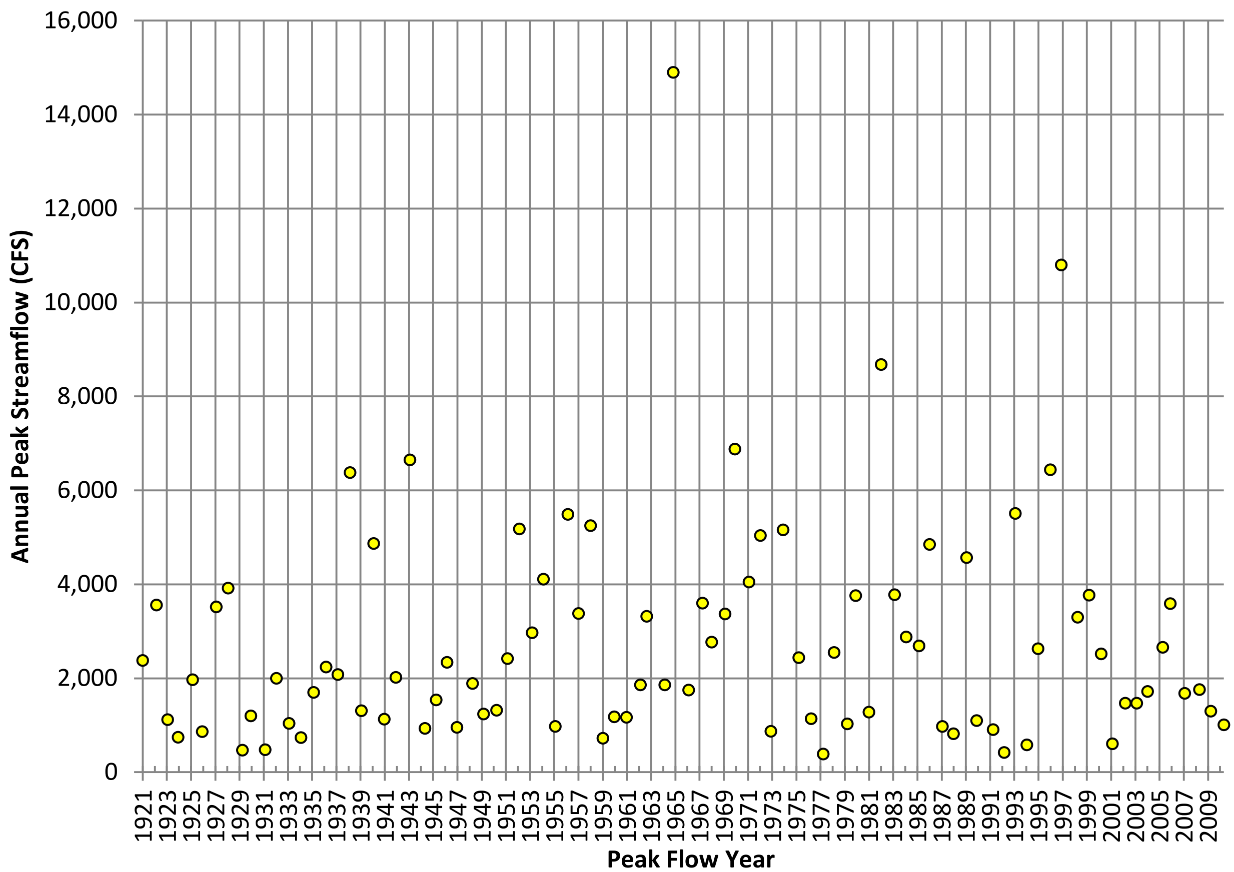



*Figure 2.3-1: Annual peak flows for USGS 11501000 Sprague River at Chiloquin, 1921 – 2010 (Source: USGS 2012 http://waterdata.usgs.gov/nwis)*

## 2.4 Geomorphology

The Sprague River Basin is characterized by headwater channels that originate in the high elevations on the fringe of the basin and feature confined valley slopes, higher gradients, coarser bed materials, and relatively low sinuosity; and low-gradient, meandering (high sinuosity), laterally-active, anastomosing (multi-channel) river systems in the valley bottoms. In the low gradient valley bottom areas, natural geomorphic processes lead to an evolutionary sequence whereby channels are created, abandoned, and reoccupied across the floodplain terrace over long periods of time. This sequence of channel avulsion has produced highly dissected wet meadow floodplains in parts of the Sprague River Basin. Channel evolution is a relatively slow, progressive process in the basin that appears to be driven more by longer-term geomorphic adjustments than by moderate or even large flood events. For instance, the 1997 flood in the Sprague River Basin, the second largest in 90 years, appears to have caused relatively little channel planform change (GMA 2007). Access to floodplains in the Sprague River Basin reduces the impact of large floods as floodwaters spread out on the broad valley, which dissipates energy.

The geomorphology of the Sprague River Basin is currently being analyzed in an ongoing geomorphic mapping effort by the USGS (O’Conner 2011). The results from this study have not been published in a report or paper, but have been summarized in a PowerPoint presentation dated 2010 by Pat McDowell and Jim O'Connor. A finding from this study that provides geomorphic context to our PPA is that the dominant process of channel migration was via cutoff, mostly chute cutoff. This is illustrated in Figure 2.4-1, which shows many meanders in the Sprague River, but few point bars. If lateral migration was a significant process for channel change, more point bars would have been identified in their analysis. They conclude that lateral migration is not a driving process for channel change in the Sprague River Basin.

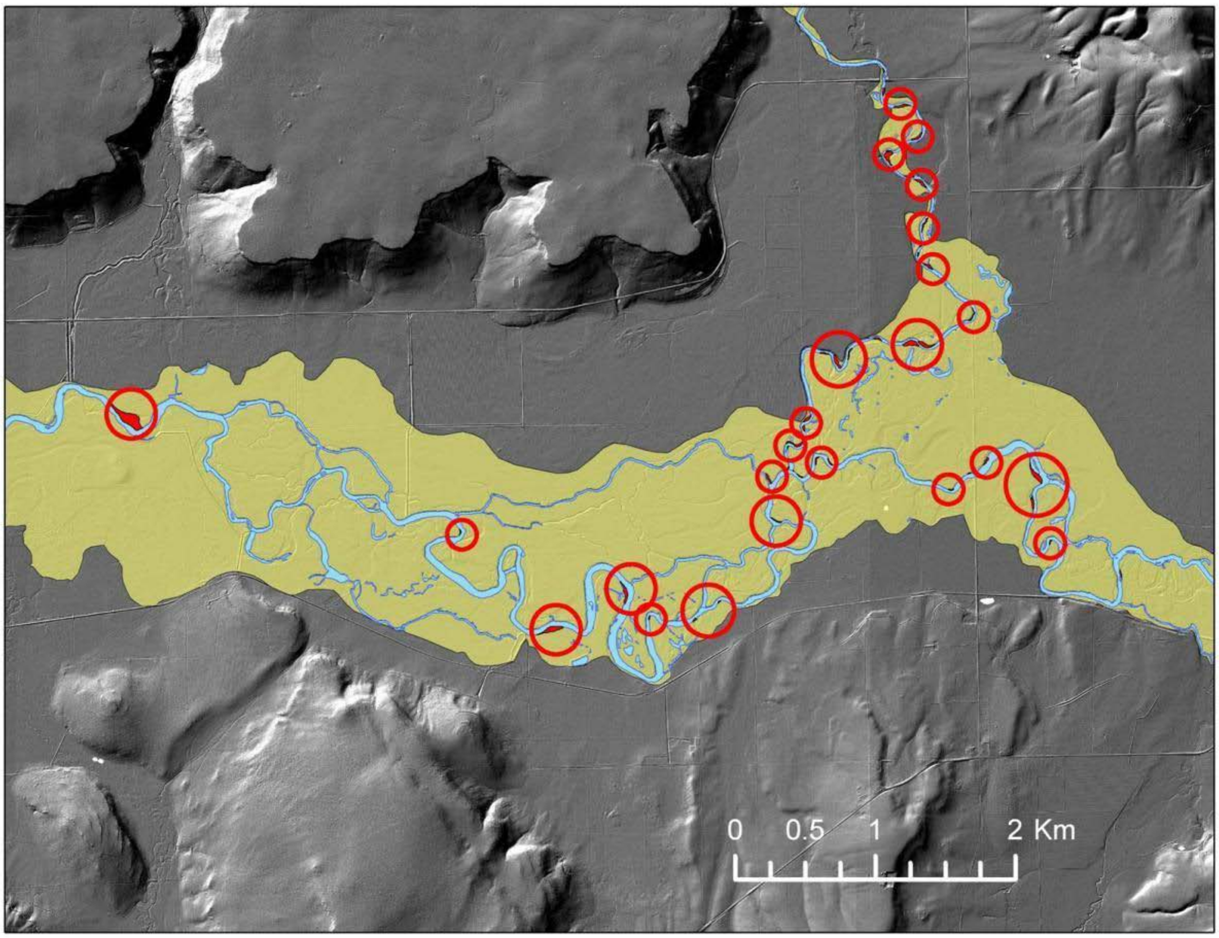



*Figure 2.4-1: Map from O'Connor and McDowell (2010) showing many meanders, but few, small point bars (located inside the red circles in the figure). In the figure north is at the top and the Sprague River flows from east to west. The Sycan River joins the Sprague from the north.*

The McDowell and O'Connor data also shows that the number of locations where there were changes in channel alignment (including cutoffs) were highest in the period from 1940-1968 (Figure 2.4-2). During that period, chute cutoffs occurred twice as frequently as avulsions or neck cutoffs.

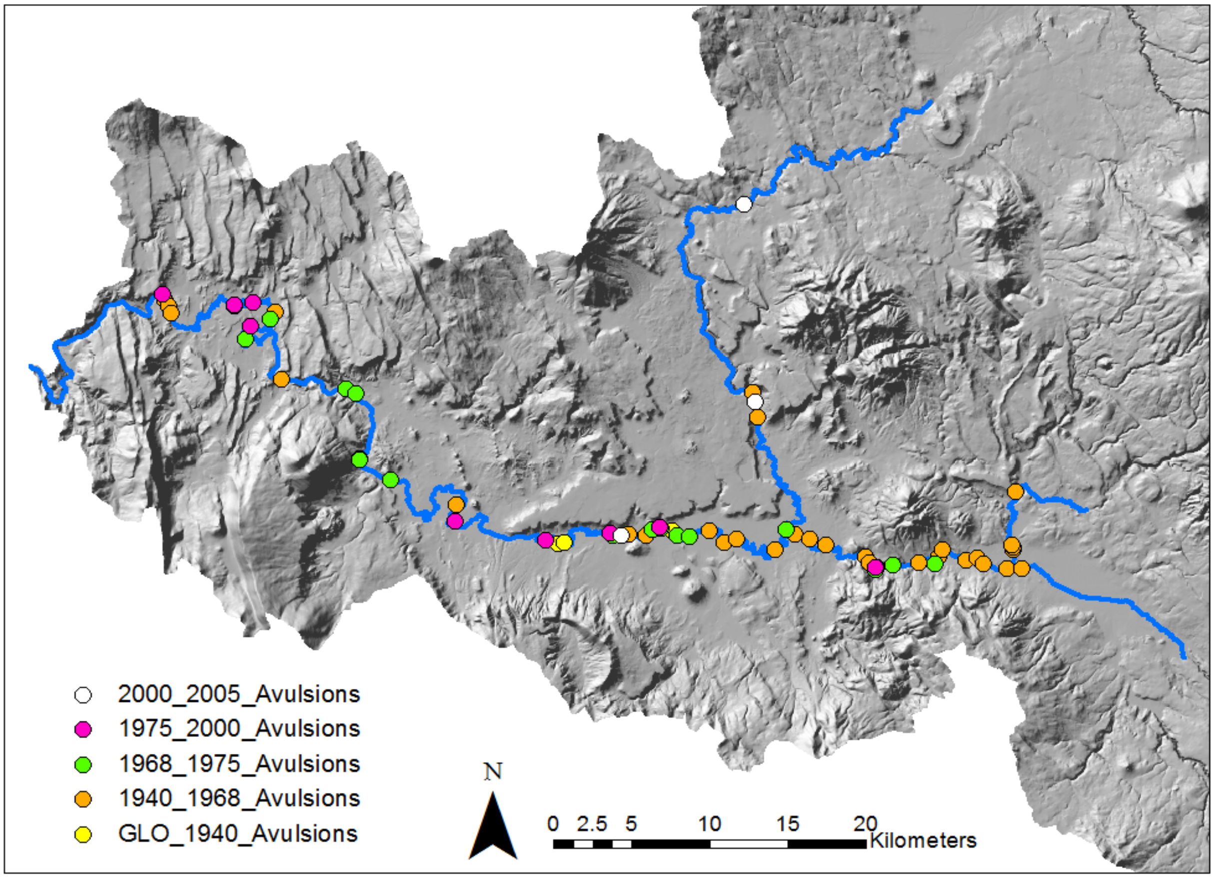



*Figure 2.4-2: Map from O'Connor and McDowell (2010) showing the spatial distribution and number of avulsions for five periods, from the 1860s to 1940, 1940 to 1968, 1968 to 1975, 1975 to 2000, and from 2000 to 2005*

Lind (2009) analyzed basin geomorphology in the context of the climate trends and historical geologic events that influenced the major periods of channel and floodplain development in the lower Sycan River. A primary driver of channel evolution is the sediment influx to the Sycan River Basin from the eruption of Mount Mazama (7660 cal *yr* BP), which created a floodplain terrace from a single flood event depositing volcanic sediments along the river corridor. Immediate incision into the outburst flood deposits after the event resulted in relatively rapid abandonment of the terrace. In the modern era, floodplain development has remained dominated by fluvially-transported, pumice-rich Mazama tephra. Stores of the Mazama tephra within the terraces and floodplain remain available sediment sources to this evolving system. The lower Sycan River currently appears to be in a state of dynamic equilibrium where two year floods typically inundate floodplain surfaces in the basin. The mainstem, North Fork, and South Fork Sprague Rivers were similarly affected by the Mazama fallout tephra, although to a lesser degree than the Sycan subbasin. Presently, the geomorphic floodplain flanking the Sprague River and its major tributaries is predominantly composed of alluvium deposited after the Mazama eruption, a product of continuous floodplain and channel processes such as channel migration and avulsion, and floodplain accretion and erosion (O'Conner 2011).

A key finding by Lind (2009) with respect to this PPA project is that the composition of the outburst flood terraces and active floodplains make them vulnerable to anthropogenic land use practices such as grazing and agriculture. This has manifested as bank failures and meander bend chute cut-offs accelerated by trampling or extensive vegetation removal at sites where livestock access the channel. Left unchecked, these impacts can lead to localized geomorphic alterations such as channel widening from bank failures, increased stream gradient, channel straightening, and bed incision (Chapman and Knudsen 1980; Kauffman and Krueger 1984; Ranganath et al. 2009).

GMA has been collecting data to calculate a sediment budget for the Sprague River Basin based on measurements made from January 2004 to February 2006. Although the study is ongoing and a detailed sediment budget describing sediment inputs, storage, rate of transport, and outflow has not yet been completed, initial analyses suggest the following trends of sediment transport through the watershed (GMA 2007):

- Overall, the South Fork Sprague contributed 60% of the measured tributary suspended sediment input, the North Fork Sprague 27%, and the Sycan 13%.
- For sites in higher gradient reaches of the tributaries, suspended sediment load is 75-80% of total sediment load, indicating that 20-25% of sediment transport occurs as bedload. Considerably smaller percentages of bedload would be expected on the mainstem Sprague River.

For each PPA we completed in the Sprague River Basin, we reviewed relevant historical aerial photographs from 1940 or 1953, 1995, 2000, 2001, 2005, and 2009 to assess the trajectory of recent geomorphic changes at those locations. The following discussion summarizes general trends in channel change at these locations. During this period, human modification is the primary driver of channel change in the Sprague River Basin. The largest changes we identified from our review of historical aerial photographs from 1940 to 2009 were the construction of levees and channel straightening or relocation to increase the amount of usable pasture. The Sprague River has remained relatively stable in the areas where the channel alignment hasn't been altered, except for reaches with meander bend cutoffs. At a few sites in the lower and middle watershed, meander bends were cut off by the main channel or a secondary channel between 1940 and 1995. Our review of the historical aerial photographs shows numerous high flow or secondary channels on the floodplain. We speculate that channel change was limited in the areas where the channel is not confined by levees because high discharge flows had access to the floodplain and secondary or high flow channels, which limited the buildup of shear stresses in the active channel.

## 2.5 Land Cover

The primary land cover types in the Sprague River Basin include forestlands (mostly on hillslopes and ridges), rangelands, irrigated pasture, grass, hay, and open water and wetlands (Table 2.5-1; Figure 2.5-1). The Sprague River Basin is well suited to raising livestock, and has been intensively used for that purpose for many decades. The most intense grazing pressure within the Sprague and Sycan basins occurred from about 80 to 120 years ago. Much of the pre-settlement riverside woodlands, riparian zones, and wetlands have been modified by diking, draining, spraying herbicides, land-clearing, and grazing (Connelly and Lyons 2007). Throughout the greater Sprague River Basin, the riparian areas within pastures typically have little to no riparian vegetation and high, eroding banks (NRCS 2005). The Upper Sprague Watershed Assessment (Connelly and Lyons 2007) concluded that “the data gathered for the watershed as a whole has indicated some general changes in riparian condition, including erosion of channels both outward and downward, local lowering of the water table, disconnection of stream channels from their floodplains, shifts in vegetation communities, and changes in certain key fish habitat features” as a result of the straightening and diking of significant reaches of the Sprague River and some of its tributaries. This description is consistent with the goals and objectives of many of the stream restoration projects we evaluated in this project.

*Table 2.5-1: Land cover types and areas in the Sprague River Basin*

| National Land Cover Dataset Type | Square Miles | Percentage of Total Area |
|---|---|---|
| Open Water | 3.2 | 0.2% |
| Developed, Open Space | 5.4 | 0.3% |
| Developed, Low Intensity | 0.7 | 0.0% |
| Developed, Medium Intensity | 0.0 | 0.0% |
| Barren Land | 5.7 | 0.4% |
| Deciduous Forest | 0.0 | 0.0% |
| Evergreen Forest | 899.7 | 55.9% |
| Shrub/Scrub | 360.8 | 22.4% |
| Grassland/Herbaceous | 241.8 | 15.0% |
| Pasture/Hay | 14.7 | 0.9% |
| Cultivated Crops | 21.2 | 1.3% |
| Woody Wetlands | 1.9 | 0.1% |
| Emergent Herbaceous Wetlands | 54.5 | 3.4% |

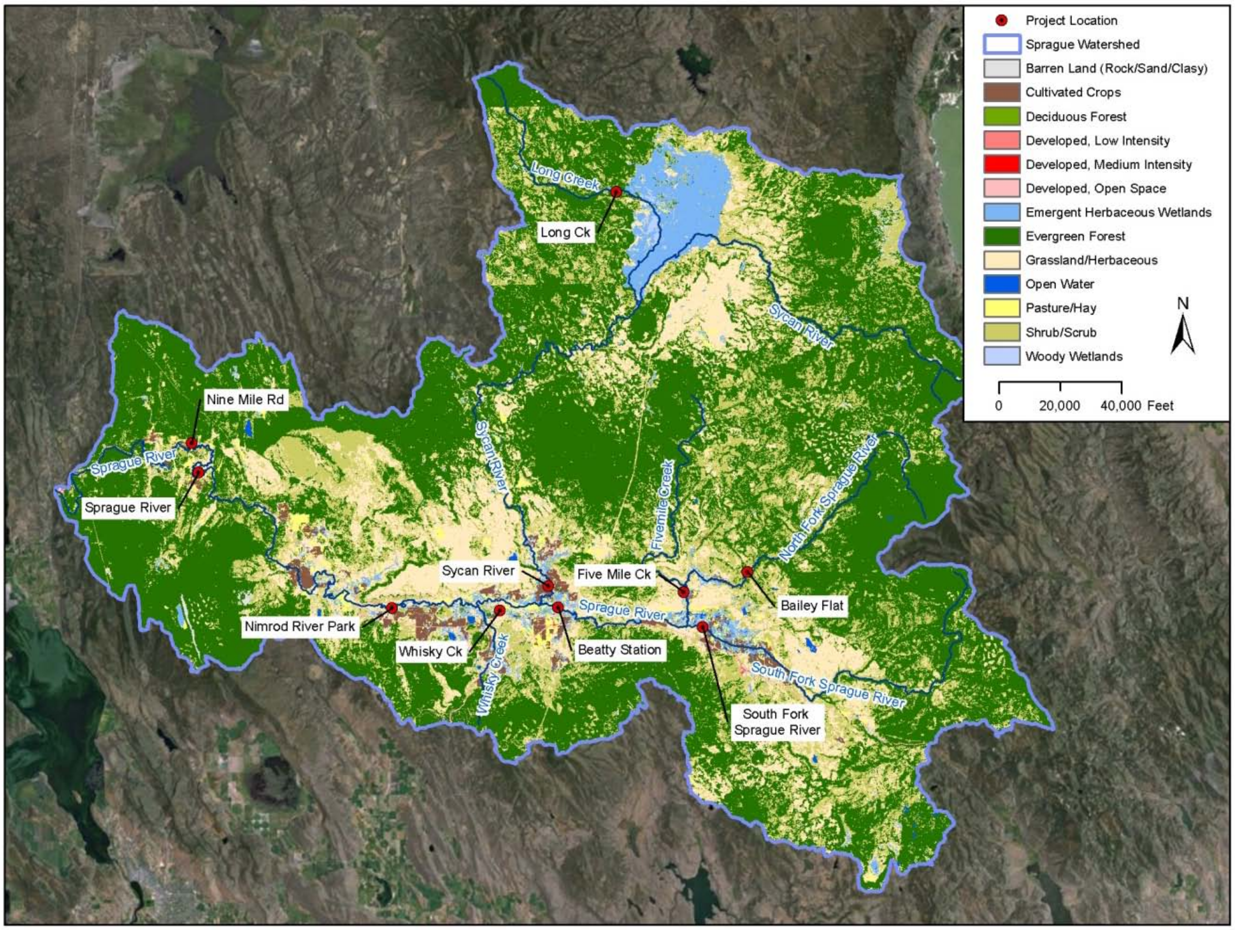



*Figure 2.5-1: Land cover in the Sprague River Basin (Source: http://www.mrlc.gov/index.php)*

Ecoregions, areas that contain characteristic, geographically distinct assemblages of natural communities and species, have been delineated within the Sprague River Basin by the Oregon Natural Heritage Program (ONHP 1995; Figure 2.5-2). An understanding of these ecoregions helped inform the lessons learned from our PPAs presented later in this report, so we have included the PPA project locations on Figure 2.5-2 as well.

- The **Pumice Plateau Forest** ecoregion comprises 59% (951 square miles) of the Sprague River Basin and is characterized by lodgepole pine in the flats and depressions, with ponderosa pine on the slopes, and white fir becoming more common at higher elevation. Understory plants include antelope bitterbrush and Idaho fescue. Riparian areas support mountain alder, stream dogwood, willows, and quaking aspen.
- The higher elevations in the south and southeast portion of the Basin are within the **Fremont Pine-Fir Forest** ecoregion (17%; 275 square miles), characterized by ponderosa pine and western juniper at lower elevation, with white fir, whitebark pine, and lodgepole pine at higher elevation. Understory plants include snowberry, heartleaf arnica, Wheeler bluegrass, antelope bitterbrush, and longstolon sedge.

- The river bottoms in the vicinity of Bly and Beatty lie in the **Klamath-Goose Lake Warm Wet Basins** ecoregion (6%; 96 square miles), where common plant species include bluebunch wheatgrass, Idaho fescue, antelope bitterbrush, mountain big sagebrush, low sagebrush, basin wildrye, and Basin big sagebrush. Wetland areas contain tules, cattails, sedges, and other wetland species.
- The surrounding uplands comprise the **Klamath Juniper-Ponderosa Pine Woodland** ecoregion (16%; 252 square miles). This ecoregion is characterized by ponderosa pine, juniper woodland, and sagebrush steppe. Wetter areas include ponderosa pine with an understory of antelope bitterbrush and bunchgrasses. Drier sites have low sagebrush, Wyoming big sagebrush, Idaho fescue, bluebunch wheatgrass, and Sandberg bluegrass. Western juniper and mountain-mahogany occur on shallow, rocky soils.
- The **Pumice Plateau Basins** ecoregion (2%; 36 square miles) is represented by Sycan Marsh, and is characterized by wetland vegetation. Lodgepole pine and scattered ponderosa pine and shrub forest occur on the driest sites.

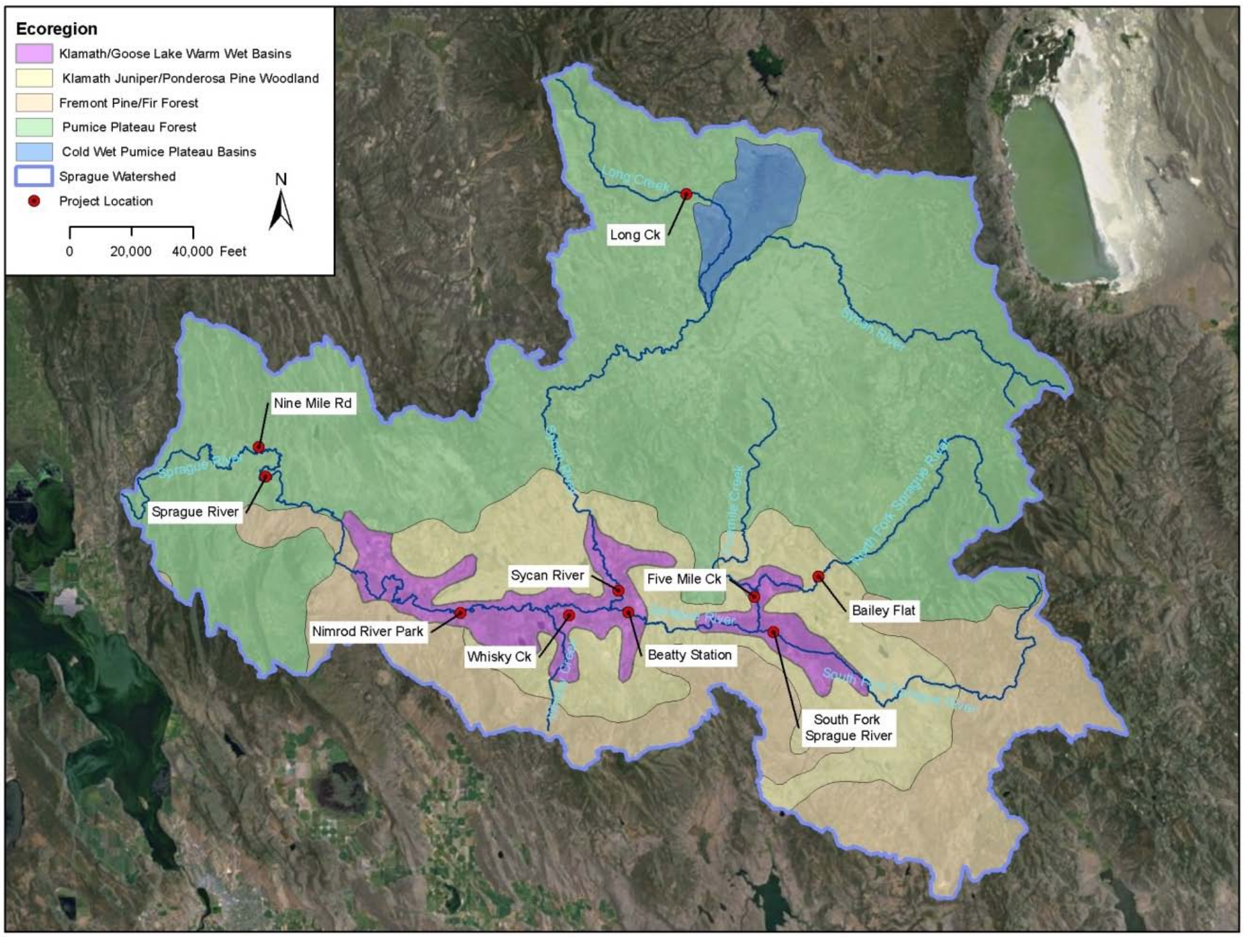



*Figure 2.5-2: Ecoregions in the Sprague River Basin (Source: ONHP 1995)*

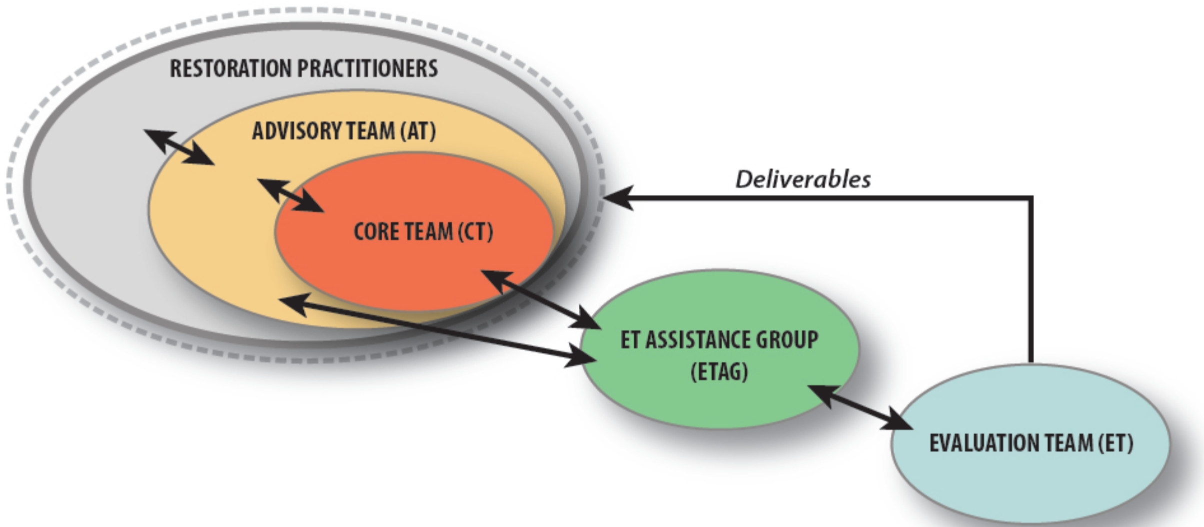
# 3 Sprague River Post Project Appraisal Framework and Conceptual Models

## 3.1 Organizational Framework

This project was a joint effort that combined a diverse set of site-specific and basin wide knowledge regarding stream restoration in the Sprague River Basin with extensive experience on the development and implementation of post-project appraisals. We worked collaboratively to develop an organizational structure that would maximize our ability to extract useful lessons learned from previously completed stream restoration projects and guide future stream restoration projects, despite the fact that most previously completed restoration projects did not have formal monitoring programs. Figure 3.1-1 is a schematic illustrating the key participants in this project. The Core Team (CT) was instrumental in the chartering and early study design phases of this project and provided administrative support throughout the duration of the project. The Advisory Team (AT) provided essential information on previously completed stream restoration projects in the basin and assisted with the selection of projects for PPA. NewFields and Dr. G.M. Kondolf comprised the Evaluation Team (ET). We led the review, organization, and PPA data collection efforts and compiled this report. Ruth Olsen from the U.S. Fish and Wildlife Service (USFWS) led the Evaluation Team Assistance Group and assisted us with all data collection and analysis for this project.

Completing a systematic evaluation of stream restoration project performance in the Sprague Basin was a challenging task. The drivers for stream restoration in the basin have changed through time, just as the practice of stream restoration itself has evolved, especially over the past 15 years. The dynamic environment surrounding the implementation of stream restoration projects in the basin is complicated further by the diverse range of stakeholders, project types, and monitoring efforts that have resulted in the stream restoration project database available for this project. We determined that this situation required the development of a formal organizational framework to both guide our implementation of site-specific PPAs and to ensure that we were able to extract all possible lessons learned to guide adaptive management of existing projects and implementation of future projects. Ultimately, this framework also informed our selection of projects for PPA and our PPA assessment methods for each site.

We convened the CT and key members of the AT for a workshop in Klamath Falls, Oregon in July 2011 to develop this organizational framework. We started our framework development process with an understanding that stream restoration goals and objectives are the most important organizing element for evaluating stream restoration projects in the basin. Goals and objectives typically reflect the drivers of restoration at the time a project was implemented and provide a basis for assessment of whether an individual project has performed as expected. Organizing this project with a framework built around goals and objectives facilitated our completion of PPAs of previously completed projects and our translation of lessons learned from the PPAs into guidance for future adaptive management and implementation of new projects in the basin.




**ADVISORY TEAM (AT)**

***Members:***
- Stakeholder Representatives

***Roles:***
- Advise CT on restoration projects, techniques, methods, approaches
- Assist CT with compiling project lists, maps, files, histories
- Assist CT with project selection
- Coordinate interviews with restoration agents and practitioners
- Work with ETAG to coordinate site visits and access for field work

**CORE TEAM (CT)**

***Members:***
- Matt Barry
- Larry Dunsmoor
- Nathan Jackson
- Shannon Peterson
- Mark Stern

***Roles:***
- Project design
- Implementation
- Communications
- Budgeting and funding allocation
- Decision making
- Review and comment on deliverables
- ET interviewing and selection
- Project troubleshooting

**ET ASSISTANCE GROUP (ETAG)**

***Members:***
- Ruth Olsen
- Sue Mattenberger
- Hoda Sondossi
- Damion Ciotti
- Dave Ross
- Jared McKee

***Roles:***
- Assist AT with compilation and review of project lists, maps, files, histories
- Assist ET with selection of projects for more detailed analysis and evaluation
- Support ET with field work and logistics
- Serve as liaison between ET and other project groups

**EVALUATION TEAM (ET)**

***Members:***
- NewFields River Basin Services
- Dr. G.M. Kondolf

***Roles:***
- Review and evaluate project lists, files, and histories
- Assist with categorizing projects by (functional) type
- Assist with selection of projects for more detailed analysis and evaluation
- Assess data needs
- Collection of additional data
- Analyze project effects
- Make recommendations for future restoration projects, including setting goals, design, implementation, and monitoring

*Figure 3.1-1: Key participants in the post-project appraisals of stream restoration projects in the Sprague River Basin*

We used an iterative approach to develop the organizational framework for this project. Framework development began at the July 2011 workshop where we started with a comprehensive review of stream restoration projects in the basin and determined that nearly all of the previously completed projects fit into one of four categories defined by the part of the river corridor ecosystem that was modified by the project. We termed these categories "classes," and the four classes are *Instream,* *Riparian, Floodplain,* and *Spring*. Each class of projects had its own unique set of goals including the goals explicitly stated in the documents supporting each project and a second set of goals reflecting the current drivers for stream restoration in the Sprague River Basin. We developed an initial summary of these goals at the July 2011 workshop with input from a group of experienced stream restoration practitioners. Working iteratively throughout the remainder of the PPA process, we refined the set of goals for each project type into a single goal statement that reflected the complete range of goals for projects in a given class and the current status of stream restoration theory and practice in the Sprague River Basin.

Next, we determined that within each class there were a limited number of project types, and within each type only a handful of possible project actions that could be implemented to achieve specific stream restoration objectives. After reviewing the database of previously completed projects and discussing plans for future restoration efforts, we completed the most important piece of the organizational framework for this project: ***linking goals and objectives by identifying the natural processes that each project action could potentially affect.*** Finally, we identified metrics and assessment methods appropriate for each affected natural process that could be used to evaluate project performance against a stated objective and to guide the planning, implementation, and monitoring of future stream restoration projects in the basin Table 3.1-1 is our organizational framework for this project.

The organizational structure summarized in Table 3.1-1 provides stream restoration practitioners and stakeholders in the Sprague River Basin a useful and convenient tool to guide monitoring and adaptive management of existing stream restoration projects and to plan, design, implement, and monitor new projects. For existing projects, Table 3.1-1 can be used to help identify the most appropriate monitoring metrics and assessment methods. For new projects, Table 3.1-1 can be used to help select the most appropriate stream restoration actions for a given set of objectives and natural processes that can be influenced, and to inform the design and monitoring of restoration actions. Further, we have designated the processes in Table 3.1-1 as either primary or secondary to assist restoration practitioners in prioritizing monitoring metrics and assessment methods most likely to support evaluation of specific actions of a given project type with respect to appropriate objectives for that project type. For example, considering the channel manipulation project type within the instream project class, one should focus on metrics such as channel geometry, channel profile, substrate, hydrology, and cover before metrics associated with other processes as these metrics are more directly linked to processes directly influenced by the actions in this project type.

*Table 3.1-1: Organizational framework for evaluating stream restoration projects in the Sprague River Basin (note: 1 = primary process(es) affected by action, 2 = secondary process(es) affected by action ordered by importance)*

| Class | Definition | Goal | Type | Action(s) | Objective(s) | Process(es) Affected by Action* | Metric(s) | Assessment Method(s) |
|---|---|---|---|---|---|---|---|---|
| Instream | The instream class includes project types and actions implemented in the active channel area bounded laterally by the extents of the riparian class of projects and defined by fluvial processes such as erosion, deposition, and sediment transport. | Maintain, create, improve, and restore more normative hydrologic, geomorphic, and sediment transport processes that create *instream* conditions and variability that better supports target and/or native aquatic plant communities and biota. | Channel Manipulation | Create new channel, reconnect old channel, prevent / reverse meander bend cutoff | Creation of more complex and diverse channel habitat | Erosion, deposition, and scour[1] | Channel geometry | Topographic survey |
| | | | | | | | Channel profile | Topographic survey |
| | | | | | | | Substrate | Facies mapping, pebble counts |
| | | | | | | | Hydrology | Stage measurements (continuous) |
| | | | | | | | Cover | Mapping and quantification of density and extent of large wood, vegetation, root structure, and other forms of aquatic cover. |
| | | | | | Creation of water quality conditions suitable for native organisms | Temperature buffering[2] | Water quality | Temperature and DO measurements |
| | | | | | | Nutrient sequestration[2] | Water quality | Nutrients and DO measurements |
| | | | | | Increased abundance and diversity of native species | Colonization by and succession of aquatic species[2] | Biological | Sampling of vegetation species presence, abundance, diversity; fish species presence, absence; macroinvertebrate species, abundance, diversity |
| | | | Habitat Creation | Construct structure | Increased abundance and diversity of native species | Colonization by and succession of aquatic species[1] | Biological | Sampling of vegetation species presence, abundance, diversity; fish species presence, absence; macroinvertebrate species, abundance, diversity |
| | | | | | Creation of water quality conditions suitable for native organisms | Temperature buffering[2] | Water quality | Temperature and DO measurements |
| | | | | | Creation of more complex and diverse channel habitat | Erosion, deposition, and scour[2] | Channel geometry | Topographic survey |
| | | | | | | | Channel profile | Topographic survey |
| | | | | | | | Substrate | Facies mapping, pebble counts |
| | | | | | | | Hydrology | Stage measurements (continuous) |
| | | | | | | | Cover | Mapping and quantification of density and extent of large wood, vegetation, root structure, and other forms of aquatic cover. |
| | | | Flow Augmentation | Reduce diversion rate | Creation of water quality conditions suitable for native organisms | Temperature buffering[1] | Water quality | Temperature and DO measurements |
| | | | | | | Nutrient dilution[1] | Water quality | Nutrients and DO measurements |
| | | | | | Creation of more complex and diverse channel habitat | Erosion, deposition, and scour[2] | Channel geometry | Topographic survey |
| | | | | | | | Channel profile | Topographic survey |
| | | | | | | | Substrate | Facies mapping, pebble counts |
| | | | | | | | Hydrology | Stage measurements (continuous) |
| | | | | | | | Cover | Mapping and quantification of density and extent of large wood, vegetation, root structure, and other forms of aquatic cover. |
| | | | | | Increased abundance and diversity of native species | Colonization by and succession of aquatic species[2] | Biological | Sampling of vegetation species presence, abundance, diversity; fish species presence, absence; macroinvertebrate species, abundance, diversity |
| | | | Fish Passage Improvement | Construct bypass channel(s), install or modify culvert(s) | Creation of hydraulic conditions suitable for fish passage | Fish migration[1] | Hydraulics | Flow depth and velocity measurements or modeling results |
| | | | | Screen diversion(s) | Reduce entrainment of fish | Fish migration[1] | Hydraulics | Flow rate and velocity measurements at screens (relative to OWEB criteria) |
| | | | | | | | Entrainment | Fish sampling at screens (relative to OWEB criteria) |

| Class | Definition | Goal | Type | Action(s) | Objective(s) | Process(es) Affected by Action | Metric(s) | Assessment Method(s) |
|---|---|---|---|---|---|---|---|---|
| Riparian | The riparian class includes project types and actions implemented in the area bounded laterally by the extents of the instream and floodplain classes of projects and characterized by a gradient of hydrologic conditions from permanent inundation at the instream margin to seasonal inundation at the floodplain margin. | Maintain, create, improve, and restore more normative hydrologic, geomorphic, sediment transport, and biological processes that create *riparian* conditions and variability that better supports target and/or native riparian plant communities and biota. | Management | Construct fences, change grazing management, plant vegetation | Increased abundance and diversity of native species | Colonization by and succession of riparian species[1] | Biology | Sampling of vegetation species presence, abundance, and diversity and fish and macroinvertebrates during times of inundation |
| | | | | | Creation of water quality conditions suitable for native organisms | Temperature buffering[2] | Water quality | Temperature and DO measurements |
| | | | | | | Nutrient sequestration[2] | Water quality | Nutrients and DO measurements |
| | | | | | Creation of more complex and diverse channel and riparian habitat | Erosion, deposition, and scour[2] | Riparian geometry | Topographic survey |
| | | | | | | | Riparian profile | Topographic survey |
| | | | | | | | Riparian sediment | Soil mapping, subsurface boring |
| | | | | | | | Riparian hydrology | Groundwater levels (continuous) and peak flow inundation depths |
| | | | | | | | Riparian hydraulics | Near bank velocity measurements or hydraulic modeling output |
| | | | | | | | Riparian cover | Mapping and quantification of density and extent of large wood, vegetation, root structure, and other forms of riparian cover. |
| | | | Expansion | Remove levee(s), create new channels | Creation of more complex and diverse channel and riparian habitat | Erosion, deposition, and scour[1] | Riparian geometry | Topographic survey |
| | | | | | | | Riparian profile | Topographic survey |
| | | | | | | | Riparian sediment | Soil mapping, subsurface boring |
| | | | | | | | Riparian hydrology | Groundwater levels (continuous) and peak flow inundation depths |
| | | | | | | | Riparian hydraulics | Near bank velocity measurements or hydraulic modeling output |
| | | | | | | | Riparian cover | Mapping and quantification of density and extent of large wood, vegetation, root structure, and other forms of riparian cover. |
| | | | | | Increased abundance and diversity of native species | Colonization by and succession of floodplain species[1] | Biology | Sampling of vegetation species presence, abundance, and diversity and fish and macroinvertebrates during times of inundation |
| | | | | | Creation of water quality conditions suitable for native organisms | Temperature buffering[2] | Water quality | Temperature and DO measurements |
| | | | | | | Nutrient sequestration[2] | Water quality | Nutrients and DO measurements |
| Floodplain | The floodplain class includes project types and actions implemented in the area bounded laterally by the extent of the riparian class of projects and the valley walls (or other geologic features that prevent lateral movement of floodwaters) and characterized by seasonal inundation. | Maintain, create, improve, and restore more normative hydrologic, geomorphic, sediment transport, and biological processes that create *floodplain* conditions and variability that better supports target and/or native riparian plant communities and biota. | Reconnection | Remove levees, excavate new connection from floodplain to channel through riparian area | Creation of more complex and diverse channel, riparian, and floodplain habitat | Erosion, deposition, and scour[1] | Floodplain topography | Topographic survey |
| | | | | | | | Floodplain sediments | Soil mapping, subsurface boring |
| | | | | | | | Floodplain hydrology | Velocity, modeling output |
| | | | | | | | Floodplain hydraulics | Floodplain velocity measurements or hydraulic modeling output |
| | | | | | | | Floodplain cover | Topographic Survey |
| | | | | | Increased abundance and diversity of native species | Colonization by and succession of floodplain species[1] | Biology | Sampling of vegetation species presence, abundance, and diversity, and diversity and fish and macroinvertebrates during times of inundation |
| | | | | | Creation of water quality conditions suitable for native organisms | Temperature buffering[2] | Water quality | Temperature and DO measurements |
| | | | | | | Nutrient sequestration[2] | Water quality | Nutrients and DO measurements |
| | | | Modification | Restore floodplain topography, excavate wetland(s) | Increased abundance and diversity of native species | Colonization by and succession of floodplain species[1] | Biology | Sampling of vegetation species presence, abundance, and diversity, and diversity and fish and macroinvertebrates during times of inundation |
| | | | | | Creation of water quality conditions suitable for native organisms | Temperature buffering[2] | Water quality | Temperature and DO measurements |
| | | | | | | Nutrient sequestration[2] | Water quality | Nutrients and DO measurements |
| | | | | | Creation of more complex and diverse channel, riparian, and floodplain habitat | Erosion, deposition, and scour[2] | Floodplain topography | Topographic survey |
| | | | | | | | Floodplain sediments | Soil mapping, subsurface boring |
| | | | | | | | Floodplain hydrology | Velocity, modeling output |
| | | | | | | | Floodplain hydraulics | Floodplain velocity measurements or hydraulic modeling output |
| | | | | | | | Floodplain cover | Topographic Survey |
| | | | Management | Change grazing management, plant vegetation, construct fence(s) | Increased abundance and diversity of native species | Colonization by and succession of floodplain species[1] | Biology | Sampling of vegetation species presence, abundance, and diversity |
| | | | | | Creation of water quality conditions suitable for native organisms | Temperature buffering[2] | Water quality | Temperature and DO measurements |
| | | | | | | Nutrient sequestration[2] | Water quality | Nutrients and DO measurements |

| Class | Definition | Goal | Type | Action(s) | Objective(s) | Process(es) Affected by Action | Metric(s) | Assessment Method(s) |
|---|---|---|---|---|---|---|---|---|
| Spring | The spring class includes project types and actions implemented directly in springs and in channels and other features that connect springs to wetlands, river channels, and other features of the landscape where local hydrology is dominated by spring flows. | Maintain, create, improve, and restore more normative hydrologic, geomorphic, sediment transport, and biological processes that create *spring* conditions and variability that better supports target and/or native riparian plant communities and biota. | Reconnection | Excavate new channel(s), install or modify culverts | Creation of water quality conditions suitable for native organisms | Temperature buffering[1] | Water quality | Temperature and DO measurements |
| | | | | | Creation of hydraulic conditions suitable for fish passage | Fish migration[1] | Hydraulics | Flow depth and velocity measurements or modeling results |
| | | | | | Increased abundance and diversity of native species | Colonization by and succession of riparian species[2] | Biology | Sampling of vegetation species presence, abundance, diversity; fish species presence, absence; macroinvertebrate species, abundance, diversity |
| | | | Enhancement | Excavate, recontour | Creation of water quality conditions suitable for native organisms | Temperature buffering[1] | Water quality | Temperature and DO measurements |
| | | | | | Increased abundance and diversity of native species | Colonization by and succession of riparian species[1] | Biology | Sampling of vegetation species presence, abundance, diversity; fish species presence, absence; macroinvertebrate species, abundance, diversity |
| | | | | | Creation of hydraulic conditions suitable for fish passage | Fish migration[2] | Hydraulics | Flow depth and velocity measurements or modeling results |
| | | | Management | Plant vegetation, construct fence(s), add gravel or other suitable substrate | Creation of water quality conditions suitable for native organisms | Temperature buffering[1] | Water quality | Temperature and DO measurements |
| | | | | | Increased abundance and diversity of native species | Colonization by and succession of riparian species[1] | Biology | Sampling of vegetation species presence, abundance, diversity; fish species presence, absence; macroinvertebrate species, abundance, diversity |
| | | | | | Creation of hydraulic conditions suitable for fish passage | Fish migration[2] | Hydraulics | Flow depth and velocity measurements or modeling results |

## 3.2 Conceptual Models

Before any ecosystem can be effectively restored or enhanced, an understanding of the critical processes and linkages responsible for its current condition and potential future evolution is required. Conceptual models are descriptions (quantitative to the extent possible) of the physical and ecological system and interactions of its various components, which can serve as the basis for developing restoration strategies. Conceptual models can take many forms, but are commonly conveyed as flow charts or diagrams showing relationships among elements and functions of the ecosystem. In an adaptive management framework (which nearly all stream restoration projects should be implemented within), the conceptual model guides the design of restoration, and as results of targeted research or pilot projects are received, either confirms hypothesized relationships or provides insights about how to modify the conceptual model and therefore subsequent restoration actions. Conceptual models can also serve valuable educational and outreach purposes by clearly and concisely conveying current understanding of the relationships that govern ecosystem behavior.

### 3.2.1 Conceptual Models for Sprague River Corridor Restoration

As the AT, ET, and ETAG developed the organizational framework described in the preceding section, we recognized a need for conceptual models to help understand the natural processes and disturbances that have led to the current conditions in the Sprague River and the likely outcomes of stream restoration actions implemented to change current conditions. We also recognized that the primary driver for stream restoration in the Sprague River Basin is the perception that human impacts have modified river corridor ecosystems in a manner that has changed the nature and magnitude of processes that create and sustain instream, riparian, floodplain, and spring ecosystems.

A range of restoration activities have been undertaken in the Sprague River Basin in response to habitat degradation, guided by (often implicit) hypotheses of how the ecosystem works, how human activity has disturbed natural processes that influence the ecosystem, and how restoration actions can restore the natural processes benefiting species. Based on a watershed-wide inventory of the primary ecological stressors and the types of restoration and enhancement activities most commonly employed to mitigate those stressors, we have developed diagrammatic conceptual models that describe a) the natural processes and source(s) of disturbance to provide a frame of reference for the ecological potential at each project site, b) the impact to ecosystem processes and critical habitat areas, c) the restoration and enhancement activities employed, and d) the objectives and/or idealized results of those activities. These models helped us communicate and structure our thinking about which physical and biological processes a given restoration action could be expected to achieve. They can be used to gain a better understanding of the appropriateness of previously completed restoration projects given the dominant processes at a site, and to help maximize the ecological potential of a future restoration action for a given location and disturbance. These models are listed in Table 3.2-1, and summarized in more detail below.

*Table 3.2-1: Selected conceptual models describing typical disturbances and restoration or enhancement activities evaluated in Sprague River PPAs*

| Conceptual Model Name | Disturbance | Restoration or Enhancement Activity |
|---|---|---|
| Meander Bend Cutoff | Meander bend cutoff initiation and progression | Meander bend cutoff plug |
| Corridor Confinement | Channel, riparian, and floodplain constriction | Levee removal, setback, and/or notching |
| Channel Simplification | Channel straightening | Channel relocation and/or recreation |
| Grazing | Riparian and floodplain grazing | Livestock management and/or vegetation planting |
| Diversions | Flow reduction and fish entrainment | Fish screening and diversion reduction |
| Springs | Disconnection and degradation of springs | Spring reconnection, enhancement, and protection |
| Wetlands | Degradation of wetlands, wet meadows, and floodplains | Restoration and reconnection of seasonally-inundated habitats |

#### 3.2.1.1 Meander Bend Cutoff Plug to Address Meander Bend Cutoff Initiation and Progression

As part of natural geomorphic evolution and adjustment to changing climatic, hydrologic, and sediment transport regimes, the Sprague River meanders across the valley-bottom floodplains, and periodically forms new channels that cut off meander bends. Meander bend cutoffs can develop by the progressive migration of an elongated bend onto itself, which forms a neck cutoff, or by the erosion of a new channel across the neck of the bend, which is known as a chute cutoff (Lewis and Lewin 1983). Three factors are found to control these avulsions: flow discharge, sediment flux, and floodplain topography (Leddy et al 1993). Channel meander rates can be accelerated by other human changes in the watershed such as upstream channel straightening which decreases the channel slope, reduction in vegetation which increases the runoff to the channel, construction of levees which concentrates flow, and timber harvest which increases runoff to the channel.

Meander cutoff plugging projects have been undertaken on the Sprague River after meander cutoff has been initiated or completed. These projects involve filling the new, shorter channel, thereby forcing the entire flow back into the former channel. Although not always explicitly stated, these projects are based on the assumption that meander cutoffs result in a permanent net reduction in channel length, sinuosity, and thus habitat value. Meander cutoffs are a natural part of dynamic river behavior, and normally a meander cutoff in one part of the river would be compensated over time by channel migration and meander enlargement just upstream or downstream, such that sinuosity remains roughly constant on a long time scale. Under this scenario, there would be no need to plug a cutoff meander, since whatever length is lost at one meander bend is compensated for by growth of other meander bends. Thus, the justification for plugging a meander bend must be an assumption that its channel will not recover its length and sinuosity through channel migration.

These assumptions can be illustrated by a conceptual model, which is depicted through a set of diagrams. A flow chart (Figure 3.2-1) illustrates the process of channel migration and cutoff, both the natural sequence and the assumed human impact sequence. The trajectories of both the mainstem and cutoff side channel habitats are shown. The top trajectory is that of the cutoff channel: it starts as part of the main channel, but then via cutoff it becomes a side channel connected at both its upstream and downstream ends. Typically the upstream end fills with sediment first, so that the inlet is blocked by an alluvial plug, while the downstream end remains connected with the main channel, forming an oxbow slough. A slough can persist for many years or even decades, depending on the river dynamics, providing connected off-channel habitat for fish and other biota. When the downstream end of the side channel (the outlet) plugs as well, the feature evolves into an oxbow lake. The oxbow begins as a fully aquatic feature, but over time fills with overbank sediment, becoming progressively more terrestrial in character, eventually filling and becoming part of the floodplain, albeit a lower-elevation swale in the floodplain. During the evolution of the oxbow slough and lake, the feature provides habitat that is distinct from the main channel and from the main floodplain. Off-channel water bodies are recognized as biodiversity hotspots and critically important habitats on the floodplain (Stanford et al 1995).

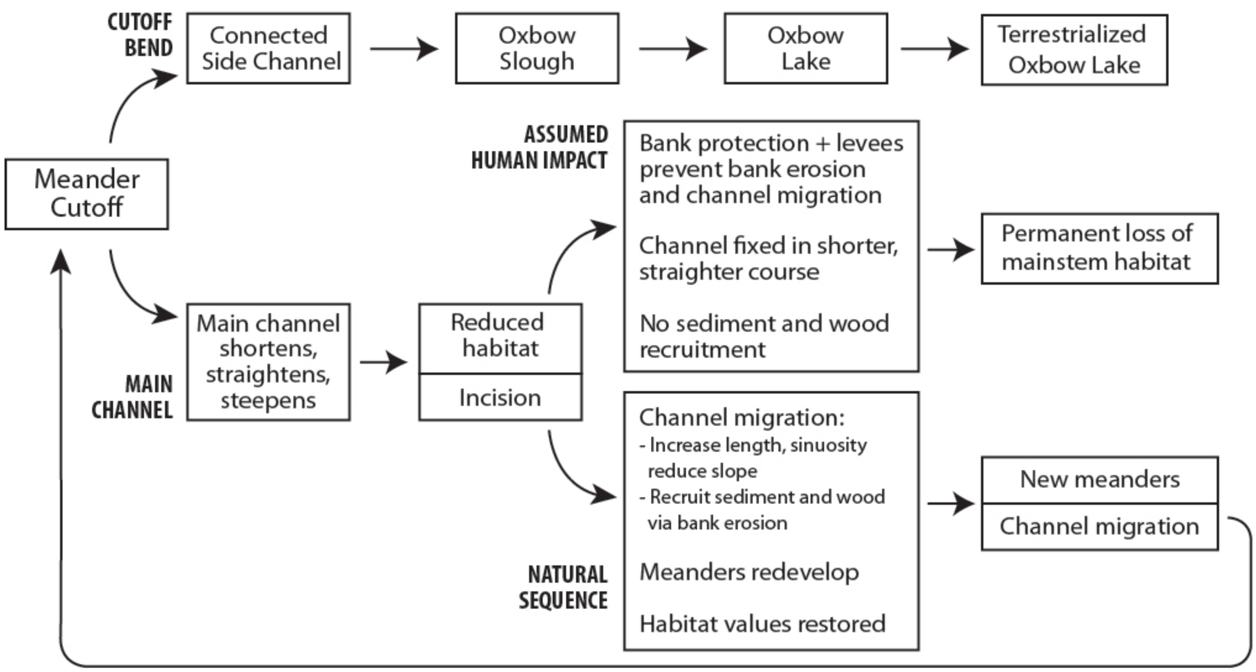



*Figure 3.2-1: Conceptual models of channel migration and cutoff in the Sprague River Basin*

The lower trajectories in Figure 3.2-1 are those of the main channel following cutoff. Immediately following the cutoff, the main channel is shorter, straighter, and steeper. These changes typically induce channel incision upstream of the cutoff, while downstream may incise as well initially, but typically aggrades with sediment eroded from the bed upstream. Channel straightening and incision generally result in morphological simplification and loss of habitat. After this, two trajectories are shown, based on two different assumptions. The lowermost path assumes that the channel continues to migrate naturally, so that meander bends enlarge and the channel increases in length and sinuosity and decreases in slope. As the meanders redevelop, habitat values associated with the meandering river channel are restored, and eventually another meander cutoff occurs and the cycle starts again.

The alternate main channel trajectory (shown in the middle, between the side channel evolution and the natural channel migration sequence) reflects the events occurring under an assumed human impact scenario, wherein natural channel migration is prevented by artificial bank protection and levees. The hypothesis here is that human alterations now prevent the channel from migrating and thereby regaining its former sinuosity, so that a loss of length and sinuosity from a channel cutoff becomes a permanent uni-directional loss of habitat complexity, with no recovery. The meander-plug restoration approach assumes this trajectory.

We can diagram side-channel and main-channel habitat values over time, based on these conceptual models (Figure 3.2-2). First, in the 'Natural Sequence' case, the meander cutoff abruptly reduces main channel habitat values, while simultaneously creating side-channel habitat values that did not exist pre-cutoff. In fact, there is arguably more overall habitat available because the total stream length is greater when the main and side channel lengths are summed. Over time, the value of the side channel as aquatic habitat evolves, typically for decades, until the oxbow lake is filled with sediment. In the meantime, the main channel has regained its sinuosity and its habitat value has recovered. While the diagram shows the oxbow filling with sediment as the meanders redevelop, in most cases the oxbows will persist in the floodplain long after the mainstem sinuosity is recovered. This is demonstrably so on floodplains that have oxbow lakes and a meandering channel. Thus, the natural processes tend to maximize habitat and habitat diversity. Under the 'Disturbed Sequence' model, the meander cutoff is followed by the same side-channel pattern as in the 'Natural Sequence' model, but the mainstem shows no recovery of length and sinuosity, similar to the 'Humpty-Dumpty model' proposed by Sarr (2002) for recovery from grazing impacts. In this scenario, mainstem habitat is locally lost, but at least partially compensated by oxbow slough and lake habitat values.

Under the 'Meander Plug Restoration' sequence, the cutoff occurs, abruptly creating side-channel habitat and degrading main-channel habitat, but before these two channels can evolve, the new cutoff channel is plugged with sediment and rock, abruptly eliminating any side-channel habitat and restoring mainstem habitat (Figure 3.2-3). The habitat will be fully restored as shown on the plot if the geomorphic effects of channel incision do not persist after reconnection, which may not be the actual case. As this restoration approach assumes no natural increase in sinuosity, it implies a constant mainstem habitat value after the plug is installed. Armoring the cutoff location will likely cause the initiation of a cutoff either upstream or downstream as the plugging has not addressed the geomorphic processes that initiated the original cutoff.

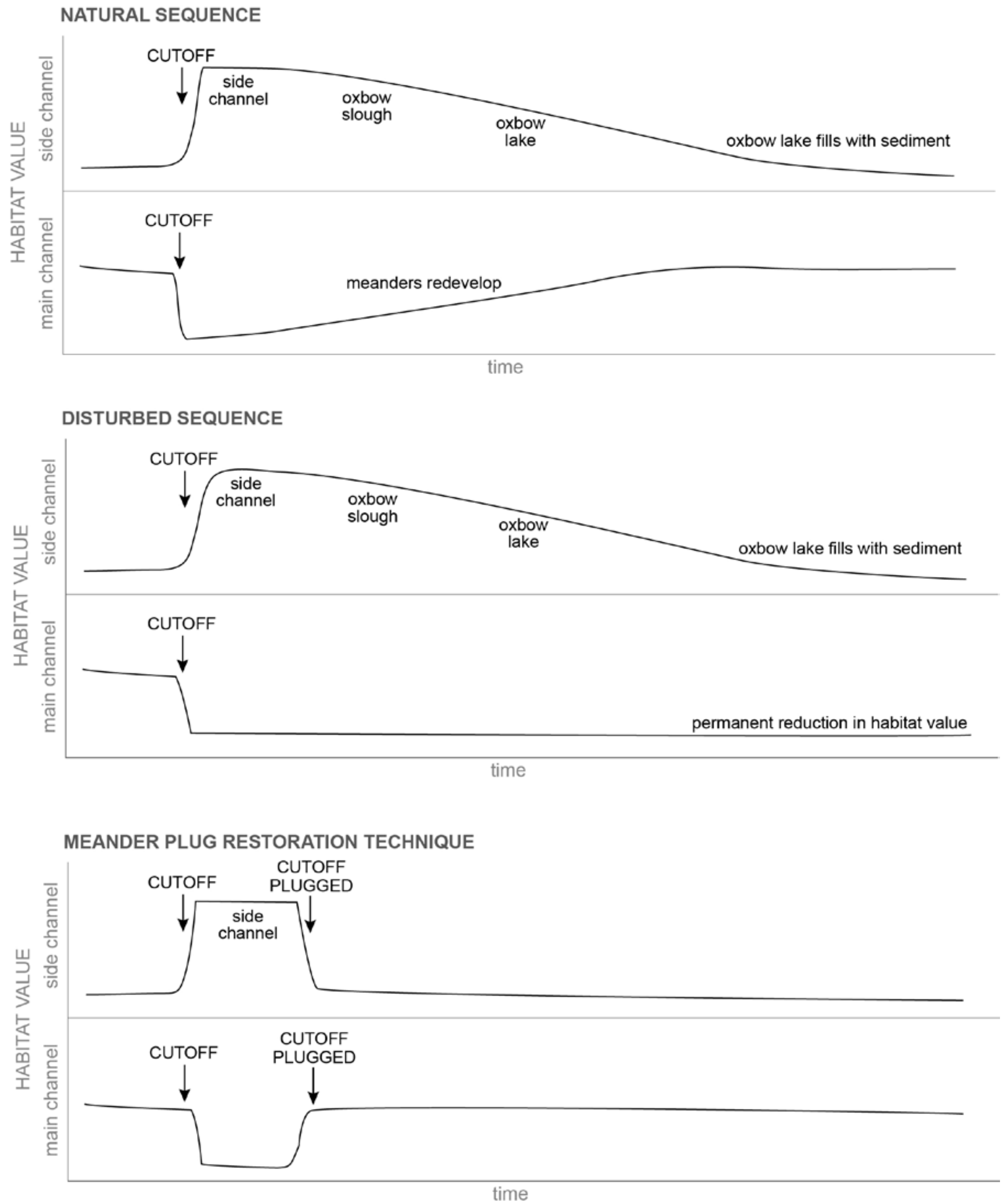



*Figure 3.2-2: Conceptual models of meander cutoff sequences and habitat values*

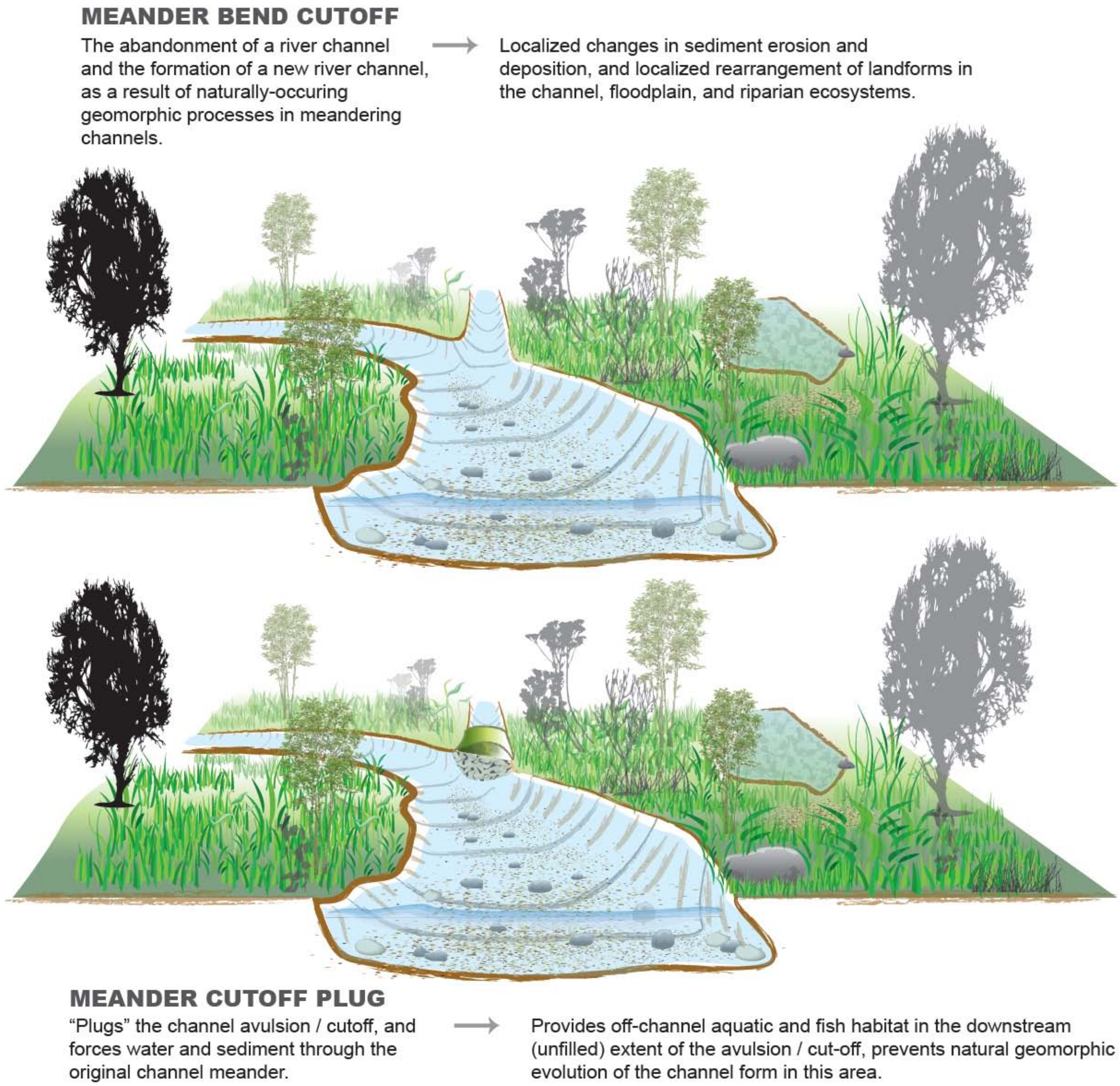



*Figure 3.2-3: Meander bend cutoff plug conceptual model*

The meander cutoff plug restoration projects in the Sprague River Basin have been controversial, largely because there is significant uncertainty about whether or not current meander cutoff processes are part of the natural dynamics of the river system (which implies there is no need to artificially interrupt the system dynamics). The justification provided in oral discussions (but not explicitly articulated in supporting restoration project documents) is that human influences have so altered fluvial processes that the channel would not regain its natural sinuosity.

The different assumptions can be stated as hypotheses and could be tested against historical data. Has the total length (and thus sinuosity) of the Sprague River channel decreased over time, as would be expected from extensive bank protection? We are unaware of any work having been done to quantify this, but we are fortunate to have data on migration rates and frequency of cutoffs since 1940 from a GIS analysis conducted by Pat McDowell and Jim O'Connor. These results have not been published in a report or paper, but have been summarized in a PowerPoint presentation dated 2010 and on their website: (http://or.water.usgs.gov/proj/Sprague/). McDowell and O'Connor analyzed aerial photographs from 1940, 1968, 1975, and 2000. In the Sprague River Basin, much of the disturbance occurred prior to 1940, when the first aerial photographs were available. They found that lateral migration rates were low overall, 0.1-0.2 m/y from 1940-2000, possibly after the channel adjusted from earlier human impact to the watershed. The dominant process of channel migration was via cutoff, mostly chute cutoff (as opposed to neck cutoff or avulsion). They tried to distinguish 'true lateral migration', involving bank erosion and gradual lateral channel migration, from the abrupt channel shifts resulting from a cutoff, and found that 'true' channel migration was greatest from 1968-1975. We could infer that 'true' migration generally involves erosion of the outside bank of meander bends and thus would tend to increase sinuosity over time. However, they included no analysis comparing the rates at which meanders regrew following cutoffs (i.e. how quickly channel sinuosity recovered after the drop in sinuosity resulting from a cutoff).

McDowell and O'Connor's data also show that lateral migration rates (including cutoffs) and number of cutoffs were highest in the first period, from 1940-1968, and have been lower since. However, 'true' lateral migration rate (i.e., non-cutoff migration) was highest from 1968-1975. Note that (probably as an artifact of when suitable air photos were available) this historical analysis compared unequal-length periods: 30, 7, and 25 years. Thus, while a set of very active years in a long period might be 'absorbed' and averaged out over a long time period, they could strongly influence the average if they occurred during a short time period. McDowell and O'Connor suggest that the higher migration rates from 1968-1975 could reflect delayed response to, and recovery from, the big floods of Dec 1964. Migrations rates could have been higher before the 1940-1968 period before the first aerial photographs were available and the 1940 – 1968 is not a perfect reference period. The overall decline in migration rates since the first period could reflect a natural cycle, of which we are observing only a small part, or a progressive, unidirectional reduction in channel mobility parallel to an increase in extent of levees constructed.

The McDowell and O'Connor analyses do not directly address the questions raised by the meander cutoff plug restoration approach, such as how rapidly the main channel regains its sinuosity post-cutoff. Another important question that would help determine the appropriateness of meander cutoff plugging is how total channel length, including secondary channels, has changed over time. The analyses presented do suggest that an adequate base of data is available to answer these questions. However, for any such analysis, a key issue is the scale at which measurements are made. The finer the scale, the longer the channel lengths will appear to be, so consistency should be adopted across points in time. Generally a scale of 1:25,000 or better should be used for a river the scale of the Sprague system.

### *3.2.1.2 Levee Removal and Modification to Address Channel Corridor Confinement*

Channel confinement by levees and other land uses (e.g. railroad grades) began at least as early as the late 1800s and has continued through to the present day, peaking during the first half of the 20th century. Levee removal or notching projects have been undertaken in the basin to reconnect floodplains with the channel and to permit floodwaters to overflow onto floodplains to provide ecological benefits and natural storage of floodwaters that reduces flood peaks downstream (Opperman et al. 2009). Conceptual models for this type of restoration (Figure 3.2-4) show first the 'Natural Process' sequence of events, as high flows exceed channel capacity and overflow onto the floodplain. The inundated floodplain provides fish with access to terrestrial food sources, enhancing juvenile fish growth, recharges groundwater. Inundated floodplains lead to higher alluvial water tables and support establishment of riparian vegetation. Connection between the channel and the floodplain allows for floodwater storage and attenuates peak flows downstream (Opperman et al. 2009).

Under the 'Altered Process' sequence, when the natural channel capacity is exceeded, overflow is blocked by levees, which causes stage to rise within the levees, increasing shear stress and commonly leading to channel incision within the levees, which ultimately leads to channel simplification and loss of instream habitat quality. Moreover, the ecological benefits of juvenile fish use of the floodplain and alluvial water table recharge are lost. The levee removal and modification restoration actions are designed to reestablish overflow onto the floodplain, and thereby revert to the 'Natural Process' sequence by removing the barrier to overflow (Figure 3.2-5). In some cases, incision of the main channel has increased its capacity so that a much larger flow is now required to overflow the channel and inundate the floodplain, so simply removing the barrier to overflow is not sufficient to induce overbank flooding. Cutting a notch into an existing levee is less expensive than removing the levee, but the resulting overbank flow patterns will be more restricted because of the influence of the constriction through which the water must flow.

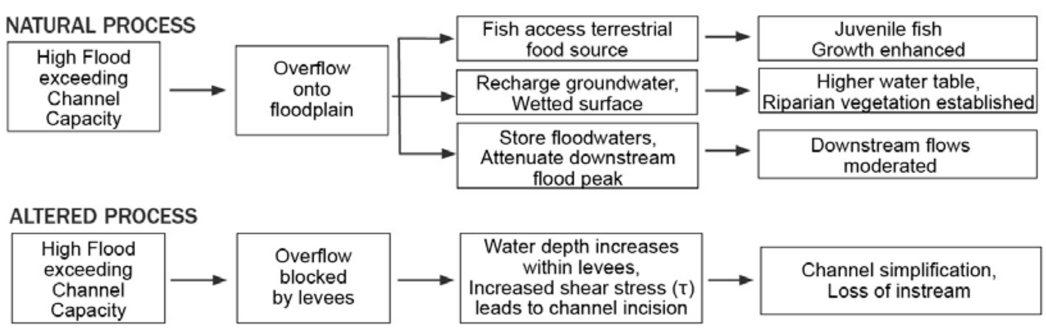



*Figure 3.2-4: Conceptual model for levee removal or levee notching, showing the natural process and altered process sequence of events*

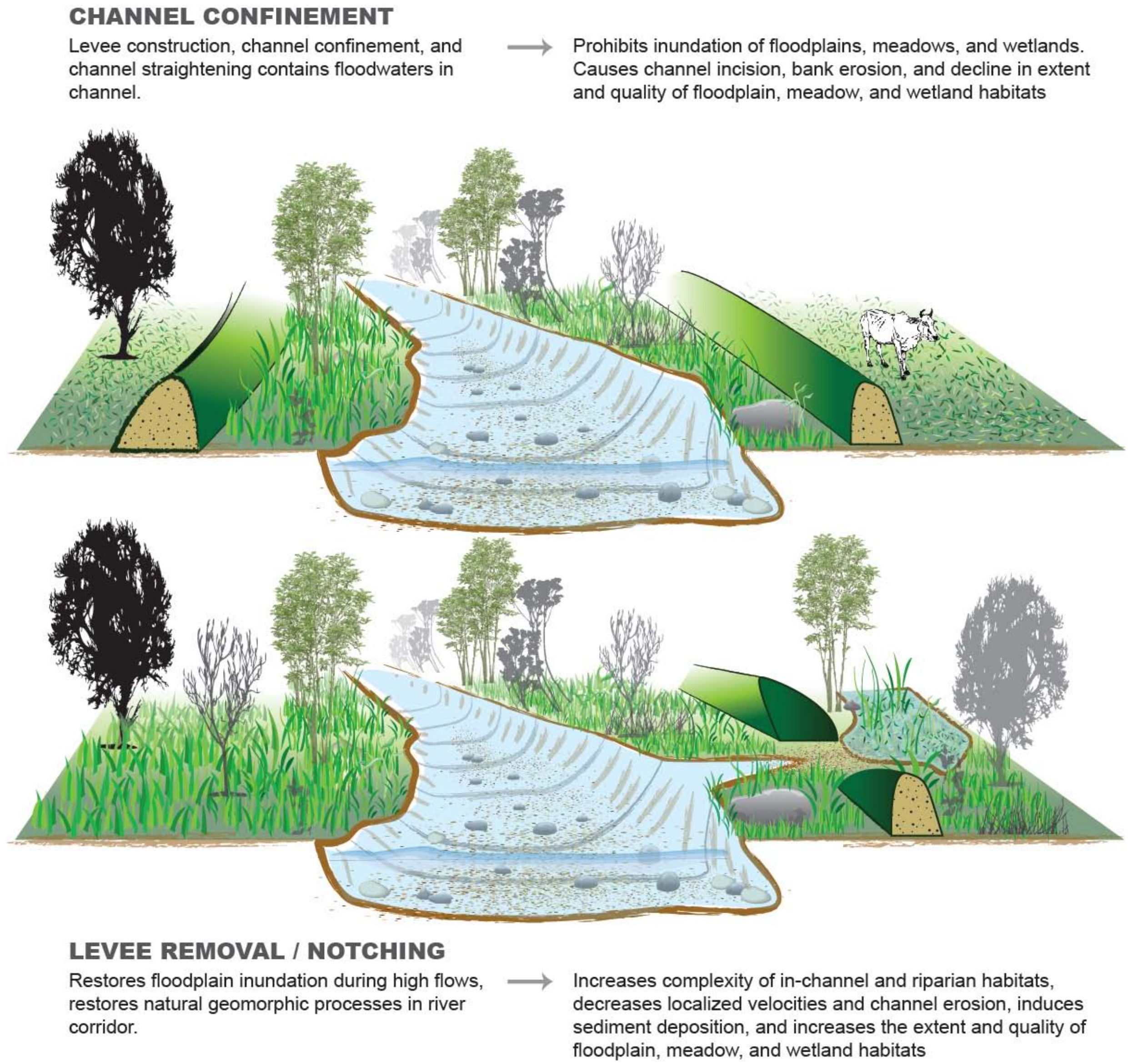



*Figure 3.2-5: Levee removal, setback, or notching conceptual model*

#### 3.2.1.3 Channel Relocation and/or Recreation to Address Channel Straightening

In many places in the Sprague River Basin, channels were straightened or ditched ("channelized") to maximize pasture and agricultural lands and / or redirect stream channels around parcel boundaries. Stream channelization describes any activity that moves, straightens, shortens, cuts off, diverts, or fills a stream channel, whether natural or previously altered. Such activities include the widening, narrowing, straightening, or lining of a stream channel that alters the volume and velocity of the water flowing through the channel. Stream channelization can lead to increases in bed gradient (channel slope) and may result in deepening and widening of the channel (Brooker 1985). Increasing the flow-carrying capacity and slope of a river channel increases flow velocity, which can also increase the potential for a stream to erode its bed and banks. These physical and geomorphic adjustments to the stream channel can have direct impacts on instream and riparian habitat quality, leading to potential overall declines in fish diversity and abundance. This is thought to occur because of reduction in habitat, elimination of riffles and pools, greater fluctuation of stream levels and water temperature, and shifting substrates (Lau et al, 2006; Chapman and Knudsen, 1980). In the Sprague River Basin, restoration of channelized reaches has involved implementing restoration actions that relocate straightened reaches to their historical channels. A conceptual model of relocating straightened reaches to their historical channel configurations to address the impacts of channelization in the Sprague River Basin is presented in Figure 3.2-6 below.

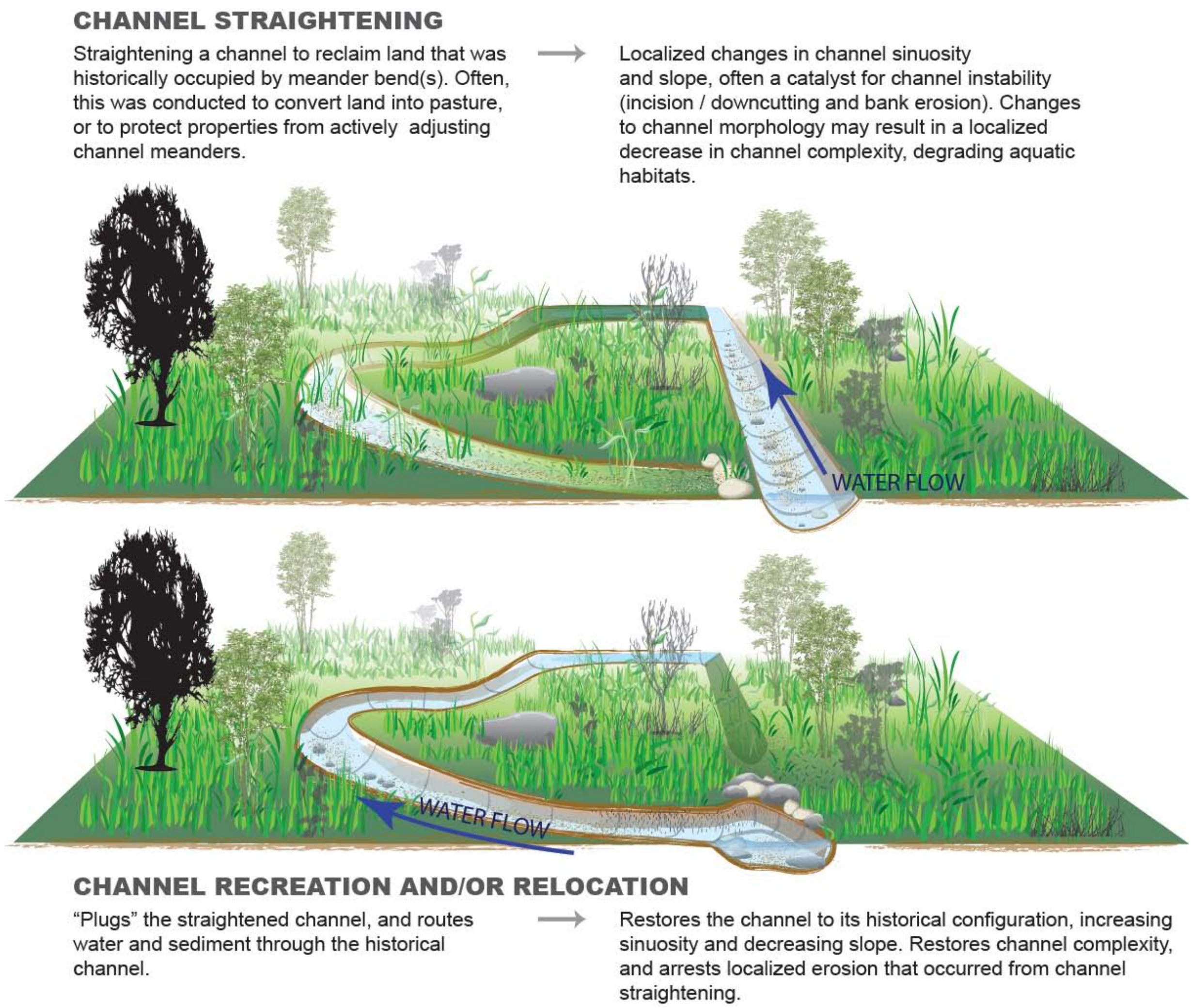



*Figure 3.2-6: Channel relocation and/or recreation conceptual model*

### *3.2.1.4 Livestock Management and Vegetation Planting to Address Livestock Grazing*

Unrestricted livestock access to stream channels has been found to negatively affect water quality, stream channel morphology, hydrology, riparian zone soils, instream and streambank vegetation, and aquatic and riparian wildlife (Belsky et al 1999; Kauffman and Krueger, 1984). Another impact from livestock access in the Sprague River Basin is the potential destruction of the clay hardpan layer that stabilizes the bed of the channels and controls channel incision. Clay hardpan can be easily broken up by mechanical excavation or livestock hoofs, which then makes the channel vulnerable to downcutting (incision) in those areas. Measurements in paired stream reaches with and without livestock access suggest that livestock exclusion practices installed on short, isolated stream reaches result in improved geomorphic and riparian vegetation conditions (Ranganath et al, 2009), as well as more woody bank vegetation, and greater bank stability (McDowell and Magilligan, 1997). A conceptual model of livestock management and vegetation planting to address the impacts of active livestock grazing in the Sprague River Basin is presented in Figure 3.2-7 below.

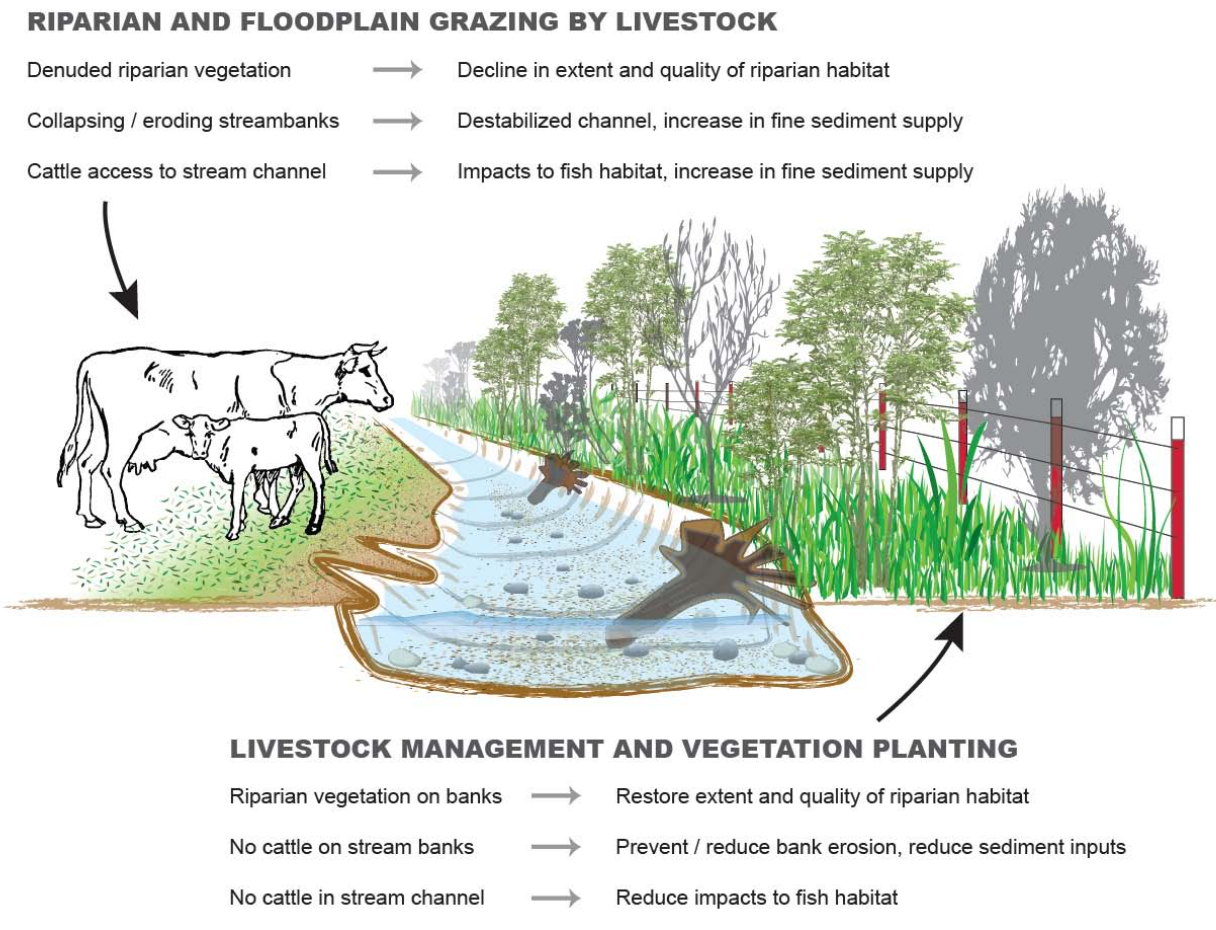



*Figure 3.2-7: Livestock management and vegetation planting conceptual model*

### *3.2.1.5 Fish Screening and Diversion Reduction to Address Fish Entrainment and Flow Reduction in Water Diversions*

Throughout the Sprague River Basin, diversions, ditches, and canals have been installed in and adjacent to the river channels to divert water, which is then used for irrigation and livestock. A direct impact of this is that fish can be captured in these diversions, which can lead to an increase in fish mortality. A fish screen is designed to prevent fish from swimming or being drawn into a diversion where water is taken for human use. They are typically designed to supply debris-free water without harming aquatic life. Throughout the Sprague River Basin, fish screens have been installed to reduce the impact on fish populations from these diversions. A conceptual model of water diversions and installation of fish screens to address the impacts of water diversions in the Sprague River Basin is presented in Figure 3.2-8 below.

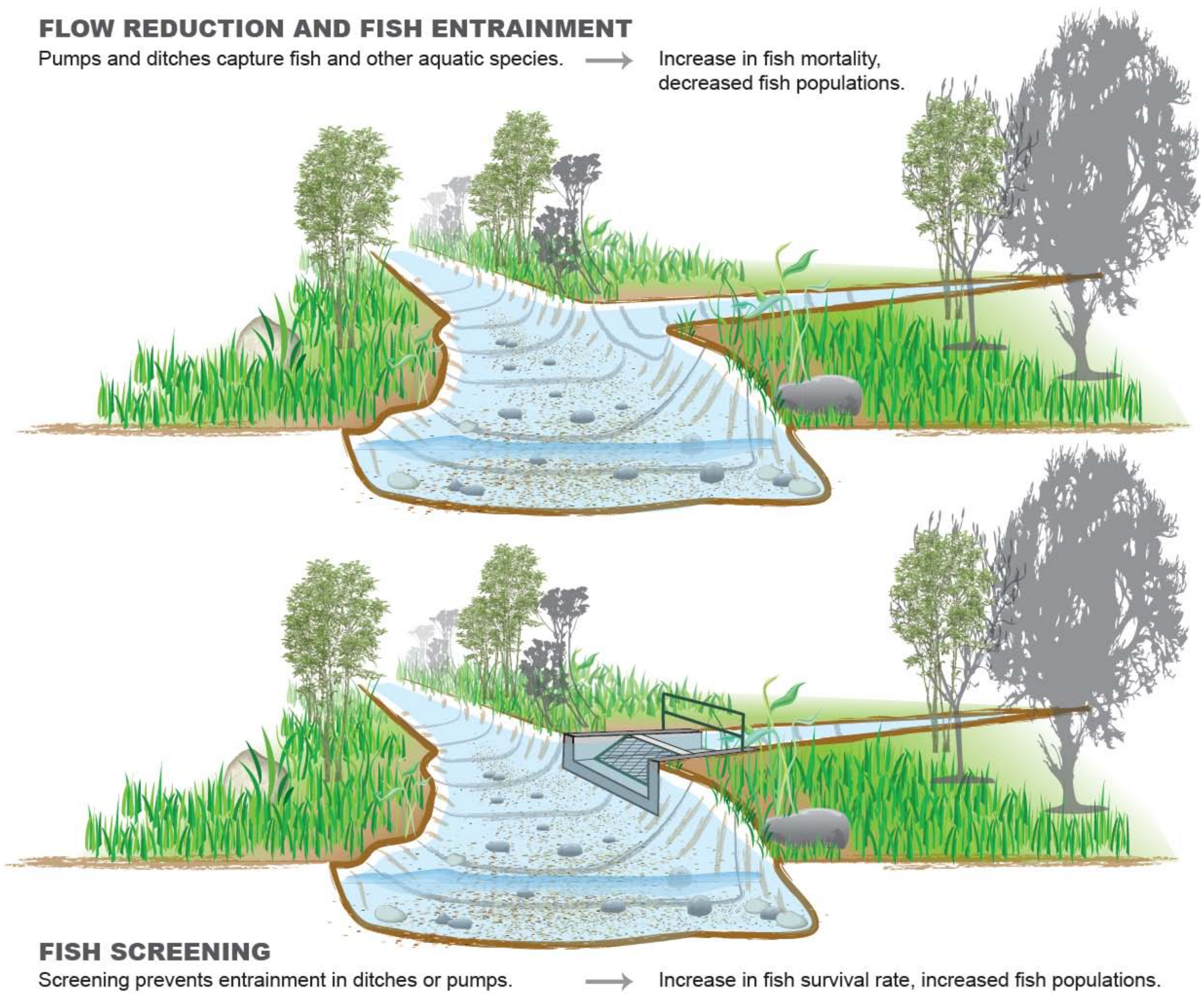



*Figure 3.2-8: Fish screening and diversion reduction conceptual model*

### *3.2.1.6 Spring Reconnection, Enhancement, and Protection to Address Disconnection and Degradation of Cold Water Springs*

Conversion of historical floodplains and wet meadows to irrigated agriculture and pasturelands, as well as channel straightening and reconfiguration, has disconnected cold water springs from the main river channel, resulting in isolated wetlands. Springs provide cold water habitat and critical spawning habitats for native fishes. They also help maintain baseflow in the main channel during the dry summer and fall seasons. Disconnection of springs has resulted in increased stream temperatures, degradation and loss of critical fish habitat, and reduction in baseflow. Restoring a direct connection between cold water springs and the main channel reduces water temperatures in the channel (at least locally), increases discharge, maintains baseflow, and provides spawning areas for endangered native fish (Figure 3.2-9).

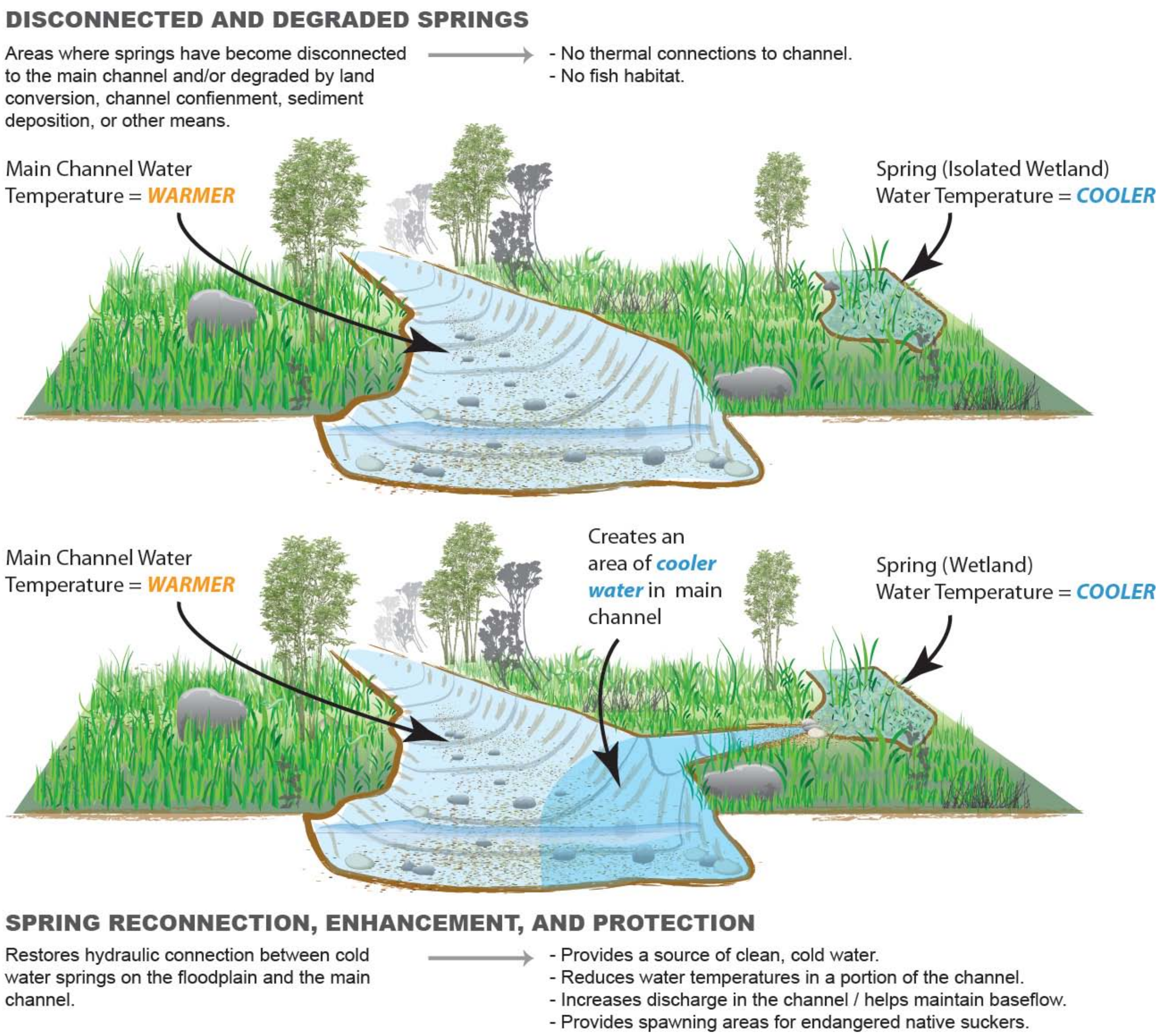



*Figure 3.2-9: Spring reconnection, enhancement, and protection conceptual model*

### *3.2.1.7 Wetland Restoration to Address Impacts to Wet Meadows and Floodplains*

Wetlands provide food, protection from predators, and other vital habitat factors for many of the nation's fish and wildlife species, including endangered and threatened species. In addition, wetland ecotypes have economic value associated with recreational, commercial, and subsistence use of fish and wildlife resources and they remove pollutants from overland flows before they reach our lakes, rivers and bays (USEPA 2012). Throughout the Sprague River Basin valley bottoms and channel corridors, wet meadows, floodplains, and other seasonally-inundated habitats have been converted to irrigated agriculture and pasturelands. This results in a direct loss of wet meadow and floodplain habitats where conversion has occurred, and impacts local and regional geomorphic, hydrologic, and ecological processes. The restoration of wetland and floodplain habitats seeks to restore these ecosystems and beneficial ecosystem processes to their approximate pre-disturbance conditions (Figure 3.2-10).

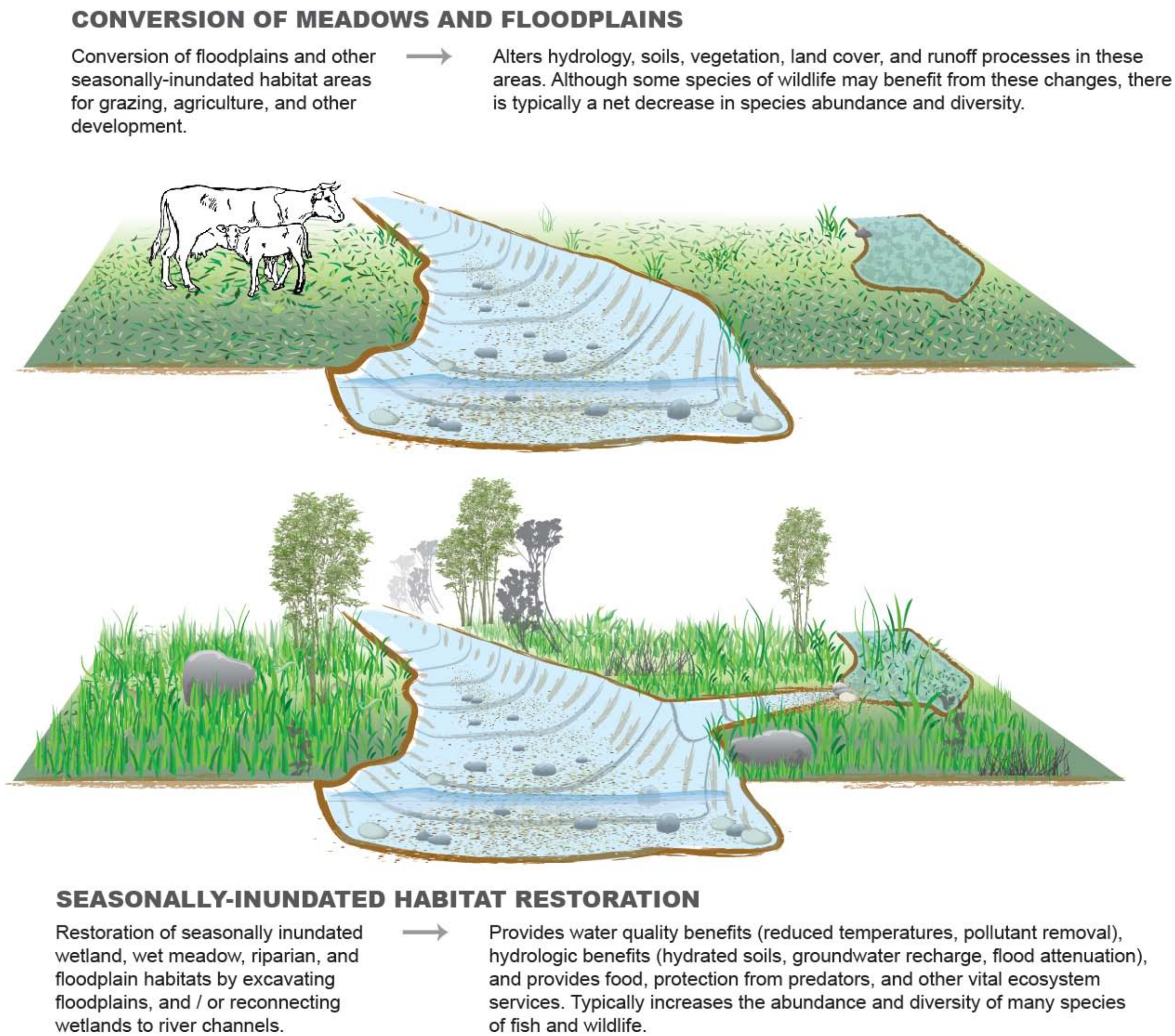



*Figure 3.2-10: Wetland, wet meadow, and floodplain restoration conceptual model*

# 4 Sprague River Basin Post-Project Appraisal Methods

We adapted widely accepted stream restoration Post Project Appraisal (PPA) methods to develop a protocol for the Sprague River Basin capable of determining the following:

1) The extent to which restoration project classes restored, enhanced, maintained, or inhibited natural processes with respect to project success criteria;
2) Different stream restoration approaches that could have been more successful in achieving site specific or basin wide goals;
3) Knowledge gaps and proposed approaches to fill them.

## 4.1 Post-Project Appraisal Overview

Post-project appraisals (PPAs) are used to evaluate restoration projects in relation to their stated goals and objectives, their ability to achieve design criteria, and their overall function from a hydrogeomorphic and ecological perspective (Downs and Kondolf 2002). PPAs provide a framework from which to learn from past project successes and failures, and provide performance feedbacks that allow adaptive management of environmental resources. PPAs can be structured to cover all aspects of project performance, such as geomorphological, ecological, biological, and social (Kondolf and Micheli 1995).

Recently, there is an improved understanding of the importance of post-project appraisals for river restoration projects (Kondolf and Downs 2002, Bernhardt et al 2005), as well as published methodologies for how to plan restoration projects to maximize the utility of PPAs and effectively utilize pre- and post-project data to aid the PPA process (Kondolf and Downs 2002; Tompkins and Kondolf 2007).

In a seminal paper on PPAs, Kondolf and Downs (2002) listed eight components of an "idealized" PPA (assuming that the project has been planned and designed to maximize the utility of PPAs, and there are resources available to obtain the necessary data). These can be categorized into activities that should occur pre-project or during the project design process, and those that should occur post-project implementation. We guided our PPAs of projects in the Sprague River Basin using these eight components, as follows.

***Pre-project or project design activities:***

9. ***Success criteria:*** defining success criteria (an explicit statement of project objectives in terms of expected outcomes from which it is possible to base a rational judgment about scheme performance) at the outset of the project or during the design process allows post-project appraisal to evaluate relative performance after implementation. For each project we evaluated in the Sprague River Basin we reviewed all project documentation and interviewed project stakeholders to generate a comprehensive list of success criteria, which we summarized as goals and objectives for each project based on project documentation. It is important to note that because our PPAs were meant to assess site specific and basin wide performance as well as provide a foundation for future stream restoration actions in the basin, we also assessed whether the

stated success criteria were appropriate with respect to site conditions, relevant conceptual models, and current best stream restoration practices.

10. ***Baseline surveys / data collection:*** identifying and collecting baseline data provide the basis against which the restoration design is assessed. Ideally, this will include a pre-project topographical survey and a period of pre-project monitoring. The requisite baseline data should be identified from the success criteria. For example, if success criteria are geomorphically-based, then geomorphic data (such as channel dimensions, slope, substrate types, etc.) should be collected, if criteria are ecologically-based, then ecosystem data (habitat types, habitat elements or parameters, etc.) should also be identified and collected. For each project we evaluated in the Sprague River Basin we collected and reviewed baseline survey data where it was available, including pre-project geomorphic and ecological monitoring data. For many projects, we found baseline data was non-existent or incomplete. For these projects, we used historical aerial photo analysis and other *secondary analytical procedures* as described further below in an attempt to bridge these data gaps.

11. ***Design rationale:*** documentation of the design process including assumptions, methods, rationales, and calculations allows post-project evaluators to minimize guesswork and subjectivity in relation to comparisons of pre- and post- project performance and post project analyses. For many projects in the Sprague River Basin, the design rationale was mostly anecdotal, as most projects did not include formal documentation of the design process and methods. In these instances, the design rationale used during the PPA was based mostly on conversations with key stakeholders and/or agency representatives who had knowledge of the restoration project. For other projects, design rationales were well documented. In these cases, we reviewed the design rationale documents and they became a key element of the PPA evaluation.

12. ***Design drawings:*** plans superimposed against a baseline topographic survey, with a level of detail that varies according to the scale, complexity, and engineering associated with a particular project provides the “design intent,” which can be used to evaluate the as-built project and geomorphic evolution of the site. Again, full sets of design drawings for most projects we evaluated in the Sprague River Basin were not available. In many cases, we determined this is because the projects were designed and implemented without drawings; either they were unnecessary (for fencing, riparian management, or other “non-structural” restoration projects), or because the restoration was performed without a formal design process (i.e. levee removal or notching, channel plugs, etc). In other cases, we determined restoration projects did include a formal design process complete with design drawings, but some of these were not made available for our PPA. For other projects, design drawings were available and became a key element of our PPA evaluation.

### *Post-project activities:*

13. ***As-built surveys:*** surveyed immediately after project implementation and detailing the actual structures and morphological modifications made, as-built surveys reflect the actual built environment, and may differ from the actual design drawings as they capture the changes that inevitably occur during the implementation process. Comparing the two sets of drawings (design drawings vs. as-built surveys) provides a ready summary of scheme compliance with design intentions. For projects we evaluated in the Sprague River Basin, an as –built survey was available for the Bailey Flat project. For the remainder, as-built surveys were not performed, and thus we did not incorporate them in the PPA evaluations.

14. ***Post-project periodic and event driven monitoring surveys:*** monitoring should be organized to address the collection of data sets required to analyze the performance of the restoration project post-implementation, relative to the success criteria. Performance factors will probably include the biological and ecological response of the restoration project, but needs also to include topographical surveys and measurement of key parameters related to hydrology, sediment transport, and flow patterns. These factors, combined with the extent of the monitoring period, are critical in determining the level of confidence reached in the performance of the project, and its sustainability. In general, the longer the period of monitoring, the more valuable the data source is likely to prove for the PPA (Kondolf and Micheli 1995). For each project we evaluated in the Sprague River Basin we collected, catalogued, and reviewed all post-project monitoring surveys, including geomorphic, biological, and ecological data (as described for each project individually in Section 5 "Project Case Studies.") For each project, a "project completion report" was typically developed, which provides a rough summary of project objectives, activities performed, and comments on successes and lessons learned. We incorporated these reports into the PPA evaluation process. We found other post project monitoring data varied considerably in their temporal and spatial scales, accuracy, completeness, and relevance to PPA evaluation.

15. ***Supplementary historical data:*** in many cases, post-project monitoring programs have not been initiated immediately after project implementation. Supplementary historical information such as aerial photographs, remote sensing, and other tools may be used to bridge temporal data gaps and make inferences to project performance. Due to the variability of post-project monitoring data for each project we evaluated in the Sprague River Basin, we performed historical aerial photography comparisons for each site (as described for each project individually in Section 5 "Project Case Studies.")

16. ***Secondary analytical procedures:*** often needed to allow translation of monitoring data to allow comparison to success criteria. For instance, the natural geomorphic evolution of a restored channel could be judged in relation to regional trends for channels of similar catchment size, stream power, etc. to allow a rating of the degree of sustainability or geomorphic health of the restored channel. Generally there is a greater dependence on secondary analysis when other data sources are absent. For each project we evaluated in the Sprague River Basin we conducted

extensive secondary analyses, focusing on historical aerial photography and hydrology, to maximize the potential for lessons learned from each project. Additionally, we incorporated anecdotal data from historical reports and project documents, and performed manipulations or translations of these data to enable comparisons with verified data.

Application of this idealized PPA process to the Sprague River Basin presented us with some challenges because the majority of restoration projects in the Sprague River Basin were not planned or designed within this framework, and we found that very little systematic post-project monitoring data was available for most projects. Therefore, our PPAs often focused on our assessment of existing conditions with respect to the goals and objectives (i.e. the success criteria) of the project. Our PPAs also resulted in establishment of baseline data for future monitoring and adaptive management.

Downs and Kondolf (2002) proposed a hierarchy of five possible “levels of investment” in PPAs to illustrate the typical learning potential associated with PPAs with a range of intensities. This scheme includes the following levels of PPA investment (as described in Downs and Kondolf 2002):

- ***Full and medium-term PPAs.*** The ultimate PPA, termed the ***full*** PPA, includes data in each of the eight pre-project and post-project components, including the existence of more than 10 years of post-project monitoring that provides a thorough understanding of the in-stream geo-hydraulic interaction of water and sediment within the restored reach. The ***medium-term*** PPA includes a monitoring period of 5–10-years, also allowing the geohydraulic reach dynamics to be understood. However, the chances of evaluating longer-term sustainability in terms of geomorphology-hydrology interactions is dependent on receiving a period of climatic normality (including extreme events and/or climatic trends) during the monitoring period.
- ***Short-term PPAs.*** In a ***short-term*** PPA, pre-project data is augmented by project monitoring for up to five years only. The monitoring period should make it possible to document relations among the flow hydraulics, the extent and type of channel change, and the basic sediment transport dynamics of individual components of the scheme. Conclusions about performance will be relative to the flows occurring since scheme installation. Secondary analysis of flow records and sequential aerial photographs will probably assist in performance speculation for larger or less frequent events.
- ***One-shot PPAs.*** The next lowest level of investment, termed here the ***one-shot*** PPA, has no repeat post-project monitoring and the quality of pre-project information may be questionable. Field survey is limited to a single site visit (the one shot) which, if it occurs soon after the scheme installation, will serve primarily to indicate the as-built condition, in which case the PPA mostly indicates the scheme’s compliance with the design. Further insights may be gained by measuring key parameters of geomorphological naturalness so that secondary analysis can indicate the *apparent* short-term success of the project. The limited temporal extent of the analysis will be a major constraint on the knowledge obtained. This type of PPA may be the typical outcome in cases where the appraisal was not funded as an integral part of the restoration plan, which was the case for most projects implemented in the Sprague River Basin.

- ***Remains PPA.*** The lowest level of PPA investment we term the ***remains*** PPA. Here, little or no information exists about pre-project objectives, baseline condition, the design process, or details of the installation. No as-builts were prepared, nor was a monitoring program undertaken. Unless the design features of installation measures can be established, there is little point in extensive post-project surveying. Understanding the scheme is mainly through secondary analysis.

Downs and Kondolf (2002) describe the typical level of understanding achieved for different components of a PPA according to the category of level of investment we describe above (Figure 4.1-1). For each case study we reviewed in the Sprague River Basin, we provide the category of level of investment in pre-and post-project monitoring data that has been attained, based on our review of available monitoring data and documentation on project planning, design, and implementation. As seen in Figure 4.1-1, the greater the level of investment in a project, the greater the opportunities for learning, the more we can understand compliance with design intentions, the more accuracy we can achieve in terms of rating short term geo-hydraulic performance, and the more probable it is that we can perform longer term evaluations of geomorphological sustainability.

While we did select projects for PPAs at least in part based on the availability of data and information about each project (see Section 3 for details), the general lack of systematic post project monitoring data for restoration projects in the Sprague River Basin meant that most of our PPAs were either one-shot or short term. We did conduct extensive secondary analyses for most projects (focusing on historical aerial photography and hydrology) to maximize the potential for lessons learned from each project. However, given the relatively “young” age of most of the restoration projects we evaluated, we were not able to make definitive conclusions about the performance of most projects. Rather, we focused on short-term performance and, perhaps more importantly, whether or not projects considered relevant conceptual models and implemented appropriate actions for the objectives of the project and the most important natural processes at each site.

| Components of PPA | Full | Medium-term | Short-term | One-shot | Remains |
|---|---|---|---|---|---|
| | Category of Post-Project Appraisal | | | | |
| Pre-project | | | *Level of commitment* | | |
| Success criteria | explicit | explicit | explicit | implicit or explicit | implicit or non-existent |
| Baseline surveys | thorough | thorough | thorough | partial or thorough | none |
| Documented design rationale | explicit | explicit | explicit | implicit or explicit | implicit or non-existent |
| Design drawings | thorough | thorough | thorough | thorough or conceptual | conceptual or none |
| As-built (record) drawings | exist | exist | beneficial | beneficial | none |
| Post-project/follow-up | | | *Level of commitment* | | |
| Periodic or event-driven monitoring | >10 years | 5–10 years | <5 years | single survey | single survey |
| Supplementary historical data | beneficial | beneficial | beneficial | necessary | necessary |
| Secondary analytical procedures | probably unnecessary | possibly unnecessary | beneficial | highly beneficial | necessary |
| Opportunities for learning | | | | | |
| Understanding compliance with design intentions | yes | yes | yes | possible | speculation |
| Indication of short-term geo-hydraulic performance | yes | probable | possible | possible | speculation or none |
| Longer-term evaluation of geomorphological sustainability | probable | possible | speculation | speculation | speculation or none |

*Figure 4.1-1: Five levels of investment in geomorphological post-project information: data requirements for each level of PPA and typical level of understanding achieved (Adapted from Downs and Kondolf 2002)*

## 4.2 Field Methods

We performed additional geomorphic and vegetation monitoring on selected projects in the Sprague River Basin to supplement the currently available post-project appraisal datasets. The specific types of post-project surveys we performed are detailed for each project in the “Project Case Studies” section of this document.

Changes to a channel resulting from geomorphic processes are detectable through periodic documentation of channel features at established, permanent field locations. A time series of channel cross-sections, longitudinal profiles, bank erosion assessments, photographs, and field observations taken in the same locations can be used to quantify and document the following geomorphic processes:

- Incision
- Aggradation
- Channel migration
- Creation or abandonment of high flow or backwater channels
- Point bar formation
- Bank erosion

- Surface and floodplain development (deposition) or scour
- Pool scour or deposition
- Upstream or downstream migration of knick points
- Bedrock outcrops or channel controlling structures such as weirs, bridge abutments, and flood control infrastructure

Riparian vegetation can often recover rapidly after disturbances or land use changes, which allows for an evaluation of effects of management on a particular area. If repeat surveys are conducted in the same area 3 to 5 years apart, data can be compared to provide indications of long-term trends (Winward 2000). We conducted greenline surveys to collect baseline vegetation community data at two project sites to be utilized in future post project assessments and to provide a snapshot view of existing post project conditions. The monitoring methods we used, and their application to specific projects in the Sprague River Basin, are described in more detail below. Table 4.2-1 shows specific monitoring methods we used at each project site.

### 4.2.1 Cross-Sections

For the Five Mile Creek, Bailey Flat, Long Creek, Nimrod River Park, Nine Mile Road, Sprague River, and Beatty Station projects, we divided the project reach into sub-reaches based on geomorphic attributes of the channel such as channel slope, form, sinuosity, bank material, and bed material. We surveyed one cross section in each sub-reach, using standard cross-section survey procedures as documented in Harrelson et al. (1994). We used a survey quality Trimble GPS for cross sections. We revisited endpins installed during previous surveys at project sites where monitoring cross sections were monumented. If no end pins were present, we collected GPS x, y, z coordinates, but did not install new cross section end pins to avoid any impact to livestock. We oriented new monitoring cross-sections perpendicular to the flow in the channel. We recorded elevations along the cross-section at breaks in slope and at significant geomorphic features (i.e. features that potentially could affect the channel form through scour, deposition, or by altering the flow path).

To assess changes in channel configuration, we compared newly collected cross-section data with historical cross-section data. We obtained post-construction cross-sections from project files or an as-built survey, or if no as-built survey was available, from final design drawings. We fitted each cross-section (historical and collected during this effort) to a common axis and plotted to facilitate a visual comparison.

### 4.2.2 Longitudinal Profiles

For the Five Mile Creek, Bailey Flat, Nimrod River Park, and Nine Mile Road projects, we surveyed longitudinal profiles following the procedures documented in Harrelson et al. (1994). A longitudinal profile is a survey of the deepest part of the channel (i.e. the thalweg) along the longitudinal flow path traversed by the channel. Longitudinal slope and hydraulic and sediment transport control features can be identified and quantified using the longitudinal profile survey. We collected survey points at visible changes in channel morphology units, such as riffles, cascades, steps, pools, and runs or breaks in slope. We used a survey quality Trimble GPS to conduct longitudinal surveys. We documented areas with significant bank erosion, scour, or deposition during the longitudinal profile survey in survey notes collected on the GPS data collector.

### 4.2.3 Photographic Monitoring Stations

We took digital photographs in the field to document channel conditions at each of the project sites. We established permanent photographic monitoring stations at cross section end points for the Bailey Flat, Five Mile Creek, and Nimrod River Park projects. We took photographs at both cross-section end points and from the thalweg of the channel to capture the channel banks and views looking upstream and downstream. We also took photographs of channel conditions including bank erosion, scour, and deposition during longitudinal profile surveys and referenced to geographic coordinates.

### 4.2.4 Bank Erosion Assessments

We conducted bank erosion assessments at two of the project sites, South Fork Sprague and Whisky Creek. We surveyed both banks of the channel, and we documented eroding banks with digital photos and GPS coordinates. We classified an eroding bank as having an erosion scar that was at least a channel width in length. We identified banks potentially subject to active erosion based on these characteristics: unvegetated, vertical or steep banks, exposed roots in bank, and anthropogenic features (such as fences) being undermined. We took digital photos looking upstream or downstream at the start and end of each eroding bank. We downloaded and incorporated GPS points into the project GIS and we measured the lengths of eroding banks and summed the lengths for the project area. We noted general geomorphic observations and included observations in the results.

### 4.2.5 Greenline Surveys

We conducted simplified greenline surveys at two project sites, South Fork Sprague and Whisky Creek, following the methods outlined in *Monitoring the Vegetation Resources in Riparian Areas* (Winward 2000). A greenline survey is a method to measure vegetation trends on streambanks by identification of riparian plant community types on a line intersect transect. The greenline is defined as the first perennial vegetation that forms a lineal grouping of community types on or near the water’s edge and most often occurs at or slightly below the bankfull stage (Winward 2000). We documented greenline surveys with digital photographs and collected GPS waypoints to define the upstream and downstream extents of each greenline. We also used GPS waypoints to identify the start and endpoints of vegetation community transects.

*Table 4.2-1: Post-project monitoring surveys performed at selected project sites in the Sprague River Basin*

| Project Site | Monitoring Methods | | | | | | |
|---|---|---|---|---|---|---|---|
| | Project Type | Cross-Sections | Longitudinal Profiles | Photographs | Bank Erosion Assessments | Greenline Surveys | Other |
| S. Fork Sprague | Management | | | X | X | X | |
| Five Mile Ck | Management, Habitat creation, and Fish passage improvement | X | X | X | | | Facies mapping of 100 ft reach |
| Bailey Flat | Channel Manipulation, Habitat creation, and Management | X | X | X | | | |
| Long Ck | Management | X | | X | | | |
| Sycan R. | Management | | | X | | | Recorded general |
| Whisky Ck | Management, Fish passage improvement, and Reconnection | | | X | X | X | |
| Nimrod River Park | Management, Channel manipulation, Reconnection, and Modification | X | X | X | | | Survey of excavated wetland |
| Nine Mile Rd | Management and Channel manipulation | X | X | X | | | |
| Southside Levee Breach | Management, Expansion, and Reconnection | X | | X | | | Wetland topographic survey |
| Beatty Station | Channel manipulation | X | | | | | |

## 4.3 Secondary Analyses

For many projects where there was limited or no pre-project data available in the project files, we conducted secondary analyses to improve our understanding of pre- and post- project conditions. These analyses included the review and comparison of historical aerial photographs, comparisons of pre- and post-project hydrology, and in-channel structure assessments.

### 4.3.1 Aerial Photography Comparisons

For each project we evaluated in the Sprague River Basin, we reviewed historical aerial photographs from 1940 or 1953, 1995, 2000, 2001, 2005, and 2009 to assess the trajectory of recent geomorphic changes at those locations. For most of these projects, the 1940 aerial photographs were the oldest set we reviewed; we used 1953 aerial photographs for the South Fork Sprague River, Long Creek, and Bailey Flat. We provide a description of the geomorphic changes for each of the project case studies in Section 5. In our comparison of historical aerial photographs we looked for changes in channel alignment, channel confinement (levees), secondary/high flow channels, oxbows, meander bends, floodplains, wetlands, and vegetation.

### 4.3.2 Hydrology Considerations

The timing of annual peak discharge events is very important to consider when assessing stream restoration projects. Large peak discharges that occur immediately after a project is constructed can cause significant changes, when the same discharge a few years later may result in minimal changes (when the project is better established). We attempted to put project performance in the context of recent hydrology events. For the period from 1998 to 2008, peak annual discharges were relatively low. By reviewing the peak discharge flow record at the Sprague River near Chiloquin (USGS gage# 11501000), we determined that the highest peak flow in the 1990s (10,800 cfs) occurred on January 5, 1997, which was a 50 year event (see Section 2 for more details). From water years 1998 to 2010 the annual peak discharge didn't get above 3,770 cfs, which is just below a 5 year event. During our field site visits and office based analyses, we put channel observation in the perspective of channel recovery after a 50 year event at the beginning of the period followed by relatively small peak discharges.

### 4.3.3 In-Channel Structure Condition Assessments

During our field site visits we conducted a reconnaissance level assessment of the condition of in-channel structures. At many of the projects, Large Woody Debris (LWD) was placed in the channel to armor chute cutoff plugs, stop bank migration and create complex habitat. During channel surveys, we located the placed structures and took field notes and digital photographs showing the performance of the structures. Observations included the height on the bank of the LWD or root wads compared to bankfull indicators and the flow during observation, evidence of overtopping of the structure, undermining of the structure, and erosion upstream or downstream of the structure. We also looked at the opposite bank to see if the structure had caused any redirected impacts such as erosion further downstream on the opposite bank.

# 5 Post Project Appraisal (PPA) Project Selection

This section describes the protocol we followed to ultimately select ten stream restoration projects as case studies for PPA. First, we compiled a master list of all stream restoration projects conducted in the Sprague River Basin from 1994 to 2008 using spatial databases and through direct communications with agencies, organizations, and consultants engaged in stream restoration in the basin. Next, we refined this list iteratively based on data availability, site access, a wide range of environmental setting data incorporated in our Spatial Post Project Appraisal Management System (SPPAMS), and finally through ongoing discussions with the Core Team (CT), Advisory Team (AT), and Evaluation Team Assistance Group (ETAG) initiated at a project selection workshop in June 2011 in Klamath Falls. From this refined list, we selected the final set of projects for PPA to be as broadly representative of watershed conditions and stream restoration action types as possible given site access and data availability constraints.

## 5.1 Spatial Post Project Appraisal Management System (SPPAMS)

We developed and implemented a Spatial Post Project Appraisal Management System (SPPAMS) to guide and organize our selection of projects for PPA and to provide a tool for future adaptive management and implementation of stream restoration projects in the basin. We added relevant spatial data layers to the SPPAMS including historical aerial photographs (1940, 1995, 2000, 2001, 2005, 2009), geology, stream network, USGS stream gages, results from a geomorphic characterization of the basin (USGS 2011), digitized notes from the ETAG on Sprague River Basin characteristics, wetlands, roads, land cover, topography, historical vegetation, results from a GAP vegetation analysis from 1998, and land ownership to help select projects that represent a range of environmental conditions. We also used the SPPAMS to organize the information collected by the ETAG from agencies, organizations, and consultants for stream restoration projects completed between 1994 and 2008. This information included project spatial databases from the USFWS Klamath Falls Office, BLM Klamath Falls Area Office, NRCS, The Nature Conservancy (TNC), USDA Fremont-Winema Resource Advisory Committee (RAC), Klamath Watershed Partnership, OWEB, and the Klamath Tribes. The ETAG also used the SPPAMS to compile project files for projects completed by River Design Group, Inc. and Balance Hydrologics, Inc., two consulting firms that have designed and implemented many of the projects in the basin.

We organized all of this information in the SPPAMS using the Project Organization Framework developed and refined at the June and July 2011 workshops and described in Section 3 of this report. This allowed us to attribute all of the projects in the master list with the appropriate combination of instream, riparian, floodplain, and spring project classes. This also allowed us to integrate the project types and actions in the Project Organization Framework (Table 3.1-1) in the SPPAMS. Drawing on the information contained in the SPPAMs, we began to identify potential projects for PPAs from the comprehensive set of projects that resulted from the initial data collection effort and is illustrated in Figure 5.1-1. The distribution of projects in the master list is concentrated in the lower and middle Sprague River Basin; the ETAG, AT, and CT identified fewer projects in the headwater tributary streams.

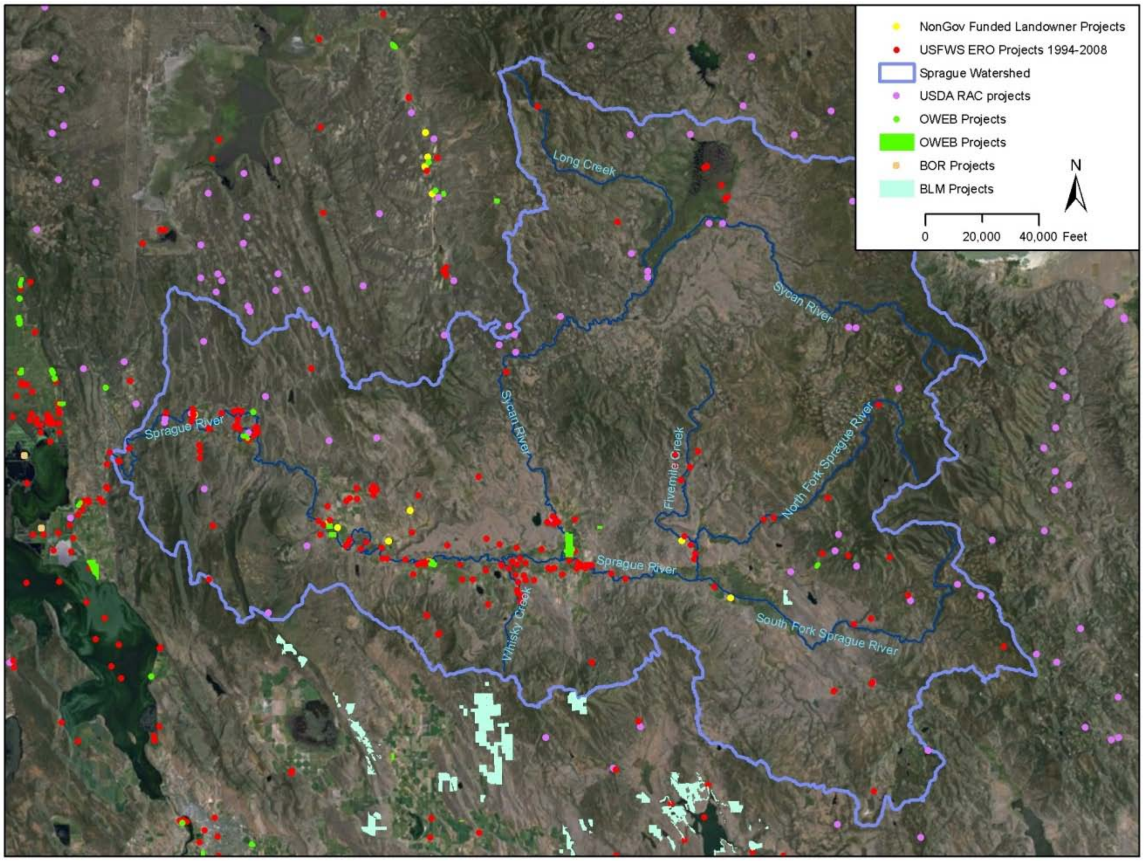



*Figure 5.1-1: Stream restoration projects completed by the USFWS, BLM, BOR, USFS, NRCS,OWEB, The Nature Conservancy, and landowners in the Sprague River Basin between 1994 and 2008*

## 5.2 Organization of Projects

From the master list of potential projects for PPA, we iteratively screened projects by spatial and related environmental setting criteria using the SPPAMS framework. The ETAG clipped the master list of projects by the Sprague River Basin boundary in GIS and compiled a list of 134 projects. The ETAG reviewed the remaining projects for the degree to which they satisfied the elements of a successful PPA and by the potential of learning from the project. The ETAG also deleted duplicate projects and combined projects that were modifications of an existing project. The resulting SPPAMS database included 39 projects (Figure 5.2-1). For this list of 39 projects, we populated their entries in the SPPAMS with attributes considered critical elements of successful PPAs as defined in Section 4 of this report. These elements included the availability of: 1) articulated success criteria; 2) pre-project surveys; 3) design rationale or justification; 4) design drawings; 5) as-built drawings; and 6) reproducible post-project monitoring surveys, project identification number, contact, lead agency, partners, other data available, and notes from agency staff about each project. The projects remaining in the refined SPPAMS data layer were clustered around the lower and middle reaches of the mainstem Sprague River. Next, we used the SPPAMS to select projects that represented a range of environmental conditions in the watershed.

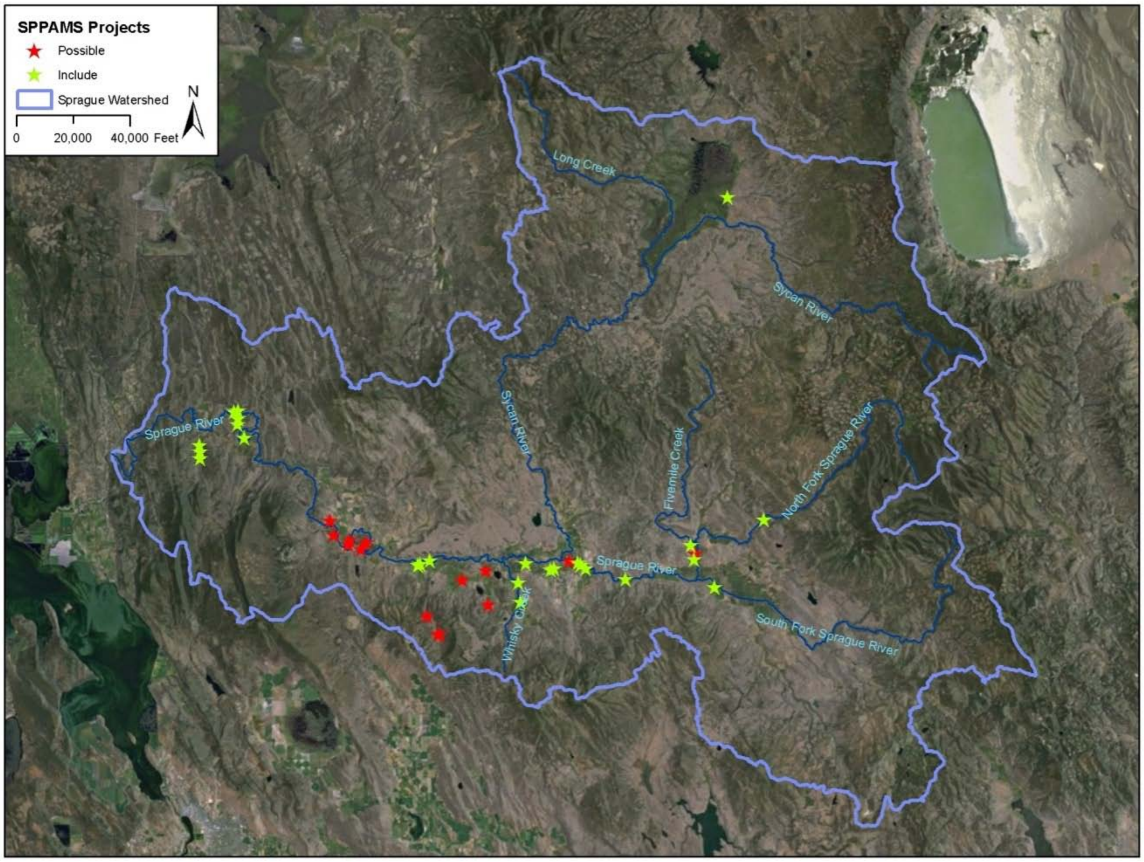



*Figure 5.2-1: Thirty-nine potential projects screened for Post Project Appraisal using the Spatial Post Project Appraisal Management System framework (projects identified by a green star comprise the twenty-eight projects reviewed before the final selection was completed)*

## 5.3 Final Project Selection

We used the SPPAMS in a project selection workshop in Klamath Falls with the ET, CT, AT, and ETAG to further refine the list of 39 projects described above down to a workable number of case studies for this project. During the final project selection process we did our best to ensure adequate representation of restoration projects with respect to project types, spatial distribution, data availability, site access and the full suite of environmental setting data contained in the SPPAMS. Using this information we further refined the list of potential projects for PPA to 28 projects identified as green stars in Figure 5.2-1.

Final selection of projects was completed iteratively by the ET with input from the ETAG based on ongoing refinement of the factors described above. Ultimately, we selected ten projects for PPA, but five of the landowners refused to grant access to their property for our PPAs, so we selected an additional five projects to maintain the equal representation of project types described above. The final ten projects that we selected for PPA are shown in Figure 5.3-1. Table 5.3-1 summarizes the key features of each project selected for PPA. Attribute information in the SPPAMS for each of these projects includes watershed location, stream name, project type and class, and a summary of available data for each project. Our final set of

PPAs include representative projects from the Sycan Marsh, upper, middle, and lower Sprague River Basin. Projects selected for PPAs range from single action (fencing) to multi-action and are representative of the complete range of projects implemented in the Sprague River Basin from 1994 to 2008. We evaluated the project types listed below in this systematic PPA effort.

- Fencing
- Wetland creation
- Floodplain reconnection
- Levee breaching
- Meander bend cutoff plugging
- Riparian planting
- Channel realignment
- Fish screen installation
- Spring reconnection
- Wetland connection .

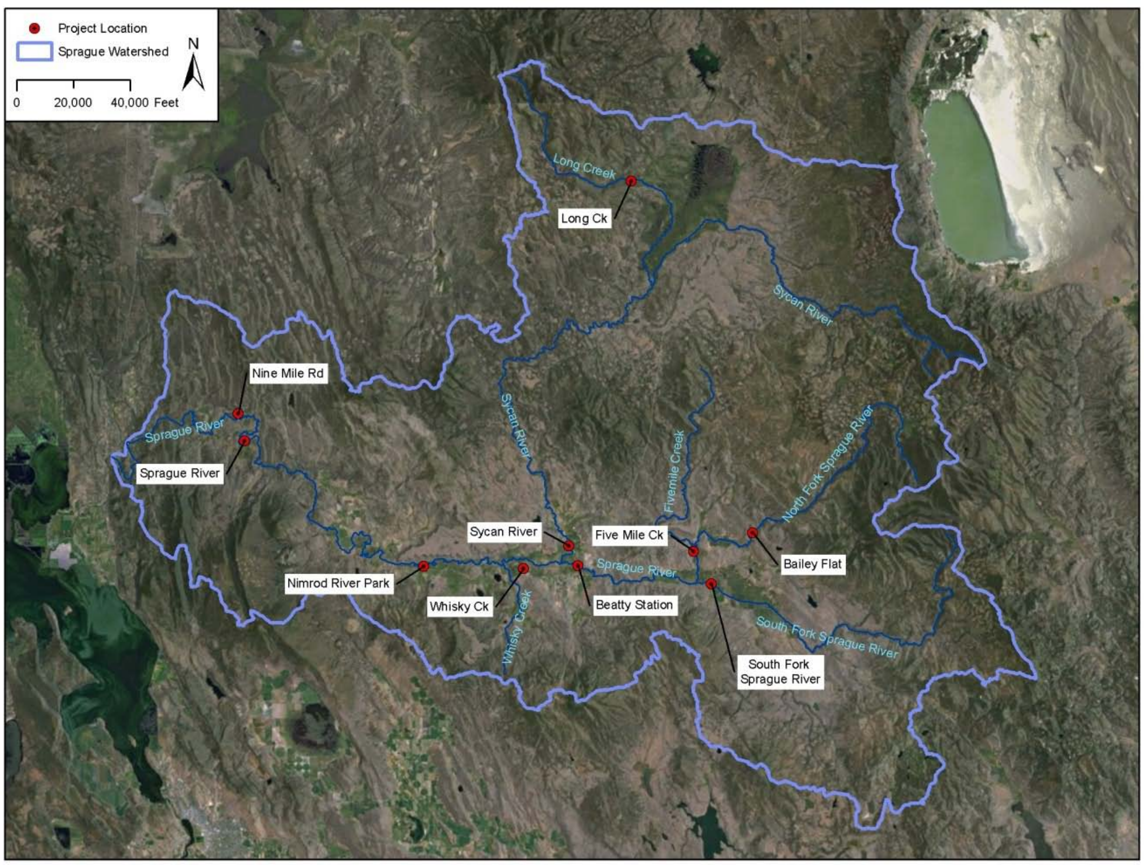



*Figure 5.3-1: Final ten projects selected for post-project appraisal within the Sprague River Basin*

*Table 5.3-1: Selected projects for Post Project Appraisal in the Sprague River Basin and key project attributes.*

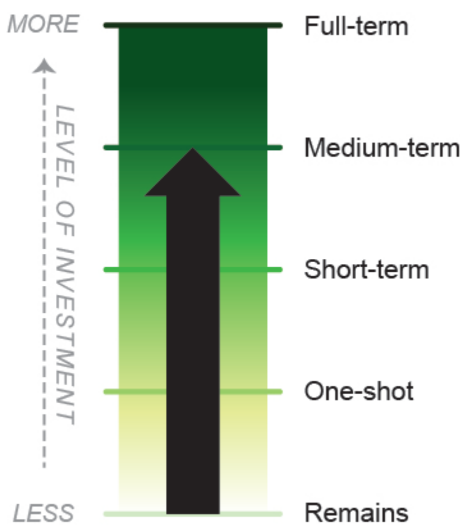
| Project Name | Stream | Location in the Watershed | Project Class | Project Type | Available Data for Post Project Appraisal: Project Objectives | Budget / Workplan | Schedule | Engineering Design | Ground Surveys or Cross Sections | Annual report | Completion report | Other Agency report | Fish data | WQ data | Other data | Aerial-pre | Aerial-post | Photo-Points | Other photos |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Fork Sprague River | S. Fork Sprague River | Upper | Riparian | Management | X | X | | | | X | X | | | | | X | X | | X |
| Five Mile Creek | Five Mile Creek | Upper | Riparian | Management | X | X | X | X | | | X | | X | X | Flow | X | X | X | X |
| | | | Instream | Habitat Creation | | | | | | | | | | | | | | | |
| | | | | Fish Passage Improvement | | | | | | | | | | | | | | | |
| Bailey Flat | North Fork Sprague River | Upper | Instream | Channel Manipulation | X | | X | X | X | | X | | X | | | X | | | X |
| | | | | Habitat Creation | | | | | | | | | | | | | | | |
| | | | Riparian | Management | | | | | | | | | | | | | | | |
| Long Creek | Long Creek | Sycan Marsh | Riparian | Management | X | | | | X | | | X | | | | X | X | X | |
| Sycan River | Sycan River | Sycan | Riparian | Management | X | X | | | X | | | | | | Flow | | X | | |
| Whisky Creek | Sprague River | Middle | Riparian | Management | X | X | | | | X | X | OWEB | | | | X | X | X | X |
| | | | Instream | Fish Passage Improvement | | | | | | | | | | | | | | | |
| | | | Spring | Reconnection | | | | | | | | | | | | | | | |
| | | | | Management | | | | | | | | | | | | | | | |
| Nimrod River Park | Sprague River | Middle | Riparian | Management | X | X | X | X | | | X | OWEB | X | | Inverts | X | X | X | X |
| | | | Instream | Channel Manipulation | | | | | | | | | | | | | | | |
| | | | Floodplain | Reconnection | | | | | | | | | | | | | | | |
| | | | | Modification | | | | | | | | | | | | | | | |

| | | | | | Available Data for Post Project Appraisal | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Name | Stream | Location in the Watershed | Project Class | Project Type | Project Objectives | Budget / Workplan | Schedule | Engineering Design | Ground Surveys or Cross Sections | Annual report | Completion report | Other Agency report | Fish data | WQ data | Other data | Aerial-pre | Aerial-post | Photo-Points | Other photos |
| Beatty Station | Sprague River | Middle | Instream | Channel Manipulation | X | X | | X | X | X | X | | X | X | 09PS | X | | X | X |
| Nine Mile Road | Sprague River | Lower | Riparian | Management | X | X | | X | X | X | X | OWEB | | | | X | | X | |
| | | | Instream | Channel Manipulation | | | | | | | | | | | | | | | |
| Southside Levee Breach | Sprague River | Lower | Riparian | Management | X | X | X | X | X | X | X | | X | X | | | | | X |
| | | | | Expansion | | | | | | | | | | | | | | | |
| | | | Floodplain | Reconnection | | | | | | | | | | | | | | | |
| | | | | Management | | | | | | | | | | | | | | | |

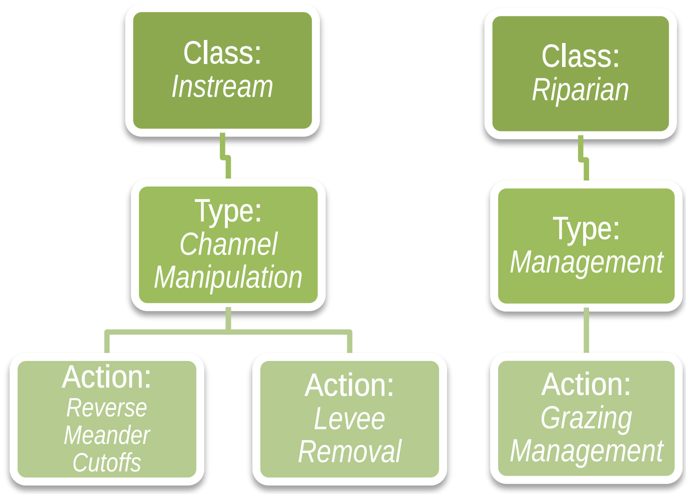
# 6 Project Case Studies

## 6.1 Nine Mile Road Project – Sprague River Mainstem

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**




### 6.1.1 PPA Synopsis

We selected this project to provide a PPA case-study of meander cutoff reversal (locally referred to as "chute cutoff plugging") combined with grazing management. This project also included levee (railroad grade) modification to increase channel – floodplain connectivity, but our PPA focused on the chute cutoff plugging and grazing management aspects of the project because documentation of the levee modification aspects was limited. The Nine Mile Road project fits both the instream and riparian classes, with channel manipulation, management, and expansion project types. Our PPA of this project was informed by the meander bend cutoff and grazing conceptual models.

The documents developed for this project listed both site specific goals (e.g. restoring geomorphic function to 1.7 miles of the Sprague River) and basin wide goals (e.g. improving fish populations of the Sprague River). These goals were supported by objectives that were also both site specific (e.g. blocking cut-off chutes) and basin wide (e.g. incrementally increasing total instream habitat in the basin – this objective was implied rather than specifically stated). We conducted our PPA of this project by evaluating limited pre-project baseline data and two years of post-project monitoring data, to which we added a third year of channel survey data and photo point observations. As we discussed in the introduction to this report, the uncertainty surrounding the present rate of channel straightening by meander cutoffs in the Sprague River Basin makes a definitive appraisal of the performance of this type of project challenging, especially at the basin scale.

The primary lessons learned from this project were that the reoccupied meander bend has incised without significant changes in channel width since the chute cutoff was plugged, and that grazing management has facilitated establishment of new vegetation growth, especially willow growth at the bioengineered chute plug structures. Basin wide lessons were harder to extract from this project, but given the significant cost and physical effort associated with chute cutoff plugging, we are uncertain about the larger-scale benefits of this practice and therefore suggest that additional investigation of the current rate of meander bend cutoff and creation as well as the habitat value of meander bends that have been cut off be completed prior to implementation of additional meander bend cutoff plugs.

### 6.1.2 Site Conditions

This project is located in a valley approximately nine miles east of Chiloquin, Oregon (Figure 6.1-1), immediately upstream of an approximately 3,000 foot long reach that was confined by levees on the north bank between 1940 and 1968. The project reach includes approximately ten meanders and has experienced very limited lateral migration except at the five locations where meander cutoffs occurred between 1940 and 2009. While the meander cutoffs have reduced local sinuosity, total channel length has actually increased since 1940 as the reach that includes the project area has transitioned from a single thread to a multi-thread planform. Riparian and floodplain areas along the project reach have likely been grazed for at least the past century (StreamWise 2007), and evidence of this land use is readily apparent throughout the project area.

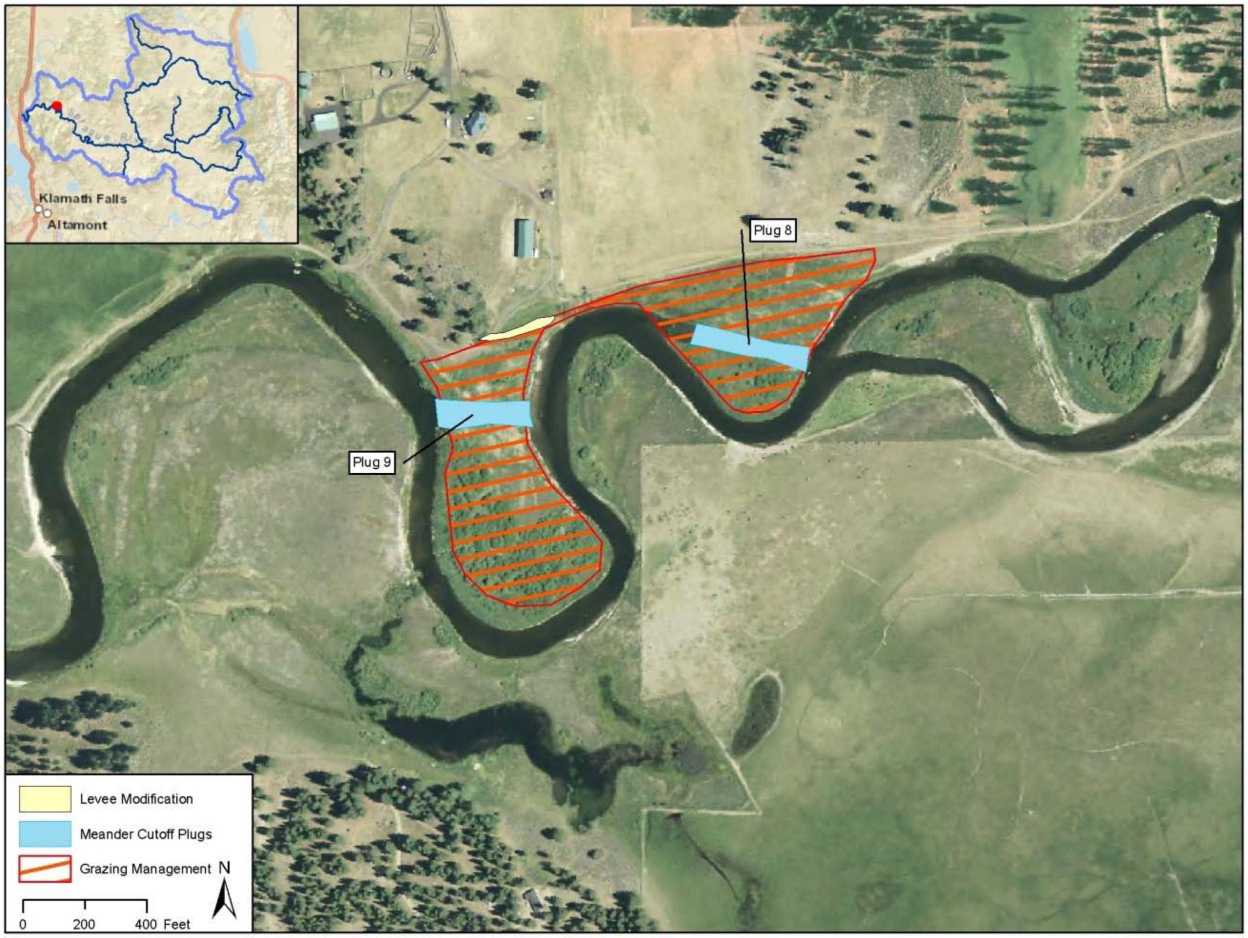



*Figure 6.1-1:The Nine Mile Road Project, approximately 9 miles east of Chiloquin, OR, included two meander cutoff plugs, planting, grazing management, and levee modifications. Aerial photograph from 2009.*

### 6.1.3 Success Criteria

The documentation for this project cited a wide range of site specific and basin scale goals and objectives. Site scale goals included restoration of hydrologic and geomorphic function to 1.7 miles of the Sprague River and enhancing 100 acres of floodplain habitat by achieving the site-specific objectives of blocking cut-off chutes, returning the river to its natural sinuosity, decreasing local channel flow velocities and bank shear stresses, creating a narrower channel, installing large wood, boulders, and soil, planting riparian species, transplanting wetland fringe sod mats, and implementing fencing and grazing management. Basinwide goals included improving fish populations (including redband trout) and restoring the form, health, and function of the Sprague River by incrementally increasing total instream, riparian, and floodplain habitat in the basin. While there was a relatively large set of objectives proposed for this project, the objectives mostly align with the objectives identified and discussed for this type and class of project in the Organizational Framework in Section 3 of this report. However, because of limited baseline, as-built, and post-project monitoring data, we were only able to assess the performance of this project with respect to a limited subset of goals and objectives.

### 6.1.4 Project Timeline

The meander cut-offs plugged by this project were present as early as 1994. The foundational document for this project (StreamWise 2002) identified and documented the need for a site survey to support the "reconnection of historic meanders…" to "restore the historic sinuosity and flow characteristics to reduce erosion and loss of habitat" in 2002. The general restoration approach proposed in this document was affirmed and refined with respect to grazing management in 2003 (Corzatt 2003), and around the same time, the landowner of the project site submitted a grant application (Webb 2003) for the project to the Oregon Watershed Enhancement Board (OWEB). The grant application was funded in September of 2003, and design documents were completed in 2004 (Schlumpberger 2004). Next, the Department of State Lands (2005) issued a "Removal-Fill Permit" in August of 2005 and construction of the two chute cutoff plugs (at sites 8 and 9) was substantially completed by the end of 2005. The largest peak flow of the last decade (3,590 cfs at Chiloquin) occurred on January 5, 2006, shortly after the project was completed. A limited post project assessment was completed in 2007 (Streamwise 2007). In addition, photo point documentation and surveys of channel geometry and longitudinal profile were completed in 2007 and 2008, along with letter-form monitoring reports with photos and qualitative observations (OWEB 2007 and 2008). Finally, we completed channel geometry and longitudinal profile surveys and reoccupied photo points in September of 2011 in support of this PPA.

### 6.1.5 Relevant Conceptual Models

The ***meander bend cutoff*** and ***grazing*** conceptual models guided our PPA of this project. The meander bend cutoff conceptual model describes how meander bend cutoffs occur and affect channel morphology, and describes the primary assumption used to justify meander bend cutoff plugs: that meander bend cutoffs result in a permanent net reduction in channel length, sinuosity, and thus habitat value. The grazing conceptual model describes how changes in cattle grazing and planting of native vegetation are typically expected to create more natural riparian conditions (see Section 3.2 for more details on conceptual models). The goals and objectives of the Nine Mile Road project indicate that the project proponents and designers were aware of the typical changes predicted by these conceptual models for the implemented actions. Exclusion of grazing from areas prone to scour and erosion and reestablishment of native riparian vegetation are proven approaches to restoring more natural riparian conditions. However, the clear focus of this project on meander cutoff plugging as the primary action suggests that alternate approaches to restoring more natural instream conditions and dynamics may have been unnecessarily discounted.

For example, additional reductions in channel confinement by levees immediately adjacent to and downstream of the project area, paired with grazing management and planting in the project area, could have been implemented instead of one or both of the meander plugs to determine whether or not such changes could contribute to more natural instream and riparian conditions at a larger scale than the actions taken by this project were able to achieve. Perhaps even more importantly, more careful documentation of local channel geometry and planform changes through time in the pre-project meander bends could have been conducted to definitively determine whether or not habitat conditions in the meander bends were actually degrading, and if so, at what rate. While this project did achieve many of its site specific objectives, there is a lack of sufficient data available to determine whether or not satisfying these objectives was better at either the site or watershed scale than other approaches that could have been applied at this site.

### 6.1.6 Post Project Appraisal

#### *6.1.6.1 Methods*

The Project Framework introduced in Section 3 lists several metrics that could be used to evaluate the performance of this type of project relative to its goals and objectives. The availability of monitoring data for this project was better than for most of the other sites we evaluated for this project. Still, ideally, a more complete suite of assessment methods would be applied to future similar projects so that more can be learned as those projects evolve through time. We collected monitoring data in September 2011 that included comparing historical and current ground and aerial photos, resurveying monitoring cross sections, and surveying a longitudinal profile of the main channel spanning both meander cutoff plugs, as well as surveys across the plug surfaces (Figure 6.1-2). We surveyed the plugs to compare with as-built data and to document plug elevations for future resurvey. A decrease in the elevation across the plug could show that the channel is attempting to re-create the cutoff. Due to problems with the survey control established for surveys prior to 2011, we had to manipulate the survey data for prior surveys using stable features at each cross section to reference historical survey data to the datum we used in 2011.

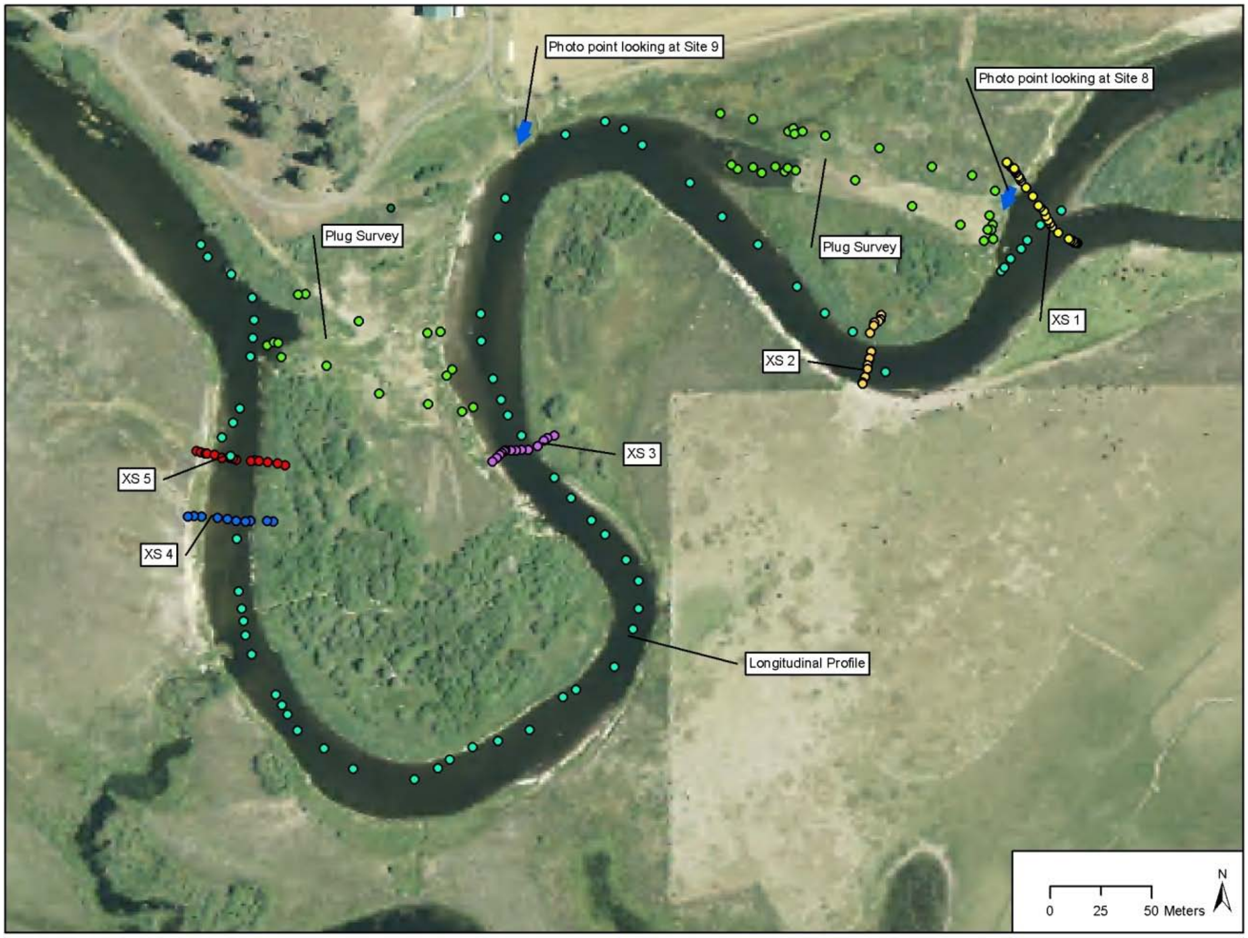



*Figure 6.1-2: Location of channel cross sections longitudinal profile used to evaluate instream changes between 2004 and 2011.*

### 6.1.6.2 Results

#### 6.1.6.2.1 Historical Photo Comparisons

We compared historical series of aerial and ground photography to evaluate post-project performance with respect to changes in channel planform, geometry, and stability of constructed features. Figure 6.1-3 includes aerial photographs from 1940, 1995, 2001, and 2009 and shows the development of the meander cut-offs by 1995, the persistence of the cutoffs and relative stability of adjacent channel areas through 2001, and the installation of the cutoff plugs by 2009. The ***meander bend cutoff*** conceptual predicts that the cutoff channel would eventually capture the entire channel, but there was no evicence of this from the aerial photographs. While we could not discern changes in channel geometry from the aerial photos, it is important to note that that the historical meanders remained relatively stable after the cutoffs formed, and that the total aquatic and riparian habitat area actually increased in this reach with the cutoffs. There was approximately 16,900 feet of channel length in 2005 prior to completion of the cutoff plug compared to only 13,500 feet in 1940 and after the plugs were completed, a difference of approximately twenty five percent. Because one of the primary basin scale objectives of this project was to increase total instream, riparian, and floodplain habitat in the basin, more detailed mapping and analysis of habitat in the project reach should have been conducted prior to the project to allow evaluation of the completed project.

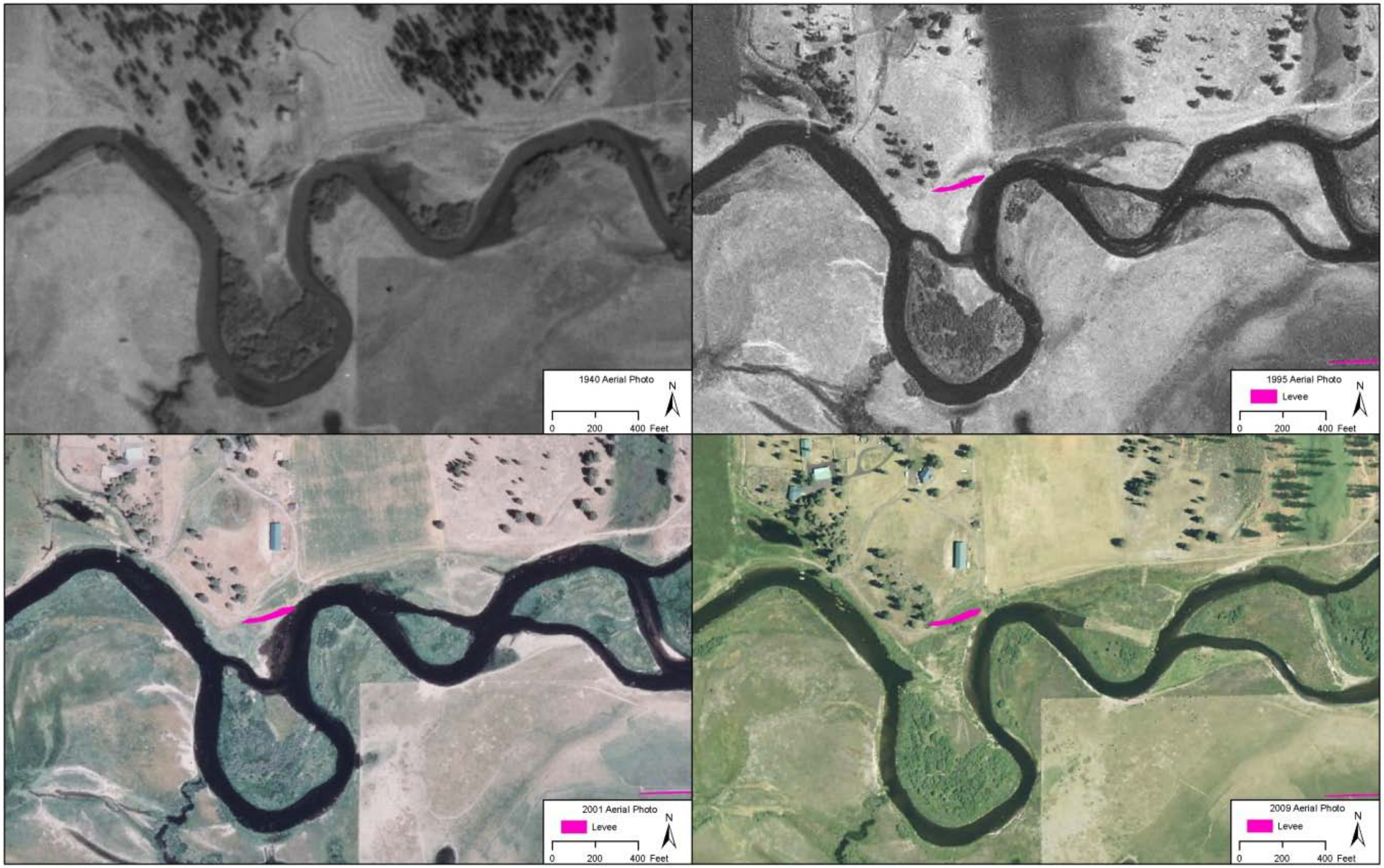



*Figure 6.1-3: Historical aerial photograph sequence of the project reach from 1940, 1995, 2001, and 2009 showing development and persistence of meander cutoffs and implementation of meander cutoff plugs.*

The 2001 and 2009 aerial photographs show that grazing management may have contributed to significant vegetation establishment on the fill material of cutoff plug nine (downstream), but significantly less vegetation establishment on cutoff plug eight.

Figure 6.1-4 and Figure 6.1-5 are historical ground photo series of the upstream faces of meander cutoff plugs eight and nine, respectively. Both photo series clearly show the stability of the upstream end of the bioengineered plug and the establishment of willows and other vegetation on the plug surface. Based on this photo monitoring, the plug appears to have performed as described in the project success criteria over the first six years since it was installed.

*Figure 6.1-4: Looking southeast (downstream) from upstream end of meander cutoff plug at site 8 in 2006, 2007, and 2011 (from left to right) showing stability of meander plug and recruitment and growth of willows and other vegetation.*

*Figure 6.1-5: Looking southeast (downstream) from upstream end of meander cutoff plug at site 9 in 2005, 2006, 2008 and 2011 (clockwise from upper left) showing installation of meander plug, meander plug inundation during spring high flows, and recruitment and growth of willows and other vegetation increasing the stability and structure of the meander plug.*

#### 6.1.6.2.2 Channel Geometry

We resurveyed channel monitoring cross sections (Figure 6.1-6 to Figure 6.1-9) to assess changes in channel geometry that have occurred since the cutoff plugs were completed and the grazing management was initiated at this site. At cross section two (Figure 6.1-7) we were also able to evaluate changes in channel geometry relative to pre-project conditions. It is important to note that we did have to manipulate historical monitoring data to facilitate these comparisons, as the control networks and monuments from previously completed surveys were not consistent. Therefore, the general trends we detected offer more reliable insights on post project performance than the exact magnitudes of the changes we discerned from this evaluation.

We observed lateral migration toward the left bank at cross section one, which is opposite the meander plug and possibly due to redirection of flows from the plug. At cross section two, in addition to the grading of the cutoff plug we documented approximately two feet of channel incision. Channel incision was not explicitly stated as a project objective, however channel narrowing was, which could imply that some incision was expected because a narrower channel would likely have to be deeper as well to convey peak flows after the conveyance capacity of the cutoff was eliminated with the cutoff plug. Interestingly, at this cross section and cross section three, there appears to have been some channel widening, as opposed to the narrowing expected by the implementers of the project. This finding highlights the need for more careful consideration of the meander cutoff and plug conceptual models when considering future cutoff projects in the basin. If this cutoff plug project is actually inducing incision that was not expected and could be detrimental to other restoration efforts in the basin (e.g. a lowered base level could reduce the effectiveness of fish passage, riparian enhancement, and other restoration project types), its local benefits may not offset its basinwide costs. We also observed incision (less than one foot) and some widening at cross section three, and possibly some lateral migration at cross section five. Our evaluation suggests that the expected channel narrowing is not yet occurring.

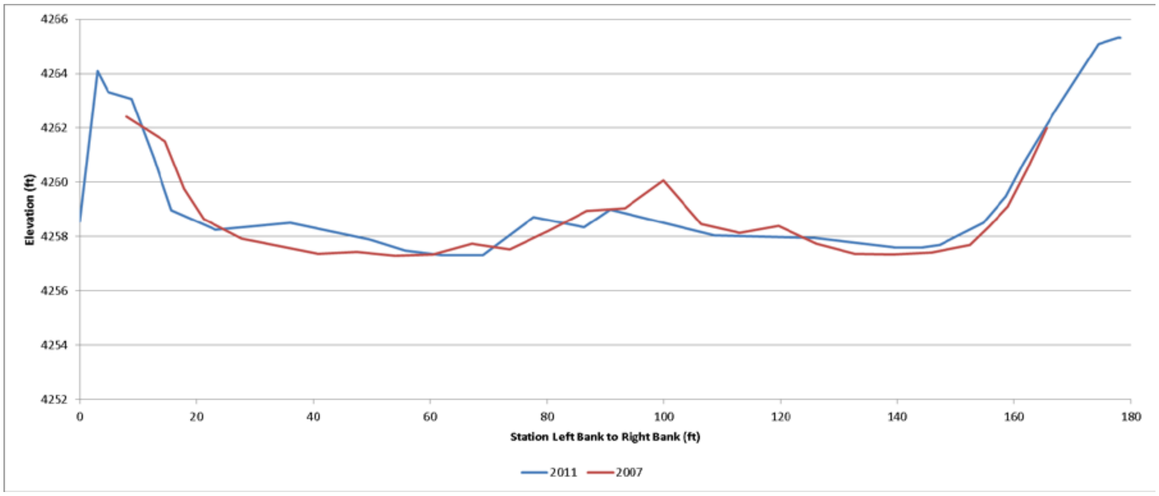



*Figure 6.1-6: Channel geometry in 2007 and 2011 at cross section number one (location shown in Figure 6.1-2)*

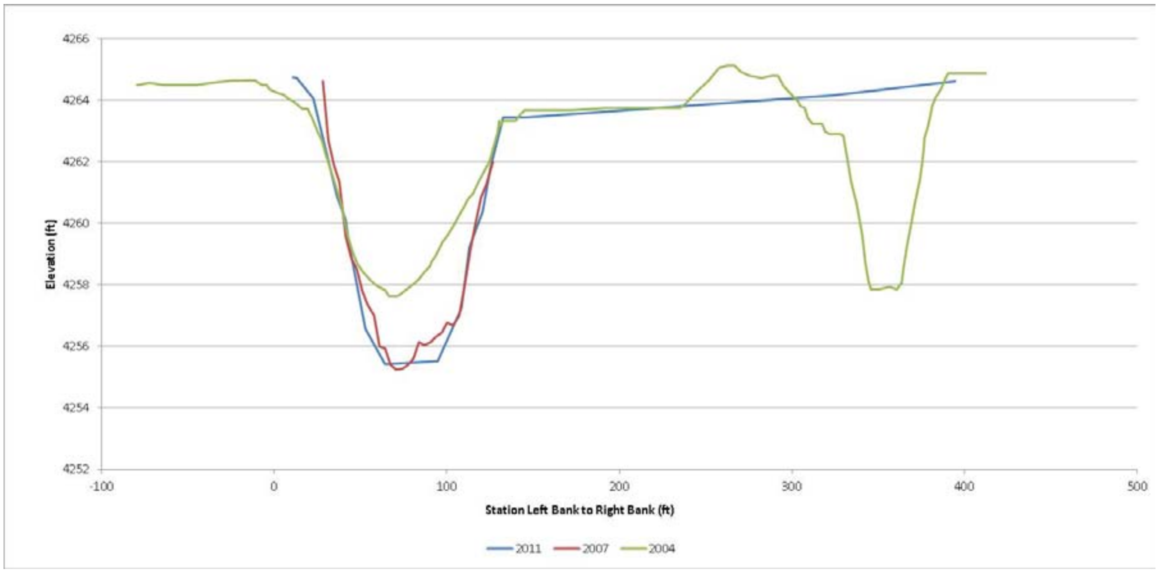



*Figure 6.1-7: Channel geometry in 2004, 2007, and 2011 at cross section number two (location shown in Figure 6.1-2)*

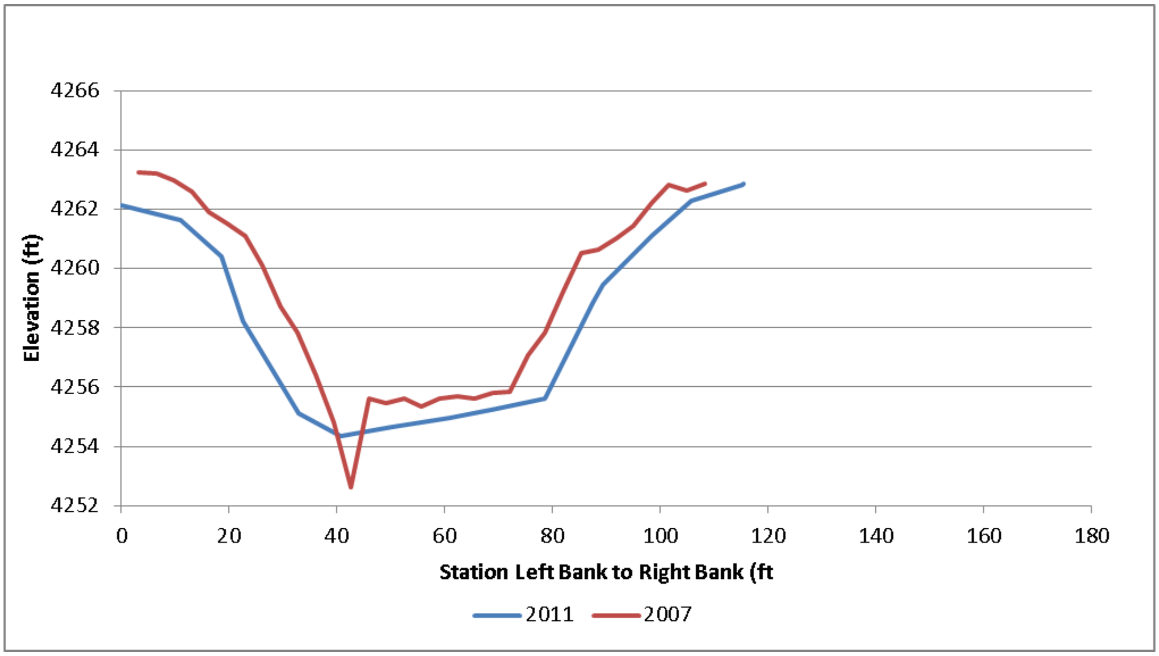



*Figure 6.1-8: Channel geometry in 2007 and 2011 at cross section number three (location shown in Figure 6.1-2)*

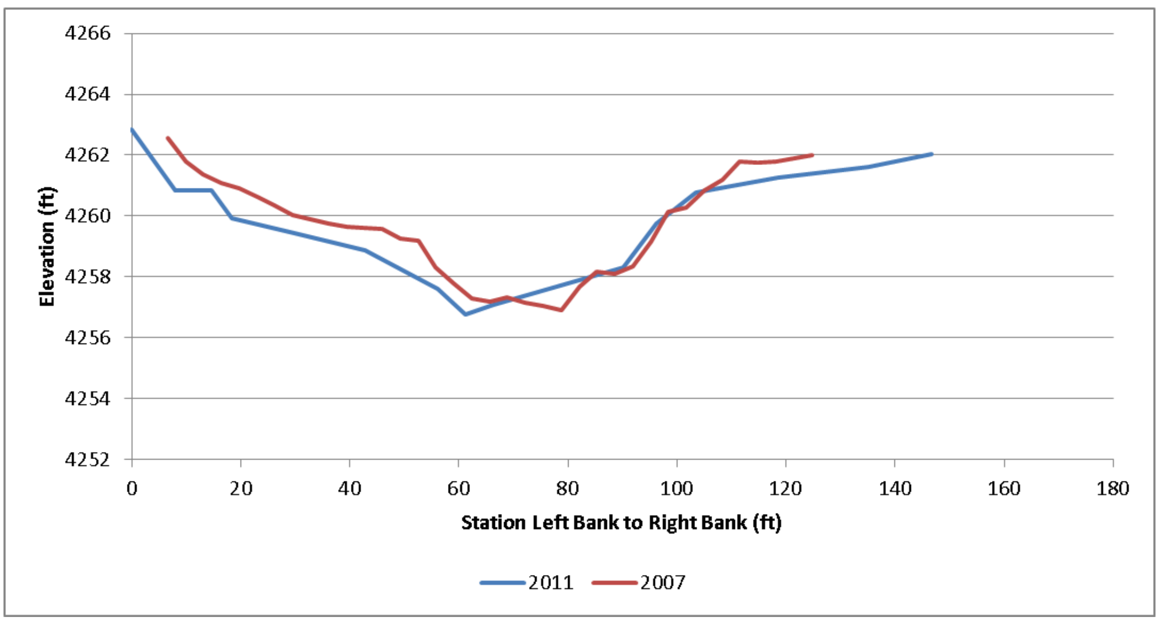



*Figure 6.1-9: Channel geometry in 2007 and 2011 at cross section number five (location shown in Figure 6.1-2)*

### 6.1.7 PPA Lessons Learned

This project resulted in a major change to the Sprague River corridor in the Sprague River Basin. Two active meander bend cutoffs were plugged and armored with bioengineered bank protection and vegetation to prevent reactivation of the cutoffs. This project involved tens of thousands of cubic yards of earthwork and hundreds of thousands of dollars in planning, design, and construction cost. Given the significance and level of effort required to implement this type of project, we felt it was important to objectively capture both the positive and negative lessons learned from this PPA. Table 6.1-1 summarizes these lessons.

*Table 6.1-1: Summary of key lessons learned from the Nine Mile Road Project*

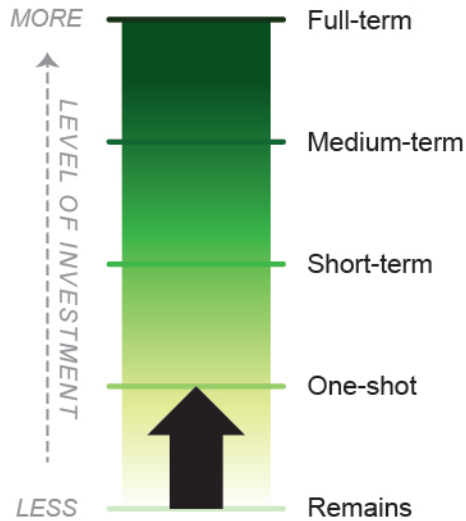
| Stream Restoration Project Life-cycle Phase | Scale for Lesson | Lessons Learned* |
|---|---|---|
| Pre-Project (goal and objective setting, planning, data collection, analysis) | Site-specific and Basinwide | Future meander cut off projects should more explicitly and carefully consider the potential processes contributing to meander cut offs (e.g. downstream confinement influencing hydraulics in the project reach) prior to design and implementation. |
| | Basinwide | If meander cut off plug projects will be considered in the basin in the future, studies to determine whether single thread channels with greater sinuosity are more or less valuable than multi-thread channels with greater total length should be completed |
| Design | Site-specific and Basinwide | Future meander cutoff designs should consider a phased approach starting with elimination of processes contributing to accelerated cut offs (e.g. levee removal, hardened bank "loosening," etc.) followed by cut off plugging when the benefits of plugging are better understood . |
| | Basinwide | If meander cut off plug projects will be considered in the basin in the future, the validity of using "historic" conditions as a reference condition for restoration design should be tested (especially in light of the changing rates of meander cut off and lateral migration documented since the 1960s) . |
| Implementation | Site-specific | The meander cutoff plug and grazing management approaches used in this project were successful and have been stable since implementation. |
| | Site-specific and Basinwide | Plugging meander cutoffs can lower the invert of the original meander channel, presumably by forcing higher flows with greater shear stresses back through the original meander channel, resulting in channel bed scour |
| | Basinwide | If meander cutoff plug projects are deemed beneficial for other locations in the basin, similar implementation approaches to those used at this site should be used . |
| Monitoring | Basinwide | A systematic framework for project monitoring is required so that future monitoring efforts are more directly tied to project goals and objectives and can be compared with contemporary monitoring efforts to assess all aspects of project performance . |

| Stream Restoration Project Life-cycle Phase | Scale for Lesson | Lessons Learned* |
|---|---|---|
| | Site-specific | Monitoring networks for this type of project should be extended upstream and downstream to assess the influence of meander cutoff plugs on channel evolution outside the project area. |
| | Basinwide | The basinwide benefit of meander cut off plug projects cannot be adequately assessed without a better understanding of the upstream and downstream channel and riparian changes related to the cut off and the value of restored single-thread planform compared to the multi-thread planform associated with active cut offs. |

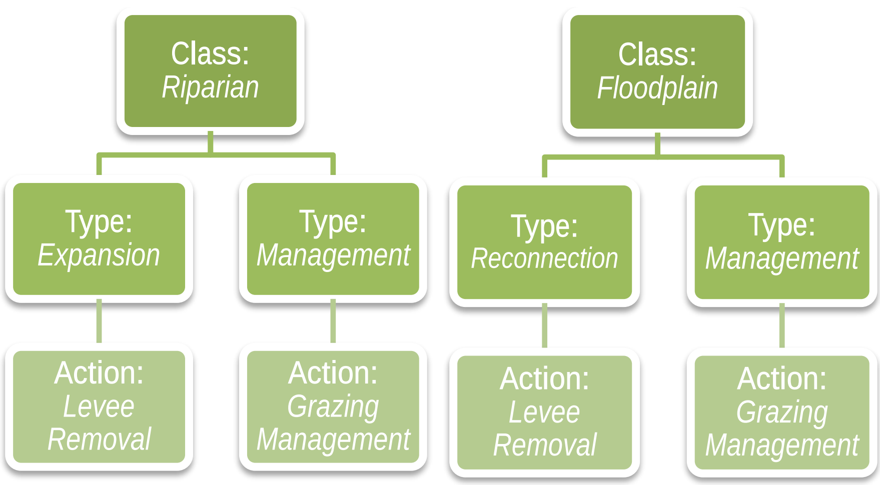
As summarized in Table 6.1-1, the most important lessons learned from this project are related to the meander bend cut off plug element of the project. Meander bend cut off plugging is a major change to river conditions supported by an understanding of the processes driving meander cut off and the resulting short and long term habitat impacts that is still uncertain. Therefore, we recommend that high priority be given to reducing the uncertainty of both of these aspects of meander cut offs before proceeding with additional future meander cut off plug projects. While this uncertainty is being reduced, sites with cut offs should consider actions that deal with other potential drivers of habitat simplification such as channel confinement or grazing. Once studies have been completed that adequately quantify the benefits of meander cut off plugging, the design and implementation approaches used in this project should be used as a guide since they appear to have been successful and likely sustainable over the long term. However, a more systematic approach to monitoring this type of project that includes expanded spatial range and better documentation of baseline conditions must be implemented to allow more detailed evaluations of future projects that can substantially reduce the uncertainties about the performance of value of this type of project at the site and basin scales.

## 6.2 Southside Levee Breach Project – Sprague River (Lower Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**




### 6.2.1 PPA Synopsis

We selected this project to provide a PPA case study of levee removal (or, more accurately, levee breaching) to restore connectivity between the Sprague River channel and its floodplain combined with grazing management. The Southside Levee Breach project fits both the riparian and floodplain classes, with expansion, reconnection, and management project types. Our PPA of this project was informed by the ***Corridor Confinement*** and ***Grazing*** conceptual models. We categorized this PPA as a one-shot based on available monitoring data and the duration of the monitoring for the floodplain wetland elements of this project.

This project had both site specific goals (e.g. creating backwater fish habitat) and basin wide goals (e.g. improving river corridor habitat for two endangered sucker species). These goals were supported by objectives that were also both site specific (e.g. removing portions of the existing levee) and basin wide (e.g. increasing availability and duration of juvenile fish nursery habitat). We conducted our PPA of this project by comparing limited pre-project survey data for two of the three reconnected floodplain oxbow wetland areas and the Sprague River with proposed design conditions and topographic surveys of the breaches, the floodplain wetlands, and the Sprague River that we conducted in 2011. We also compared historical aerial photographs of the site and ground photos taken at similar photo monitoring locations.

The primary lessons learned from this PPA were that this type of floodplain reconnection project requires hydrologic and hydraulic monitoring of the floodplain and the constructed levee breaches to understand changes in hydraulic connectivity between the channel and floodplain and the implications of the restored connection for fish and other organisms use of the floodplain and sustainability of the breach. In addition, we learned that biological monitoring should be conducted regularly in reconnected floodplain habitats like the ones created by this project, as these habitats appear to attract juvenile and adult fish (including suckers) and could cause stranding if the connectivity between the river channel and the floodplain is compromised.

### 6.2.2 Site Conditions

This project is located on a ranch that borders approximately 3.5 miles of the Sprague River (river mile 24-27.5), and is located 11 miles East of Chiloquin, OR off the Sprague River Highway (Figure 6.2-1). The river has a tight south – north meander near the middle of the project area but is otherwise relatively straight through the site. There is forested high ground in the southwest corner of the site. The remainder of the site is floodplain that has been modified with irrigation channels, roads, and other infrastructure. The defining feature of the site from the perspective of this project is the levee along the south bank of the river.

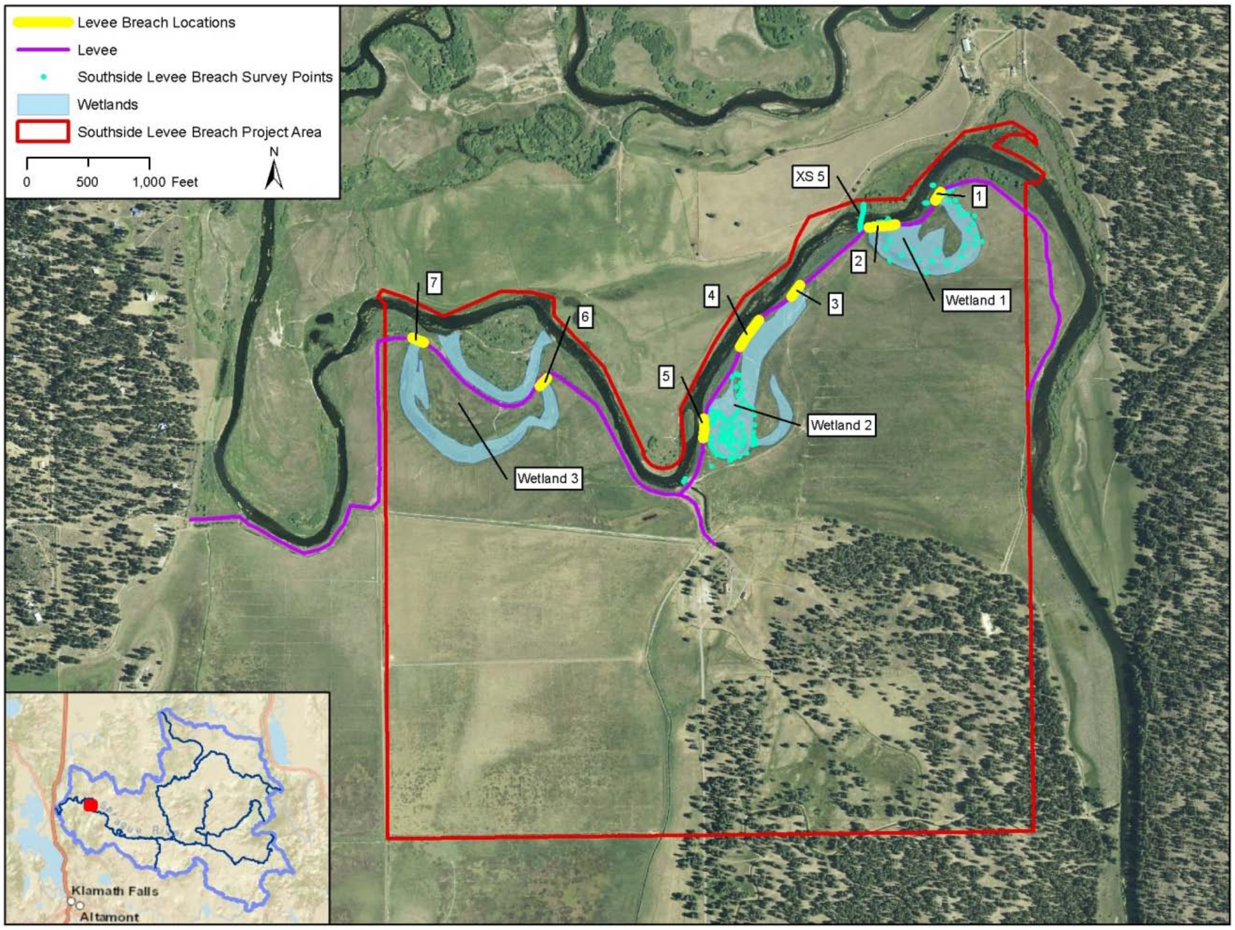



*Figure 6.2-1: The Southside Levee Breach Project, approximately 11 miles east of Chiloquin, OR, included reconnection of three floodplain wetlands using seven levee breaches. We conducted our PPA on Wetland 1 and Wetland 2. Aerial photograph from 2009.*

### 6.2.3 Success Criteria

The documentation for this project cited a wide range of site specific and basin scale goals and objectives. Site specific goals included improving the flood frequency of the Sprague River floodplain and promoting availability of backwater fish habitat. Basin wide goals included improving river corridor habitat for two endangered sucker species, improving water quality, and increasing ecological function through restoration of a more natural hydrologic regime. The project also had site specific objectives including removing, lowering, or breaching portions of the existing levee network that prevent flooding during frequent flood events, and basin wide objectives including increasing availability and duration of juvenile fish nursery habitat by increasing inundation in back water channels and increasing availability and duration of emergent and open water wetland for waterfowl habitat through modification of the hydrology of backwater habitats.

### 6.2.4 Project Timeline

The levees between floodplain wetlands 1 and 2 and the Sprague River constructed between 1940 and 1968 prevented the river from accessing its floodplain in these areas during relatively small peak flows (i.e. less than 2 – 5 year recurrence interval flows). Peak flows greater than the 20-year return-interval likely overflowed the levees (Interfluve 2006), however there would have been no direct flow path from the floodplain back into the channel on the receding limb of high peak flows prior to this project. The livestock grazing that historically occurred on this property was discontinued in 2003. A detailed assessment of the Wayne Ranch conducted in 2005 (RDG 2005) compiled basic site data (channel, floodplain, and levee surveys; air photo analysis) and identified restoration opportunities for the site, including floodplain reconnection. The 2005 assessment determined that the floodplain wetlands were inundated by spring runoff, but were not connected to the Sprague River below the 1-year flow. The restoration concept advanced by the 2005 plan discounted full floodplain channel reactivation and noted that significant volumes of fine sediment had deposited in wetland 1 and wetland 2 (referred to as wetland 3 in the 2005 plan).

A 2006 inundation analysis and conceptual design (Interfluve 2006) used a Hydrologic Engineering Center River Analysis System (HEC-RAS) model to analyze hydraulics and locate levee breach locations and elevations. The design for the breaches was completed and all necessary permits were acquired for construction of the breaches in 2007. Baseline water quality and fish presence/absence monitoring was also completed in 2007, just prior to the construction of the levee breaches in late 2007. The spring 2008 peak flow in the Sprague River was less than 2000 cfs at Chiloquin (less than a 2-year flow) but did flow through the levee breaches and into the floodplain wetlands. Subsequent fish sampling in 2008 showed significant fish use of the reconnected floodplain areas by a range of species including larval suckers, which required emergency flow diversions to the floodplain wetland during the summer months to prevent stranding of suckers. A summary of monitoring activities through 2008 was completed in early 2009, and we conducted this PPA in 2011.

### 6.2.5 Relevant Conceptual Models

The ***Corridor Confinement*** and ***Grazing*** conceptual models guided our PPA of this project. The corridor confinement conceptual model describes how levees directly disrupt the hydraulic connection between the river and its floodplain, and indirectly contribute to degradation of both off-channel (by dewatering) and instream (by concentrating high flow energy) habitats. The grazing conceptual model describes how changes in cattle grazing are typically expected to facilitate development of more natural riparian and floodplain vegetation conditions (see Section 3.2 for more details on conceptual models). The goals and objectives of the South Side Levee Breach project indicate that the project proponents and designers were mostly aware of the typical changes predicted by these conceptual models for the implemented actions associated with this project, with one important exception. The project goals and objectives rightly focused on reconnecting the channel and floodplain, restoring a more natural floodplain inundation frequency, and providing off-channel nursery habitat for native suckers. However, the nuance of the channel confinement conceptual model that was not considered was that a levee breach does not function in exactly the same way as complete levee removal, especially with respect to fish passage onto and off of the reconnected floodplain. A levee breach creates a single point of connection between the channel and floodplain with unnatural hydraulic and sediment transport characteristics. A complete levee removal restores more natural hydraulic and sediment transport dynamics to the inundated riparian zone, which would limit or even eliminate the breach stability and fish passage challenges faced in the initial years of this project. To determine the length of levee breach needed to restore natural hydraulic and sediment transport dynamics, we recommend conducting modeling to identify hydraulic and sediment transport thresholds that could influence performance.

### 6.2.6 Post Project Appraisal

#### *6.2.6.1 Methods*

The Project Framework introduced in Section 3 suggests prioritizing monitoring for this type of riparian expansion and floodplain reconnection project by first measuring physical changes in riparian and floodplain conditions along with biological colonization of both areas, followed by secondary measurements of changes in water quality (e.g. temperature and nutrients). Monitoring activities to date have included all of these types of measurements. However, the biological monitoring has focused almost exclusively on fish use while mostly ignoring vegetation colonization; the physical topography monitoring has been conducted in the channel but not in the reconnected floodplain wetlands; and the water quality monitoring has not been continuous.

Therefore, to leverage and supplement the available monitoring data for this project, we conducted historical aerial and ground photograph comparisons to track coarse scale changes in floodplain conditions, surveyed topography in the reconnected floodplains, the constructed levee breaches, and the adjacent Sprague River (Figure 6.2-2) to identify major changes since construction, and compiled results from fish sampling conducted using the EPA EMAP protocol in 2007 and 2008. We did not use the water quality sampling data collected at this site because it was not collected continuously before and after the project and therefore was not conducive to project performance evaluation because of seasonal and other influences on water quality that we could not account for with the available data.

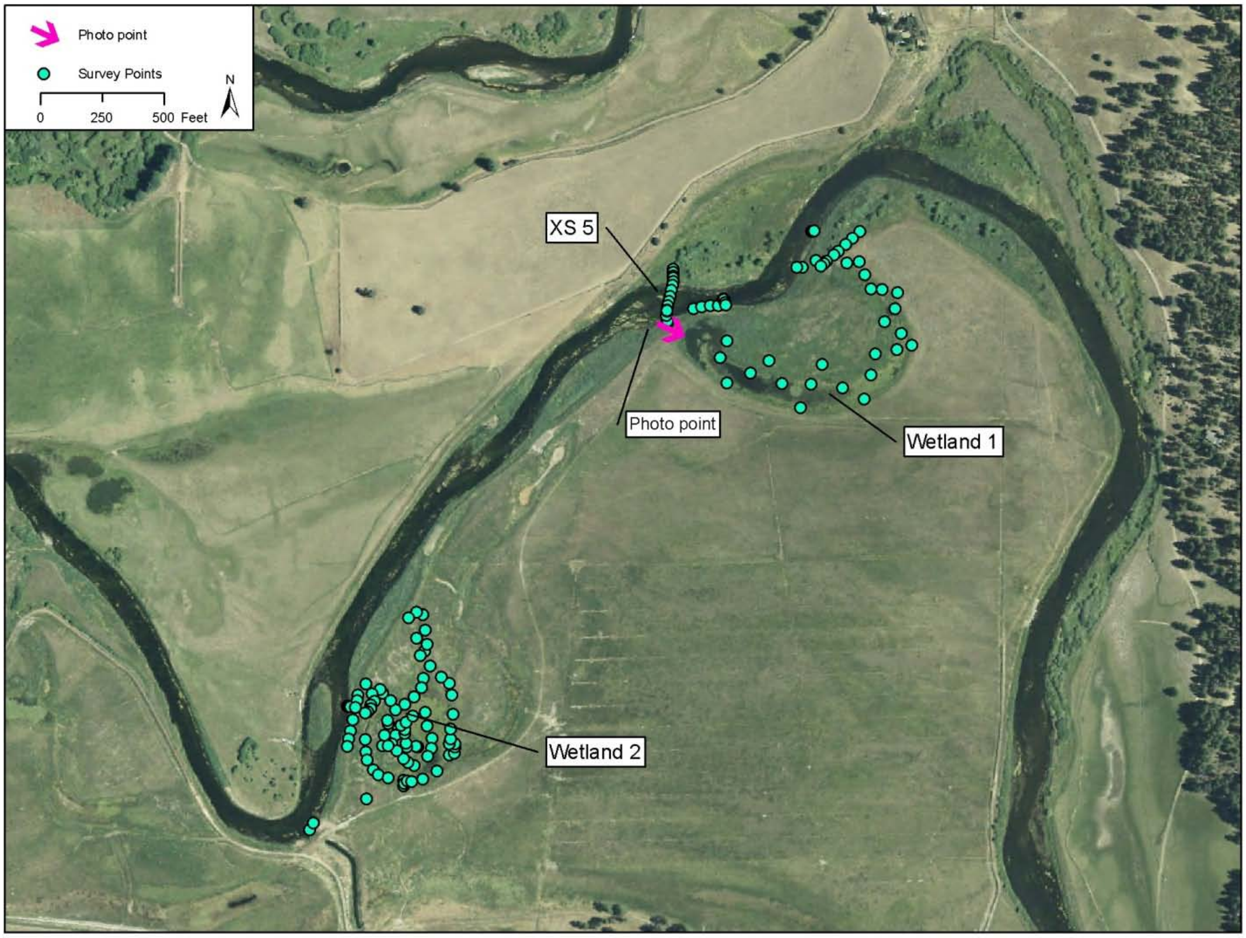



*Figure 6.2-2: Location of channel cross sections and longitudinal profile used to evaluate instream changes between 2004 and 2011.*

### 6.2.6.2 Results

#### 6.2.6.2.1 Historical Photo Comparisons

We compared series of historical aerial and ground photographs to evaluate post-project performance with respect to changes in channel planform, geometry, and stability of constructed features. Figure 6.2-3 includes aerial photographs from 1940, 1995, 2001, and 2009 and shows that the Sprague River channel along the reconnected floodplains has been extremely stable over time, and that between 2001 and 2009 slight differences in floodplain wetland vegetation appear to have occurred – likely related to the exclusion of grazing and possibly due to the levee breaches as well.

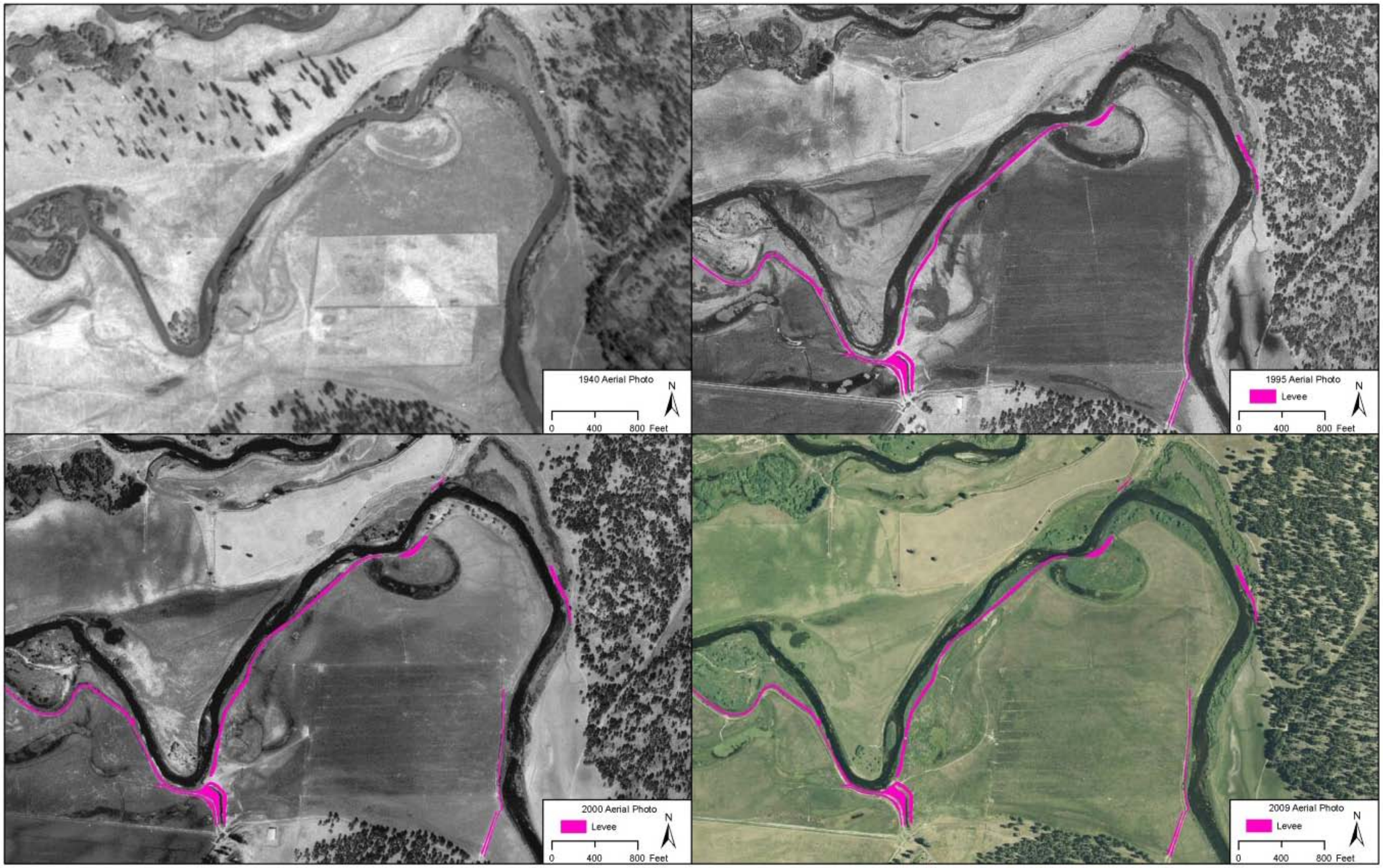



*Figure 6.2-3: Historical aerial photograph sequence of the project reach from 1940, 1995, 2000, and 2009 showing stability of Sprague River channel and expanded floodplain wetland vegetation extent in wetlands 1 and 2.*

Figure 6.2-4 is a pair of historical ground photos looking southeast into levee breach 2 in wetland 1 showing the difference in both wetland and upland vegetation between 2005 and 2011. Grazing was eliminated in 2003, so this change could be partially attributed to natural vegetation succession without grazing pressures. The restored connectivity, especially in the immediate vicinity of the levee breach, could also be partially responsible for this change. Of course, the change could also be related to differences in the time of year of the photo. However, the condition of the upland vegetation suggests that both pictures were taken during a relatively dry period, so it is likely that the observed differences are not just seasonal.

*Figure 6.2-4: Looking southeast into the western arm of wetland 1 in 2005 and 2011 showing increased coverage of both wetland and upland vegetation in and adjacent to the floodplain wetlands.*

#### 6.2.6.2.2 Compilation of fish monitoring results

We compared the results from the EMAP fish surveys in October 2007 (Sprague River only) and in June 2008 (Sprague River and reconnected floodplain wetlands). Both surveys detected large scale suckers (11 in 2007, 18 in 2008) in the river. The 2008 survey detected fish in the wetlands as well, with high numbers of unidentified juvenile suckers in wetland 3. The 2008 survey indicates that the hydraulic connection between the river and floodplains was functioning, although perhaps more effectively at wetland 3. Additional future fish monitoring in the reconnected floodplain habitats will be critical for refining our understanding of both the site specific and basin wide benefits of this type of project.

#### 6.2.6.2.3 Levee breach and floodplain wetland survey comparisons

Figure 6.2-5, Figure 6.2-6, and Figure 6.2-7 show the surveyed topography of levee breaches 1, 2, and 5 in 2011 compared with the conceptual design elevations proposed for the breaches (Interfluve 2006). It is unclear why the constructed levee breaches are all six to seven feet higher than the proposed elevations, and we were not able to acquire any later design documents explaining this difference. However, we know from the 2008 peak flow that the breaches are activated by less than a 2-year flow, which is consistent with the conceptual design. Therefore, the discrepancy between proposed and design elevations may not be important. Clearer documentation of the design process would have helped us understand the importance of this discrepancy. All of the breaches have maintained their flat bottom profile, with very minor deposition at breach five.

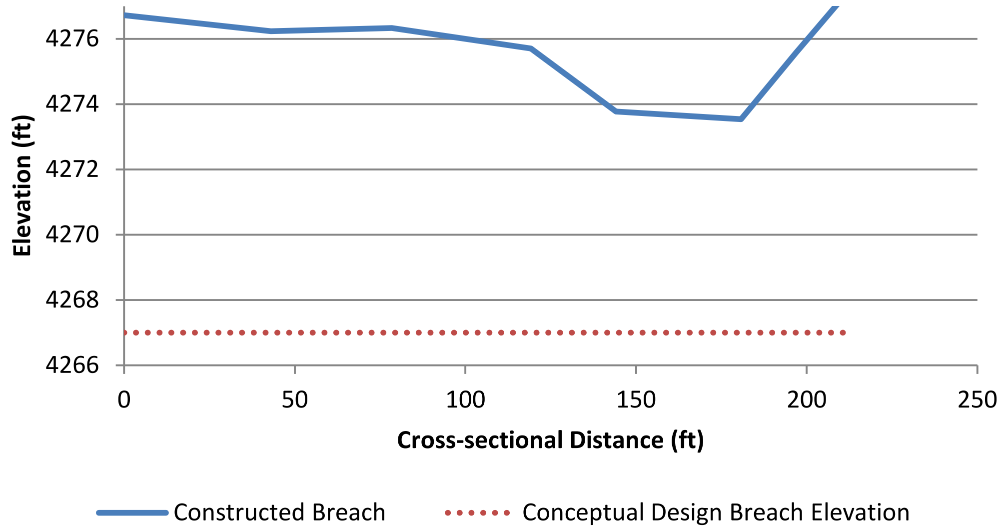



*Figure 6.2-5: Levee breach geometry in 2011 and in the proposed conceptual design at Breach #1 (location shown in Figure 6.2-1)*

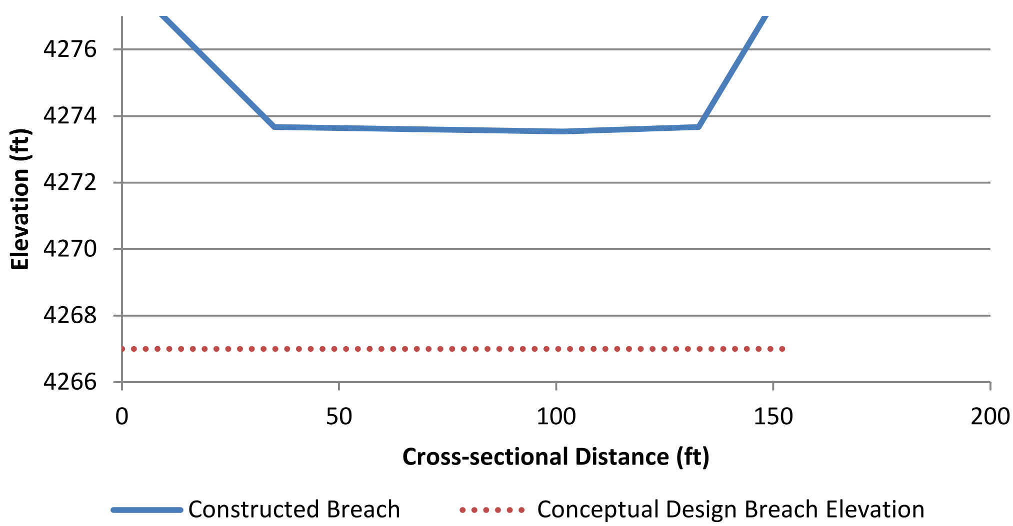



*Figure 6.2-6: Levee breach geometry in 2011 and in the proposed conceptual design at Breach #2 (location shown in Figure 6.2-1)*

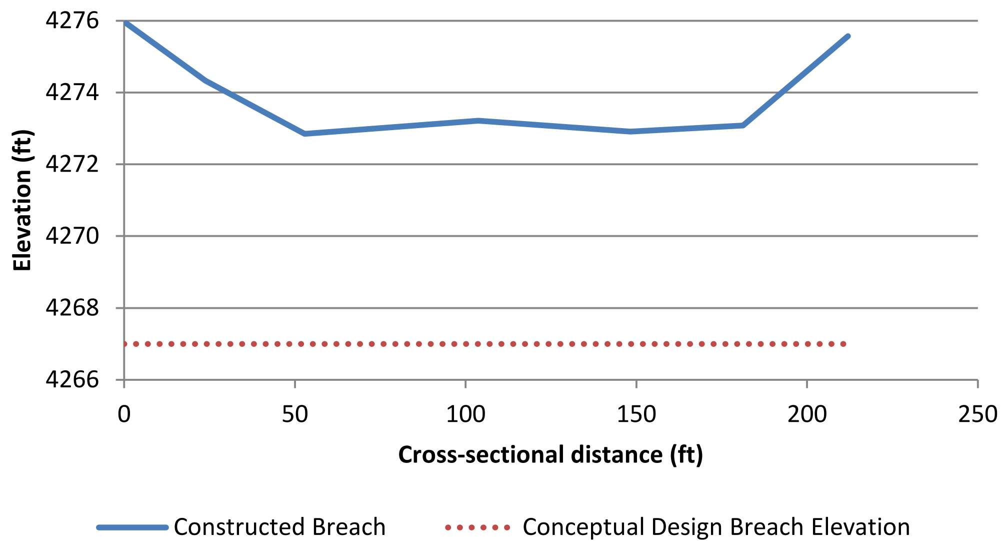



*Figure 6.2-7: Levee breach geometry in 2011 and in the proposed conceptual design at Breach #5 (location shown in Figure 6.2-1)*

We also compared the longitudinal profile through wetland one from breach one to breach two between 2005 and 2011 (Figure 6.2-8). We had to adjust the previously collected survey data to the same datum as our 2011 data to make this comparison. It appears that the reconnected floodplain wetland habitat has aggraded between half and one foot at the upstream end and degraded slightly at the downstream end. This is an important trend to monitor as excessive aggradation could reduce or even eliminate valuable fish habitat that has been made accessible by this project.

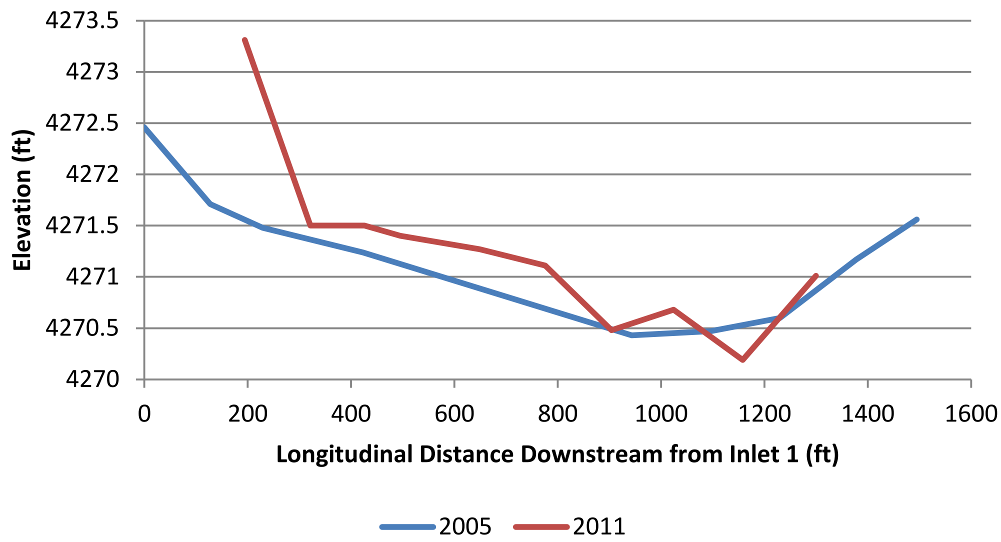



*Figure 6.2-8: Wetland 1 thalweg longitudinal profile from inlet one to inlet two showing slight aggradation at the upstream end and slight degradation at the downstream end (location shown in Figure 6.2-1)*

### 6.2.7 PPA Lessons Learned

This project resulted in reconnection of previously disconnected instream, riparian, and floodplain habitats and enhancement of these areas through changes to grazing practices. In general, this project appears to have achieved its success criteria, and additional projects of this type would likely contribute substantially to the achievement of basin wide goals. We did learn some important lessons from our PPA of this project. These are summarized by stream restoration project life cycle phase in

Table 6.2-1 below. Most of these lessons are related to the need for better understanding of the hydraulic characteristics of levee breaches and the characteristics of fish use of reconnected floodplain habitats. Practitioners should incorporate these lessons in future similar projects to continually improve performance.

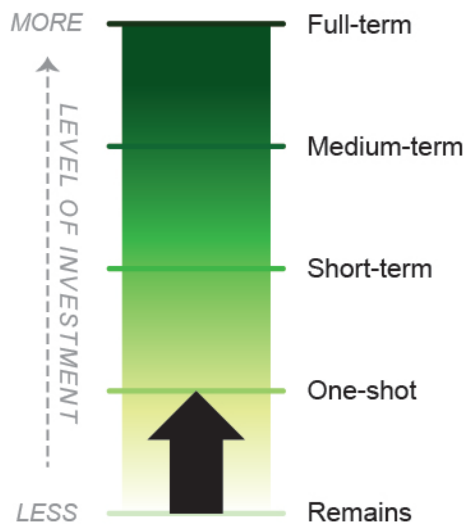
*Table 6.2-1: Summary of key lessons learned from the Southside Levee Breach Project*

| **Stream Restoration Project Life Cycle Phase** | **Scale for Lesson** | **Lessons Learned*** |
|---|---|---|
| Pre-Project (goal and objective setting, planning, data collection, analysis) | Basinwide | The feasibility of complete levee removal versus levee breaches should be evaluated for future similar projects to determine whether the lower maintenance requirements associated with complete removal could offset the additional cost of full removal. |
| | Site-specific | Site hydrology should be assessed to ensure appropriate understanding of hydraulic connectivity potential prior to design. |
| Design | Site-specific | Breach design should consider fish passage, erosion, scour, and deposition to avoid unexpected and unwanted changes to breach geometry and performance. |
| Implementation | Basinwide | Fish (including suckers) will access formerly isolated floodplain habitats through levee breaches. |
| | Site-specific and Basinwide | Fish monitoring after inundation flows should be conducted to identify potential stranding problems |
| | Site-specific | Stranding problems can be addressed by diverting water into the floodplain habitat during warm dry periods or by reconfiguring breaches to facilitate better passage into and out of the floodplain by providing stable positive drainage pathways back to the channel. |
| Monitoring | Basinwide | More systematic and regular fish sampling is required to understand use characteristics of fish in reconnected floodplain habitats. |
| | | Continuous water quality monitoring before and after the project is required to detect changes in water quality that are attributable to the project. |

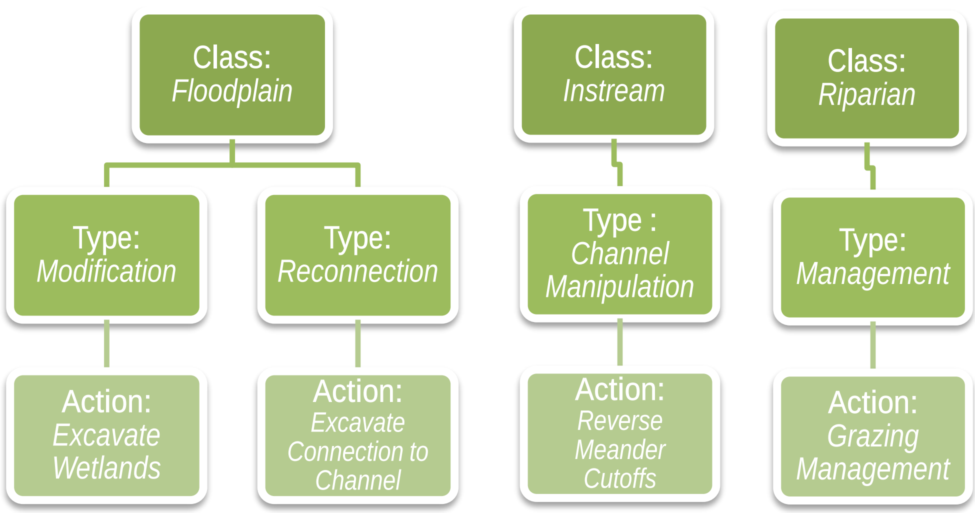
*SS = Site Specific / BW = Basin Wide

## 6.3 Nimrod River Park Project – Sprague River (Lower Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**




### 6.3.1 PPA Synopsis

We selected this project to provide a PPA case-study assessing the excavation and reconnection of seasonally-inundated floodplain wetlands on the Sprague River and a meander cutoff reversal (locally referred to as a "chute cutoff plug") combined with grazing management. The Nimrod River Park project fits the instream, management, and floodplain class, with modification, reconnection, channel manipulation, and management project types. Our PPA of this project was informed by the wetland, meander bend cutoff, and grazing models.

The documents developed for this project listed general as well as site specific objectives (e.g. enhance 2.5 miles of riparian habitat and 130 acres of wetlands, provide fish and wildlife habitat, improve water quality, increase stream flows, trap sediments from the river, improve geomorphic conditions, increase ground water elevations, and provide riparian habitat and cover). Our PPA of this project was constrained by the lack of pre- and post-project monitoring data. We evaluated aerial photographs and ground-based photographs of the site referenced to flow conditions preceding the photograph date, to which we added current (fall 2011) survey data and a historical aerial photography analysis. The primary lessons learned from this project were that the seasonal wetlands function as designed. They systematically filled as stage increased and held water during high flows and then systematically drained. Reed canary grass dominates the site and vegetation management is needed for habitat enhancement for vegetation and terrestrial species. Basin wide lessons were harder to extract from this project, but given the significant cost and physical effort associated with chute cutoff plugging, we are uncertain about the larger-scale benefits of this practice and recommend additional considerations for future similar projects later in this section.

### 6.3.2 Site Conditions

The Nimrod River Park project is located on both sides of the Sprague River near the town of Sprague River, Oregon, south of Drews Road (Figure 6.3-1). The project site is a wide floodplain of the Sprague River, with numerous oxbows, seasonal wetlands, and swales. The riparian area was historically occupied by willows and cottonwoods. The land was converted to irrigated pastureland, displacing the riparian forests and seasonal floodplain wetlands.

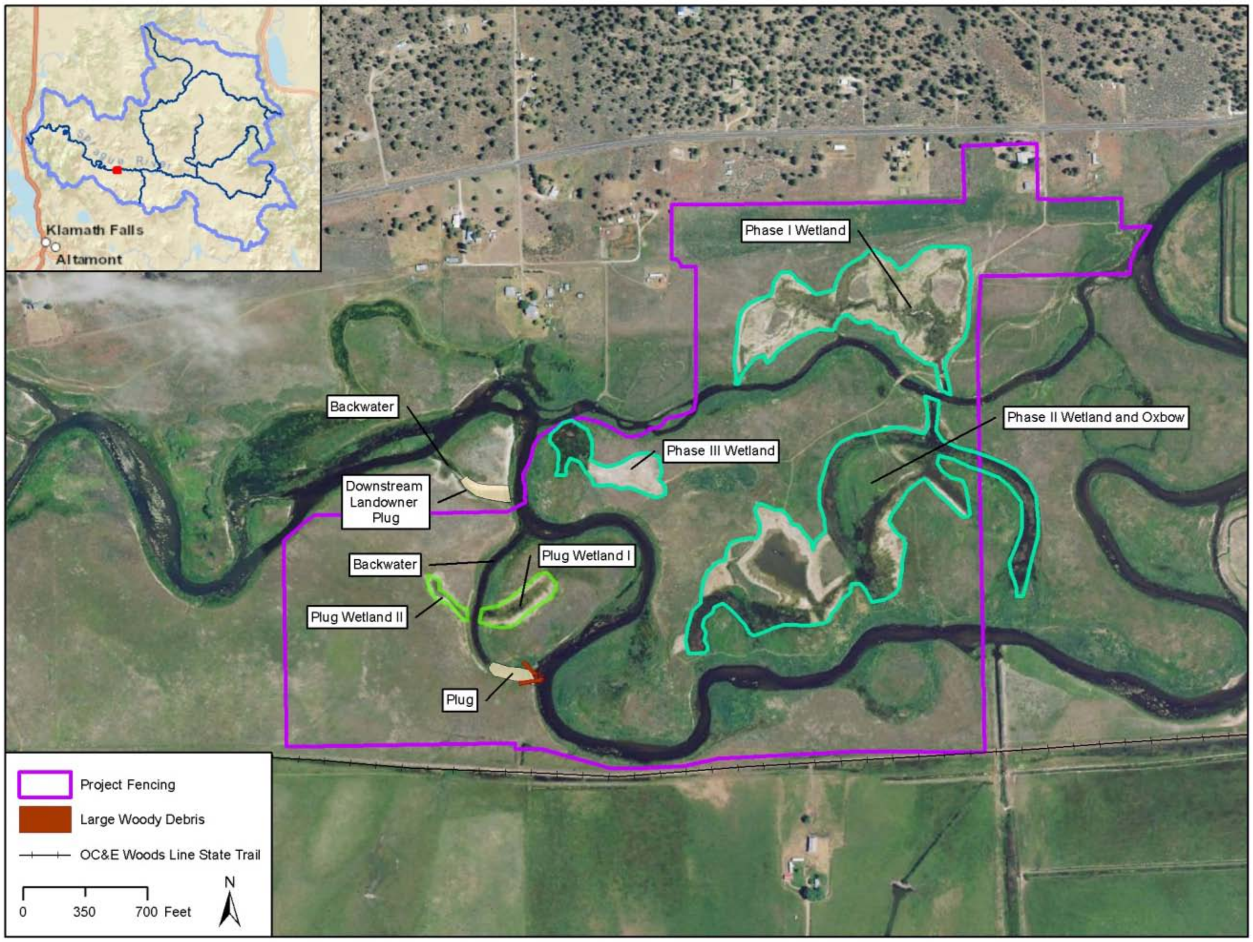



*Figure 6.3-1. Location of the Nimrod River project showing project wetlands, fencing, and plug.*

### 6.3.3 Project Success Criteria

The documentation for this project cited a wide range of site specific and basin scale goals and objectives. Site scale goals included enhancement of 2.5 miles of riparian habitat, restoration of 130 acres of wetlands restored with wetland and aquatic plants to provide habitat for resident and migrating birds, juvenile fish, reptiles, amphibians, and mammals, improve fish habitat, improve water quality by trapping fine sediment and absorbing nutrients in the wetlands, narrowing and deepening the channel with a gravel bed, prevent shortening of channel by avulsion channel cute off, increase the elevation of the local water table, increase the shade along the river by 20% from 2.5 miles of woody vegetation, and increase stream flows (USFWS 2002, OWEB 2002, Weekley 2005). Basin wide goals included improving fish habitat for native species and restoring the form, health, and function of the Sprague River by incrementally increasing total instream, riparian, and floodplain habitat in the basin. While there was a relatively large set of objectives proposed for this project, the objectives mostly align with the objectives identified and discussed for this type and class of project in the Organizational Framework in Section 3.1 of this report. However, because of limited baseline, as-built, and post-project monitoring data, we were only able to assess the performance of this project with respect to a limited subset of goals and objectives.

### 6.3.4 Project Timeline

The landowner incorporated 259-acres of their property into a Wetland Reserve Program (WRP) easement in the 1990's, which limited the types of land uses that could be implemented on the site, and prohibited livestock grazing. USFWS pre-project monitoring included discharge measurements (2000), macroinvertebrate sampling (2001), wildlife surveys (frogs and birds in 2001, fish in 2003), water quality (DO, temperature, pH, conductivity, nitrates, phosphates in 2001), stream cross-sections (year unspecified), and photo-monitoring (year unspecified). The excavations for Phase 1 Wetland (Figure 6.3-1) began in 2001 and were completed in summer 2003. Three areas of floodplains adjacent to a back-channel feature of the Sprague River (a significant meander bend cutoff), called the "inlet channel" in the project documentation, were excavated to create "flow-through wetlands," designed with an inlet and/or outlet to the Sprague River channel(s) so that no fish would be isolated or entrained as high flows recede from the wetland. Phase 1 of the project included 25 acres of wetlands north of the inlet channel and 550 willows manually planted in areas adjacent to the excavated wetland and river. Phase 2 Wetland (Figure 6.3-1) excavations began in late summer 2003 and were finished in September 2004. Phase 2 included reconnecting a historic oxbow to the Sprague River, involving 85 acres of wetland excavations on the "island" to the east and the south of the inlet channel. Phase 3 wetland (Figure 6.3-1) began in September 2004, and was completed in late 2004. Phase 3 included 25 acres on the northwest area of the "island" south of the inlet channel.

The channel plug and shallow floodplain wetlands in the western portion of the site (Figure 6.3-1) were implemented in 2005. Two small excavated wetland swales were also developed in the areas that were used as "borrow" for the fill dirt. Documentation of this portion of the project is limited, including only photographs and pre-project surveys of the portion of the channel to be plugged (used for estimates of quantity of fill). Objectives for the meander cutoff plug were not documented in the available materials for this project.

Extensive vegetation planting were conducted on the project site. Seedlings and stakes from native cuttings were planted in the spring and fall by hand (14,600 units) or with an excavator fitted with a mechanical planting attachment (5,000 units) during the period of construction. Trees were planted along the river corridor, the inlet channel, and around the edges of the excavated wetlands, including over 18,000 willows, 500 aspen, 500 red alder, 300 red osier dogwood, 300 cottonwood, and 30 Klamath plum. Bulrush clumps and rooted wocus plants were transplanted from other areas on the property into the wetlands.

This project was initiated by the landowners, and received initial support and funding from numerous federal and state agencies, particularly the Oregon Watershed Enhancement Board (OWEB) and the USFWS. Additionally, non-profit groups such as Ducks Unlimited, and for-profit consulting firms such as RDG were involved in project funding, planning, design, implementation, and monitoring. The landowners managed the project, and were responsible for planning, design, and implementation (construction) activities. The project files contained documentation of wide variety of issues and problems that occurred throughout the life of the Nimrod River Park project, including funding and permitting issues, issues with project planning, design, and construction, strained relationships between project partners, and accusations of mismanagement and embezzlement of project funds. In 2008, after all restoration activities on the site had been completed, the landowners during the project period sold the property to a new owner.

### 6.3.5 Relevant Conceptual Models

The ***wetland, meander bend cutoff, and grazing*** conceptual models guided our PPA of this project. The meander cutoff plug conceptual model describes how the prevention or reversal of meander cutoffs is typically expected to create more natural instream conditions and dynamics, and the grazing conceptual model describes how changes in cattle grazing and planting of native vegetation are typically expected to create more natural riparian conditions. The wetland conceptual model describes how the restoration of seasonal wetlands and the reconnection of wetlands to the river channel provide biological, ecological, geomorphic, and water quality benefits both locally and at the basin scale (see Section 3.2 for more details on conceptual models). The goals and objectives of the Nimrod project indicate that the project proponents and designers were aware of the typical changes predicted by these conceptual models for the implemented actions for the wetland and grazing components of the project. With limited design documentation for the plug project we are uncertain if the project proponents or designers were aware of the typical changes associated with plug projects. From our review of other plug projects, alternate approaches to restoring more natural instream conditions and dynamics may have been unnecessarily discounted. Exclusion of grazing from areas prone to scour and erosion and reestablishment of native riparian vegetation are proven approaches to restoring more natural riparian conditions.

For example, wetland creation and connection combined with grazing management and planting in the project area, could have been implemented instead of the meander plug to determine whether or not such changes could contribute to more natural instream and riparian conditions at a larger scale. Perhaps even more importantly, more careful documentation of local channel geometry and planform changes through time in the pre-project meander bends could have been conducted to definitively determine whether or not habitat conditions in the meander bends were actually degrading, and if so, at what rate. While this project did achieve a few of its site specific objectives, the majority were not met. Without pre-project data we were unable to determine whether or not this project satisfied the specific objectives for a meander plug project at the site or watershed scale. Other approaches could have been applied at this site with greater success.

### 6.3.6 Post Project Appraisal

#### *6.3.6.1 Methods*

The Project Framework (Table 3.1-1 in Section 3) lists several metrics that could be used to evaluate the performance of this type of project relative to its assumed goals and objectives. The availability and completeness of monitoring data for this project was limited by a lack of pre-project monitoring data, and limited post-project monitoring. Although project documentation discusses pre-project monitoring by the USFWS, this data was not available for the PPA. The only data available for the PPA include the following: post-project fish electroshocking surveys (2005), Pre-project cross-sections across the Ridgeway channel plug to estimate quantities of fill for the plug (2005), Pre- and post-project photographs (both aerial photographs and ground-based photo-monitoring).

To supplement the available post-project monitoring datasets, we performed additional analyses including comparing historical and current aerial photos, and collecting baseline survey data (cross-sections, longitudinal profiles) of channel and wetland areas in the vicinity of the channel plug (Figure 6.3-2). This baseline survey data does not allow us to evaluate changes in channel, wetland, and floodplain geometry as part of this PPA, since no pre-project survey data exists. However, it is intended to be used as a baseline dataset to evaluate the geomorphic evolution of the site over time, as a basis for future monitoring and adaptive management of the project, and to assess general performance trends relative to the documented success criteria.

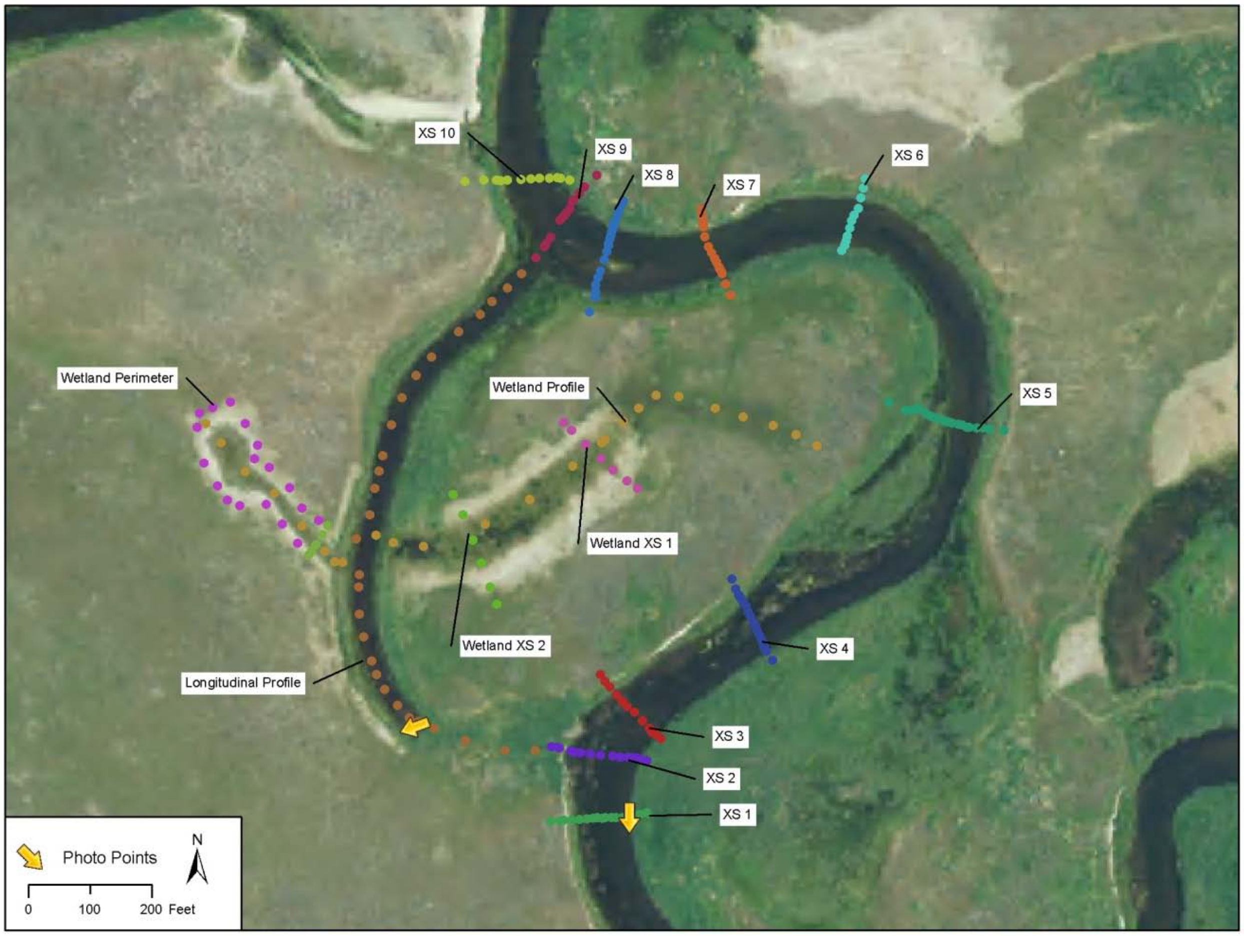



*Figure 6.3-2: Location of channel cross sections and longitudinal profile surveyed on October 13, 2011 and location of photo points.*

### *6.3.6.2 Results*

#### 6.3.6.2.1 Channel Geometry

As-built channel cross sections were not conducted as part of this project for the wetland components or the channel plug. To provide a base line for future monitoring at the project site, we surveyed ten cross sections on October 13, 2011 at the channel plug and backwater channel (Figure 6.3-2). We limited channel cross sections to areas where we could wade across the channel. Many portions of the channel were too deep to wade. We plotted the cross sections and made general observations of the channel geometry.

Figure 6.3-3 and Figure 6.3-4 illustrate the current channel geometry. The bed material was predominately clay, silt, and sand. We noted a deep slot had been carved through the clay layer for much of the channel and creating a deep thalweg. Example cross sections that capture this feature include 2, 5, and 8 (Figure 6.3-3 and Figure 6.3-4).

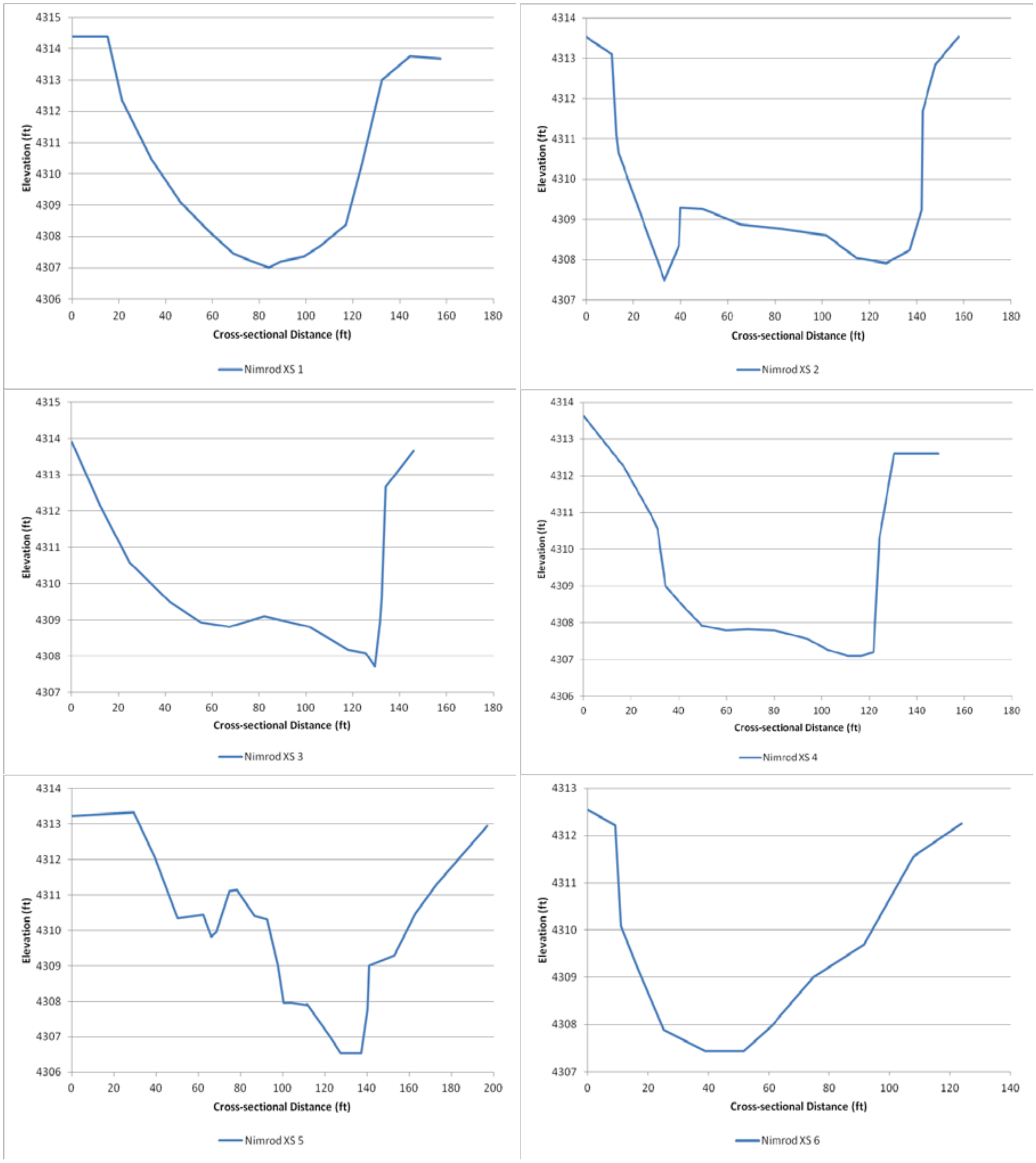



*Figure 6.3-3: Cross sections 1 through 6 surveyed in October 13, 2011.*

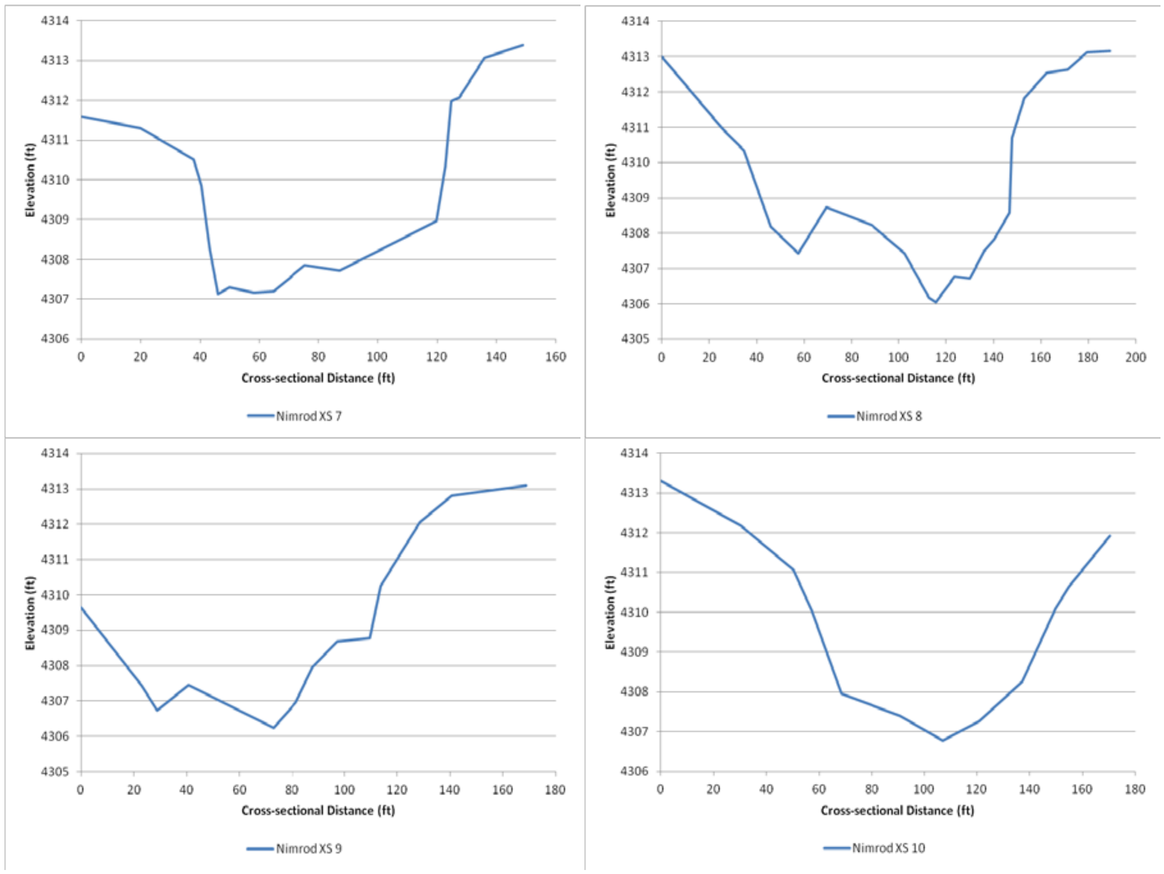



*Figure 6.3-4: Cross sections 7 through 10 surveyed in October 13, 2011.*

Repeat surveys of our channel cross section will show if the channel plug is meeting the stated objectives of narrowing and coarsening of the bed.

### 6.3.6.2.2 Longitudinal Profile

We conducted a longitudinal profile as part of our PPA for this project along the channel plug and plug backwater on October 13, 2011. The upstream extent was the outside bank across the channel from the plug and the downstream extent was the outside bank across the channel from the confluence with the mainstem Sprague River and the plug backwater channel (Figure 6.3-2). We plotted the longitudinal profile which includes cross sections 2 and 9 at the upstream and downstream extent, respectively (Figure 6.3-5). The head of the channel plug is armored with Large Woody Debris (LWD), and we observed some scour along the toe of the plug at the boundary with the mainstem. The upstream plug is shown on the longitudinal profile from station 140 to 400. The longitudinal profile shows that the plug backwater is undated at flows below the bankfull discharge and will provide the hydraulic connection to the channel for rearing habitat for fish.

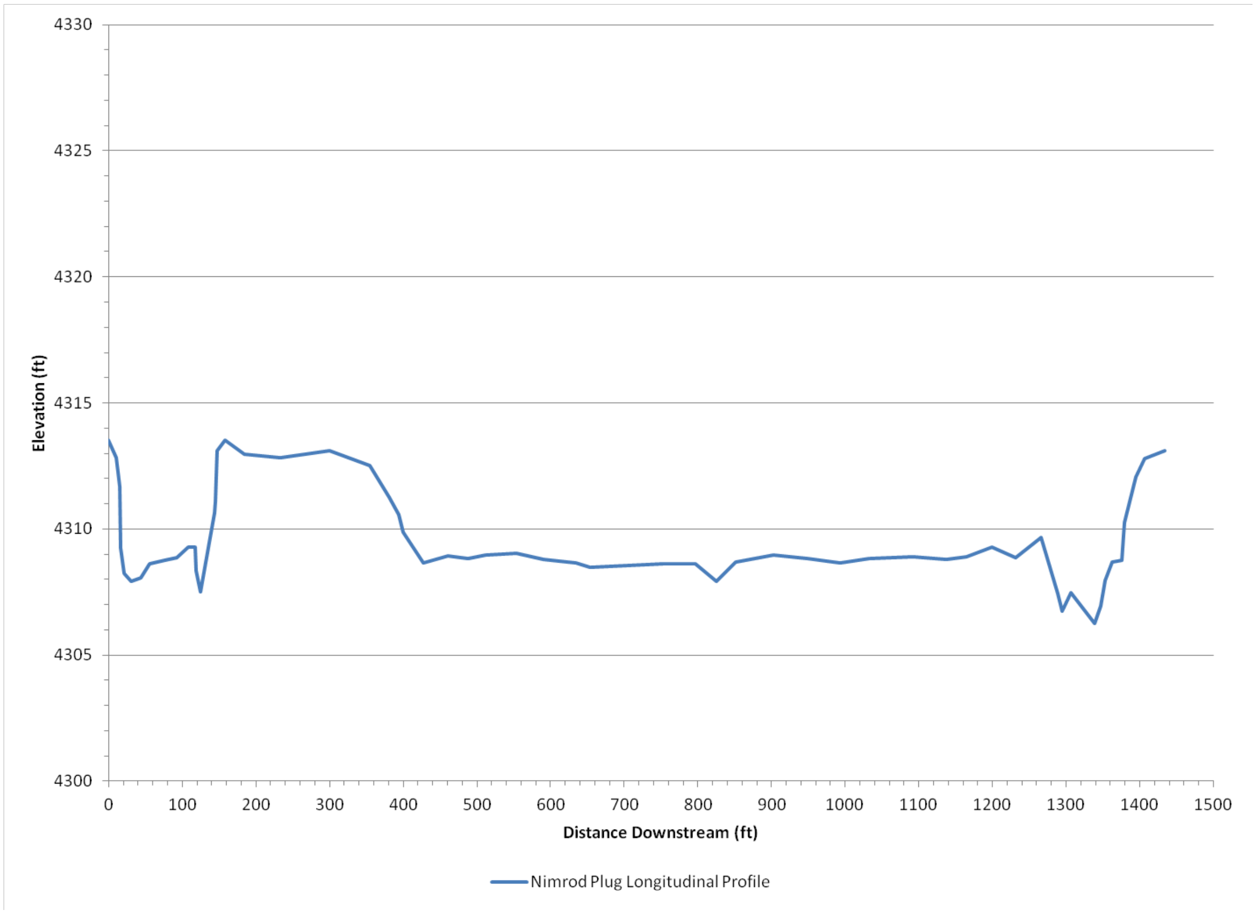



*Figure 6.3-5: Longitudinal profile surveyed on October 13, 2011, as part of this study. The upstream extent of the longitudinal profile incorporates cross section 2 and the downstream extent of the longitudinal profile incorporates cross section 9 where the plug and backwater channel intersect the mainstem Sprague River.*

### 6.3.6.2.3 Site Photographs and Visual Assessments

A library of photographs from the project site exists, spanning the pre-project, implementation, and post-project periods. Upon examination of these photographs, and confirmed by visual site observations in 2011, we came to the following conclusions: plantings experienced high mortality rates, few large trees or shrubs are present, upper terraces are colonized by non-native grasses, emergent wetland vegetation is present in some locations, and totally absent in other locations. The locations of photographs are shown in Figure 6.3-2. Figure 6.3-6 shows the change in the vegetation downstream from the tail of the channel plug and Figure 6.3-7 shows the change in vegetation looking south from the opposite bank from the channel plug between ground photographs taken in 2005 and 2011. Both figures show an increase in reed canary grass and limited woody vegetation establishment.


*Figure 6.3-6: Conditions in 2005 showing the as-built condition from the tail of the channel plug (left image). Photograph taken from the downstream extent of the channel plug in 2011 (right image). Comparison of the photographs shows an increase in grass and rushes, but no increase in woody vegetation.*


*Figure 6.3-7: Conditions in 2005 showing the as-built condition of the channel banks and floodplain looking south from the bank opposite of the channel plug (left image). The same location in 2011 (right image). Comparison of the photographs shows an increase in grass and rushes and limited increase in woody vegetation.*

### 6.3.6.2.4 Historical Photo Comparisons

We performed comparisons of historical aerial photographs, analyzing changes in planform channel alignment, vegetation, and other site conditions from 1940 to 2009 (Figure 6.3-8). We made the following observations: significant areas of seasonal wetlands and inundated floodplain were located adjacent to the main and secondary river channels in the 1940 aerial photograph, very few changes to Sprague River channel alignment and configuration from 1940 to 2000, and no noticeable changes in the extent of riparian vegetation, trees, or large shrubs from 1940 to 2009.

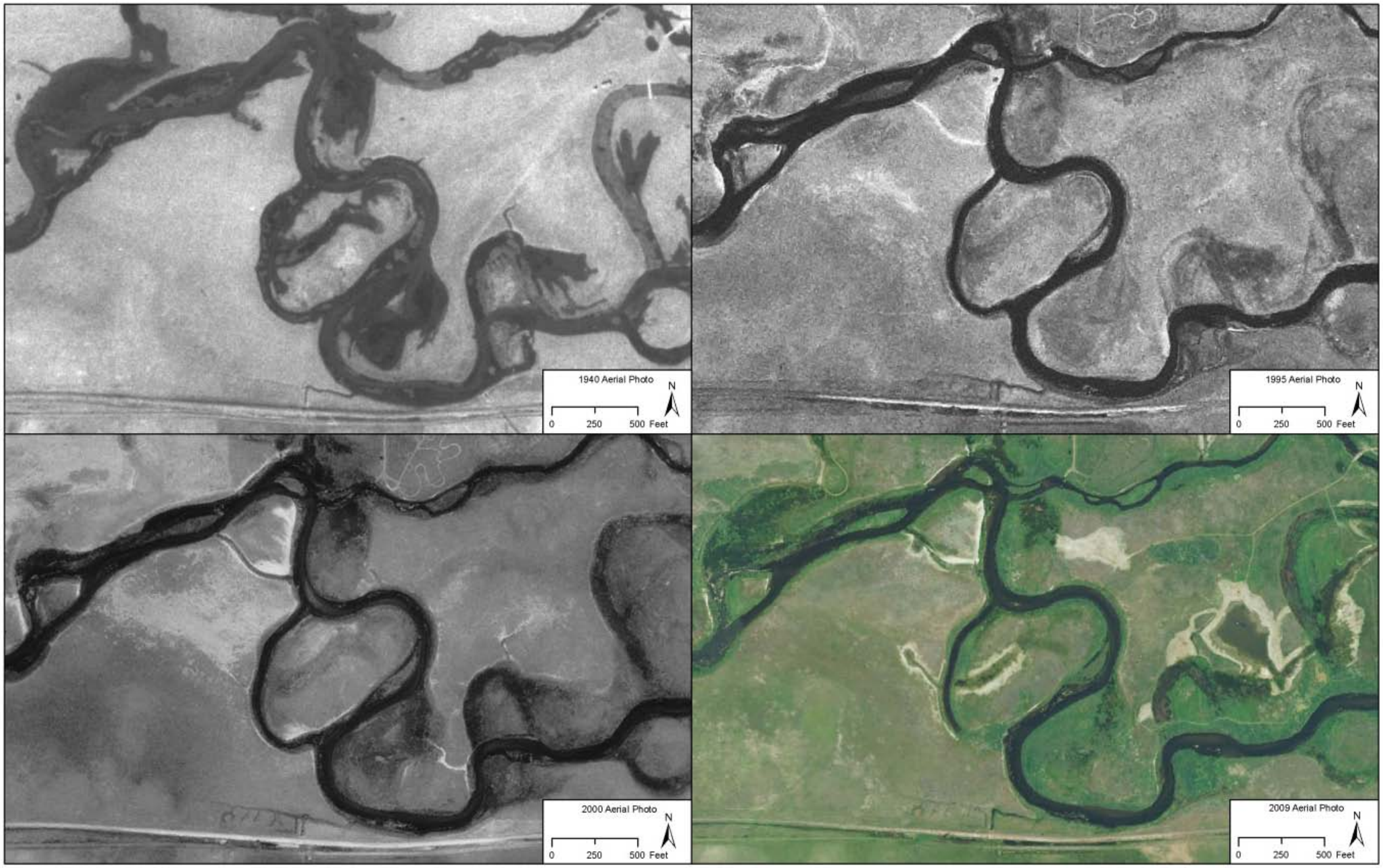



*Figure 6.3-8: Historical aerial photographic comparison of the Nimrod River Park Project site. Aerial photographs from years 1940 (top left), 1995 (top right), 2000 (bottom left), and 2009 (bottom right).*

##### 6.3.6.2.5 Fish Monitoring

An electroshocking fish survey was performed by Murphy and Hodge at three sites on the Nimrod River Park project on August 10th, 2005. The following fish species were identified: tui chub, blue chub, fathead minnow, black bullhead, lamprey, speckled dace, sucker, sculpin, and yellow perch. Suckers were found at all three sites. Because this fish monitoring effort did not sample a reference site, and because no pre-project fish monitoring data was available, it is impossible to draw conclusions about how the restoration project has affected native fish species either at the site or basin scale.

### 6.3.7 PPA Lessons Learned

This project required significant investment of resources for the planning, design, and implementation including construction costs. Perhaps most importantly, documentation of the planning process conveys that the lack of clearly defined goals and objectives associated with the Nimrod River Park project resulted in mistrust and damaged relationships between many of the project partners. Given the significance and level of effort required to implement this type of project, we felt it was extremely important to objectively capture both the positive and negative lessons learned from this PPA.

Review of the project site photographs and aerial photographs suggest that new wetland areas were constructed that appear to be functioning as intended from a hydrologic process perspective. However, the degree to which the project is providing fish and wildlife habitat, improving water quality, increasing stream flows, trapping sediments from the river, improving geomorphic conditions, increasing ground water elevations, and providing riparian habitat and cover is impossible to determine. Additionally, project photographs suggest that the vegetation planted as part of the restoration project is largely failing, due to poor design and/or implementation, lack of proper maintenance (irrigation), as well as cattle grazing that has occurred since project completion.

As we have found in other PPAs in the Sprague River Basin documented in this study, the primary lesson learned from the Nimrod River Park project is that specific, measureable, and time-bound project goals and objectives must be clearly defined from the outset of the project to allow the development of performance metrics and monitoring assessment methods that drive the design process as well as the post-project monitoring effort. The articulation of specific design criteria for this project based on such objectives would have led to the development of a much more rigorous and well-documented design process, making the restoration project much more likely to succeed and amenable to PPA. For example, if specific riparian restoration objectives had actually driven the design of the project (in terms of amount of shading, habitat for specific species of birds, etc. over a given number of years), then a much more detailed, thoughtful, and scientifically-based planting plan could have been developed to achieve those objectives, in addition to a maintenance plan that would help keep the restoration plantings alive, including irrigation, invasive species eradication, restrictions on harmful land uses, or installations of livestock exclusion fencing in those areas.

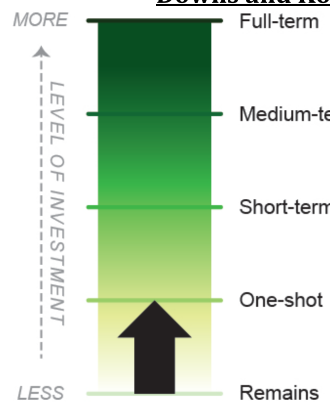
Finally, project documents including letters, reports, and interviews from resources agencies, consultants, and the landowner suggest that a landowner-driven and managed restoration project such as the Nimrod River Park project have a much higher risk of being inefficient and ineffective, and ultimately, have a higher risk of failure. That could be in part due to the unique set of personalities and diverging personal goals and objectives for this particular project. Therefore, a clear lesson learned from this project was the importance of tailoring the entire stream restoration effort (from analysis through monitoring) to key people involved in a project that both honors their involvement and enforces certain minimum requirements about the overall implementation of the project. Table 6.3-1 summarizes this and other important lessons learned from this PPA.

*Table 6.3-1: Summary of key lessons learned from the Nimrod River Park Project*

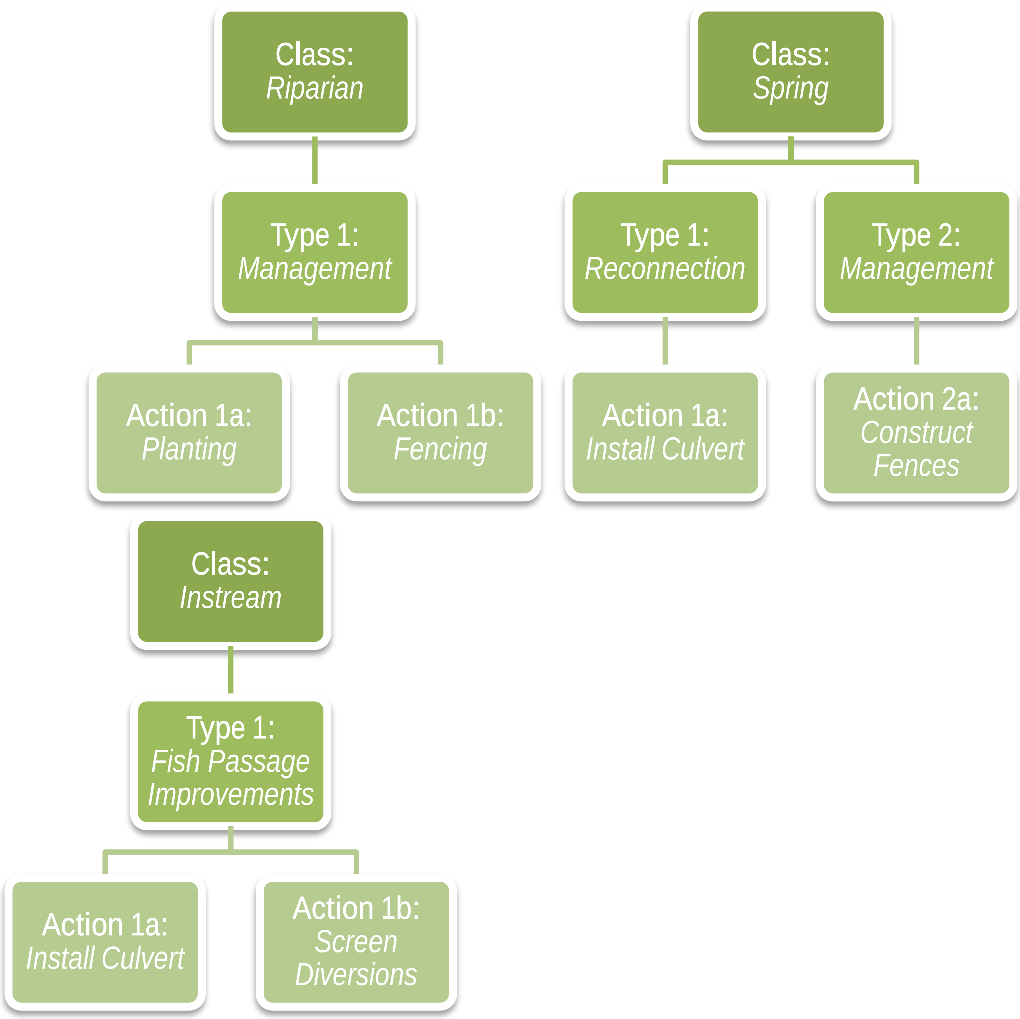
| **Stream Restoration Project Life-cycle Phase** | **Scale for Lesson** | **Lessons Learned** |
|---|---|---|
| Pre-Project (goal and objective setting, planning, data collection, analysis) | Site-specific | Goals and objectives should be developed at the project outset, and be specific, measurable, and time-bound. Pre-project data collection should be keyed to the goals and objectives, to allow comparison of specific elements / attributes of the restored system. |
| Design | Site-specific | A planting plan should be developed as part of the restoration design process, and include a post-project maintenance plan. |
| | Site-specific and Basinwide | Vegetation management is required to control non-native species. |
| Implementation | Site-specific and Basinwide | Projects where the landowner acts as both the project manager and construction contractor have a higher risk of being inefficient and ineffective. |
| | Site-specific and Basinwide | To reduce woody vegetation mortality, study local groundwater, use cages to protect plants from predators, control predators with trapping for 3 years. |
| Monitoring | Site-specific and Basinwide | Relevant pre- and post-project monitoring should be tied to specific objectives such as channel change (cross sections and long profile), inundation in wetlands (pressure transducers), and plant survival (mortality surveys). |
| General | Site-specific | Additional data required (to support monitoring objectives noted in the previous lesson learned) to show that aquatic, riparian, or floodplain habitat conditions improved as a result of project. |

## 6.4 Whisky Creek Project – Sprague River (Middle Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**



### 6.4.1 PPA Synopsis

We selected the Whisky Creek project because it was an example of a multi-benefit project that combined fencing, diversion screening, riparian planting, and spring reconnection. This project was also the only example of a project with a spring re-connection component. We categorized the PPA of this project as a one-shot as described in Section 4 because limited monitoring was conducted. The Whisky Creek project fits into our Project Framework classes of riparian, springs, and instream, and includes projects types of management, reconnection, and fish passage. Projects actions include fencing, planting, culvert placement, and diversion screening. Evaluating this project allowed us to assess the benefits of many different restoration activities on one project. The site-specific goals of this project were to improve water quality and quantity, stabilize wetlands, and screen an irrigation diversion. The basin wide goals were to improve water quality by reducing sedimentation through riparian corridor fencing and decreasing water temperatures by re-connecting a spring to the channel. Spring reconnection also increases the quantity of water flowing into the Sprague River. The conceptual models we considered during the evaluation of this project are **Springs**, **Diversions**, and **Grazing**. This project is representative of the multi-stemmed and low gradient valley reaches of the Sprague River. We reviewed the photographic post-project monitoring report, as well as the cooperative agreement and status reports in the project file. We conducted a baseline bank assessment and greenline surveys as a baseline for future monitoring along the Sprague River. Lessons learned included that restoration can be compatible with increased economic viability by increasing grazing opportunities on a property by connecting the spring to the river and reducing the ponded area of the spring. We learned that although cattle have been excluded from the riparian corridor, bank failures continue to occur. We also learned that woody riparian vegetation has not colonized the riparian corridor as predicted by conceptual models, and woody vegetation planted by the NRCS experienced high mortality rates from predators and prolonged inundation. The grasses in the riparian corridor have regenerated, but we found that non-native invasive species were common throughout the project reach.

### 6.4.2 Site Conditions

The project is located in the middle watershed on the Sprague River (Figure 6.4-1), about two river miles upstream from the confluence with Whisky Creek and about 3 miles west of the town of Beatty. The channel planform in this reach is characterized by a highly sinuous, multiple thread channel. The channels in this reach are separated by large islands and the valley is confined to the north by the Knot Tableland mesa. The OC&E Woods Line State Trail, the former railroad grade that has been converted into a bike path and trail, is the southern boundary of the project area and is adjacent to the spring. A levee was constructed in the 1960's on the south bank of the channel and is set back from the active channel in most of the project reach. The levee was constructed to increase the amount of usable pasture. Oxbow wetlands and cutoff channels are common in the middle reach of the Sprague River and a large meander bend adjacent to the irrigation diversion canal and fish screen was cut off by the main channel in the 1960's. The abandoned channel has become an oxbow wetland, and the perched channel connection with the mainstem conveys water near bankfull discharge. Ranching is the dominant land use and the surrounding land has been grazed by livestock since the 1800's.

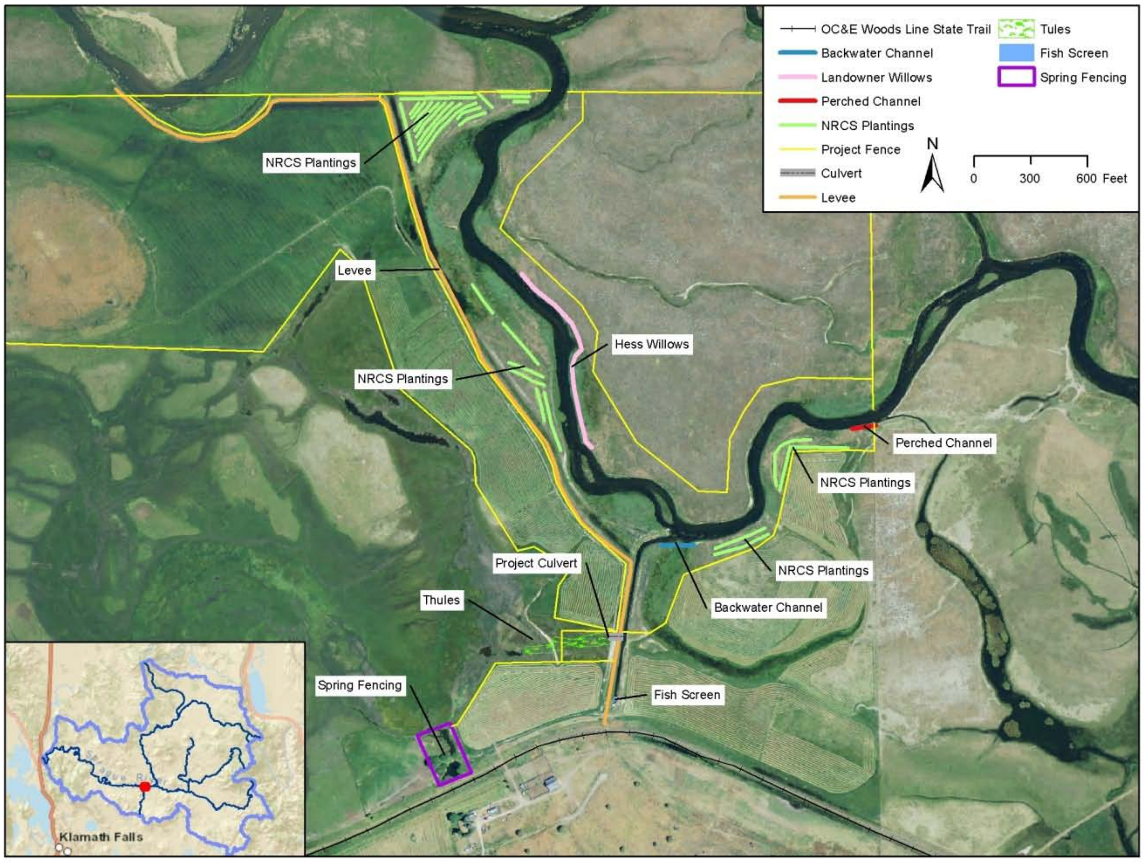



*Figure 6.4-1: The Whisky Creek Project is located in a low gradient valley in the middle watershed. Project features include riparian corridor fencing, spring fencing, culvert placement, fish screen, and NRCS plantings.*

### 6.4.3 **Success Criteria**

The project objective stated in the cooperative agreement 1140-I-J529 is to restore fish habitat and contribute to the recovery goals of the Lost River and short nose suckers. Cooperative agreement 11450-I-J515 further states that overall goals of the project are to promote restoration of wetland function and resource values within the Sprague River system and to promote the diversity of riparian vegetation. This agreement also includes goals for a project that has not been completed on Whiskey Creek. The OWEB grant #208-4008 defines three measurable goals for spring reconnection including 1) increase the source of cool water to Sprague River to reduce temperature, 2) increase late season flow in the Sprague River, and 3) increase endangered species spawning habitat. The goals for the OWEB grant portion of the project are clearly articulated and site specific, which allows for evaluation of success by monitoring, but goals don't include specific objectives for the fish screen. Comparing the stated objects from the project documents to the objectives recommended in the Project Framework in Section 3.1 for the project class and types shows that objectives of reducing entrainment for the fish screen type should be added.

#### 6.4.4 Project Timeline

Initial meetings with the landowners occurred prior to 2001, when the initial cooperative agreement was signed. The original project included plans to restore or enhance 450 acres of wetlands, uplands, and riparian areas (Cooperative Agreement 11450-I-J529). The scale of the project was significantly reduced, and installation of 6,515 ft of fencing under this agreement was completed by September 2004 (Klamath Tribes, 2004). A second cooperative agreement was signed in 2001 for installation of fencing, fish screen, and willow, cottonwood, and aspen planting (cooperative Agreement 11450-I-J529). Between 2001 and 2003 the landowner also entered into the NRCS CREP program; however, we didn't find any documentation on the NRCS project in the project files. Authorization for further project funding was developed under the Sprague River Ranch Management Plans Project funded by the USFWS in 2006 to identify projects to improve water quality and fish habitat. The Klamath Watershed Partnership, along with the USFWS and other partners, undertook the Whisky Creek project to improve water quality by reducing nutrient loading and decreasing water temperatures and to increase water supply by re-connecting the spring to the mainstem Sprague River in 2007 under OWEB Grant #208-4008.

Actions implemented as part of this project included installation of the fish screen, fencing of the spring area, and re-connection of the spring to the irrigation diversion channel. Project work funded under the OWEB grant was completed in 2008. A project completion report (Project Completion Report 2009) and a monitoring report (2010 Monitoring Report) were completed for the OWEB funded portion of the project. The completion report contained photographs of the fish screen, head gate from the spring, and new fence. The completion report stated that the project's success is being leveraged to explore additional spring reconnection projects throughout the watershed. In 2010, a monitoring report noted the increase in tules in the channel from the spring to the culvert and included five photographs from photo monitoring points. On December 1, 2011, we completed our greenline survey and bank erosion assessment.

#### 6.4.5 **Relevant Conceptual Models**

Based on our review of the complete file for the Whisky Creek project, appropriate conceptual models include **Grazing**, **Diversions**, **Springs**, and **Corridor Confinement** (Section 3.2). At the Whisky Creek project site, the impacts from channel confinement do not follow the conceptual model. The levee was constructed on the south bank of the channel and the river has access to the floodplain on the opposite side of the river. Further, the levee is setback from the channel for the majority of its length. The cattle grazing conceptual model predicts that the channel will experience bank erosion, reduction in riparian vegetation, and a decrease in water quality. The conceptual models for both cattle grazing and channel confinement predict significant alteration in channel cross section, profile, alignment and changes in riparian vegetation. The fish screen conceptual model predicts that fish become stranded in irrigation canals and that fish screens prevent entrainment. The spring re-connection conceptual model is unique to this PPA and predicts that re-connecting springs improves water quality by decreasing water temperatures in the mainstem or creating cold water refugia. Springs connected to the channel also provide spawning habitat for endangered suckers. Our review of the project documents show that the physical processes illustrated in the spring re-connection, fencing, and fish screen conceptual models were considered in the project design in terms of water quality and fish habitat. The conceptual models for both fencing and planting predict an increase in channel complexity and stability and biological colonization and succession of riparian vegetation.

We think the project implementers used the correct conceptual model for spring re-connection, but the difference in scale between the quantity of cold water flowing from the spring (0.5 cfs, OWEB cooperative agreement 208-4008) and the discharge in the Sprague River during our field work (274 cfs at the Sprague near Chiloquin USGS gage 11501000), minimizes the thermal impact of the spring on water temperatures in the Sprague River. We are also concerned that the length of the culvert under the levee to connect the channel from the spring with the irrigation diversion channel that connects to the Sprague River could be a barrier to fish passage. The cattle exclusion conceptual model predicts that denuded banks will revegetate, first by grasses followed by forbs and woody riparian species. However, woody vegetation is not common along the low gradient valley reaches of the Sprague River and the dominant vegetation types may be grasses and forbs. The channel confinement conceptual model is partially applicable at this project site as only one side of the channel is leveed. The levee may impact flows paths and bank erosion by directing flow towards the opposite bank where the channel migrates up against the levee face. Restriction of flow on the south side of the floodplain also forces more flow over the north side of the channel and floodplain.

### 6.4.6 Post Project Appraisal

#### *6.4.6.1 Methods*

One project completion report was completed for the spring re-connection, spring fencing, and fish screen installation portion of the project (Klamath Watershed Partnership, 2009). We used this report and field observations to assess the success of the spring re-connection. No post project monitoring has been conducted on the riparian planting and cattle exclusion components of the project. We determined that conducting a greenline survey and bank erosion assessment would give us the best snapshot assessment of the project's success and establish baseline data for future monitoring. On December 1, 2011 we conducted a simplified greenline survey and bank assessment. Both assessments were documented with digital photographs and GPS waypoints, and details on the methods used for our assessment can be found in Section 4. Additional assessment methods recommended in the project matrix for spring reconnection include flow, temperature, and dissolved oxygen measurements and survival, density, bathymetry measurements for the planting and fencing action. Assessment methods recommended for diversion screening include hydraulics at the screen and entrainment sampling. We selected the methods described above to develop a snap shot of site conditions with limited access to the property. Observations and descriptions from the land owner provided additional information on the spring reconnection.

#### *6.4.6.2 Results*

##### 6.4.6.2.1 Greenline Survey

To evaluate the success of riparian vegetation regeneration and native grass and forb composition we conducted three greenline surveys within the CREP easement, two on the south bank of the channel and one on the north bank of the river island( Figure 6.4-2). We found that the dominant community type along this whole river reach is composed of meadow foxtail grass, along with areas of rushes and sedges, patches of reed canary grass, and areas that were a mixture of sedges with sage, short grass and annuals (Table 6.4-1). We observed that vegetation along the greenline was generally continuous, but due to the survey being late in the year, all vegetation was basically dormant, with many of the annuals, rushes and grasses being very weathered and difficult to identify or quantify (Figure 6.4-3). Areas along the outer portions of the riparian zone during our greenline survey were populated by meadow foxtail mixed with sagebrush, as well as bands of willow/currant/rose/aspen plantings that were done with the CREP planting and are contained on 10’ wide weed barrier cloth (Figure 6.4-4 and Figure 6.4-5). The effects of cattle exclusion are clearly shown in the photograph we took from the upstream boundary of the project area in Figure 6.4-6. Fencing has allowed grasses to regenerate and has increased the height of grasses along the channel; however, our survey results show that the composition of grasses is predominately non-native species.

We surveyed cross-sectional transects along each greenline, but we were unable to cross the river at the transect locations. We conducted transects from the bank to either the CREP fence, or to the furthest planting area or upland edge. In areas with NRCS tree plantings, we conducted additional woody species counts (Table 6.4-2).

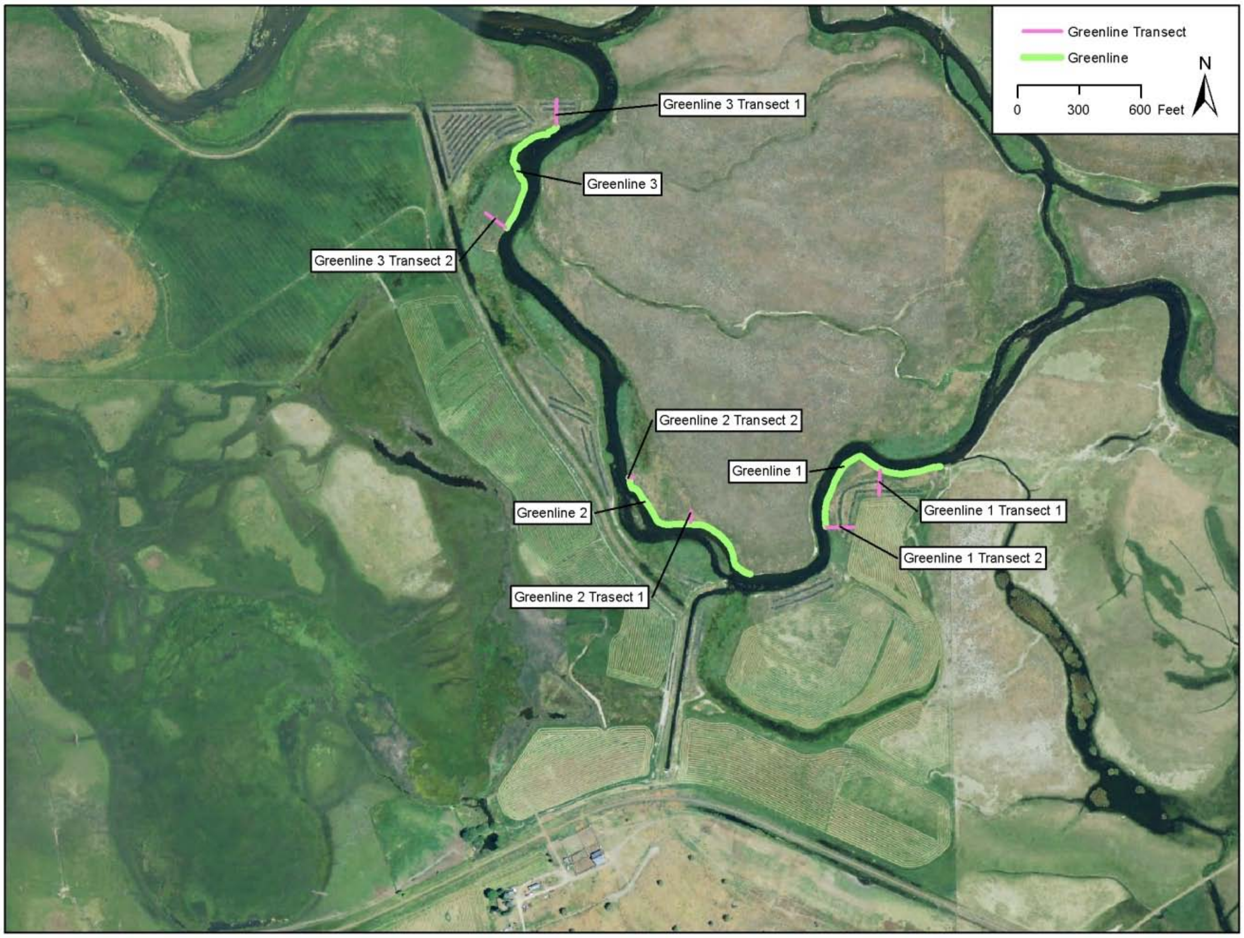



*Figure 6.4-2: Location of greenline surveys and transects we conducted for this report.*


*Figure 6.4-3: Photo showing the sage and meadow foxtail grass community on the upper bench, with a small patch of reed canary grass (indicated by arrow) among annuals and grazed sedges and grasses on the lower bench.*


*Figure 6.4-4: Photo showing willow planting with weed barrier in the CREP easement area.*


*Figure 6.4-5: Photo showing a cut bank with sage and meadow foxtail grass community on the top of bank, and rushes on a lower ledge at the edge of water.*

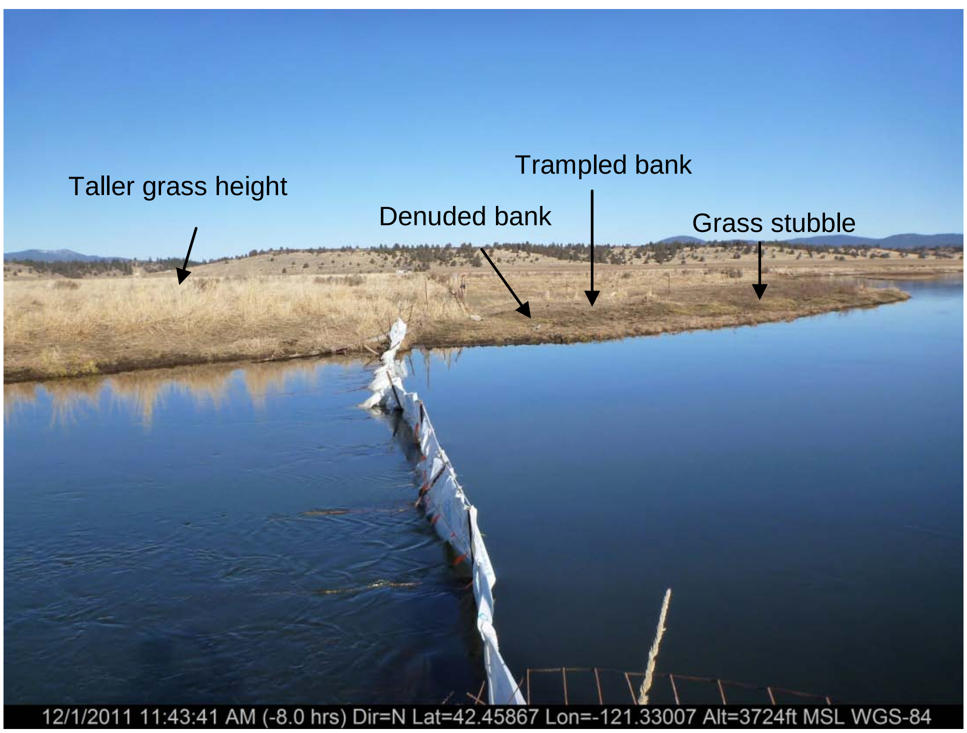



*Figure 6.4-6: Comparison of vegetation height and coverage in the riparian corridor between the grazed property upstream and downstream of the fence. The photograph shows lower vegetation height and trampled banks on the grazed property.*

From the results of our greenline survey, we learned that the vegetation communities along this reach are mostly non-native species, but with more species diversity compared to the South Fork Sprague River project. We encountered the Meadow Foxtail grass community most often in the three greenline surveys and transects. To quantify the change in vegetation and evaluate the success of different vegetation management prescriptions, we recommend conducting greenline surveys during post-project monitoring.

*Table 6.4-1: Summary of our greenline survey results showing the dominance of reed canary grass.*

| Transect | Length (ft) | Community Type | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Meadow Foxtail Grass Community | Sedge Community | Sedge / Grass / Sage / Annuals Community | Canary Grass Community | Rush Community | Upland Sage Zone | Willow Planting Zone |
| Greenline #1 | 818 | 378 (46%) | 28 (3%) | 194 (24%) | 43 (5%) | 175 (21%) | 0 (0%) | 0 (0%) |
| Greenline #2 | 900 | 120 (13%) | 147 (16%) | 60 (7%) | 72 (8%) | 471 (52%) | 30 (3%) | 0 (0%) |
| Greenline #3 | 821 | 250 (30%) | 101 (12%) | 37 (4%) | 72 (9%) | 362 (44%) | 0 (0%) | 0 (0%) |

*Table 6.4-2: Summary of our greenline woody species survey results at the intersection with the NRCS planting strips.*

| Transect | Species | Mature (<50% dead) | Mature (>50% dead) | Size 0-3’ | Size >3-6’ | Size >6-10’ |
|---|---|---|---|---|---|---|
| Greenline #1, transect #1 | Willow | 2 | 3 | | 2 | 1 |
| Greenline #1, transect #2 | Willow | 5 | 1 | 1 | 1 | 3 |
| | Currant | 1 | | | 1 | |
| Greenline #2, transect #1 | Willow | 3 | 1 | 1 | 2 | |
| | Aspen | 1 | | | 1 | |
| Greenline #2, transect #2 | Willow | 2 | | | 2 | |
| | Rose | 3 | | 2 | 1 | |

#### 6.4.6.2.2 Bank Erosion Evaluation

The fencing conceptual model predicts that degraded banks will recover after cattle are removed from the riparian corridor. To evaluate the performance of this project with respect to channel bank conditions, we conducted a channel bank erosion evaluation. Without a bank condition assessment of pre-project conditions, we were unable to quantify the change in bank condition after completion of the fencing project. However, our analysis did indicate that eroded banks still comprise a significant portion of the channel length (Figure 6.4-7 and

Table 6.4-3). This finding highlights the importance of considering all potentially applicable conceptual models in the planning and implementation of river restoration projects. The Sprague River has experienced land use changes that have created long-term impacts. The general conceptual models show that the channel is still in a stage of adjustment from levee construction and grazing and may result in long-term bank erosion.

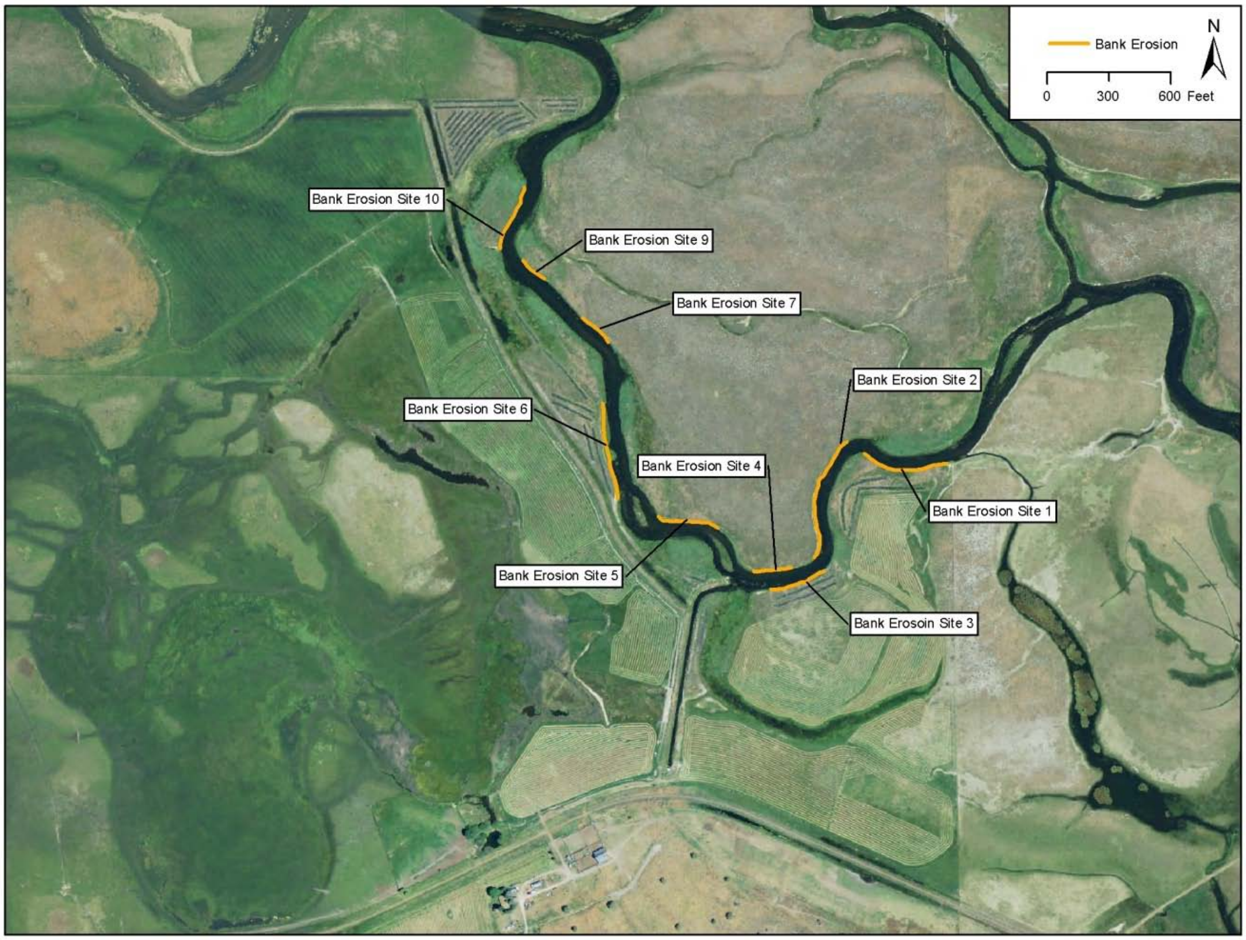



*Figure 6.4-7: Bank erosion sites identified during post project appraisal.*

Our bank assessment covered both banks of the channel in the project area (Figure 6.4-7). We identified ten bank erosion sites along 4,642 feet of river resulting in a total bank length of 9,284 feet. The ten bank erosion sites we identified totaled 2,926 feet in length, which is 63% of the channel length and 32% of the total bank length (Table 6.4-3). We recommend conducting future bank erosion assessments to determine the background amount of bank erosion in the Sprague River system, as bank erosion is a common feature in meandering, low gradient river systems.

*Table 6.4-3: Summary of bank erosion sites*

| | |
|---|---|
| Total Bank Length (ft) | 9,284 |
| Total Channel Length (ft) | 4,642 |
| Total Channel Bank Length Classified as Eroding (ft) | 2,926 |
| Percent of Channel Classified as Eroding | 63% |
| Percent of Channel Bank Classified as Eroding | 32% |

Bank erosion at channel bends typically contains a cut bank on the outside bend and a depositional point bar on the inside of the bend (Figure 6.4-8). In the project reach we observed bank erosion sites located on straight reaches of the channel where the eroded material formed a lower surface that was vegetated with grass and forbs (Figure 6.4-9). This suggests that land use processes are driving channel change.


*Figure 6.4-8: Bank erosion on an outside bend of the channel and deposition on a point bar on the inside of the bend.*


*Figure 6.4-9: Bank erosion where eroded material has formed a lower surface that has been colonized by grasses and forbs.*

### 6.4.6.2.3 Observations

Our field observations during the site visit and conversation with the land owner provided additional insights on project performance. The fencing around the spring has preserved mature riparian vegetation, and we observed large trout in the spring (Figure 6.4-10) during the site visit. However, the connection to the spring has been compromised by encroachment of tules into the channel from the spring to the culvert to the irrigation channel (Figure 6.4-11). This observation alerted us to the importance of considering the long-term sustainability and maintenance of the channels connecting springs to the Sprague River in future spring reconnection projects.

We observed the fish screen at the end of the irrigation channel apparently functioning as designed, with weeds and other debris recently removed from the screen. We were limited to the general observations of the performance of the NRCS vegetation planting in the CREP area as no background data was available on the number, species, or location of plantings. Black weed cloth shows the location where the NRCS planted plugs of shrubs and where woody riparian vegetation was used to reduce the competition with grasses. We identified planting areas from aerial photographs and show the location of the planting areas in Figure 6.4-1. Based on our observations during the site visit, the success of planting fell into three general categories: unsuccessful establishment (characterized by small, dead plants); successful establishment, but killed or growth stunted by predators (Figure 6.4-12); and successful establishment (characterized by medium to large size vegetation). Lessons from the NRCS vegetation planting are discussed in more detail in the lessons learned section below.


*Figure 6.4-10: Photograph showing fenced spring. The water is clear and mature riparian vegetation borders the spring.*


*Figure 6.4-11: Photograph taken from the levee looking up the channel towards the spring. Tules are shown blocking the channel upstream of the culvert.*


*Figure 6.4-12: NRCS planted willow in the fenced riparian with about 50% of the branches removed by beaver.*

#### 6.4.6.2.4 Historical Aerial Photograph Analysis

We reviewed historical aerial photographs to assess the changes before and after the project and to identify trends in channel change at the site. Our review of the historical photographs from 1953 to 2009 (Figure 6.4-13) shows many changes to the channel and floodplain. The meander bend in the southern portion of the 1940 aerial photograph was cutoff and a levee on the southern bank of the channel was constructed by 1995. An irrigation channel was also cut from the Sprague River adjacent to the downstream extent of the meander bend during the same time period. By 1995, mid-channel bars or islands are common features in the channel. Our review also shows that the likely flow path of the spring in 1940 was to the north and then to the east to connect with the Sprague River near the downstream extent of the project reach. Based on our field observations, the current channel alignment from the spring takes a more direct path to about the midpoint of the irrigation diversion channel.

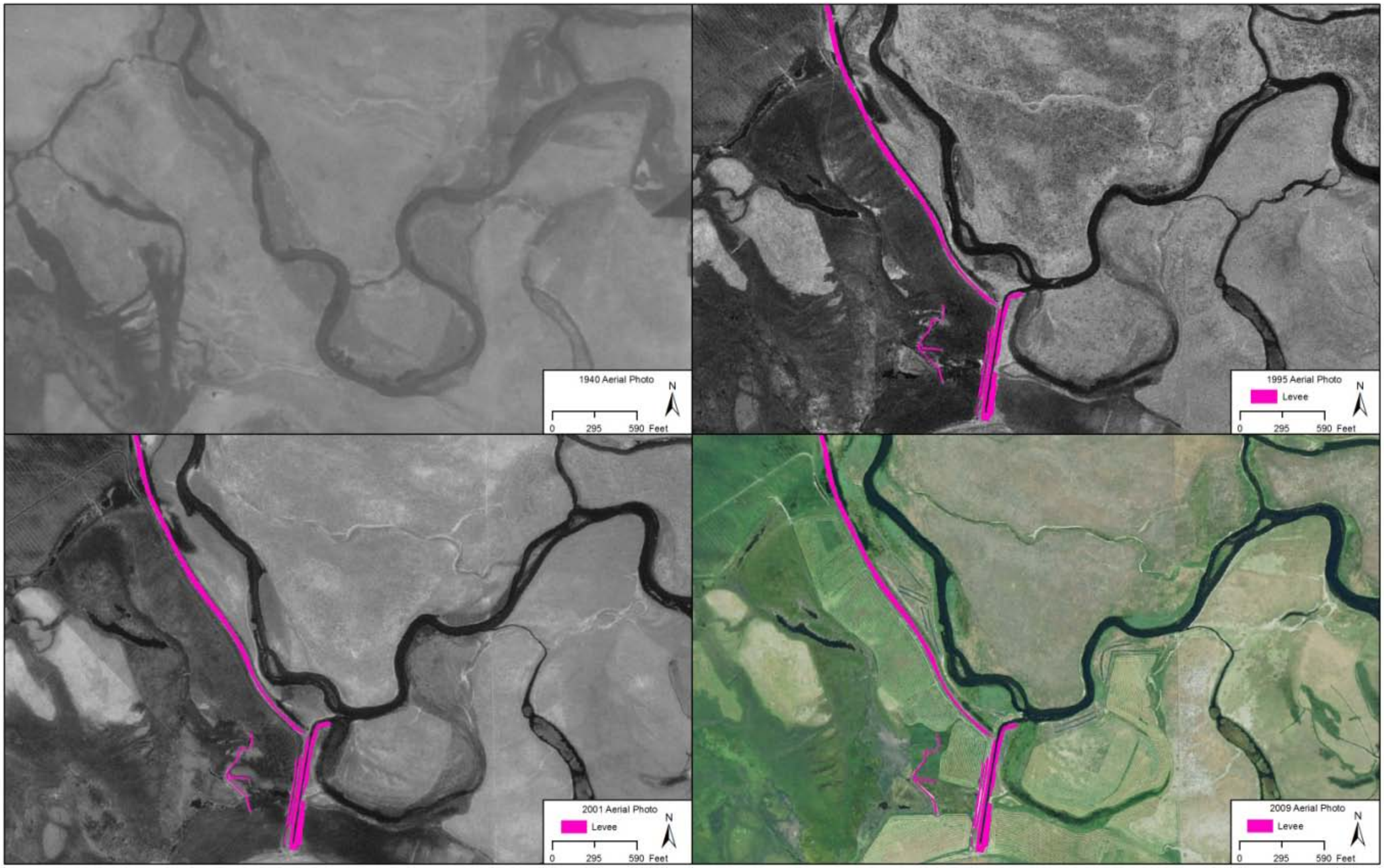



*Figure 6.4-13: Historical aerial photographs from 1940, 1995, 2001, and 2009 of the project site. Levees digitized from the 2000 aerial photograph are shown in pink on the 2000, 2001, and 2009 aerial photographs.*

### 6.4.7 PPA Lessons Learned

Based on our review of project documents, our field observations and measurements, conversation with the land owner during our site visit, and our PPA, we identified a variety of useful lessons from the Whisky Creek project at the site and basin scale. Table 6.4-4 presents a summary of lessons learned at the site and basin scale by restoration project life-cycle phase.

*Table 6.4-4: Summary of key lessons learned from the Whiskey Creek Project*

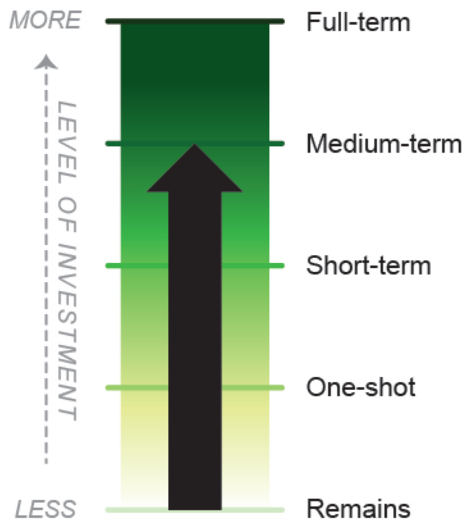
| Restoration Project Life-cycle Phase | Scale for Lessons | Lessons Learned |
|---|---|---|
| Pre-Project – Goals/objectives, Planning, Data Collection, Analysis | Basinwide | Collect pre-project and as-built baseline data to assess project success and further learning about project types in the Sprague River Basin. |
| | Site-specific and Basinwide | Regeneration of native grasses and forbs requires vegetation management. Cattle exclusion alone has resulted in regeneration of predominately non-native species. |
| | | An understanding of groundwater surface water interaction is necessary to determine planting elevations (If willows are too close to the river the water level is too high and they are killed by beaver, if they are too far away from the river, the water table is too low and the mortality rate is high). |
| | Basinwide | Basin wide vegetation management is required to reduce non-native vegetation species to achieve basin wide goals of restoring native vegetation. |
| | Site-specific and Basinwide | Establishment of native forbs and woody vegetation requires planting, predator control, and correct groundwater conditions or else the morality rate is very high. |
| | Site-specific and Basinwide | Fencing reduces hoof shear on banks, but basin wide geomorphic processes (such as impacts from levees or channel straightening) may continue bank erosion. |
| | | Vegetation regeneration creates a buffer strip in the riparian corridor and likely decreases fine sediment and nutrient input into the channel, which improves basin wide water quality. |
| | | Timing is important for reed canary grass control as cattle prefer young plants (flash grazing in the riparian corridor). Mature reed canary grass doesn't provide good habitat for native species, competes with native vegetation, and isn't controlled by flood irrigation or flooding. |
| Design | Site-specific and Basinwide | To decrease riparian corridor fencing maintenance and maximize habitat, setback fences at channel bends to account for migration/bank erosion and include secondary channels in the riparian corridor fencing area. |
| | | Mature reed canary grass provides cover for mice and other rodents to girdle riparian plantings. |
| | | Use 2 ft willow stakes (planted 1 ½ ft deep) for planting as willow plugs had high mortality rates. |
| | | During dry years mice and other rodents burrow under weed cloth and girdle planted vegetation. |
| | | Flood irrigation is common in the Sprague River Basin and reduces gopher populations on pastures. When pastures are converted from pasture to wetlands or floodplain habitat, need to control gopher population reduce mortality of riparian plantings. |

| Restoration Project Life-cycle Phase | Scale for Lessons | Lessons Learned |
|---|---|---|
| | | Establishment of native forbs and woody vegetation requires analysis and planning of planting technique, predator control, weed control, correct groundwater and surface water hydrology for colonization of native species. |
| | | During wet years beaver eat woody vegetation higher up on the floodplain. |
| | Site-specific | Willow planted in clumps with an excavator had higher success than plugs. |
| | Site-specific and Basinwide | Maintain spring connection for fish passage. |
| Implementation | Site-specific and Basinwide | GPS/Survey features constructed/planted (fences, plants) to inventory what was done on each project site and to assist in future project assessment and monitoring. |
| | | To increase the survival rate of riparian vegetation, include 3 years of trapping to protect vegetation from predators. |
| | | Use wire baskets to protect vegetation from beaver (wire baskets were left on site, but never installed by NRCS contractor). |
| | | Golden currant and wild rose compete with reed canary grass and should be planted with greater frequency to help control reed canary grass. |
| | | Flash or rotational cattle grazing in the riparian corridor may help control non-native vegetation species such as star thistle and young reed canary grass. Cattle preference for non-native species is life stage dependent by species and limits the usefulness of cattle grazing for non-native vegetation control in the riparian corridor. |
| Monitoring | Site-specific and Basinwide | Design of spring re-connection channel should take into account sedimentation and wetland species vegetation encroachment. The measured discharge at the spring is 0.5 cfs, but tules have plugged the channel from the spring to the culvert. Hand removal of tules failed to open the channel. Mechanical excavation is now required. |
| | Site-specific | Channel bank failures have continued post-project, but bank failures have remained vegetated and have created a stable lower surface in the channel, which decreases fine sediment input into the Sprague River. |
| | Site-specific and Basinwide | Include detailed monitoring plan with cooperative agreement so that land owner agrees to access requirements for project monitoring and potential adaptive management (include schedule and equipment/benchmarks to be placed on property) |
| General | Site-specific | Levee constructed on the project site has increased water surface elevation on island across the channel and wetter conditions on the island have allowed more canary to establish. |
| | Site-specific and Basinwide | Regenerated vegetation in the riparian corridor of cattle exclusion areas is attractive to cattle for grazing. Project design and long term maintenance should be included in the project to prevent adjacent cows from migrating onto project properties from upstream or downstream properties. |

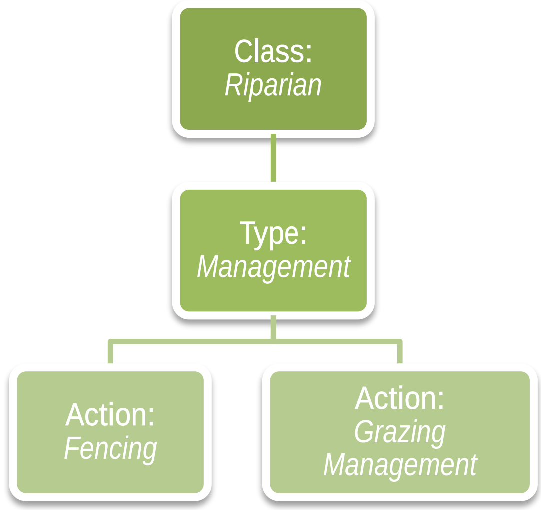
We learned that adaptive management actions are required to restore the connection between the channel and spring. Better understanding of the groundwater and surface water interaction and predators in the planning, design, implementation, and monitoring phases of this project would have improved the success of NRCS plantings. At the planning level, consideration of all relevant conceptual models would have improved the development of measurable objectives and perhaps expanded the scope of the project to address channel confinement in addition to fencing and diversion screening. The project contributes incrementally to the basin wide goal of providing more normative hydrologic, geomorphic, sediment transport, and biological processes that create riparian conditions and variability that better supports target and/or native riparian plant communities and biota in the Upper Klamath Basin. However, additional work appears to be required at this site to maximize the basin wide benefits possible.

## 6.5 Sycan River Project (Middle Sycan Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type, and Actions**




### 6.5.1 PPA Synopsis

We selected this project for post project appraisal to provide a case-study of fencing without floodplain or wetland modifications. The Sycan River project fits in the riparian class and the management type. Our PPA of this project was informed by the cattle exclusion conceptual model introduced earlier in this document.

Evaluating this project allowed us to assess site specific and basinwide benefits of cattle exclusion projects in a low gradient valley reach of the Sprague River Basin. The site-specific goals of this project were to design and implement a grazing plan and riparian fencing to improve river/riparian/wetland complexes significantly degraded due to historical management of cattle grazing. The basin wide goal of this project, which was not explicitly stated, was to improve habitat for several threatened species and endangered species. Another basinwide goal was to use the project to showcase to demonstrate cost-effective cattle-compatible restoration for other landowners in the basin. This project is representative of other cattle exclusion projects in low gradient valley reaches of the Sprague River. Formal post-project monitoring has been conducted for this project, but the only data available for our review was limited to summary information. After we completed our site visit for this project, we were given additional data for water temperature, water quality, photography monitoring sites, and cross sections surveyed in 2003. With the limited information, we were able to extract basic project performance information by reviewing grant applications and status reports in the project file. To supplement this information, we conducted a reconnaissance level assessment of the project and took digital photographs to document our observations. We compared these photographs to historical ground photographs of the project. We learned that riparian fencing and grazing management in the riparian corridor has resulted in the regeneration of sedges, rushes, grasses, and limited willows. Bank erosion continues to occur, but riparian vegetation has stabilized eroded banks as predicted by the conceptual models for this type of project. By evaluating this project we learned that cattle exclusion does improve the condition of channel banks and allows vegetation to regenerate, and we recommend that this project and future cattle exclusion projects include detailed vegetation management prescriptions to reduce non-native species with a monitoring component that allows for adaptive management of vegetation restoration.

### 6.5.2 Site Conditions

The project is located near the middle of the Sprague River Basin (Figure 6.5-1). The downstream extent of the project is approximately a mile upstream of the confluence with the Sprague River and extends about one and a half miles upstream to the Drews Road bridge. The community of Beatty is located about two and half miles to the southeast from the project site. Godowa Springs Road is the eastern boundary of the project site, and Drews Road is the Northern boundary of the project area. The Knott Tableland is located to the northwest. The project site is located in the Sycan River Valley downstream of a steep and narrow canyon called Coyote Bucket. The Sycan River meanders across the broad valley and seeps and springs on terraces adjacent to the river contribute to the channel's discharge and reduce river temperatures. In the upper Sycan River watershed, the 25,000 acre Sycan Marsh is drained by the Sycan River. Land uses in the basin since the mid 1800s have included fur trade, timber extraction, farming, ranching, and residential development. The surrounding land has been grazed by livestock since the 1800's and ranching and the fur trade likely had the greatest impact on river conditions by modifying river processes and degrading river stability (RDG 2007).

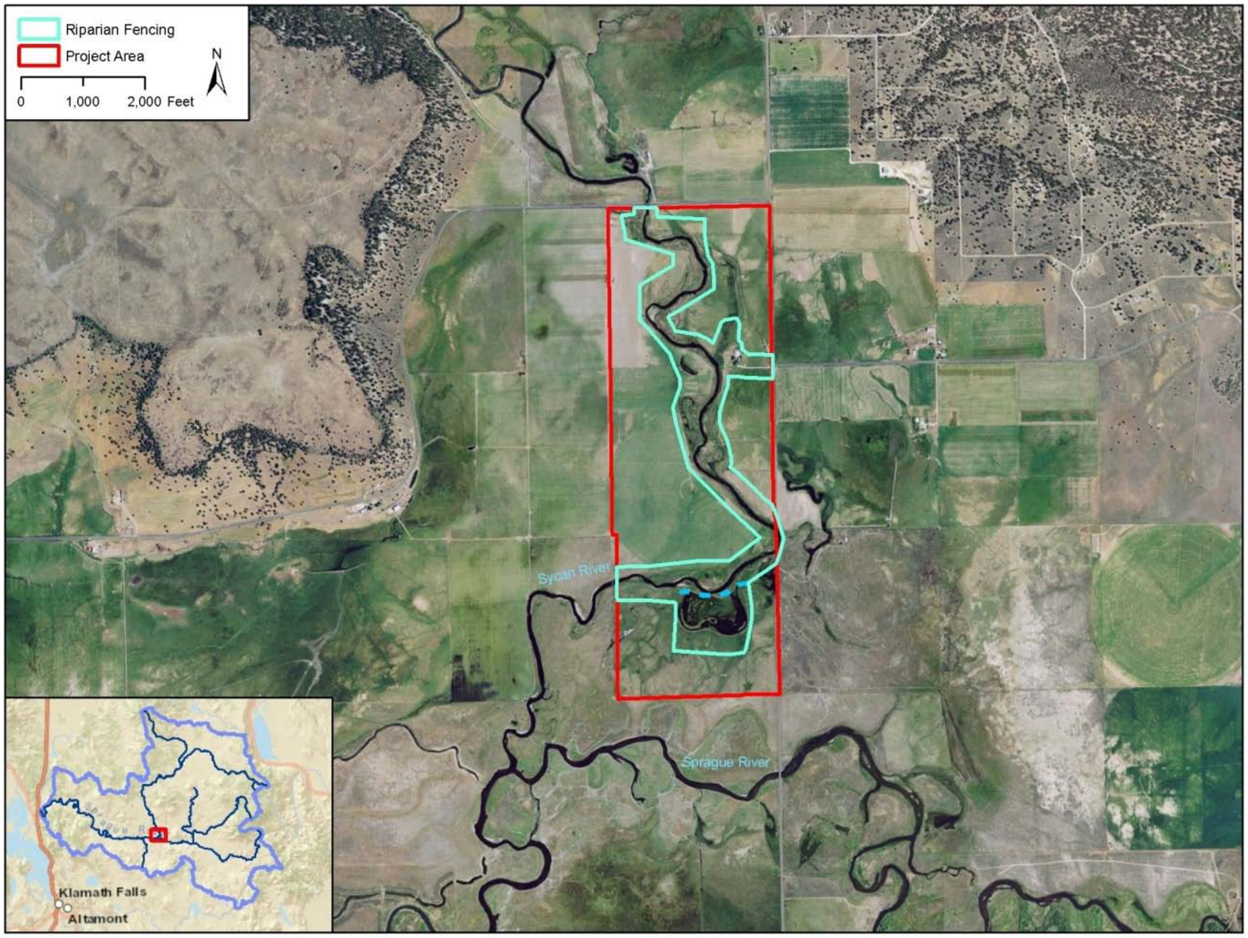



*Figure 6.5-1: The Sycan River Project is located in a low gradient valley in the upper watershed. The downstream extent of the project site is located approximately 1 mile upstream from the confluence with the Sprague River. Project features include riparian fencing on both sides of the channel and wetland fencing.*

### 6.5.3 Success Criteria

Most of the projects in our evaluation included an objective aimed at minimizing the impact of cattle to improve water quality. The Sycan River project was one of three projects that we evaluated with the primary objective of reducing the impacts of cattle grazing on riparian and aquatic habitats. The project goals for the Sycan River project included outreach to use the project as a demonstration for ecologically-compatible private lands management. Selecting this project allowed us to evaluate the effectiveness of riparian fencing and grazing management. Ranching is the dominant land use along the channel and the project reach is representative of typical channel and land use types for the mainstem Sprague River.

The project objective stated in the OWEB completion report for the project (Sustainable Northwest, 2005) was to design and implement a grazing plan and riparian fencing to improve significantly degraded river, riparian, and wetland complexes due to historical management of cattle. The undated OWEB project description adds outreach and demonstration goals to use the property as a place to share learning about ecologically-compatible private lands management. The Oregon Watershed Restoration Reporting Form (2005) contains individual goals for riparian, wetland, and upland, grazing and irrigation management. The measurable objectives we indentified in the Oregon Watershed Reporting Form (2005) include riparian, wetland, upland, grazing, and irrigation management components. Riparian objectives include: increase stream shading, increase structure and complexity, increase spawning and resting habitat, streambank stabilization, decrease erosion and stream sedimentation, decrease contaminant input, and decrease livestock access to streams. Wetland objectives include: increase the storage capacity of wetlands, increase the net area of wetlands, increase vegetation to filter runoff, increase vegetation for cover and nesting, increase vegetation to provide shade, and increase water to the stream during low flows. Upland, grazing, and irrigation management objectives include: increase streambank stability, increase future shading to stream, increase/improve native plant species composition, increase upland water storage capacity, decrease erosion stream sedimentation, decrease run-off contaminant input to stream, decrease stream temperatures, and decrease livestock access to stream. In terms of grazing management the goal of the fencing project is to provide a tool for landowners to more effectively control the timing, duration, and season of use of the riparian corridor by ranch cattle and assist in the recovery of the vegetation on the property (Sustainable Northwest, 2007). The monitoring and progress report (Klamath Tribes, 2010) further states the purpose for the conservation easement was established to protect ranchland stewardship, restore/enhance conservation values, provide compatible ranch, recreational, and educational opportunities, and prevent any land uses that would interfere with ranch stewardship or conservation of the property. The objectives listed for a fencing action in the Project Framework in Section 3 of this report include the creation of improved habitat for aquatic organisms and utilization of created habitat by native organisms. The objectives stated in the project documents are complementary to the recommended objectives.

### 6.5.4 Project Timeline

The initial application for OWEB funding was submitted in 2001 and was not approved. The objectives of the original request included excavating vertical banks to stable 2:1 slope banks, re-establishing the meander width ratio, reconnecting the springs to the river, restoring the off-stream wetlands, and fencing the riparian area. The estimated cost for the project was approximately $500,000 per river mile. The OWEB funding request was modified in 2003 for purchase and construction of riparian fencing to support rotational and seasonal grazing plans and significant cattle reduction. The fencing project was completed in October, 2005. Formal baseline data collection and monitoring was conducted at the site for vegetation (2005, 2007, 2010) and geomorphology (2000, 2003, 2006, 2010); however, detailed monitoring reports or data were not included in the project file. Monitoring results were summarized in one compliance monitoring report (2007) and in a presentation by the Klamath Tribes in 2010. We completed our reconnaissance level assessment in late 2011. After our field site visit, the Klamath Tribes provided additional monitoring data and progress report from 2010 (Klamath Tribes, 2010) that we included in our PPA.

### 6.5.5 Relevant Conceptual Models

The **Grazing** conceptual model guided our PPA of the Sycan River project and is described in further detail in Section 3.2 of this report. The Grazing conceptual model predicts significant alteration in channel cross section, channel profile, channel alignment, and changes in riparian vegetation, leading to bank erosion, reduction in riparian vegetation, and degradation of water quality from livestock access to the riparian corridor. Livestock management and vegetation planting will lead to an increase in channel complexity and stability that will promote biological colonization and succession. Our review of the project documents suggests that the physical processes illustrated in the conceptual model were considered in the project design in terms of vegetation and water quality.

### 6.5.6 Post Project Appraisal

#### *6.5.6.1 Methods*

The Organizational Framework introduced in Section 3.1 lists several metrics to evaluate fencing projects relative to the project's goals and objectives. Metrics recommended for this type of project include channel and floodplain geometry, longitudinal profile of the channel, hydrology, sediment characterization, and riparian cover. Post project monitoring has been conducted for this project, but detailed monitoring results were not included in the project file. Additional monitoring data and progress report were provided to us after our site visit. On November 12, 2011, we conducted a reconnaissance level assessment of vegetation and bank erosion, and documented field observations with digital photographs (**Error! Reference source not found.**) and GPS waypoints (a detailed description of these methods can be found in Section 4 of this report). We also compared historical aerial and ground photographs to assess channel and vegetation changes over time. We used the water temperature data and time series of the ground photographs to compare changes over time at the site.

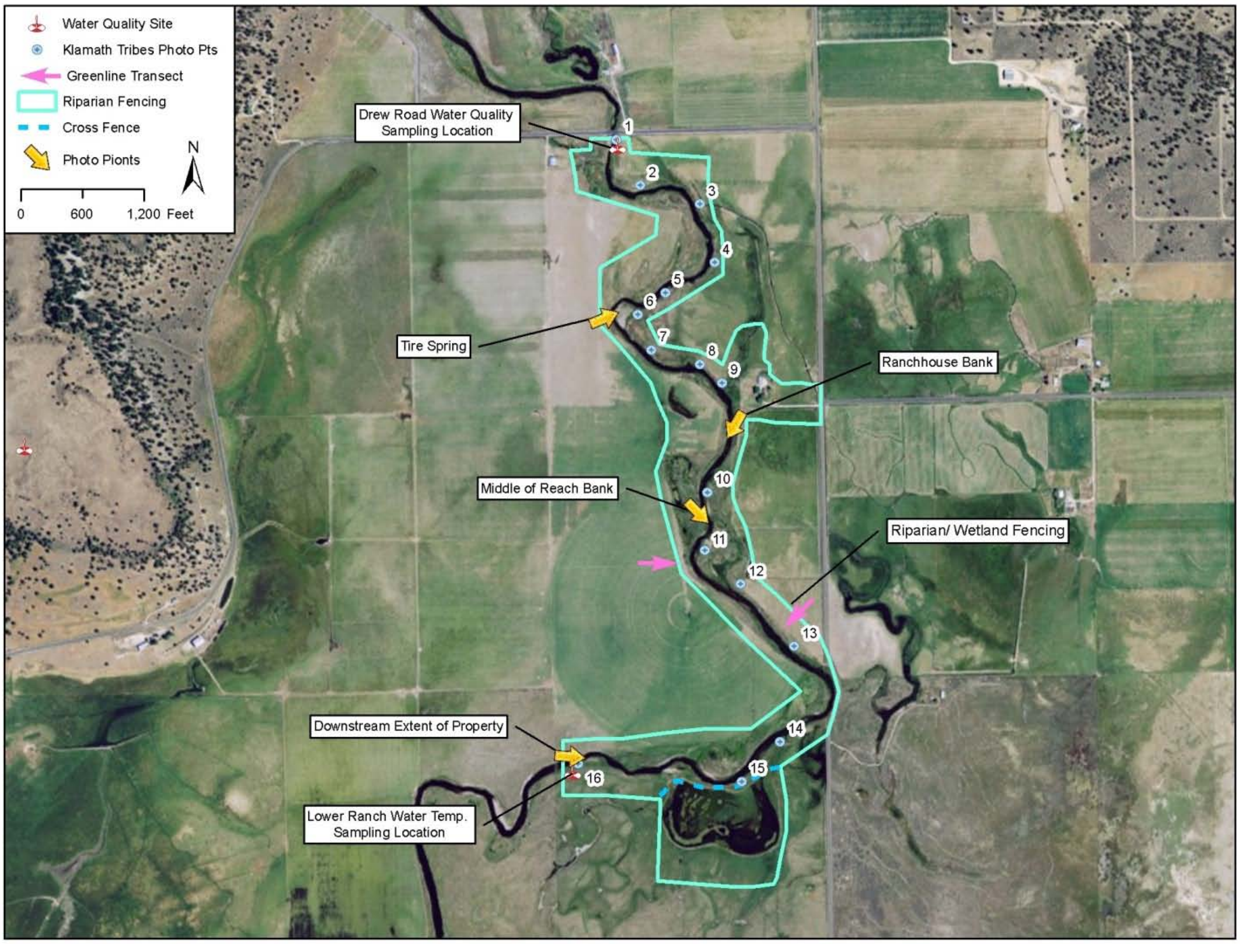



*Figure 6.5-2: Base map showing project riparian fencing, location of digital ground photographs (yellow arrows), two greenline transects (pink arrows), and the water temperature monitoring locations (blue dots).*

### 6.5.6.2 Results

#### 6.5.6.2.1 Post-Project Monitoring Evaluation

The documents that we reviewed in the project file referenced formal monitoring at the site, but limited monitoring information was available for our review except for two compliance monitoring reports (2007 & 2010), which contained general descriptions, a PowerPoint presentation from the Klamath Tribes (2010) summarizing biogeomorphic monitoring at the project site, and a PowerPoint presentation summarizing 16 ground photography monitoring locations from 2001 to 2010. The availability of monitoring data for this project was better than other sites we evaluated for this project, and using the Downs and Kondolf (2002) PPA rating system we characterized the project's monitoring investment as medium term. Still, ideally, a more complete suite of assessment methods would be applied to future similar projects so that more can be learned as those projects evolve through time. Also, data collected from monitoring needs to be consolidated and stored in one location so that it can be reviewed. The compliance monitoring report (2007) states that the fencing has been instrumental in helping the landowners manage their cattle and that riparian recovery has been excellent in the past few years. Strong recovery of sedge/rush comminutes and significant regeneration of several species of willows was noted. The report establishes the baseline condition was almost completely denuded of vegetation and provides pre- and post-project photographs, which we revisited. The report further states that channel changes include significant expansion of point bars and associated meanders, some development of pool-riffle sequences, significant accumulation of sediments, bank building, and narrowing of the river channel. In terms of the project goal to use the project to demonstrate cost-effective, cattle-compatible restoration in the Sprague Valley, the project site has been visited or featured in numerous forums, panels, and conferences. Qualitatively the project has achieved the project objectives, but without the data collected from monitoring activities the learning from this project was limited.

We reviewed the summary results of vegetation monitoring from 2005, 2007, and 2010 and geomorphic baseline data collection and monitoring from 2000, 2003, 2006, and 2010. Comparison of the 17 thalweg points over a ten year period shows channel incision and deposition. Before the construction of the riparian fencing in 2005 the channel was incising (2000-2003). The post-project channel bed elevations in 2006 show that the channel bed elevation increased compared to the pre-project bed elevation in 2003. During the four year period from 2006 to 2010, the channel has incised slightly, but most of this change is isolated to scour at pools that had been partially filled before the 2006 event (Figure 6.5-3).

After reviewing the first draft of this report, the Klamath Tribes provided cross section data from 2003 for 21 cross sections. The Klamath Tribes were unable to locate cross section data from the other years in time for final publication of this report. Therefore, we were not able to consider channel geometry changes in this PPA. This highlights the need for careful data storage and documentation in support of post project appraisals.

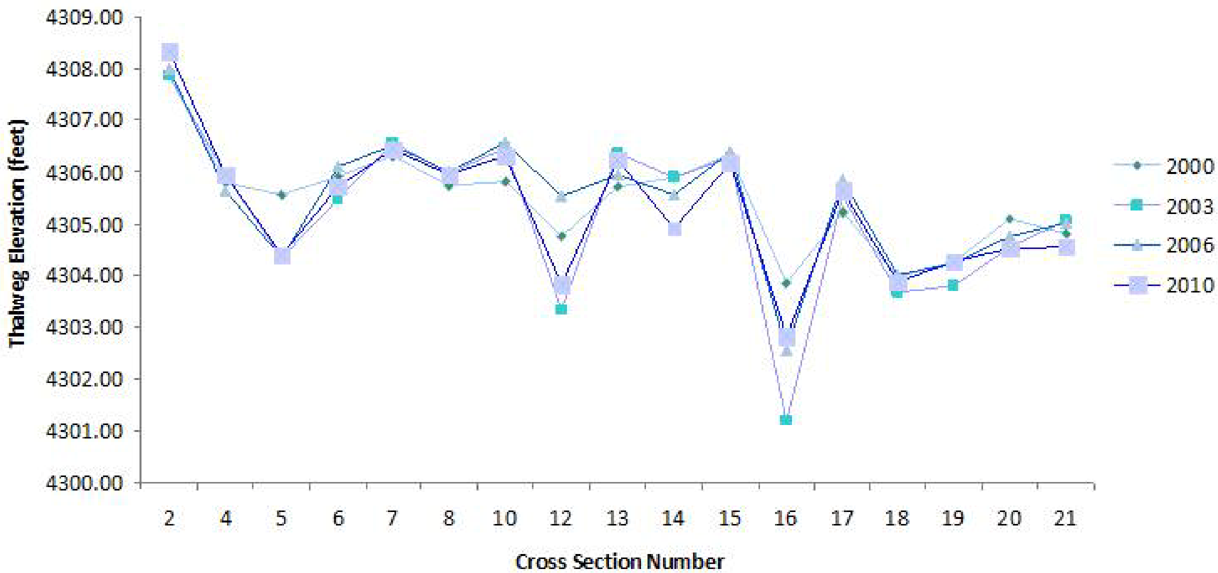



*Figure 6.5-3: Thalweg elevation change over ten years. The riparian fencing project was completed in 2005 and baseline data was collected for earlier project conceptual designs in 2000 and 2003.*

Three greenline surveys in 2005, 2007, and 2010 summarized in the Hughes (2010) presentation shows relatively little change in riparian vegetation along the channel edge. The inability of the greenline surveys to detect the increase in the riparian vegetation along the river is explained by lateral shifts in the location of the greenline as the channel experienced incision and deposition. The greenline was following the early seral stage of riparian vegetation colonization on the channel banks as the greenline shifted with changes in bed elevation and does not follow the trends identified in the comparison of ground photographs in the section below. The 2010 Progress Report states that no woody plants were detected in the 2005 transects and two willows were detected in 2007.

A water quality monitoring site was established downstream of Drews Road at the upstream extent of the project area in 2003. Between September 2003 and January 2010 158 water quality samples were collected. Data collected includes temperature, pH, dissolved oxygen, conductivity, oxidation reduction potential, ammonia nitrogen, nitrate, total nitrogen, soluble reactive phosphorus, and total phosphorus. We compared the temperature data from the Drews Road water quality sampling location with the temperature data collected at the downstream monitoring location. **Error! Reference source not found.** shows the comparison between temperature at the upper and lower sites. Measurements were made within 30 minutes of each other on the days that water quality parameters were collected at the Drews Road site. **Error! Reference source not found.** shows a similar pattern at the two sites, but water temperatures peak at higher values at the lower site. This suggests heating through the project site during hot periods.

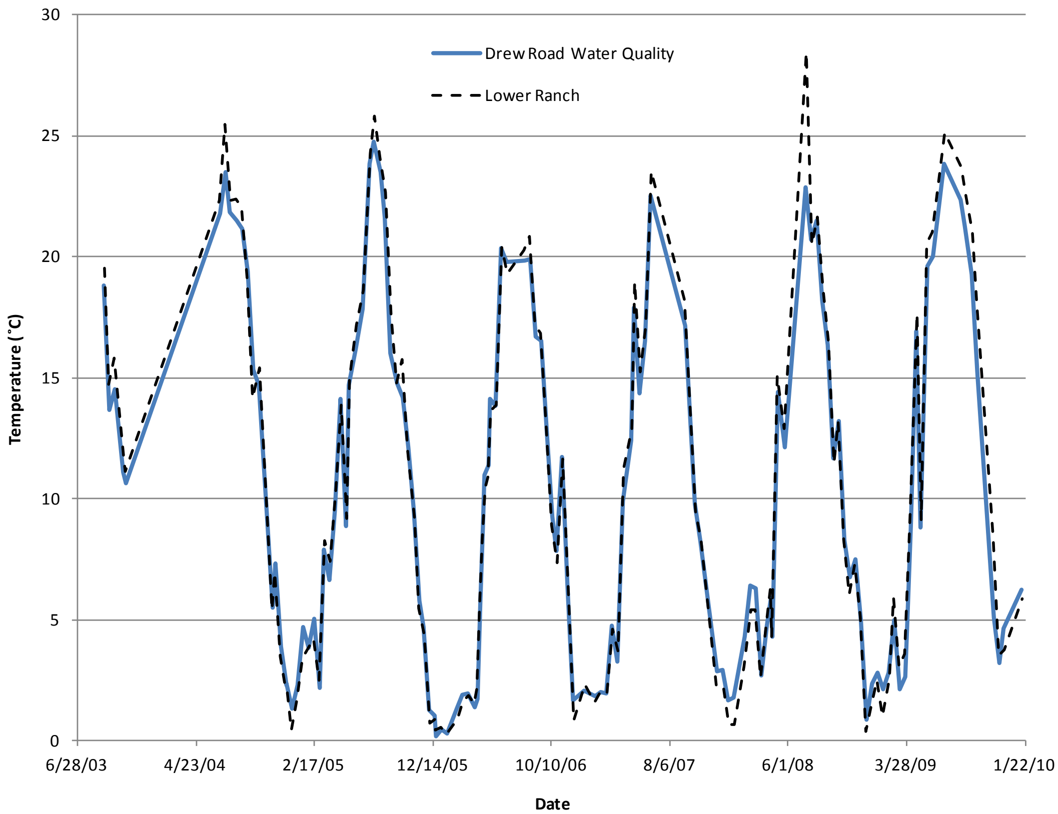



*Figure 6.5-4: Temperature comparison between the Dews Road water quality sampling location and the lower ranch temperature monitoring location.*

### 6.5.6.2.2 Historical Ground Photograph Evaluation

To visually assess changes in riparian vegetation and bank conditions, we compared pre-project photographs for the project with photographs taken by the Klamath Tribes and the photographs that we took during our field reconnaissance. The locations of photographs are shown in **Error! Reference source not found.**. Figure 6.5-5 shows the change in the vegetation around the Old Tire Spring and Figure 6.5-6 shows the change in bank condition and riparian vegetation west of the ranch house. Figure 6.5-7 is taken in the middle of the project reach and shows revegetation of grass, sedge, and rush communities. Figure 6.5-8 shows the increase in vegetation at the downstream extent of the property. Figures 6.5-9 to 6.5-12 show the change in vegetation and bank condition at the Klamath Tribes photo points 2, 7, 12, and 13, which illustrate representative changes in the project reach. These photos show grass as the dominate vegetation type. In Figure 6.5-11 bare or eroded banks have been vegetated with grass. These photos do not show an increase in woody vegetation along the channel.

*Figure 6.5-5: Conditions in 2001/2002 showing the pre-project condition of the Old Tire Spring (left image). The same spring in 2011 (right image). Comparison of the photographs shows an increase in vegetation and decrease in trash. Both changes improve water quality.*

*Figure 6.5-6: Conditions in 2001/02 looking at the east bank of the Sycan River adjacent to the ranch house on the project property (left image). Similar location and perspective in 2006 (middle image) and again in 2011(right image) showing regeneration of vegetation in th riparian corridor ). Vegetation on the bank helps stabilize the bank and reduces erosion and fine sediment input into the Sprague River Basin.*

*Figure 6.5-7: Conditions in 2001/02 from the middle of the project reach (left image). Similar location and perspective in 2011 showing regeneration of vegetation in the riparian corridor (right image).*

*Figure 6.5-8: Conditions in 2001/02 on the west bank of the Sycan River at the downstream extent of the project property (left image). Conditions in 2011 showing regeneration of vegetation in the riparian corridor as a result of the fencing project completed in 2005 (right image).*

*Figure 6.5-9: Conditions in 2001/02 from the Klamath Tribes photo point 2 Angle D (left image). Similar location and perspective in 2011 showing regeneration of vegetation in the riparian corridor (right image).*

*Figure 6.5-10: Conditions in 2001/02 from the Klamath Tribes photo point 7 Angle D (left image). Similar location and perspective in 2011 showing regeneration of vegetation in the riparian corridor (right image).*

*Figure 6.5-11: Conditions in 2001/02 from the Klamath Tribes photo point 12 stream channel (left image). Similar location and perspective in 2011 showing regeneration of vegetation in the riparian corridor (right image).*

*Figure 6.5-12: Conditions in 2001/02 from the Klamath Tribes photo point 13 Angle D (left image). Similar location and perspective in 2011 showing regeneration of vegetation in the riparian corridor (right image).*

#### 6.5.6.2.3 Historical Aerial Photograph Evaluation

We reviewed historical aerial photographs to assess the changes before and after the project and to identify trends in channel change at the site. Our review of the historical photographs from 1940 to 2009 (Figure 6.5-13) shows that the channel has simplified over time. However, by 1940, land use impacts (ranching, farming, and timber extraction) had already impacted the channel. The largest changes we identified between the 1940 and 1995 aerial photographs show disconnection between the channel and cutoff meander bends and off-channel wetlands in the downstream extent of the project reach. The large fenced wetland in the downstream portion of the project reach was further cut off from the channel when a levee was constructed by 1995. In the upstream extent of the project reach, the islands we identified in the 1940 aerial photographs have become bars or terrace features by 1995.

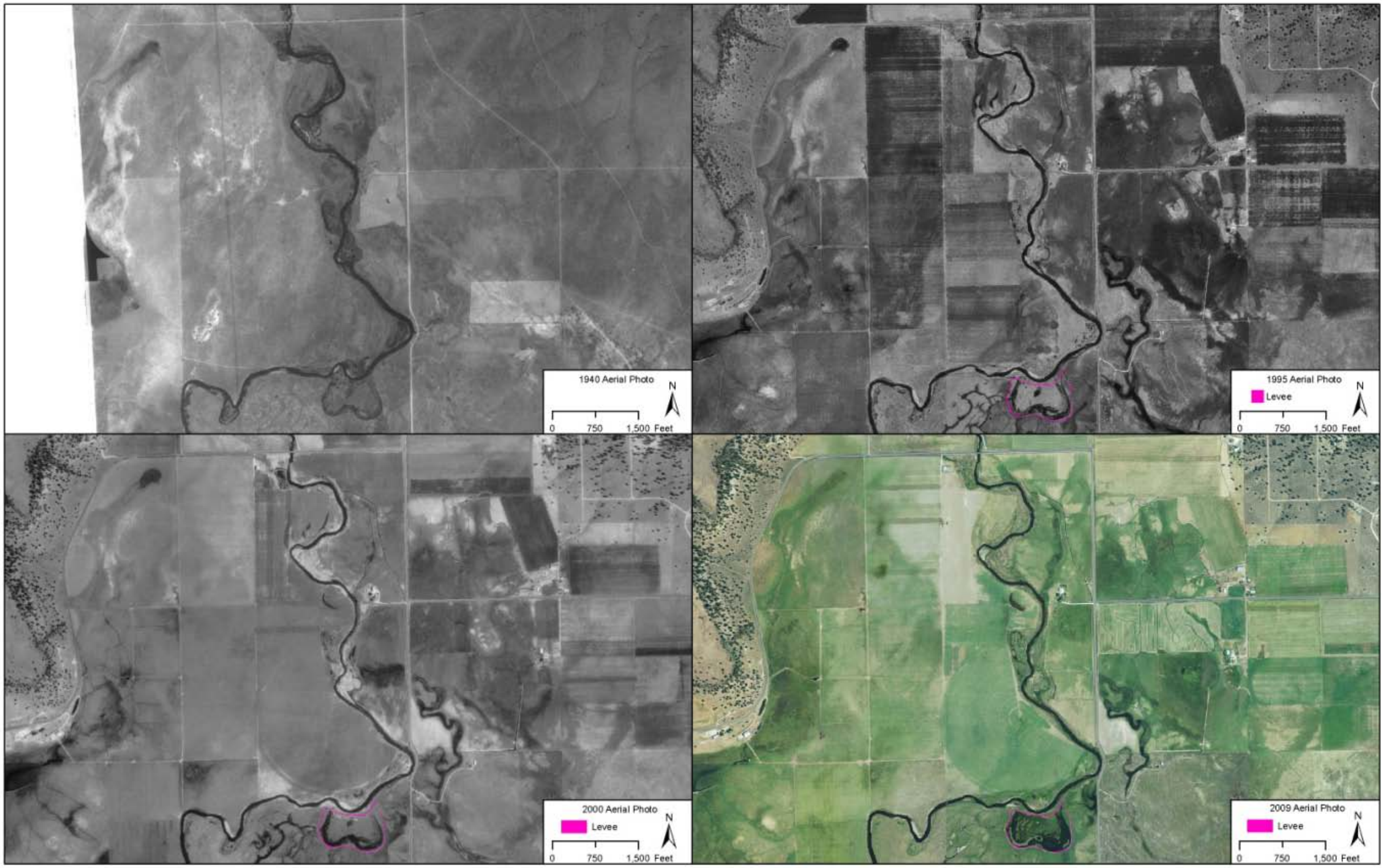



*Figure 6.5-13: Comparison of historical aerial photographs from 1940, 1995, 2000, and 2009 showing levee locations from 1995.*

### 6.5.7 PPA Lessons Learned

Based on our review of project documents, our field observations, and this PPA, we identified a variety of useful lessons from the Sycan River project at the site and basin scale. Table 6.5-1 presents a summary of lessons learned at the site and basin scale by restoration project life-cycle phase.

*Table 6.5-1: Summary of key lessons learned from the Sycan River Project*

| Restoration Project Life-cycle Phase | Scale for Lesson | Lessons Learned |
|---|---|---|
| Pre-Project – Goals/objectives, Planning, Data Collection, Analysis | Site-specific and Basinwide | Improve monitoring data management so that the data collected can be used for quantitative evaluation of project performance and more accurate assessment against project success criteria. |
| | | Establishment of native forbs and woody vegetation requires analysis and planning of planting technique, predator control, weed control, correct groundwater and surface water hydrology for colonization of native species. |
| | | Fencing reduces cattle impacts on banks and allows regeneration of riparian vegetation, but basin wide geomorphic processes may continue bank erosion. |
| Design | Site-specific and Basinwide | Setback fences at channel bends to account for migration/bank erosion |
| | Basinwide | Need for cost-effective approach to private landowners restoration that can be replicated across the Sprague River Basin (such as riparian fencing and grazing management plans) |
| Implementation | Site-specific and Basinwide | GPS/Survey features constructed/planted (fences, willows planted by landowner) to document project features. |
| | Site-specific | Use barbed wire and railroad ties to re-enforce fence posts at property boundaries where pressure on fences is greatest from adjacent landowner livestock. |
| | Site-specific and Basinwide | Flash or rotational livestock grazing in the riparian corridor may help control non-native vegetation species such as star thistle and young reed canary grass. Cattle preference for non-native species is life stage dependent and may limit the usefulness of livestock grazing for non-native species control in the riparian corridor (e.g. once reed canary grass reaches maturity, cattle will look for other plants to eat). Long term maintenance should be included in the project budget to prevent cattle from adjacent properties from migrating onto project properties. |
| Monitoring | Site-specific | Continue vegetation and geomorphic monitoring (cross sections and longitudinal profile) to assess project success and adaptively manage the project. |
| | Site-specific and Basinwide | Determine percent composition of the vegetation communities that are non-native species using plots instead of greenline surveys, which are impacted by channel geometry changes. |
| | Site-specific | Install fence posts on both sides of the channel banks to mark the ends points of cross sections. |
| | Site-specific and Basinwide | Standardize monitoring data so that monitoring can be replicated from the data in the report (all photos and surveys should be georeferenced). |
| General | Basinwide | Basin wide landowner cooperation is required for significant restoration of the Sprague River Basin and this project was a good demonstration of cooperation between the landowner, agencies, and stakeholders that provided educational opportunities for other landowners. |

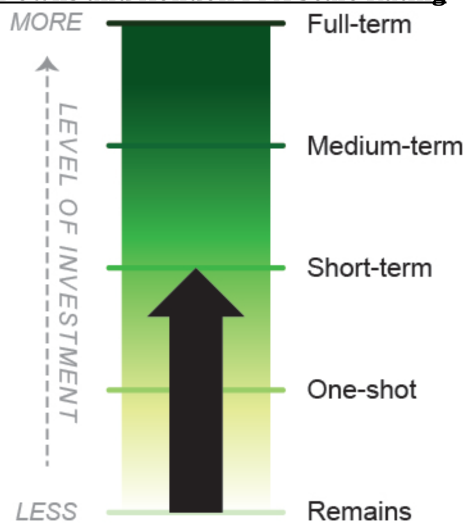
| Restoration Project Life-cycle Phase | Scale for Lesson | Lessons Learned |
|---|---|---|
| | | Fencing and cattle management plans are a common ground between agencies, stakeholders, and nonprofits that may lead to larger restoration projects on private land. |
| | | Vegetation regeneration creates a buffer strip in the riparian corridor that decreases fine sediment and nutrient input into the channel and improves water quality at the basin wide scale. |

At the project site scale, we learned that relatively minor changes to the planning, design, implementation, and monitoring of this project could have improved its overall performance. This project has the most post-project monitoring of any of the projects we reviewed, but most of the data is not available. A better data management framework must be implemented to store monitoring data that has been collected for this project and retain data during staff turnover.

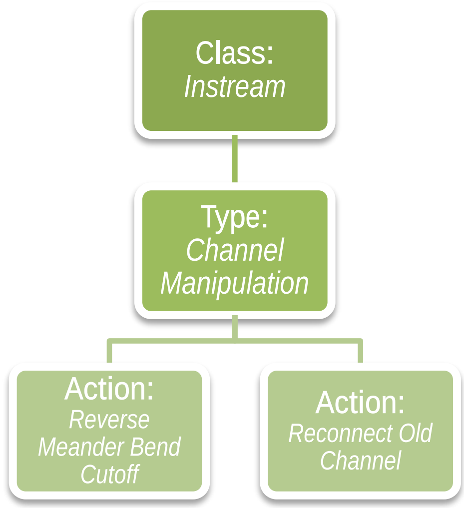
We learned from our post project appraisal of the Sycan River project that the project contributes to the basin wide goal of providing more normative chemical, thermal, and physical aquatic conditions expected to benefit native fish populations and water quality in the Upper Klamath Basin by re-establishing vegetation in the riparian corridor. However, additional work appears to be required at this site to maximize the basinwide benefits possible in terms of native vegetation regeneration. In terms of reducing erosion and sedimentation, fencing projects provide quantifiable benefits at a low cost.

## 6.6 Beatty Station Project – Sprague River (Middle Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**




### 6.6.1 PPA Synopsis

We selected this project to provide a PPA case-study of multiple meander cutoff reversals using meander cutoff plugs, and reconnection to a historic channel. Project documentation also describes excavation and planting of seasonal wetlands on the floodplains, but our PPA focused on the chute cutoff plugging and channel reconnection aspects of the project. The Beatty Station project fits the instream class and the channel manipulation project type. Our PPA of this project was informed by the meander cutoff plug conceptual models.

The documents developed for this project listed site specific goals (e.g. improved aquatic and riverside habitat conditions for endangered fish species, improved and expanded wetland habitat for migratory waterfowl, and reconstructing a section of the Sprague River to increase channel stability, wetland habitat diversity, and fish habitat complexity). These goals were supported by objectives that were both site specific (e.g. modify pre-existing river channel dimensions and morphology to more closely resemble the historic conditions) and basinwide (e.g. improve channel functions and channel-floodplain connectivity). We conducted our PPA of this project by evaluating limited pre-project baseline data and up to 5 years of post-project monitoring data, to which we added current (November 2011) survey data and photo point observations, as well as a historical aerial photography analysis. As we discussed in the introduction to this report and in the Nine Mile Road PPA, the uncertainty surrounding the present rate of channel straightening by meander cutoffs in the Sprague River Basin makes a definitive appraisal of the performance of this type of project challenging, especially at the basin scale. The primary lessons learned from this project were that:

- meander bend chute cutoff plugging does not significantly improve aquatic habitat conditions for native fishes as compared to reference sites;

- proper channel restoration design techniques must be employed for the primary river channel to mitigate channel adjustment that can occur as a result of the meander bend chute cutoff plugs; and
- project goals and objectives must be organized and coordinated between all project partners, and expressed in terms that are specific, measurable, and temporally constrained.

### 6.6.2 Site Conditions

The Beatty Station project occurs on private property which includes 511 acres on both sides of the Sprague River approximately 1 mile north of Beatty, Oregon and east of Godowa Springs Road (Figure 6.6-1). This project was coordinated with restoration of the upstream landowner whose property includes many springs, and is an important spawning area for suckers and redband trout. This reach is one of the few areas where resident Lost River suckers have been found in the Sprague River (USFWS, unpublished data).

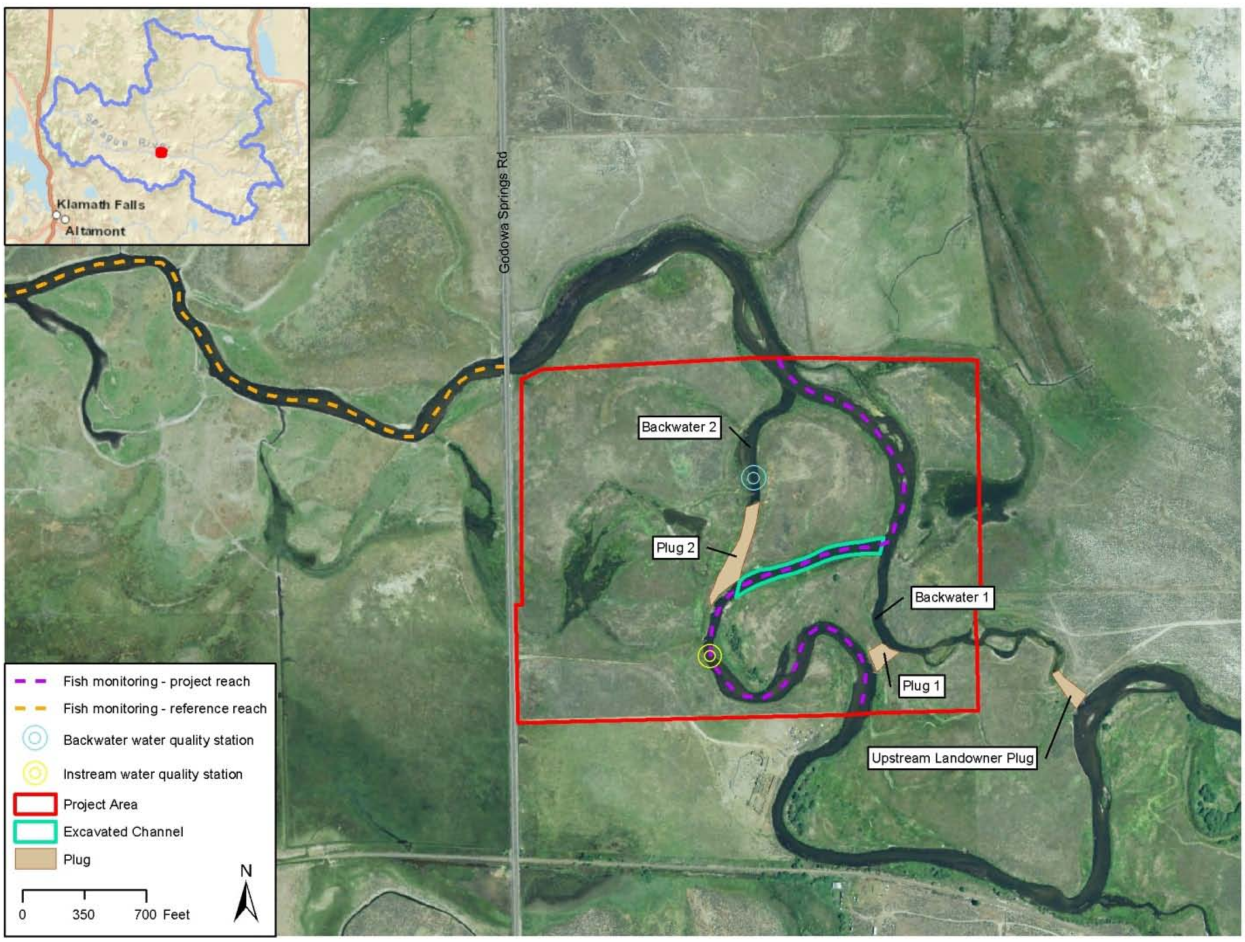



*Figure 6.6-1: Beatty Station project site showing the main restoration project elements and the USFWS post-project fish and water quality monitoring locations*

Historically, this area was intensively grazed by livestock. However, in 1999 the landowners enrolled their properties in the Wetland Reserve Program (WRP) administered by the Natural Resources

Conservation Service (NRCS). The WRP requires landowners to manage their property primarily as wetland and riverine habitat to benefit fish and wildlife. Livestock grazing and other land use practices are now restricted.

Pre-restoration project aerial photos of the Beatty Station project site show large cut-off channels in this reach splitting the flow and shortening the river channel (Figure 6.6-2).

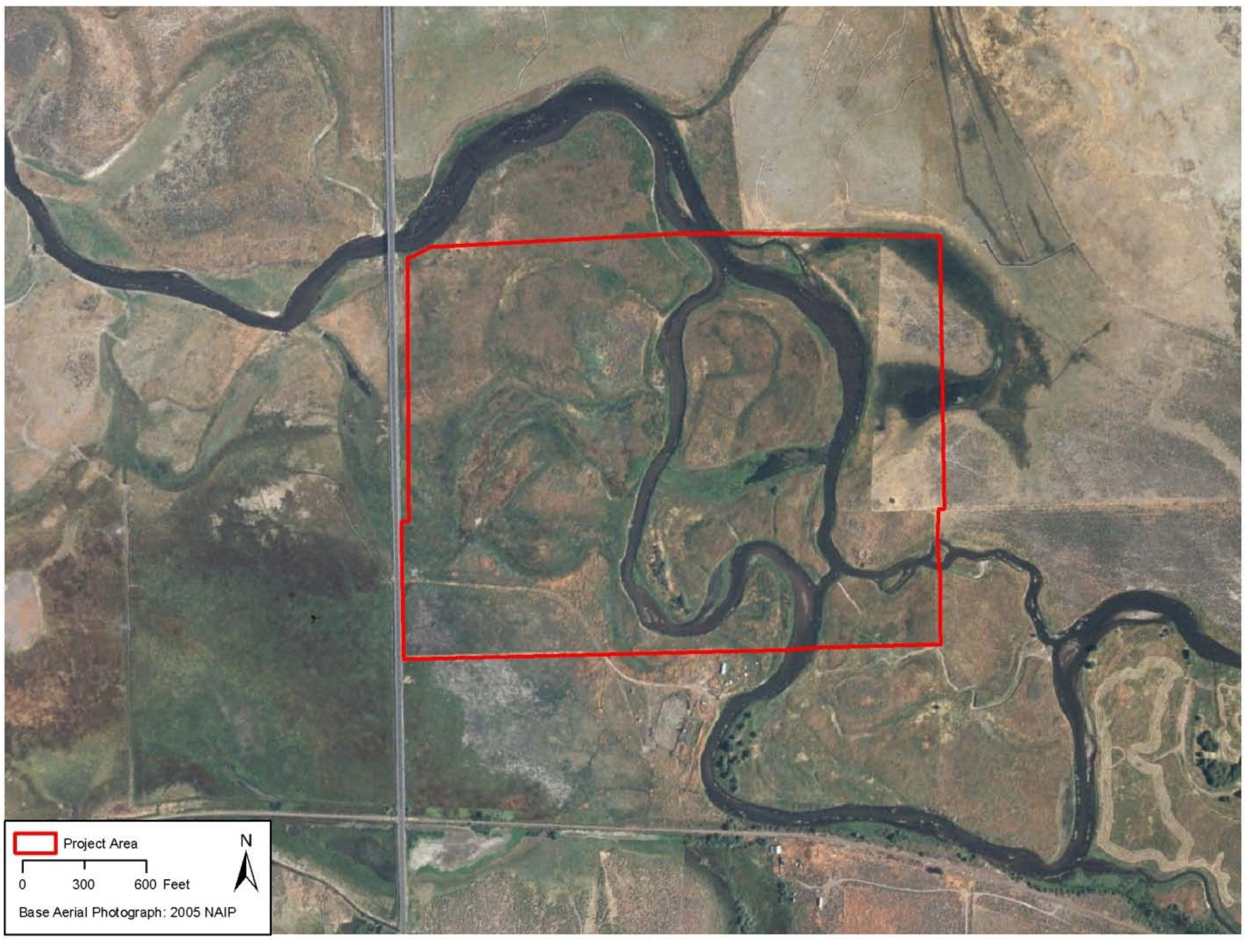



*Figure 6.6-2: Beatty Station project pre-restoration aerial photograph (2005)*

Beginning in 2005 and extending into 2007, the landowner in partnership with the USFWS, NRCS, Oregon Department of State Lands, and the U.S. Army Corps of Engineers, initiated restoration on the Beatty Station project site. Actions on the property included constructing two meander cutoff channel plugs, reconstructing approximately 800 ft of historical channel, building seven engineered log jams and bioengineered soil lift banks, excavating two seasonal wetlands on the floodplain to create hydrologic connections to the river for larval and juvenile fish habitat as well as habitat for shorebirds and migratory waterfowl, and developing a floodplain revegetation plan. The two plugged cutoff channels were shaped into backwater wetlands and planted with willow seedlings. This project was completed in conjunction with an upstream channel cut-off plug project on the adjacent property (Figure 6.6-1).

Additionally, a revegetation plan was developed for the restoration project, which included vegetated soil lifts (90 linear bank feet), seeding (a total of 0.2 acres), live willow staking (along 5,600 feet of stream banks), containerized plantings (over 1.84 acres), invasive species control, and a maintenance and monitoring plan including temporary irrigation (Geum Environmental Consulting, 2006.) It is unclear how much of this planting plan was implemented, and in which locations. Troy Bradt of RDG has provided data indicating that at least some planting did occur, as well as sporadic weed treatments in years 1 and 2 post-construction. Temporary irrigation occurred during project construction and planting but not in post-project years.

### 6.6.3 Success Criteria

The Beatty Station project includes a wide range of goals and objectives. These were compiled from project planning and design documents; different entities involved with the project tended to have different success criteria for the project.

Project goals included providing improved aquatic and riverside habitat conditions for endangered fish species (shortnose and Lost River suckers, Klamath redband trout), improving and expanding wetland habitat for migratory waterfowl adjacent to the Sprague River, and increasing channel stability.

Project objectives included modifying river channel dimensions and morphology to more closely resemble historical conditions, diverting multiple channels in the project area into a single channel to increase depth and lower temperatures in the main channel, modifying existing backwater sloughs to enhance habitat for larval and juvenile suckers and redband trout, increasing aquatic habitat diversity by adding stable large wood to channel margins, increasing the channel length, and augmenting the riparian vegetation community, excavating upland areas to generate fill material and increase floodplain habitat areas, selectively planting wetland plants around the newly created wetlands to create habitat cover and feedstocks for migratory waterfowl, protecting and improving restored wetlands to emulate critical natural flow patterns to support viable populations of native fish, increasing base flow aquatic habitat volume in a primary channel and providing off-channel habitat, providing educational and monitoring activities to foster improved design and management, improving channel functions and channel-floodplain connectivity, improving water quality, improving riparian vegetation conditions, providing off-stream water storage, and improving aquatic habitat diversity.

### 6.6.4 Project Timeline

In 1999, the landowners incorporated approximately 500-acres into a Wetland Reserve Program (WRP) easement. Since 2000, several agencies and cooperators including the USFWS, NRCS, Ducks Unlimited and other organizations, have conducted monitoring on the project site including peizometers, groundwater wells, temperature loggers, river cross-sections, vegetation plots, fish surveys, and maintenance of a USFWS bioassessment site. Phase 1 of the restoration project (including construction of meander bend cutoff plugs, diversion of the river into a single newly constructed channel, engineered log jams, and soil lifts, and riparian revegetation) was initiated and completed in fall 2006. Additionally, two seasonal wetlands were excavated from the floodplain. In 2007 and 2008, the USFWS conducted post-restoration fish and water quality monitoring on the project site.

### 6.6.5 Relevant Conceptual Models

The ***meander cutoff plug*** conceptual model (Section 3.2-3) informed and guided our PPA of the Beatty Station project. The goals and objectives for the project indicate that the project proponents and designers were aware of the typical changes predicted by these conceptual models for the implemented actions.

However, it is unclear how degraded the pre-project conditions were in terms of stated project objectives (especially in terms of fish habitat and channel conditions), and thus how effective this project was at achieving its habitat and geomorphic enhancement goals. More careful documentation of aquatic and riparian habitat conditions, as well as local channel geometry and planform changes through time in the pre-project channel could have been conducted to definitively determine whether or not habitat conditions were poor or were degrading, and if so, at what rate. While this project did achieve many of its site specific design objectives, there is a lack of sufficient data available to determine whether or not satisfying these objectives has really enhanced or restored habitat conditions at either the site or watershed scale.

### 6.6.6 Post Project Appraisal

#### *6.6.6.1 Methods*

The Project Framework (Section 3.1) lists several metrics that could be used to evaluate the performance of this type of project relative to its goals and objectives. These include topographic surveys, facies mapping, pebble counts, hydrologic records (stage measurements), and the mapping and quantification of density and extent of large wood, vegetation, root structure, and other forms of aquatic cover to assess geomorphic performance. The measurement of vegetation, fish, and macroinvertebrate species presence, abundance, and diversity would allow determination of the increase in abundance and diversity of native species in the restored habitat areas. Finally, the measurement of water quality parameters (particularly temperature, dissolved oxygen, and nutrients) would allow assessment of water quality conditions for native organisms.

We compared pre-project cross-section surveys collected during the design phase with as-built cross-sections and post project cross sections that we collected in 2011 to compare channel geometry over a 6 years spanning project implementation. A longitudinal profile of the channel was performed by RDG during the design phase, but no follow-up longitudinal profile surveys have been performed. No pre- or post-project channel substrate data was available for the project area. Hydrologic data including continuous stage measurements only exists through 1992, when the relevant USGS gage (11497500 Sprague River near Beatty) was discontinued. Data that include pre-project aquatic or riparian habitat surveys, fish monitoring, and water quality monitoring either do not exist, or were not made available for the PPA. The USFWS performed several years of post-project fish and water quality monitoring in the main channel, backwater channels, and reference reaches (for fish monitoring). Finally, photo-monitoring of post-restoration project features provides an indication of channel stability and the success of revegetation efforts (Figure 6.6-3).

To supplement the available post-project monitoring data, we collected additional monitoring data in November 2011 that included assembling historical and current ground and aerial photos, taking photographs at photo-monitoring locations, and resurveying monitoring cross sections (Figure 6.6-3).

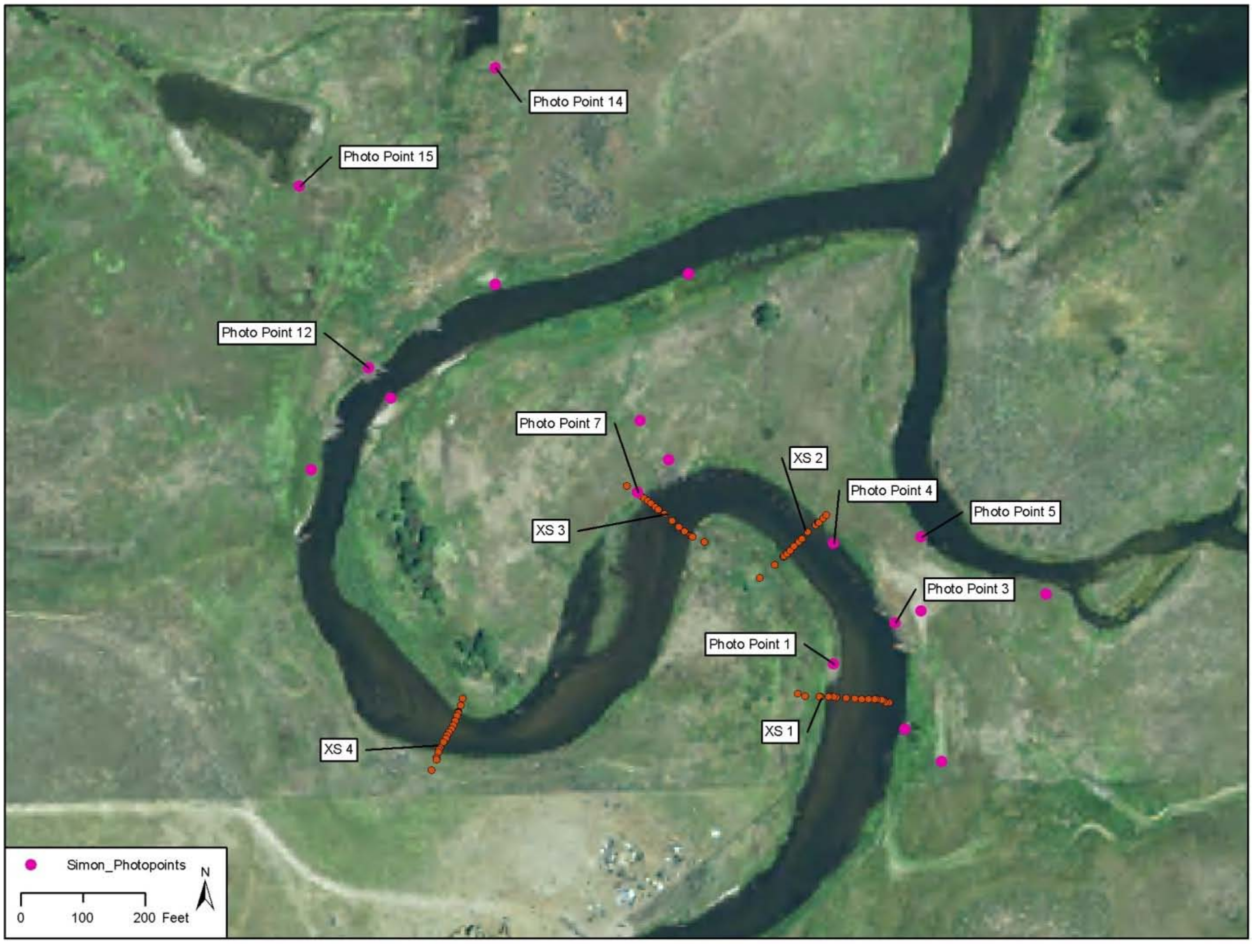



*Figure 6.6-3: Location of channel cross sections used to evaluate instream changes between 2005 and 2011, and photo monitoring stations used to evaluate post-project channel stability and revegetation.*

### *6.6.6.2 Results*

#### 6.6.6.2.1 Channel Geometry

We compared pre-project and as-built channel cross-sections from 2006 with post-project cross sections from November 2011 in a portion of the channel adjacent to the southernmost meander cutoff plug on the Simon property and immediately upstream of the reconstructed channel (Figure 6.6-4 to Figure 6.6-7). Note that NewFields uses different numbering for cross-sections than the numbering used by RDG (thus NewFields cross-section 1 is the same as RDG cross-section 2, NewFields cross-section 2 is the same as RDG cross-section 3, etc.)

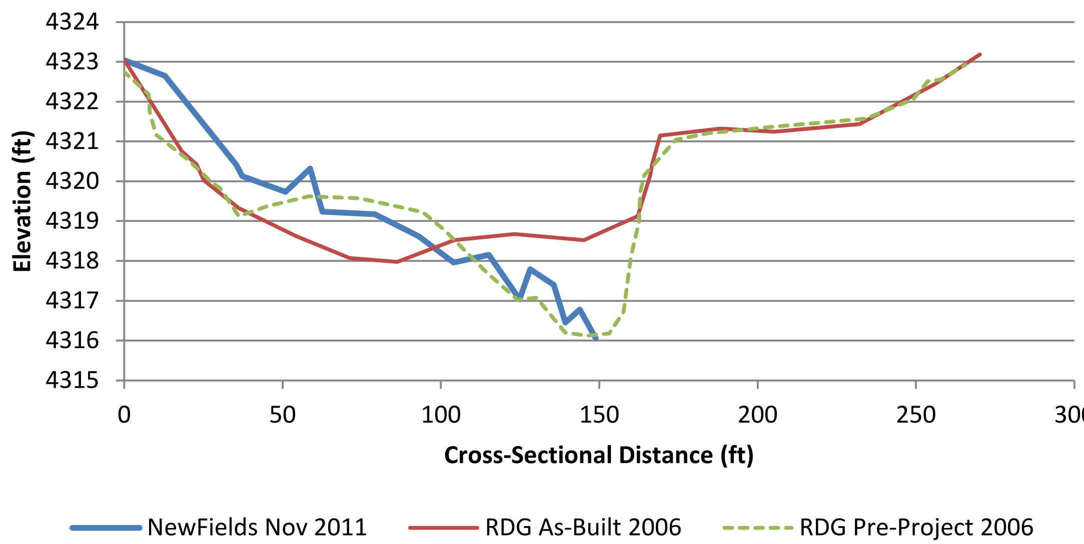



*Figure 6.6-4: NewFields cross-section 1 (RDG cross-section 2). 2011 cross-section survey was incomplete and only reached midway across channel, thalweg was too deep to safely collect data during the survey.*

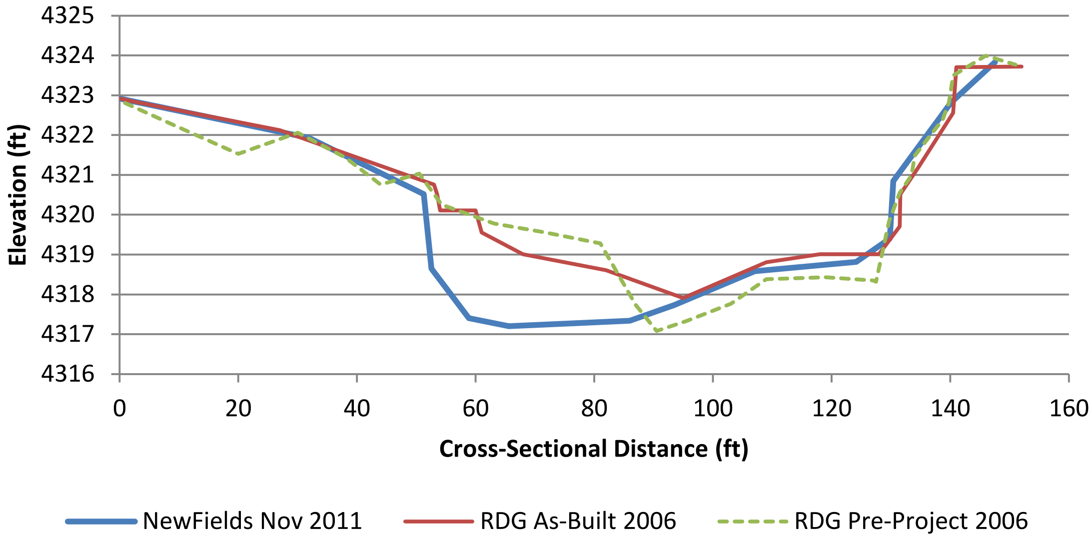



*Figure 6.6-5: NewFields cross-section 2 (RDG cross-section 3)*

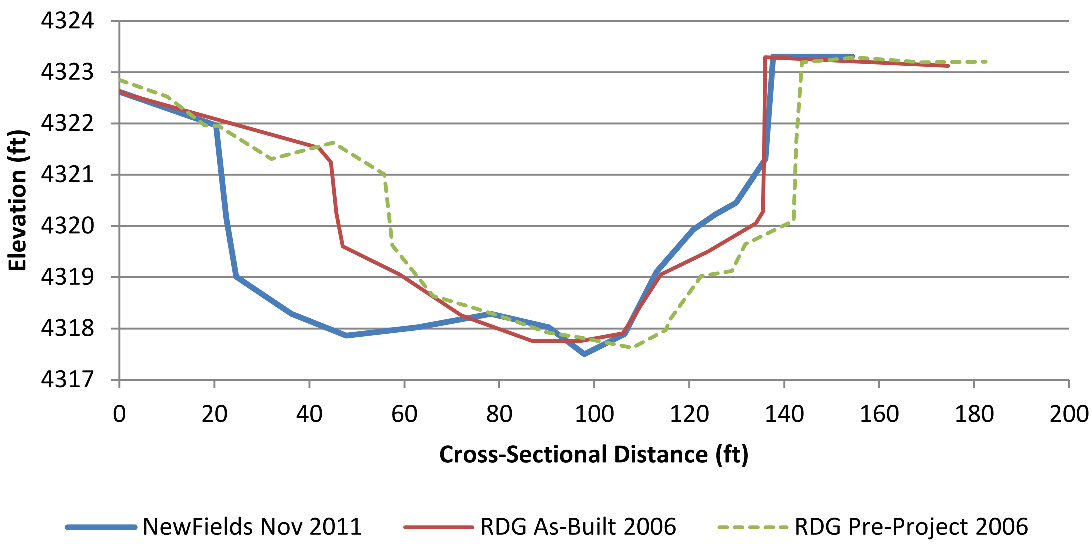



*Figure 6.6-6: NewFields cross-section 3 (RDG cross-section 4)*

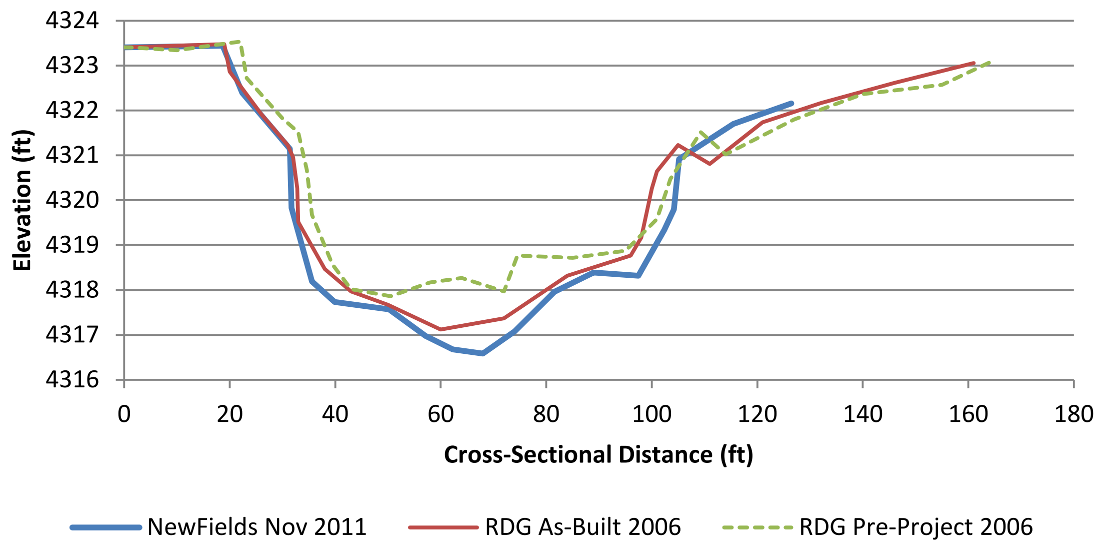



*Figure 6.6-7: NewFields cross-section 4 (RDG cross-section 5)*

Cross-section 1 includes only a partial survey of the channel from the left bank towards the channel thalweg. Interestingly, cross-section 1 appears to be evolving towards the original, pre-project channel dimensions, showing incision (deepening) of almost 2 feet from the as-built cross-section, with the thalweg migrating towards the right bank of the channel.

Cross-sections 2 and 3 show significant channel adjustments, with the cross-sectional area increasing substantially, and the channel widening more than 20 feet towards the left bank. Additionally, cross-section 2 shows incision (deepening) of almost 0.7 feet and cross-section 3 shows incision of a few inches. Cross-section 4 shows an overall widening and deepening of the channel cross-sectional area.

These transects all display a trend of channel widening and deepening from the as-built condition. Cross-section 1 occurs next to Plug 1, and cross-section 2-4 occur downstream of two meander bend cutoff plugs (the Upstream Landowner Plug and Plug 1). It appears likely that the plugs have increased the amount of flow in the main channel of the Sprague River, and that channel geometry is adjusting to accommodate the augmented discharge in this area. It is also apparent that restored channel was not adequately sized in this reach, which has led to rapid geomorphic adjustment. We consider this to be a design-related error, and not due to extremes in hydrology or climate, as the largest flow on record since the project was designed is less than a 2-yr event. After reviewing this PPA, RDG stated that the expansion of the channel cross sectional area was an expected outcome. The design assumption was that by increasing flow in the reach, the additional shear would scour the sand bed that dominated the reach, and that some channel widening would be expected occur in places where channel margin sediments are more mobile than the channel bed material (likely hardpan). While success criteria did include deepening of the channel, systematic widening was not clearly articulated as a desired project outcome. This highlights the need for clear and detailed success criteria in the early stages of project development.

### 6.6.6.2.2 Historical Photo Comparisons

Photographic monitoring stations have been established at various locations on the project site, and photographs ranging from 2005 to 2011 document changing conditions at these locations post-project (Figure 6.6-3).

Figure 6.6-8 shows the evolution of site conditions from 2006 (left), August 2009 (middle), and Nov 2011 (right) at photo-monitoring station 4, looking upstream from the right bank.


*Figure 6.6-8: Photo sequence of Sprague River main channel and riparian vegetation conditions at photo-monitoring station 4, looking upstream from the right bank, 2006 (left photo), August 2009 (middle photo), and Nov 2011 (right photo).*

Figure 6.6-9 shows the evolution of site conditions from 2005 (top left), Sept 2007 (top right), June 2009 (bottom left), August 2009 (bottom middle) and Nov 2011 (bottom right) at photo-monitoring station 12, looking downstream from the left bank at the engineered logjam on the face of Plug #2 and the newly constructed main channel.


*Figure 6.6-9: Photo sequence of Sprague River main channel and riparian vegetation conditions at photo-monitoring station 12, looking downstream from the left bank, 2005 (top left photo), Sept 2007 (top right), June 2009 (bottom left), August 2009 (bottom middle) and Nov 2011 (bottom right).*

Figure 6.6-10 below shows the evolution of site conditions from 2005 (top), Sept 2007 (bottom left), August 2009 (bottom middle), and Nov 2011 (bottom right) at photo-monitoring station 14, looking north into the backwater channel #2 from the channel plug.


*Figure 6.6-10: Photo sequence of the Backwater 2 conditions at photo-monitoring station 14, looking north from the channel plug, 2005 (top), Sept 2007 (bottom left), August 2009 (bottom middle), and Nov 2011 (bottom right).*

We considered the differences in seasons, water levels, and photograph orientation when assessing the photos and determined that at all sites there appears to be very little change in the composition, density, and extent of riparian vegetation. The riparian zone appears to be dominated by grasses (assumed to be predominately reed canary grass (*Phalaris arundinacea*)), with no evidence of willows or other restoration plantings.

Recent photos and correspondence with Troy Bradt at RDG provides evidence that willow plantings on parts of the site are more successful (Figure 6.6-11). According to Mr Bradt, "willow success has been high in certain locations especially at Plug 2, adjacent to the excavated channel, and around the excavated wetland. The willow community at Plug 2 is at least 5 ft high now."

*Figure 6.6-11: Recent willow growth in and around Plug 2 (photos from Troy Bradt, RDG, 2012).*

There are no noticeable changes in channel alignment, bank erosion, or condition of the structures (engineered log jams and soils lifts). That is likely due to the short monitoring period. However, it also contradicts the channel adjustments seen in the cross-sectional analyses. This could be explained by the fact that the cross-sectional adjustments appear to be taking place within the wetted channel, and not (yet) manifesting as bank erosion along the wetted channel / upper terrace margins.

We performed additional comparisons of historical aerial photographs of the project site, analyzing changes in planform channel alignment, vegetation, and other site conditions from 1940 to 2009 (Figure 6.6-12). The following trends are visible:

- Denuded floodplain vegetation in 1940
- Very few changes to Sprague River channel alignment and configuration from 1940 to 2000
- Minor increases in the extent of riparian vegetation in 2009 (post-project)

As part of the design process, RDG performed analyses of historical channel conditions (RDG 2006). Using a General Land Office (GLO) map from 1872, they identified just one primary channel in 1872 in this reach of the Sprague River. By 1941, meander cut-offs and channel avulsion processes had created three active channels that conveyed discharge during baseflows (Figure 6.6-13). A portion of the main channel depicted in the 1872 GLO map became disconnected from the baseflow channel network, but the segment was active as flows approach the bankfull stage.

This analysis was used as justification to assume that the channel was on a geomorphic trajectory of straightening and simplifying. It also was the foundation of the restoration design concept, which reoccupied the historic main channel segment that is shown on the 1872 map, but became disconnected by 1940/41.

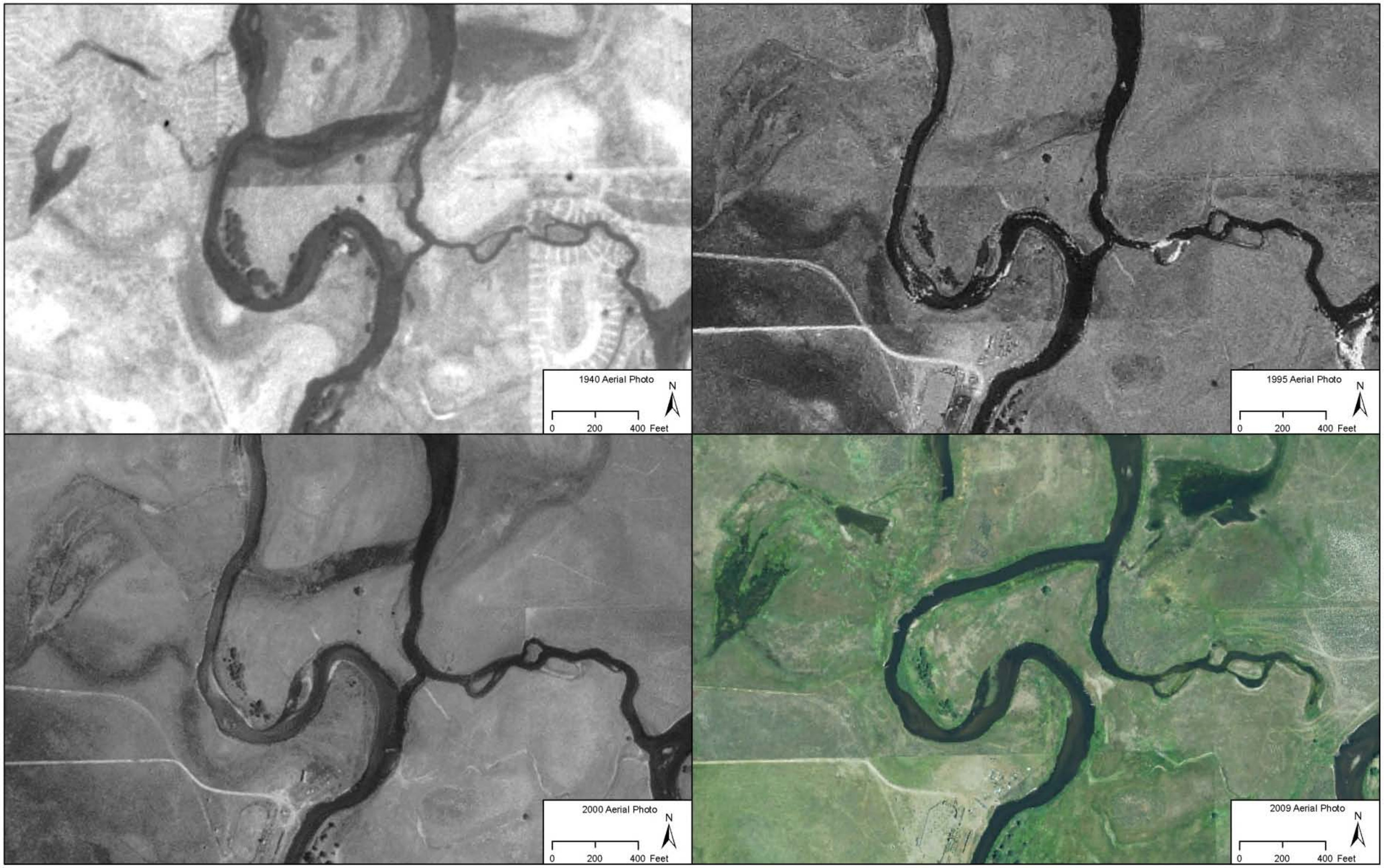



*Figure 6.6-12: Historical aerial photo comparison of the Beatty Station project site. Aerial photographs from years 1940 (top left), 1995 (top right), 2000 (bottom left), 2009 (bottom right)*

*Figure 6.6-13: Historical aerial photo comparison of the project site showing the 1872 channel alignment (left) and the 1941 channel alignment (right) shown in blue overlaid on a recent aerial photograph (Source: RDG 2006)*

#### 6.6.6.2.3 Fish Monitoring

The USFWS conducted post-restoration fish monitoring in 2007 and 2008 at the Beatty Station project site (Hodge and Buettner 2009). The following is a summary of their methods and results.

Fish monitoring was conducted using a 16 foot cataraft and electrofisher system. Monitoring of fish assemblages on the mainstem of the Sprague River consisted of 5 raft electrofishing surveys including one in 2007 (9/11) and 4 in 2008 (6/19, 8/15, 9/18, and 10/28). All surveys began near the upstream boundary of the property and ended just upstream of Godowa Springs Road at the island below backwater wetland #2. A reference reach was sampled for fish on two occasions from Godowa Springs Road downstream approximately 1,800 meters for comparison with the restored reach (9/11/07, 6/19/08). Fish monitoring was conducted on four occasions in 2008 at backwater #1. These were the same dates as sampled in the mainstem of the Sprague River. At backwater #2, fish sampling occurred on three dates in 2008 (6/19, 8/22, 10/28). Fish monitoring locations are displayed on Figure 6.6-1.

Ten fish species were sampled from the mainstem Sprague River at the project site in 2007 and 2008. Seven native fish species were present including blue chub (*Gila coerulea*), Klamath largescale sucker (*Catostomus snyderi*), lamprey (*Lampetra* spp.), Lost River sucker, marbled sculpin (*Cottus klamathensis*), redband rainbow trout (*Onchorynchus mykiss*), speckled dace (*Rhinichthys osculus*), and tui chub (*Gila bicolor*). The three non-native fish present included the brown bullhead (*Ameiurus nebulosus*), brown trout (*Salmo trutta*), and fathead minnow (*Pimephales promelas*). Native fish comprised over 95% of the 516 fish captured on the mainstem Sprague River restoration area. Marbled sculpin was the most abundant fish species comprising 68% of total fish captured and the only fish present in all surveys. It was typically collected in shallow areas with a gravel bottom. Blue chub was the second most abundant species comprising 11% of the total fish captured. Most other fish species including blue chub were sampled from deeper pools and runs with either a gravel or sand bottom and sparse vegetation. Klamath largescale suckers (KLS) accounted for 5% of the total fish captured. The total number of species sampled was higher in June (9 species) and August (10 species) than September (2 species) and October (3 species) in 2008. It is assumed that species that were present in June and August and absent during September and October moved out of the survey area. It is also possible that due to the low flow conditions in the fall that some fish moved away from the raft electrofisher as it drifted through the reach and were not sampled.

Nine fish species were sampled from the reference reach on the mainstem of the Sprague River including seven native and two non-native species. Overall native fish comprised 97% of the overall catch of 61 fish. The most abundant fish species in the reference reach at 23% was KLS. Blue chub were the second most abundant fish in the reference reach at 18%. LRS were the third most abundant species comprising 16% of the total catch.

Eleven species were present in backwater #1, including 5 native and 6 non-native species. Native species captured included blue chub, tui chub, KLS, marbled sculpin, and redband trout. Non-native fish species included brown bullhead, fathead minnow, pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*) and bluegill (*Lepomis macrochirus*). Overall non-native fish comprised 57% of the 102 fish captured in backwater #1. This backwater was dominated by dense submergent and emergent vegetation with a hard-packed silt bottom. Largemouth bass was the most abundant fish in backwater #1 comprising 20% of the total catch. Yellow perch and pumpkinseed comprised 11% and 10% of the catch, respectively. The most abundant native fish species were the blue chub and tui chub which comprised 14% and 12% of the total catch, respectively. KLS accounted for 8% of the total catch.

Ten fish species were present in backwater #2 including 5 native and 5 non-native species. Backwater #2 was typically shallow (<0.5 m) and dominated by heavy submergent and emergent vegetation with a hard-pack silt bottom. Native fish represented 52% of the 248 fish collected. Blue chub was the most abundant native fish accounting for 15% of the total fish captured. KLS were the second most abundant native fish comprising 10% of the overall catch. The fathead minnow was the dominant non-native fish comprising 32% of total fish captured. Pumpkinseed was the second most abundant non-native fish at 10% followed by brown bullhead, largemouth bass, and yellow perch. Number of species sampled was highest in October (9 species) and lowest in August (5 species). The higher diversity of fish species in October was due in part to presence of yellow perch and largemouth bass.

Hodge and Buettner (2009) stated that a rigorous statistical analysis of restoration project effectiveness is not possible on the Beatty Station restoration site because of a lack of pre-project fish monitoring and a small amount of post-project monitoring. However, based on these preliminary results, they made the following conclusions:

- Native fish species dominate the fish community in the mainstem river channel. This appears to be due in part to the good habitat conditions and relatively good water quality in this river reach.
- Although native fish species including endangered Lost River suckers, Klamath largescale suckers and redband trout were found in both the restored reach and a reference site immediately downstream, it is likely that habitat conditions have been improved for native species on the Beatty Station restoration site.
- The restored backwater wetlands had higher percentages of non-native species including largemouth bass, pumpkinseed, fathead minnows, yellow perch, and brown bullhead than the mainstem river channel. However, even with non-native fish present, substantial numbers of age-0 and age-1 juvenile suckers were documented in the backwater wetlands.
- The restored backwater wetlands provided habitat to mostly juvenile fish.

#### 6.6.6.2.4 Water Quality Monitoring

The USFWS also conducted post-restoration water quality monitoring in 2007 and 2008 at the Beatty Station project site (Hodge and Buettner 2009).

Continuous water temperature data was collected from 4/4/07 to 11/14/07 on the mainstem Sprague River (Figure 6.6-14), with the following results:

- Water temperature ranged from a minimum of 5ºC on 4/12/07 to a maximum of 27ºC on 7/9/07.
- Mean daily temperature increased from April through early July and decreased from mid July through November.
- During April and again in October and November mean daily water temperatures were 8-10ºC.
- Mean daily temperatures from May through September ranged from 15-23ºC.
- Daily temperature fluctuations generally ranged from 2-3ºC during the spring and fall and 5-7ºC for the summer months.

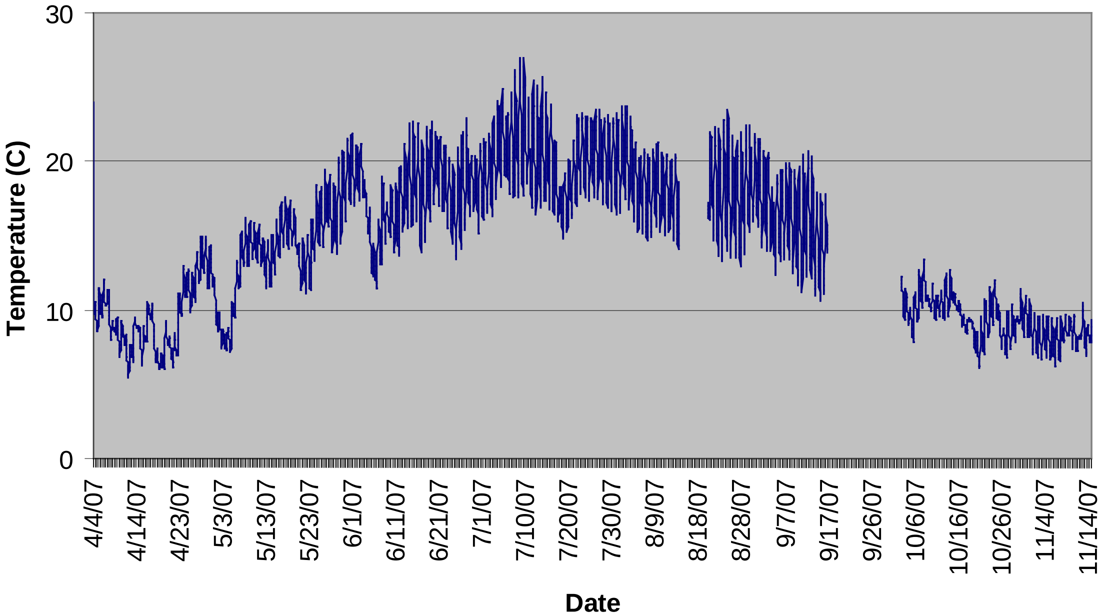



*Figure 6.6-14: Water temperatures at the Main Channel Sprague River sampling site April through November 2007.*

From 7/3/08 to 9/2/08, water temperature, dissolved oxygen, pH and conductivity were monitored continuously at one mainstem Sprague River site and one backwater wetland (Backwater 2; Figure 6.6-1). A comparison of the water temperature data collected between the mainstem Sprague River and Backwater 2 in 2008 is illustrated in Figure 6.6-15, and is summarized as follows:

- The water temperature variation followed similar daily patterns throughout the study with the backwater site sustaining higher temperatures and also larger diurnal variation.
- The mainstem river site varied diurnally from 2-5ºC throughout the study period with a maximum temperature of 22ºC and a minimum of 12ºC. The backwater site had daily temperature fluctuations ranging from 5-12ºC diurnally with a maximum of 26ºC and a minimum of 10ºC.
- The larger variation in water temperature at the backwater wetland site was due to increased solar warming in shallow water (<0.5m) and lack of water movement.

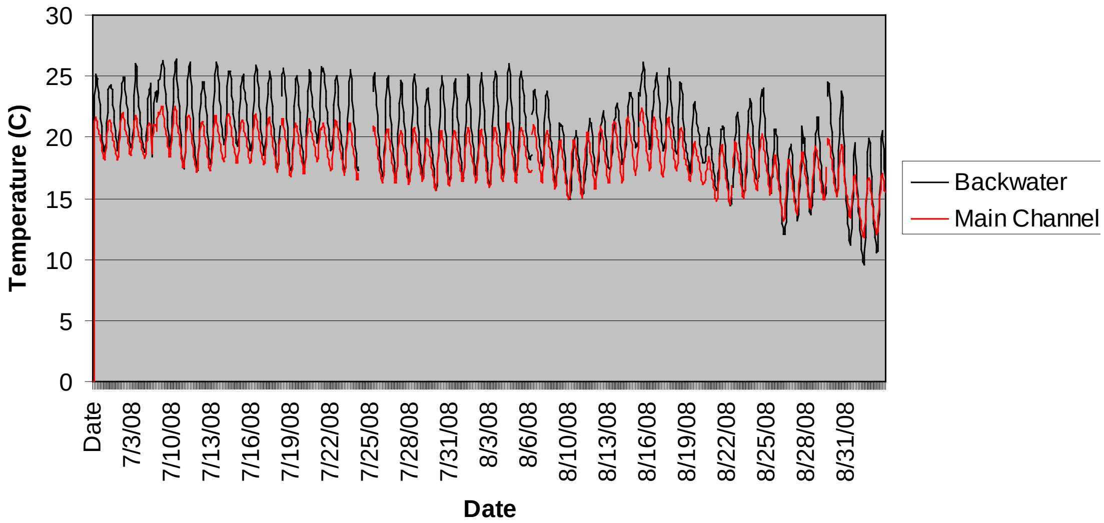



*Figure 6.6-15: Comparison of water temperatures at the Main Channel Sprague River sampling site and Backwater 2 sampling site in July and August 2008.*

Comparison of the DO data collected at the mainstem Sprague River site and Backwater 2 in 2008 on the Beatty Station project site is illustrated in Figure 6.6-16, and is summarized as follows:

- The mainstem river site had consistently high DO levels with a maximum DO level of about 13 mg/L and a minimum of 6 mg/L with diurnal variations ranging from 3-5 mg/L.
- Maximum DO level in wetland #2 was16 mg/L and a minimum of 0.2 mg/L with a diurnal variation of 5-15 mg/L.
- DO levels for backwater #2 had daily variations 2-3 times those observed at the mainstem river channel site.
- The larger diurnal variations in DO levels in the backwater wetland were due primarily to photosynthesis and respiration by dense submergent and emergent vegetation in the backwater and lack of water movement.

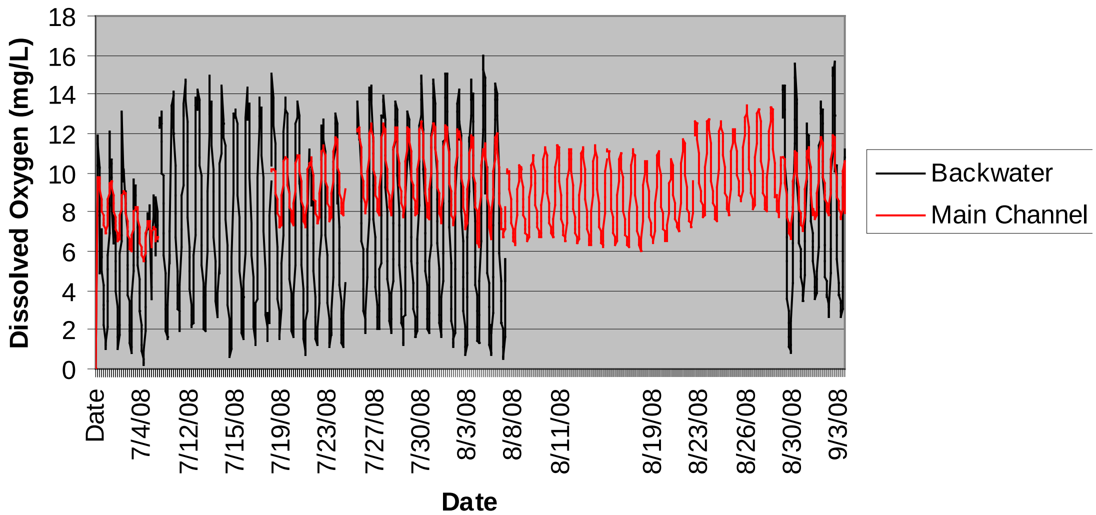



*Figure 6.6-16: Comparison of dissolved oxygen at the Main Channel Sprague River sampling site and Backwater 2 sampling site in July and August 2008.*

A comparison of the pH data collected for the mainstem Sprague River and Backwater 2 is illustrated in Figure 6.6-17. The pH in the mainstem river channel site ranged from 7.8 to 9 compared to 7.0-10.1 for Backwater 2. The higher diurnal fluctuation in the backwater wetland was likely due to dense aquatic plants and the daily plant photosynthesis cycle with plants removing carbon dioxide from the water during the day and releasing it at night.

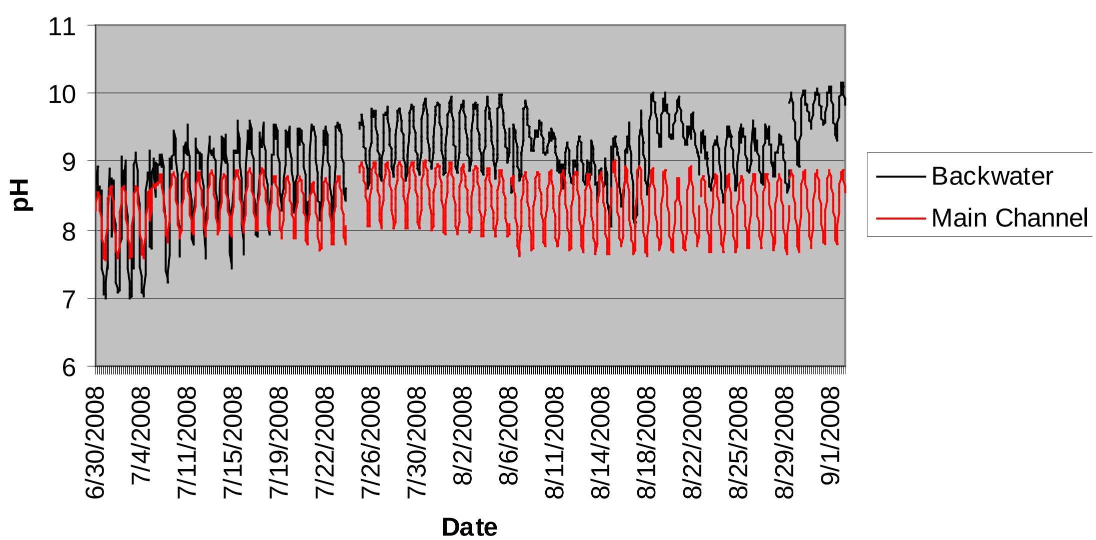



*Figure 6.6-17: Comparison of pH at the Main Channel Sprague River sampling site and Backwater 2 sampling site in July and August 2008.*

A comparison of conductivity for the mainstem Sprague River and Backwater 2 on the Beatty Station project site is illustrated in Figure 6.6-18. Conductivity was slightly higher in the mainstem river channel than the backwater wetland. Conductivity ranged from about 90-120 aeS/cm with little diurnal variation.

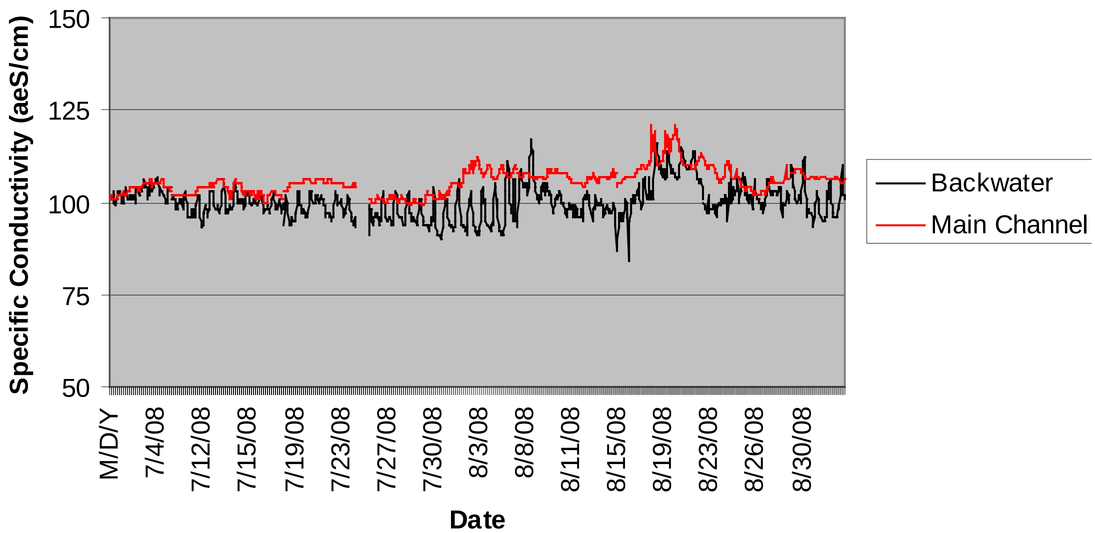



*Figure 6.6-18: Comparison of specific conductivity at the Main Channel Sprague River sampling site and Backwater 2 sampling site in July and August 2008.*

Based on these results, Hodge and Buettner (2009) concluded that:

- Water quality conditions in the mainstem Sprague River and backwater wetlands on the Beatty Station restoration project site during the summer were adequate for the endangered sucker rearing based on their temperature, DO, pH, and conductivity tolerances.
- DO levels dropped below stressful (4 mg/L) and lethal levels (2 mg/L) during a portion of most days during July and August 2008. The fact that juvenile suckers continued to persist in the backwater wetlands under these conditions suggests these fish can tolerate low DO levels for short periods of time (a few hours per day).
- Water temperatures >15 ºC are considered chronic and >20 ºC acute stressful for redband trout. During June through August water temperatures exceeded 20ºC almost daily. It is possible that the trout seek refuge in cool water inflow areas just upstream (George Springs, Spring Creek) during the day when temperatures exceed 20ºC and move into the restoration site reach for a portion of the day to feed.

### 6.6.7 PPA Lessons Learned

This project resulted in a major change to the river corridor in the Sprague River Basin. Three active meander cutoff chutes were plugged and armored with engineering log jams and vegetation to prevent reactivation of the cutoffs, and flow was diverted into a single historic channel. This project involved a significant investment in planning, design, and construction costs. Given the significance and level of effort required to implement this type of project, we felt it was extremely important to objectively capture both the positive and negative lessons learned from this PPA.

The degree to which the goals and objectives of the project were attained varies:

1) Post-project monitoring data by the USFWS concludes that *fish habitat oriented goals* (improved aquatic and riverside habitat conditions for endangered fish species, including shortnose and Lost River suckers and Klamath redband trout) ***may*** be on the path to attainment (data 1-2 years after project construction does not show significant variations between the restored and reference reaches).
2) No post-project monitoring data on *improved and expanded wetland habitat for migratory waterfow*l exists, thus attainment of that goal is inconclusive.
3) The goal of *reconstruct[ing] a section of the Sprague River to increase channel stability…* was not attained. Post-project monitoring shows that the channel is actively adjusting following restoration. The eroding pre-project banks have been stabilized in the backwater, but the post-project channel is incising.

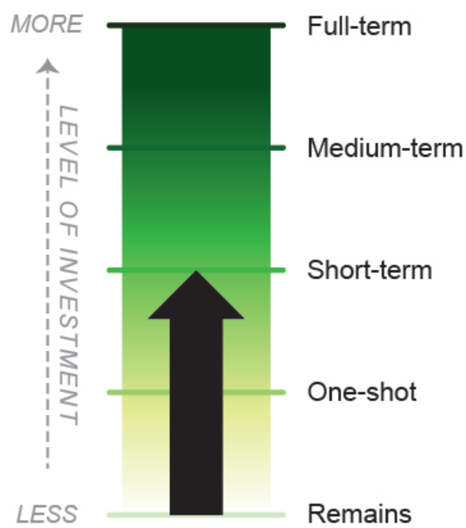
Design objectives relating to restoring channel alignment to the historical conditions, increasing the length of the channel, increasing channel-floodplain connectivity, increasing aquatic habitat diversity, improving off-channel fish habitat, improving water quality, improving riparian habitat conditions, and expanding and improving floodplain habitat conditions were more or less attained. Because design objectives were not expressed in terms that were specific, measureable, or temporal, it is very difficult to rate overall project success. Additionally, project documentation shows that multiple, sometimes overlapping, sometimes contradictory goals and objectives were expressed by different entities throughout the planning and design process. Better coordination of project goals and objectives from the outset would allow a more coherent, organized approach towards the PPA process. Finally, because a specific pre-and post-project monitoring framework was not established for the Beatty Station project from the outset, many of the PPA assessment methods are not viable. Ideally, a more complete suite of assessment methods would be applied to future similar projects so that more can be learned as those projects evolve through time Table 6.6-1 summarizes these lessons.

*Table 6.6-1: Summary of key lessons learned from the Beatty Station Project*

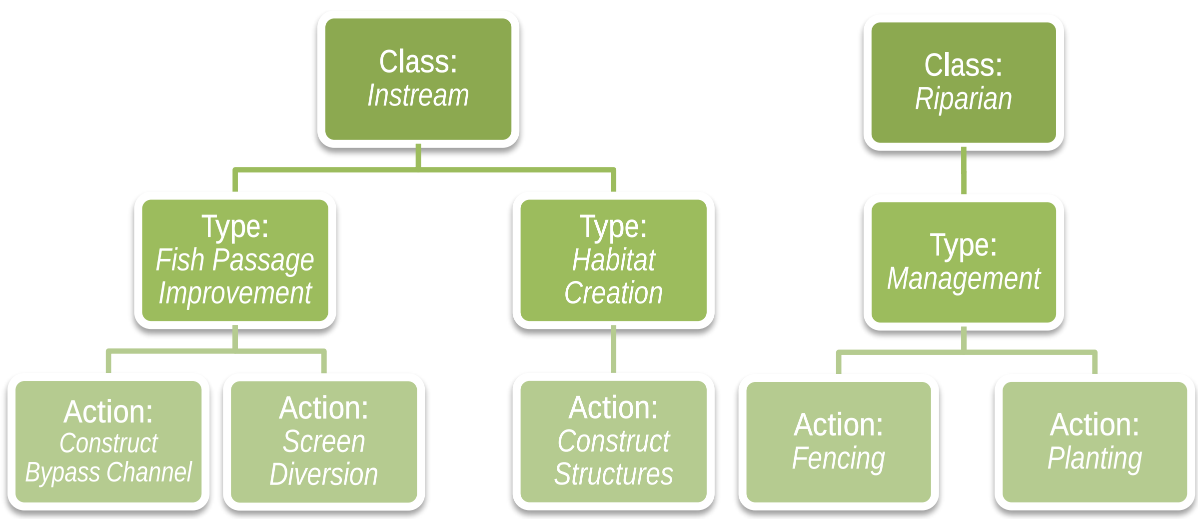
| **Stream Restoration Project Life-cycle Phase** | **Scale for Lesson** | **Lessons Learned** |
|---|---|---|
| Pre-Project (goal and objective setting, planning, data collection, analysis) | Site-specific | Goal and objective setting needs to be coordinated between the landowner, the resource agency partners (USFWS, NRCS, others), and the restoration designer (RDG). |
| | Site-specific and Basinwide | Goals and objectives should be specific, measurable, and temporal to allow PPA process to measure the degree to which they are attained. |
| | Site-specific | Pre-project data collection should be keyed to the goals and objectives, to allow comparison of specific elements / attributes of the restored system. |
| Design | Site-specific | The restored channels were undersized due to design-related error(s), likely stemming from not considering the impact of channel plugs on augmenting flows through the primary channel. |
| | | Consider “geomorphic reach” scale processes when designing restoration projects. |
| Implementation | Site-specific | The poor to moderate success of the revegetation effort on the project site was likely due to lack of irrigation post-construction and overall lack of post-construction vegetation management. Future projects could enhance the success of revegetation efforts by developing and executing a vegetation management plan. |
| Monitoring | Site-specific and Basinwide | More attention to obtaining relevant pre- and post-project monitoring datasets, tied to specific objectives. |
| | Site-specific | Monitoring network for this type of project should be extended upstream and downstream to assess the influence of meander cutoff plugs on basin scale processes. |
| | Site-specific and Basinwide | Include post-project geomorphic monitoring in the project budget. |
| General | Site-specific | No data to show that aquatic, riparian or floodplain habitat conditions improved as a result of project. |
| | | Conduct a detailed study on meander cutoff disconnection to determine if instream habitat is actually being “lost” |

## 6.7 Five Mile Creek Project (Upper Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**




### 6.7.1 PPA Synopsis

We selected this project to provide a PPA case-study of a fish barrier bypass channel combined with fish habitat structure placement, installation of a fish screen, fencing, and riparian planting. We categorized this PPA as Short Term based on data availability and the period of pre- and post-project monitoring. Instead of building a fish ladder at this site, the historical channel was reconnected to bypass an irrigation diversion dam. This project was a component of a larger project on the adjacent landowner's property. Funding between the two projects was mixed as the adjacent landowner previously owned the entire project area. Our PPA focused on the fish barrier bypass/historical channel reconnection, fish screen, fish structures, fencing, and riparian planting aspects of the project. The 5 Mile Creek project fits both the instream and riparian classes, with fish passage improvement, habitat creation, and management project types. Our PPA of this project was informed by the channel simplification, grazing, and diversions conceptual models.

The documents developed for this project listed both site specific goals (e.g. habitat improvement and fish passage) and basin wide goals (e.g. improve habitat conditions for suckers and other fishes of the Sprague River and in the 26 miles of Five Mile Creek and tributaries upstream of the project site). These goals were supported by objectives that were also both site specific (e.g. providing passage around a fish barrier, creating overhead cover using riparian vegetation, undercut banks and large woody debris features) and basin wide (e.g. increased habitat for fish). We conducted our PPA of this project by evaluating design documentation and as-built longitudinal profile, to which we added a second longitudinal profile and baseline cross sections, and photo point observations. The primary lessons learned from this project were that future, similar channel relocation projects adjacent to irrigation infrastructure should include consideration of an overflow spillway to bypass the weir so that high flows are not inadvertently directed into irrigation canals, more detailed vegetation and channel monitoring, integration of soil investigations with development of design criteria, and more careful consideration of vegetation planting timing. The two primary basin wide lessons were learned from this project. First, more detailed monitoring at the site scale is important to fully understand how this type of project functions over time because it appears to be a great way to improve fish passage and has applications throughout the basin. Second, restoring connectivity within the basin is feasible by reactivating historical channel features.

### 6.7.2 Site Conditions

This project is located in the upper watershed of the Sprague River Basin on a tributary to the North Fork Sprague River. The project site is located in an alluvial valley bottom approximately ¼ mile upstream of the confluence with the North Fork Sprague River (Figure 6.7-1) and approximately 5 ½ miles to the north west of the community of Bly. The project reach is impacted from grazing and an irrigation diversion is located at its upstream end. After 1940, the reach was straightened. Project features include a fish screen installed on the irrigation diversion at the upstream extent of the project reach that was funded by ODFW and riparian fencing implemented by the NRCS. These project features are shown in Figure 6.7-1.

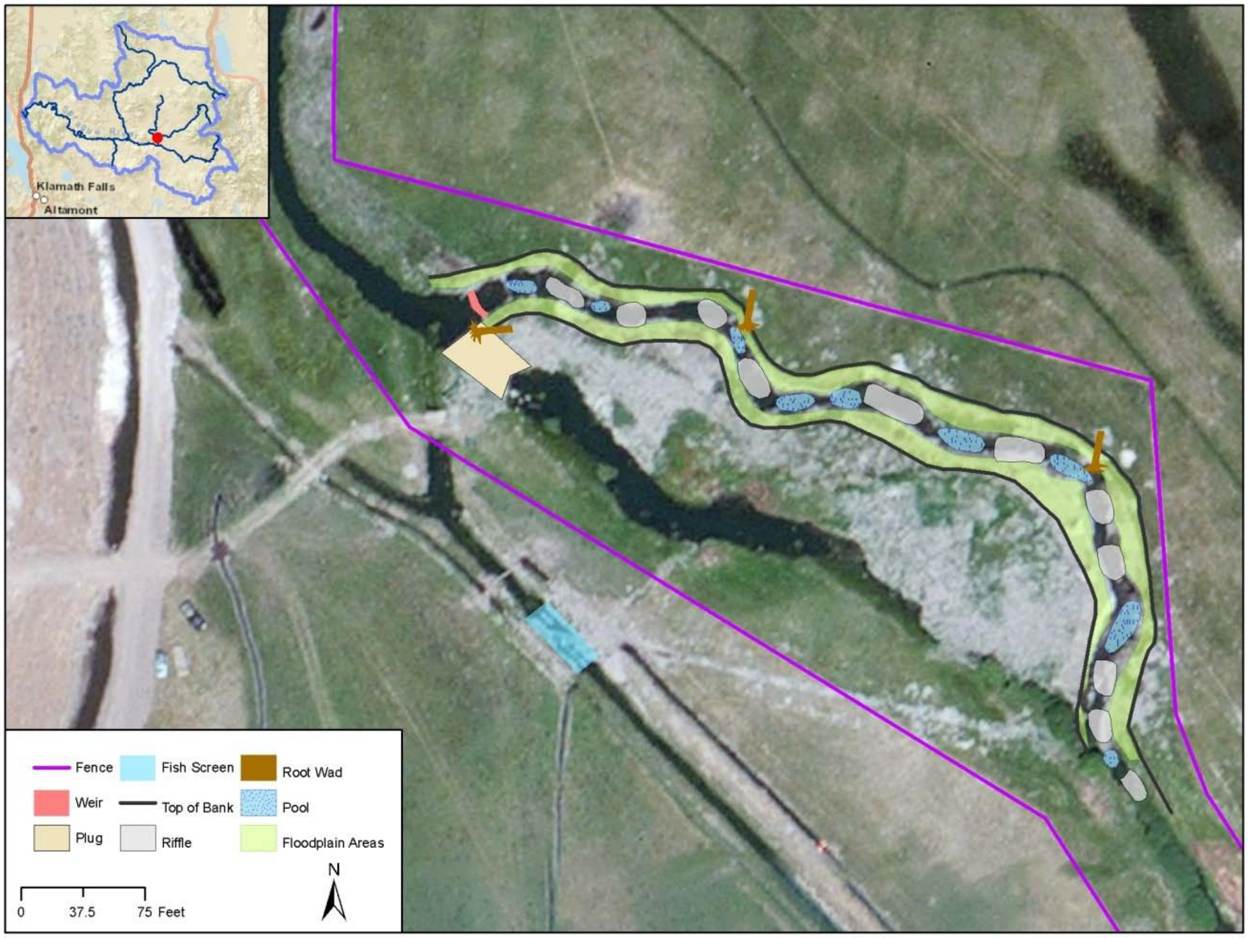



*Figure 6.7-1: The Five Mile Creek Project on Five Mile Creek is approximately ¼ mile upstream of the confluence with the North Fork Sprague River. The project includes a fish screen, channel bypass/relocated channel for fish passage, riparian planting, riparian corridor fencing, and root wad structures.*

### 6.7.3 Success Criteria

The documentation for this project cited a wide range of site specific and basin scale goals and objectives. General site scale goals included increasing the amount of habitat for spawning and refuge for suckers, Redband trout, and other native fish species by removing a fish passage barrier. Specific site goals included bypassing the diversion structure for the irrigation canal utilizing a historical, remnant channel, installing large woody debris features, re-establishing riparian vegetation to stabilize banks, providing overhead cover, and controlling water temperatures (Balance 2009). Basinwide goals included restoring habitat values for the fishery and other native species, and improving water quality with regard to water temperature. The objectives mostly align with the objectives identified and discussed for this type and class of project in the Organizational Framework in Section 3.1 of this report.

### 6.7.4 Project Timeline

The origins of this project and related projects completed to date are summarized in the Long Term Strategic Plan (Bulkley 2011) developed by the previous and currently adjacent landowner. The Black

Drake Ranch originally comprised 954 acres that included 2.5 miles along the North Fork Sprague River and 2.5 miles along Five Mile Creek. The Ranch was divided recently and the lower portion of the Ranch, including the project site, was sold. Due to this recent change in ownership of the project site, most of the project documents reference projects on the original Black Drake Ranch. In 2005, Working Landscape Alliance (WLA) conducted a field visit, discussed future restoration projects, and conducted two Proper Functioning Condition assessments on Five Mile Creek and the North Fork Sprague River. The WLA group consisted of landowners, Wayne Elmore, Janice Staats, Mike Lunn, Hugh Barrett, Danette Watson, and Mike Connelly. WLA recommended establishing clear objectives for future restoration projects and developing a comprehensive ranch management plan. In 2006, the cooperative agreement between the USFWS and the Klamath Basin Ecosystem Foundation provided funds to install riparian corridor fencing along one mile of Five Mile Creek and ½ mile along the North Fork Sprague River, repair seven headcuts, construct hardened livestock crossings, and install off-site watering stations. Only the fencing was completed in the project reach, initially in 2005-06 followed by fencing upgrades in both 2008 and 2010.

Photo and water temperature monitoring have been conducted on the Black Drake Ranch from 2007 to 2010, along with two fish census monitoring efforts in 2007 (Bulkley, 2011). The fish screen at the site was installed and functional in Spring, 2009. The bypass project was completed in December 2009 and adjustments were made to the project in 2010 and 2011. The foundational document for the bypass channel component of the project is the Balance Hydrologics, Inc. design and implementation memorandum from January, 2009. This document provides the project objectives and design basis. Design rational and fish passage requirements were documented. The general approach proposed in this document was to reoccupy 600 ft of the remnant channel to bypass the diversion dam using a meandering channel with a series of pools and riffles. Narrow gaps were designed in the channel to provide adequate depth for passage at low flows (Balance Hydrologics, Inc. 2009). No as-built survey was included in the scope of work for this project, but a channel profile was surveyed in 2010 by Balance Hydrologics, Inc. Finally, we completed channel geometry and longitudinal profile surveys and established of photographic monitoring locations on July 25, 2011 in support of this PPA.

### 6.7.5 Relevant Conceptual Models

The ***channel simplification***, ***grazing***, and ***diversions*** conceptual models guided our PPA of this project. The channel simplification conceptual model describes how channelization eliminates instream and riparian habitat, and how reversal of channelization is typically expected to create more natural instream conditions and dynamics. In this case the channel was relocated to a remnant channel instead of building of a fish ladder around a diversion barrier. The diversions conceptual model applies to the fish screen installed on the diversion canal to reduce fish entrainment. Lastly, the grazing conceptual model predicts that the channel will experience bank erosion, reduction in riparian vegetation, and degradation of water quality from livestock access to the riparian corridor and that managing or excluding cattle access should increase channel complexity and stability, ultimately leading to biological colonization and succession (see Section 3.2 for more details on conceptual models). The goals and objectives of the Five Mile Creek project suggest that the project proponents and designers were aware of the typical changes predicted by the conceptual models for the implemented actions. Restoring a historical channel alignment to bypass a fish barrier and installation of a fish screen combined with fencing can lead to improved habitat conditions for fish and reduced bank erosion that can be a chronic source of fine sediment to the channel.

### 6.7.6 Post Project Appraisal

#### *6.7.6.1 Methods*

The Project Framework introduced in Section 3.1 lists several metrics that could be used to evaluate the performance of this type of project relative to its goals and objectives. The availability of monitoring data for this project was limited to an as-built longitudinal profile, which is more information than we had for other sites we evaluated for this project. Still, ideally, a more complete suite of assessment methods would be applied to future similar projects so that more can be learned as those projects evolve through time. We collected monitoring data in July 2011 that included eleven cross sections, a longitudinal profile, and historical and current aerial photos (Figure 6.7-2). We also collected additional data to be used for comparisons with future monitoring efforts including ground photograph monitoring points at the eleven cross section locations.

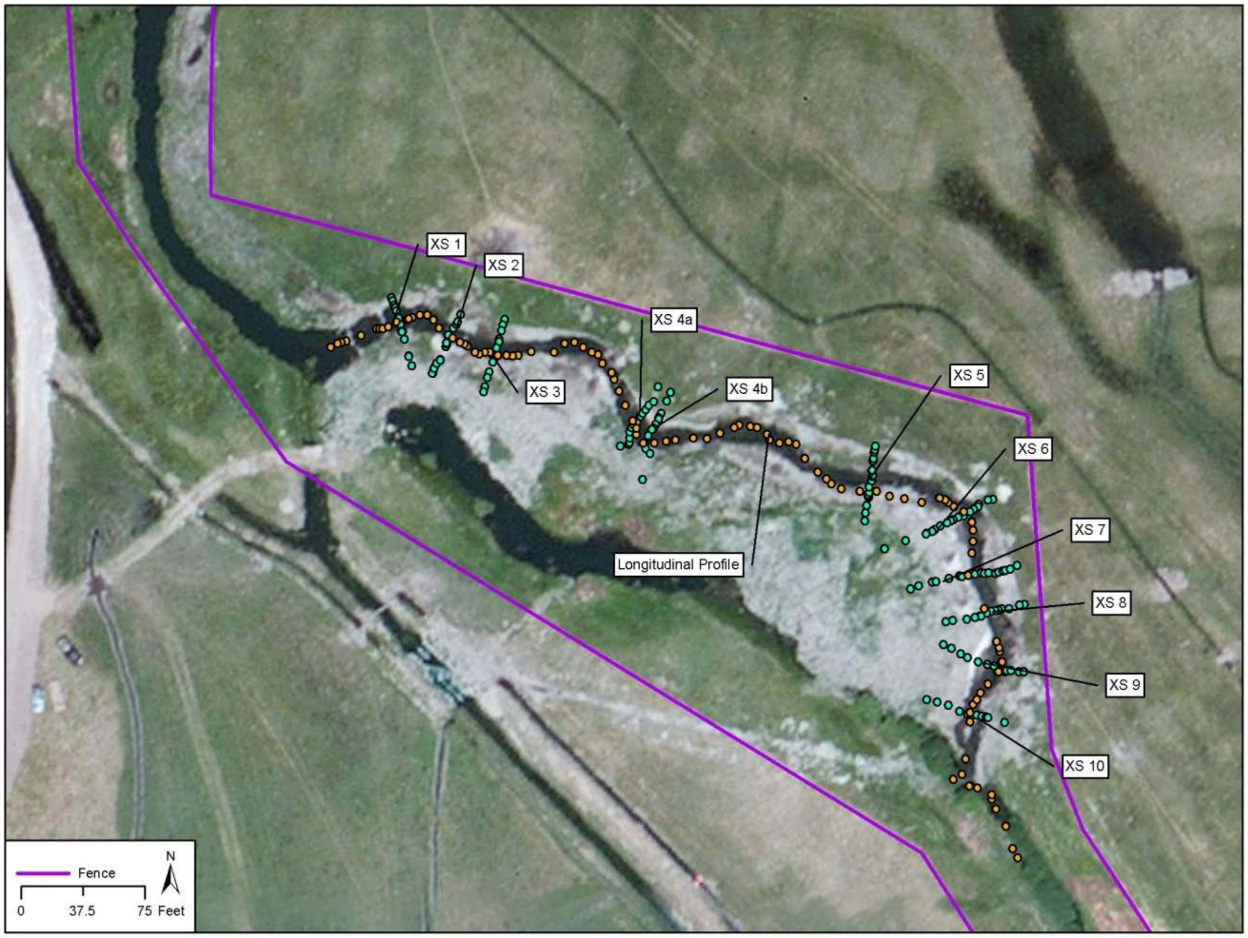



*Figure 6.7-2: Location of channel cross sections, and longitudinal profile used to evaluate instream changes between 2009 and 2011.*

## 6.7.6.2 Results

### 6.7.6.2.1 Historical Photo Comparisons

We reviewed historical aerial photographs to assess the changes before and after the project and to identify trends in channel change at the site. Our review of the historical photographs from 1940 to 2010 (Figure 6.7-3) shows many changes to the channel and floodplain. The channel alignment was significantly altered between 1940 and 1995 and between 2000 and 2010. We were unable to identify the main channel path in the 1940 aerial photograph, but there appears to be two channels on the east and west side of the dense riparian vegetation. We identified pastures on both banks of the channel and the irrigation canal. By 1995 the channel had been relocated, straightened, and riparian vegetation was converted to pasture. The 2010 aerial photograph shows the as-built condition, which restores some of the sinuosity apparent in the 1940 aerial photograph.

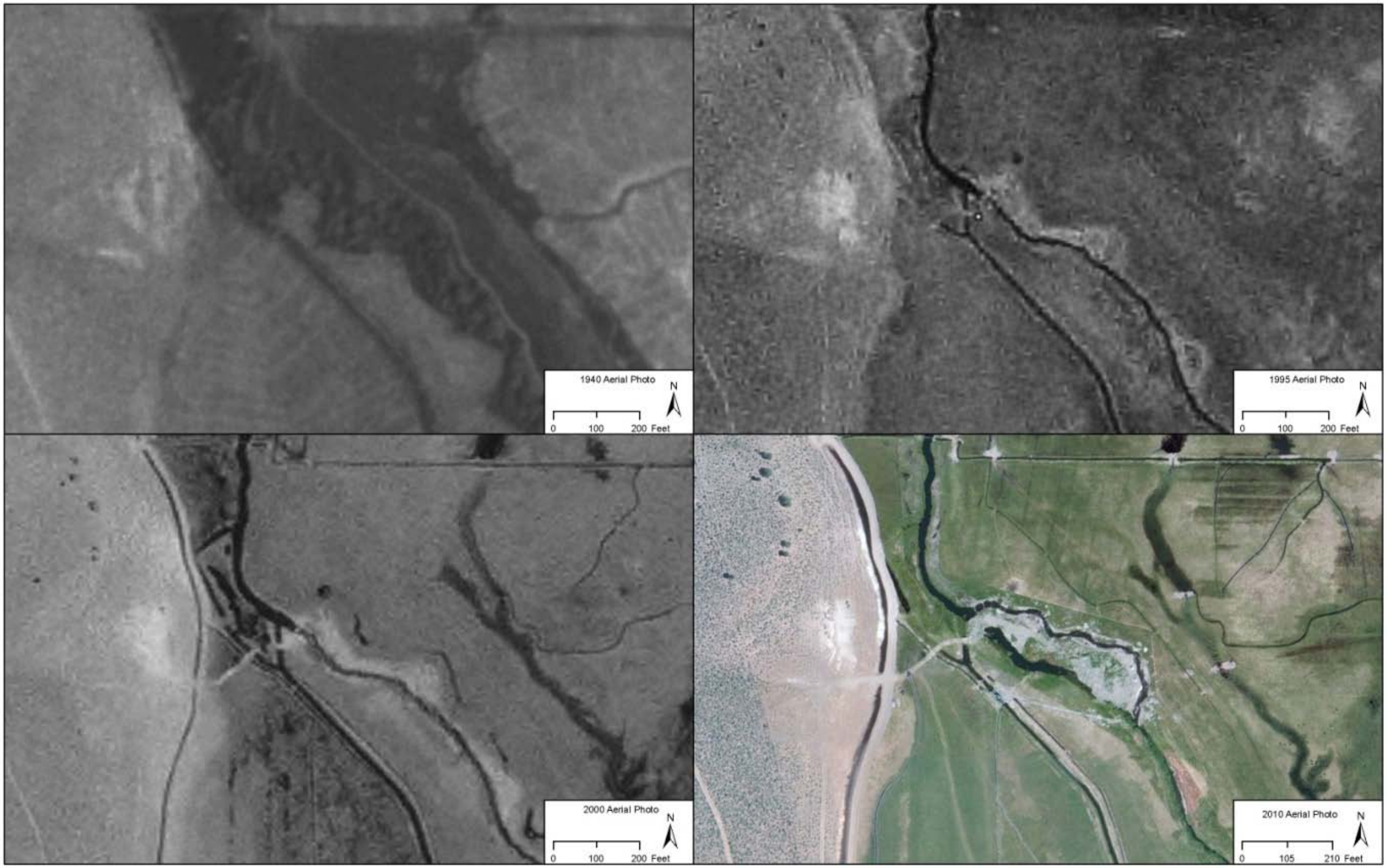



*Figure 6.7-3: Comparison of historical aerial photographs from 1940, 1995, 2000, and 2010 of the project site. The channel has been straightened from the 1940 condition and then relocated in the 2010 aerial photograph.*

#### 6.7.6.2.2 Channel Geometry

As-built channel cross sections were not conducted as part of this project. To provide a base line for future monitoring at the project site, we surveyed eleven cross sections on July 25, 2011. We plotted the cross sections and compared the existing channel geometry to the conceptual channel design drawings. Figure 6.7-4 and Figure 6.7-5 illustrate the current channel geometry. The typical cross sections included in the design drawings for this project (Balance 2009) show a multi-stage channel. The multi-stage channel consists of a low flow channel and a floodplain bench contained within the top of the bank. Based on our review of hydrology data and discussions with people familiar with the site, it is apparent that overbank peak flows occurred in both 2010 and 2011. Because no as-built cross sections were conducted for this project, we compared our cross sections to the typical cross sections in the design drawings (Balance 2009b) to show channel simplification and scour of the floodplain bench in Figure 6.7-4 and Figure 6.7-5. We used the typical cross sections from the design drawings for either riffle or pool, depending on the cross section location on the design longitudinal profile. Both riffle and pool typical cross section contains a floodplain bench, but the typical pool cross section is deeper than the typical riffle cross section. The location of the typical cross sections in relationship to the surveyed cross sections is approximate and was included for comparison of the general channel shape. Our comparison shows that cross sections 2, 5, and 9 have maintained the inset floodplain bench. Cross section 3 appears to have experienced deposition in the flow channel and the floodplain bench. The channel at cross sections 4a, 8, 10 has widened from the typical cross section shape and the floodplain bench has been eroded. Cross section 1 is in the transition from the original channel to the excavated channel and is likely not suitable for comparison. The channel form of cross section 4b shows that the floodplain bench has been eroded and cross section 6 shows that the channel has widened above the floodplain bench and has eroded a secondary high flow channel along the toe of the transition from the floodplain bench to the top of bank slope. Lastly, cross section 7 shows erosion of the floodplain bench and channel widening. In general, the floodplain bench in the design drawing was not maintained in the channel after two years with greater than bankfull discharges.

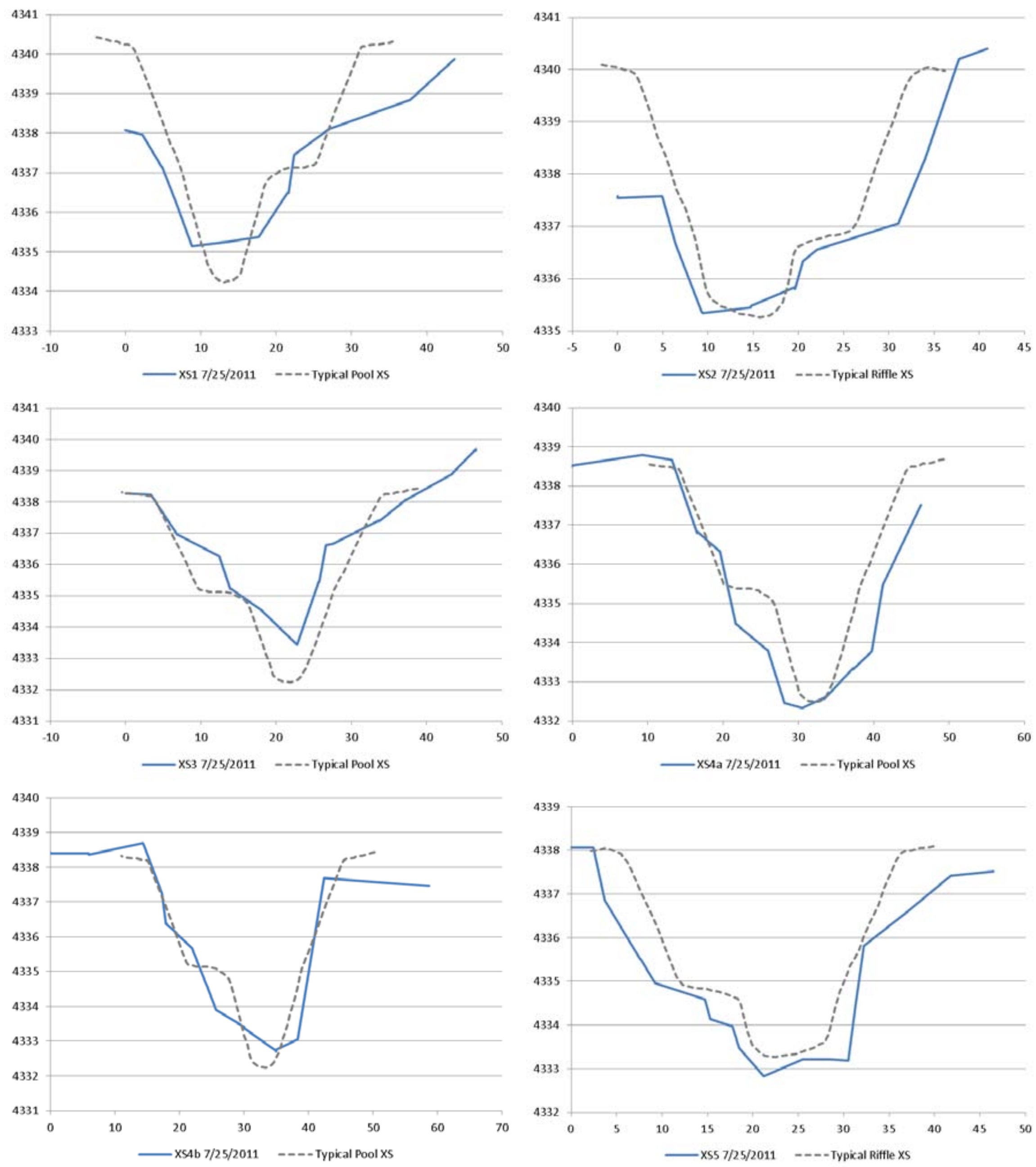



*Figure 6.7-4: Cross sections 1 through 5 surveyed in July, 2011 shown in blue, solid line. Typical riffle or pool cross section from design drawing as reference shown in dotted, gray line (not to scale).*

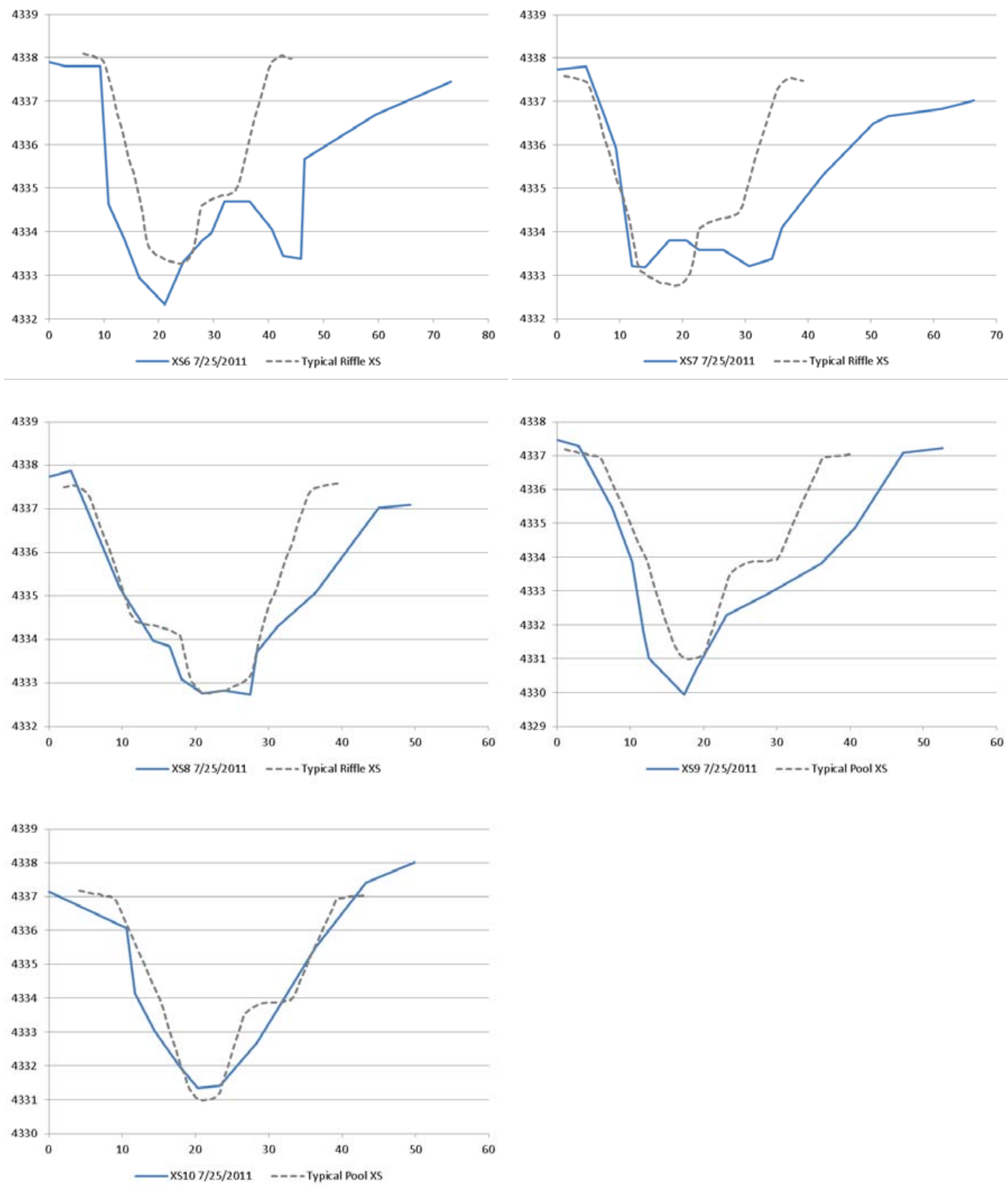



*Figure 6.7-5: Channel cross sections 6 through 10 plotted from our July, 2011 survey shown in blue, solid line. Typical riffle or pool cross section from design drawing as reference shown in dotted, gray line (not to scale).*

Repeat surveys of our baseline channel cross sections will provide information on the magnitude of channel change in the bypass channel and the channel stability.

### 6.7.6.2.3 Longitudinal Profile

We conducted a longitudinal profile as part of our PPA for this project on July 27, 2011. We plotted the Balance Hydrologics, Inc. longitudinal profile with our surveyed profile in Figure 6.7-6. Based on our review of hydrology data and discussions with people familiar with the site, it is apparent that overbank peak flows occurred in both 2010 and 2011, and that flows greater than bankfull were expected to alter the longitudinal profile in the recently constructed channel. Riparian vegetation planted after construction had not established root systems sufficient to stabilize channel banks after less than a complete growing season. Therefore, we observed significant changes in the channel thalweg longitudinal profile.

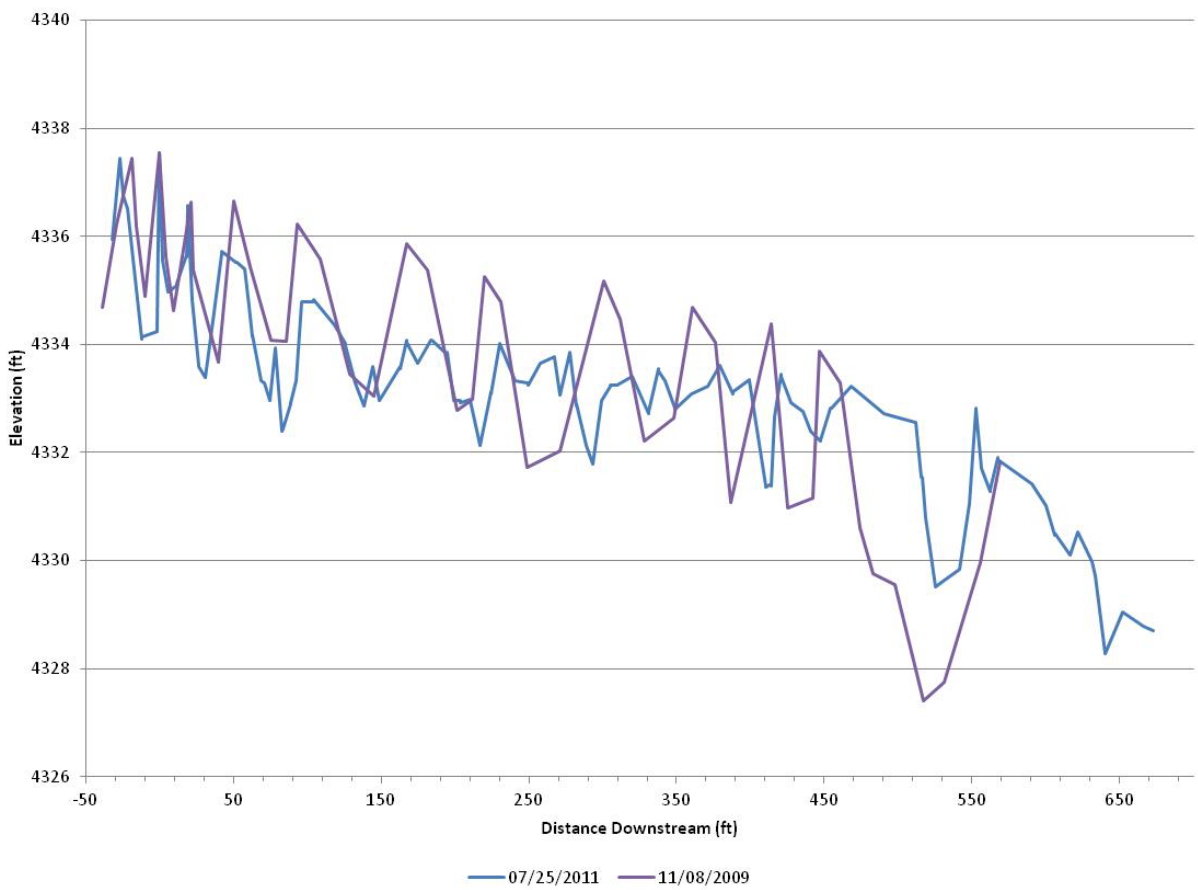



*Figure 6.7-6: Comparison of longitudinal profiles surveyed in November, 2009, by Balance Hydrologics, Inc. and our survey in July, 2011 as part of this study. Channel change between the two surveys shows scour of riffles and pools in the upstream portion of the reach and scour of riffles and deposition in pools in the downstream portion of the reach.*

Our comparison of the two longitudinal profiles shows that there has been longitudinal migration of the channel features in the middle portion of the reach and significant sediment deposition in the downstream pool. We identified transport of bed material from the riffle at station 50 downstream to station 450. Our comparison of the profiles shows that the pools at stations 70 and 220 deepened while the pools at station 250, 340, 440, and 500 experienced sediment deposition. In general, the channel maintained the riffle pool sequence in the Balance design, but the elevation difference between the riffles and pools decreased.

#### 6.7.6.2.4 Ground Photograph Monitoring Points

We established ground photographic monitoring locations at each cross section end pin and the thalweg (deepest part) of the channel. We took digital photographs looking upstream, across the channel, and downstream from each cross section end pin. From the channel thalweg, we took digital photographs looking upstream and downstream and towards both banks. As-built photos of this project were not available for comparison. We collected GPS waypoints at each digital photograph and used software to write the GPS coordinates, date, and time on each photograph. We exported the coordinates and the file name of each photograph to a GIS shapefile and incorporated the shapefile into the SPPAMS for the project. Photos from our survey show bank erosion from high flows and high mortality of planted alders and willows as illustrated in Figure 6.7-7.


*Figure 6.7-7: Conditions in July, 2011, showing bank erosion (left image) and high mortality/low vigor of willow and alders planted in the project reach (right image).*

### 6.7.7 PPA Lessons Learned

Based on our review of project documents, our field observations and measurements, and our PPA, we identified a variety of useful lessons from the Five Mile Creek project at the site and basin scales. It is important to note that lessons learned from the Five Mile Creek project were applied to the Bailey Flat project (S. Mattenberger Per. Com. 2011) described later in this document. Lessons from the Five Mile Creek project applied to Bailey Flat include the importance of conducting as-built surveys of the channel geometry and longitudinal profile. Another lesson from Five Mile Creek applied to Bailey Flat was the method for replanting on-site alders. Alders were removed from the existing channel at Five Mile Creek and then stock piled for a week before replanting along the relocated channel. During the stock pile period many of the alders dried out and did not survive when they were replanted. At the Bailey Flat project, alders were replanted in clumps and on the same day as they were removed. Table 6.7-1 presents a summary of lessons learned at the site and basin scale by restoration project life-cycle phase.

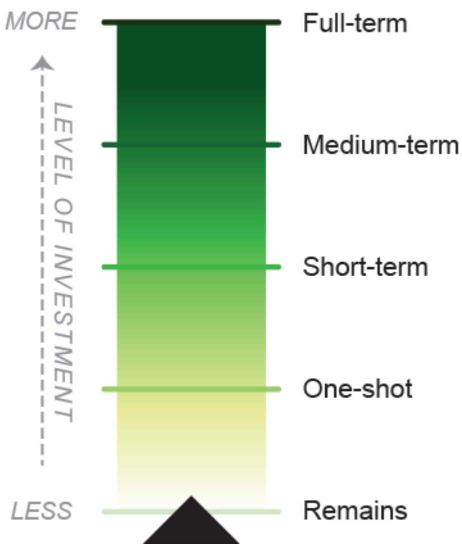
*Table 6.7-1: Summary of key lessons learned from the Five Mile Creek Project*

| **Stream Restoration Project Life-cycle Phase** | **Scale for Lesson** | **Lessons Learned** |
|---|---|---|
| Pre-Project (goal and objective setting, planning, data collection, analysis) | Site-specific | A more detailed analysis of channel scour and sediment mobilization for a wider range of flows could have yielded design less susceptible to excessive channel adjustments in response to the first high peak flow after construction. |
| | | A clear understanding of subsurface geologic conditions is important to the success of channel relocation projects. Dig soil trenches to assess soil profiles across the site, identify lenses of material such as sand, gravel, or ash, and adjust subsequent steps in the project life cycle to account for the differences in permeability, groundwater flow, and resistance to streambank erosion. |
| Design | Site-specific | Design spillway to convey peak discharge around irrigation diversion to avoid overtopping irrigation diversion and causing downstream flooding. |
| | | Incorporate discussion of expected channel adjustment after construction and determine thresholds for adaptive management. |
| | | Establish benchmarks to document water stage for irrigation diversions to guide channel hydraulics design. |
| | | To prevent flooding or channel avulsion, design entry of relocated channel with the mainstem wide enough to convey high flows. |
| | | Maintain the hydrologic connectivity of the former main channel (i.e., the channel now abandoned) so that it functions as a slough, its water levels partially controlled by the level of the flowing channel and easily accessible to fish. Avoid fill that eliminates or severely reduces this connectivity and habitat for fish. |
| Implementation | Site-specific and Basinwide | To maximize the short growing season in the Sprague River Basin, plant early in the construction period. Planting was not completed until October at the end of the growing season, limiting the root development and bank strength on the Five Mile Creek project. |
| | | To increase vegetation survival, transplant on-site vegetation on the same day. |
| | Site-specific | Dewater channel to build channel plug to prevent leaking. |
| Monitoring | Site-specific and Basinwide | To maximize the learning from monitoring, require formal monitoring reports that include documentation of the datums, benchmarks, and the processed data files. |
| | | To assess improvements in fish habitat, replicate pre-project fish population surveys and conduct red counts if spawning habitat is enhanced or created in the project. |
| | | To assess project success and learn for future restoration actions, conduct as-built surveys including longitudinal profile, cross sections, LWD, fences, etc. |
| General | Site-specific | Include fish monitoring metrics to assess habitat improvement and passage goals. |
| | | Match monitoring plan with goals and objectives of the project. |

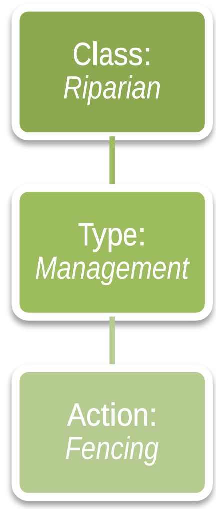
We learned that additional design analysis should have been conducted for hydraulics, sediment transport, and scour and deposition in the channel. During the spring 2011 runoff, rocks had to be removed from the weir at the upstream extent of the reach to stop water from spilling into the irrigation canal. A spillway was installed around the weir in the summer of 2011 to convey high flows around the weir. The channel experienced a greater than bankfull events the first two years after construction and many of the pools were partially filled with sediment. The design documentation doesn't include any discussion of the potential channel adjustment or thresholds for adaptive management actions. Further monitoring is required to determine if the channel has adjusted or if designed pool and riffle sequences are unsustainable in this reach. We also learned from our post project appraisal of the Five Mile Creek project could improve the quality and quantity of spawning habitat in the Sprague River Basin. Additional monitoring is required to determine if these goals are achieved. Monitoring metrics should include red counts, pebble counts, and fish population surveys upstream of the irrigation diversion at the upstream extent of the project site.

## 6.8 South Fork Sprague River Project (Upper Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type, and Action**




### 6.8.1 PPA Synopsis

We selected this project for post project appraisal to provide a case-study of fencing without floodplain or wetland modifications. This project also included installation of water troughs and a water gap (cattle crossing), but we concentrated on the fencing aspect of the project. The South Fork Sprague River project fits in the riparian class with management project type. Our PPA of this project was informed by the cattle exclusion and channelization conceptual models introduced earlier in this document.

Evaluating this project allowed us to assess site specific and basinwide benefits of cattle exclusion projects in a low gradient valley reach of the Sprague River Basin. The site-specific goals of this project were to improve the riparian corridor by eliminating hoof shear and cattle impact within the riparian zone and increasing native grasses and forbs and to improve water quality by reducing nutrient and fine sediment inputs. The basin wide goal of this project was to improve water quality by reducing sedimentation and bank erosion. This project is representative of other cattle exclusion projects in low gradient valley reaches of the Sprague River. No formal post-project monitoring data was available for this project; however, we were able to extract basic project performance information by reviewing the cooperative agreement and status reports in the project file. To supplement this information, we conducted a channel bank condition assessment and greenline surveys to evaluate post-project performance based on the best available data and information and to serve as a baseline for future monitoring. We learned that although cattle have been excluded from the riparian corridor at this site for approximately two years, bank failures continue to occur and woody riparian vegetation has not yet colonized the riparian corridor as described in the project documents and predicted by the conceptual models for this type of project. The grasses in the riparian corridor have regenerated; however, the species we identified in the greenline survey were predominately non-native invasive species. By reviewing this project we learned that cattle exclusion does improve the condition of channel banks and allows vegetation to regenerate, and we recommend that future cattle exclusion projects include detailed vegetation management prescriptions to reduce non-native species with a monitoring component that allows for adaptive management of vegetation restoration.

### 6.8.2 Site Conditions

The project is located in the upper watershed on the South Fork Sprague River (Figure 6.8-1). The downstream extent of the project is about a mile upstream of the confluence with the North Fork Sprague River and extends about 3 ½ miles upstream from the Camp Six Road bridge. The community of Bly is located about 2 miles southeast of the project site. Highway 140 is the southern boundary of the project area, but does not intersect the channel. The OC&E Woods Line State Trail, the former railroad grade that has been converted into a bike path and trail, roughly parallels the channel. The project site is located in a broad valley that collects runoff from the North Fork and South Fork Sprague rivers and the Sycan River. The valley is drained by the Sprague River to the west of the project site and the surrounding land has been grazed by livestock since the 1800’s. The river was straightened and leveed by the US Army Corps of Engineers in the 1950’s. Aerial photographs from 1940 show that the channel was more sinuous and included secondary channels and cutoff channels prior to levee construction. After confinement by the levees the channel was simplified and cut off from secondary channels.

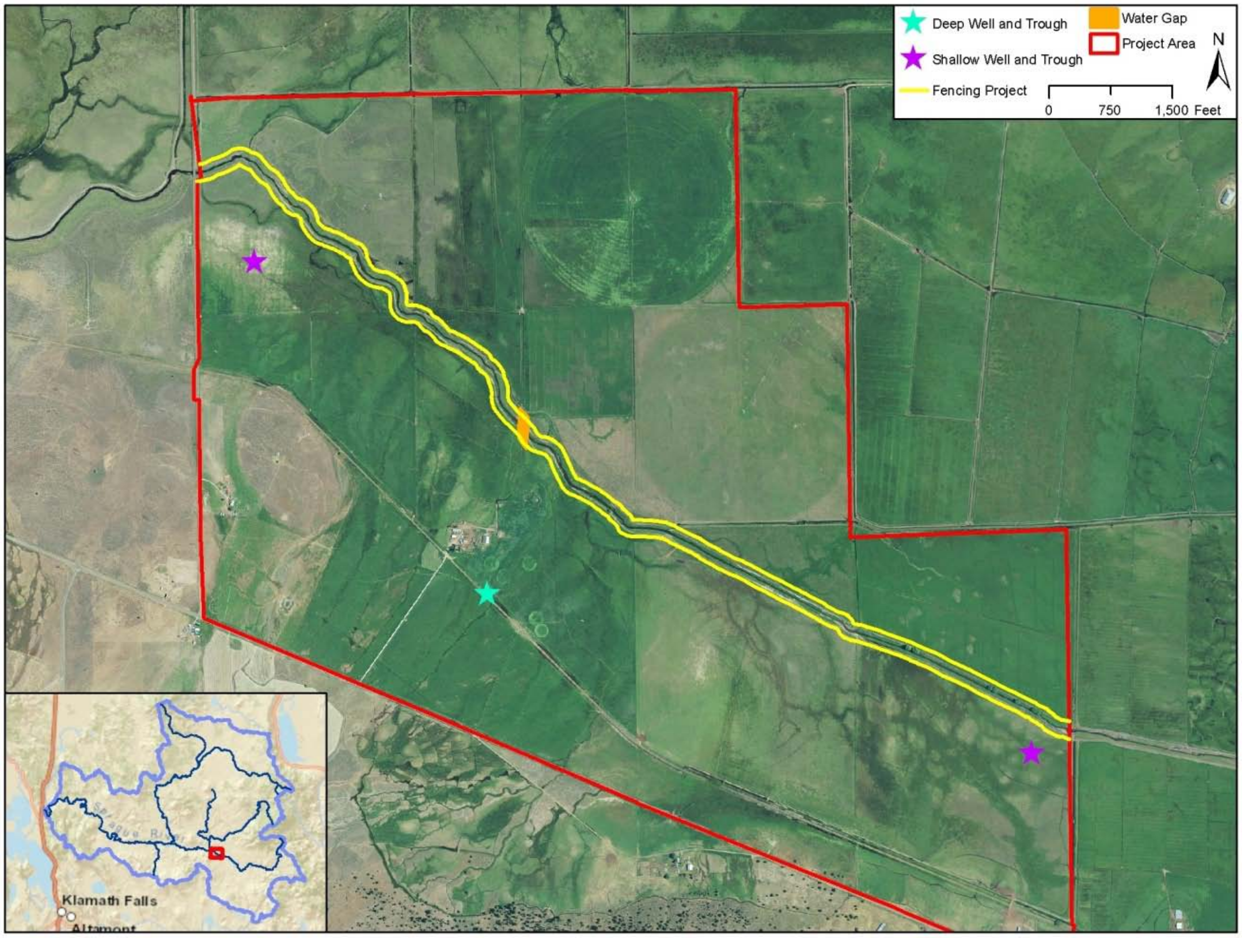



*Figure 6.8-1: The South Forth Sprague River Project is located in a low gradient valley in the upper watershed. The channel was straightened and confined by levees in the 1950s. Project features include fencing on both sides of the channel, water gap channel crossing, and off-channel cattle watering stations.*

### 6.8.3 Success Criteria

Most of the projects in our evaluation included an objective aimed at minimizing the impact of cattle to improve water quality. However, the South Fork Sprague River project was one of three projects that we evaluated with the primary objective of reducing the impacts of cattle grazing on riparian and aquatic habitats by excluding cattle. Selecting this project allowed us to evaluate the effectiveness of cattle exclusion independent of other actions. Multi-objective projects, which include actions such as revegetation or wetland creation along with cattle exclusion, are common in the Sprague River Basin. The Sycan River and Long Creek projects are described elsewhere in this document and are the other two riparian fencing projects that we evaluated. The South Fork Sprague River project is unique in that the channel is confined by levees. Ranching is the dominant land use along the channel, and except for the levees in the project area, the project reach is representative of typical channel and land use types for the mainstem Sprague River.

The project objective stated in the cooperative agreement (USFWS 2007) is to improve the management of the riparian corridor of the South Fork Sprague River by installing fencing and providing off-stream watering and a water gap. To minimize the impact from cattle crossing from pastures on opposite sides of the river, a water gap (i.e. rocked stream crossing) was installed. The channel bed throughout much of this reach is composed of a hardpan clay layer, which is a common feature throughout the Sprague River Basin. While this layer is resistant to erosion from fluvial processes, it is easily disturbed by mechanical excavation or by cattle entering and crossing the river. The specific problems indentified in the cooperative agreement as the drivers for this project include excess sediment and nutrients and excess bank erosion. The measurable objectives indentified in the cooperative agreement to address the identified problems include: 1) elimination of hoof shear and cattle impact within the riparian zone, and 2) increased abundance of native grasses and forbs. Flash grazing (a grazing management prescription where an area is grazed briefly, but with a higher concentration of animals to capitalize on a forage resource, for example a non-native species or weed) is prescribed in the ranch management plan (KWP, undated) and the cooperative agreement (USFWS 2007) in the riparian areas as a management tool to improve riparian health after stream banks have stabilized.

The stated objectives of the proposed grazing rotation are expected to provide native grasses, forbs, and shrubs the opportunity to regenerate by altering the frequency and duration of grazing (KWP 2009). The fenced off riparian area will be maintained as a future rotational grazing area during the late fall or early winter, limiting the time cattle have access to the riparian corridor. The grazing strategy for the fenced riparian zone will be determined by the recovery of bank vegetation, diversity of bank vegetation, the presence of forbs or woody species, and soil moisture content less than 10%. Grazing will not be allowed for the first 2-4 years after completion of the project, and when grazing does commence, a stubble height of 4-6 inches will be maintained (KWP, undated). At the time of this report, grazing management of the riparian corridor had not yet started. Once grazing practices are instituted the project action will change from fencing to fencing and grazing management. The objectives listed for a fencing action in the Project Framework in Section 3.1 of this report include the creation of improved habitat for aquatic organisms and utilization of created habitat by native organisms. The objectives stated in the project documents are complementary to the recommended objectives.

### 6.8.4 Project Timeline

Initial authorization for project funding was included in the USFWS Sprague River Ranch Management Plans Project in 2006, which was an effort to identify projects to improve water quality and fish habitat. The Klamath Watershed Partnership, along with the USFWS and other partners, undertook this project to reduce stream bank erosion to improve water quality in the South Fork Sprague River. After initial meetings for this project, local landowners were concerned about the potential changes on their lands and about signing agreements with outside sources. Project design was completed in 2007, and the Cooperative Agreement was signed in July, 2007. After the restoration team and landowners came to an agreement, the project was implemented and the first mile of fencing was completed in the summer of 2008. Modifications were made to the restoration plan to avoid potential landowner conflicts over shared off channel watering infrastructure, and fencing and a water gap were completed in 2009 (KWP 2009). We completed our greenline survey and bank erosion assessment in late 2011.

### 6.8.5 Relevant Conceptual Models

The **Grazing** and **Channel Confinement** conceptual models guided our PPA of the South Fork Sprague River project and are described in further detail in Section 3.1 of this report. The channel confinement conceptual model shows that levee construction or channel straightening causes channel incision and bank erosion. The riparian and floodplain grazing conceptual model predicts that the channel will experience bank erosion, reduction in riparian vegetation, and degradation of water quality. The conceptual models for both riparian and floodplain grazing and channel confinement predict significant alteration in channel cross section, channel profile, channel alignment, and changes in riparian vegetation. The conceptual models for fencing and levee removal predict an increase in channel complexity and stability that will lead to biological colonization and succession.

Our review of the project documents suggests that the physical processes illustrated in the cattle grazing conceptual model were considered in the project design in terms of vegetation and water quality. However, the disconnection between the active channel and floodplain from channel incision and levee construction was not explicitly considered in the planning or implementation of the project. The goals of this project of reducing nutrients, sediment, and bank erosion would have been better served if both conceptual models had been taken into account in the project design. For example, setting back levees to the riparian corridor fence line or reconnecting secondary channels may have reduced erosion associated with channel confinement.

### 6.8.6 Post Project Appraisal

#### *6.8.6.1 Methods*

The Organizational Framework introduced in Section 3.1 lists several metrics to evaluate fencing projects relative to the project's goals and objectives. Metrics recommended for this type of project include channel and floodplain geometry, longitudinal profile of the channel, hydrology, sediment characterization, and riparian cover. No post project monitoring had been conducted for this project prior to this study. We collected vegetation and bank erosion data to evaluate current conditions with respect to stated success criteria and to serve as a baseline for future monitoring and adaptive management for this project. We conducted a simplified greenline survey and channel bank condition assessments on the most downstream mile of this project in November 2011. We documented both assessments with digital photographs and GPS waypoints. A detailed description of the methods we used for this assessment can be found in Section 4 of this report. We also compared historical aerial photographs to assess channel and vegetation changes over time.

#### *6.8.6.2 Results*

##### 6.8.6.2.1 Greenline Survey

To evaluate the performance of this project with respect to stated riparian vegetation success criteria, we assessed regeneration and native grass and forb composition with a greenline survey alternating between the right and left bank for approximately one mile near the downstream extent of the project site (Figure 6.8-2). The effects of cattle exclusion are clearly shown in the two photographs taken from the Camp Six Road Bridge in Figure 6.8-3. Cattle exclusion over the past two years has allowed grasses to regenerate and has increased the height of grasses along the channel; however, the composition of grasses is predominately non-native species. Without management or planting, non-native species out compete the native plant species.

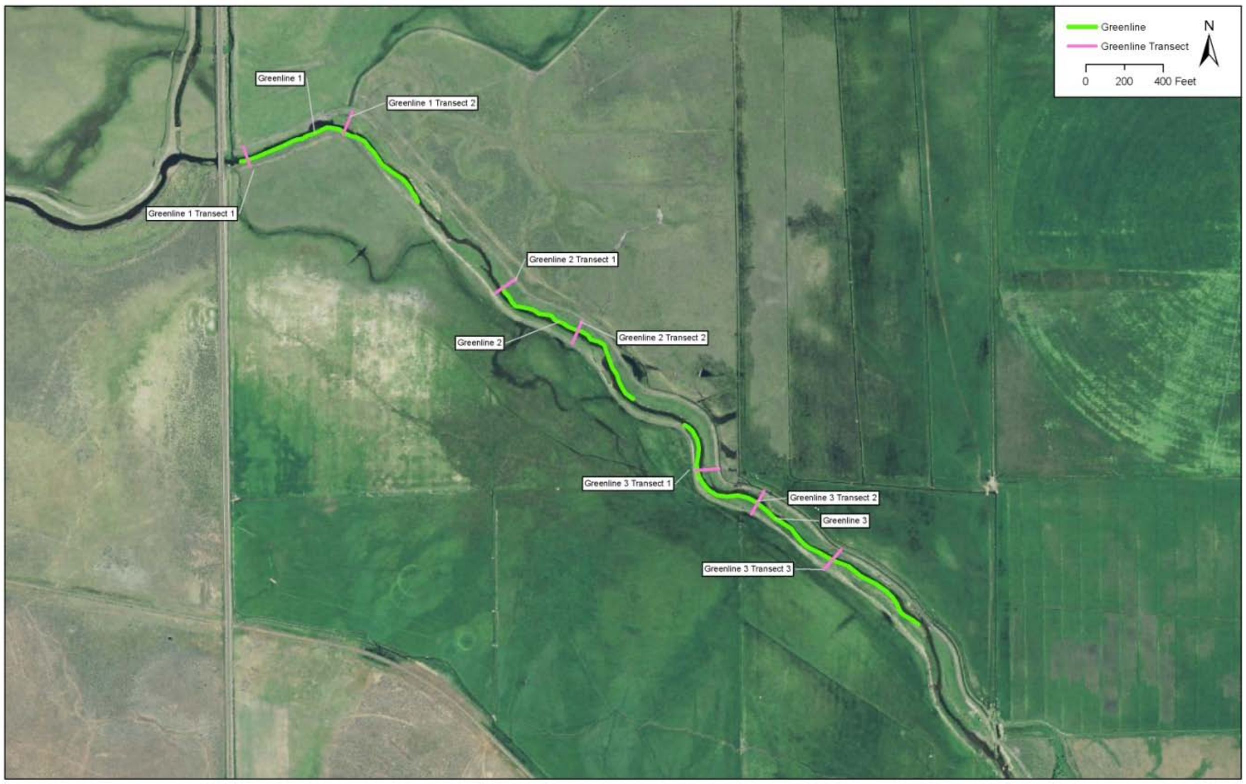
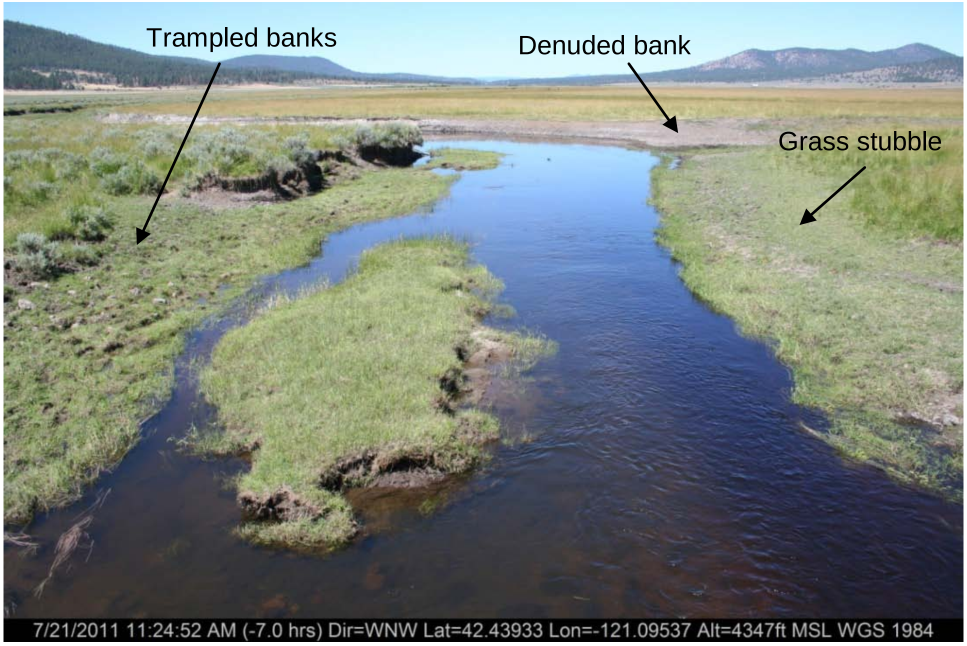



*Figure 6.8-2: Location of greenline surveys and transects in the downstream most mile of the project.*



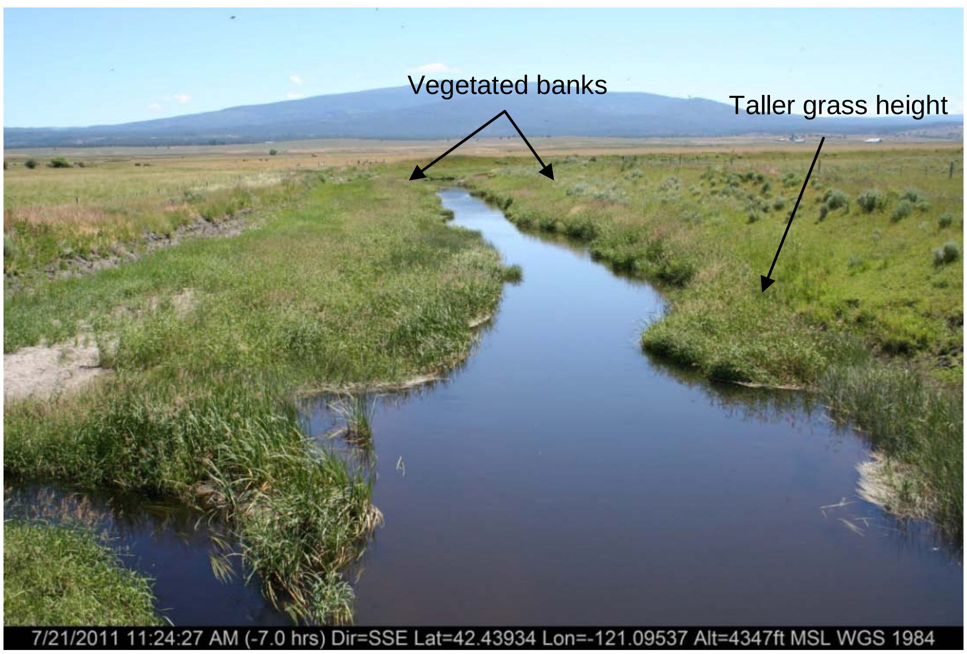




*Figure 6.8-3: Comparison of vegetation height and coverage in the riparian corridor between the grazed property downstream of the Camp Six Road Bridge (top photo) and the project property (lower photo) upstream of the Camp Six Road Bridge. The top photograph shows lower vegetation height and trampled banks on the grazed property. Note this photograph was taken in July 2011.*

From the results of this greenline survey we learned that the vegetation communities along this reach are dominated by reed canary grass, with a lesser component of rushes (likely Baltic rush) and sedges (primarily beaked sedge) (Figure 6.8-4). Vegetation along the greenline was generally continuous, but because we conducted the survey late in the year, all vegetation was dormant, with many of the annuals, rushes, and grasses extremely weathered and difficult to identify (Figure 6.8-4). Some areas along the greenline, and to a larger extent on the upper portions of the riparian zone, were populated by other species of bunchgrasses, rushes, and small sedges. There were also areas containing weedy species, such as annual grasses, mustards and forbs, but this was a small proportion of the overall project area (Figure 6.8-5).

We also performed cross-sectional transects along each greenline to evaluate how the vegetation composition changed with distance from the channel. Because this section of the river runs between two levees, we considered the riparian zone as the area between the levees. We determined that areas further from the river channel and on the upper bench of the floodplain and onto the levees tended to have a more variable mix of grasses, along with sagebrush and weedy species such as curly dock, thistles, and mustards. The results of the greenline survey are summarized below in Table 6.8-1.

*Table 6.8-1: Summary of greenline survey results showing the dominance of reed canary grass*

| | | Community Type | | | |
|---|---|---|---|---|---|
| Transect | Total Length (ft) | Reed canary grass (ft) | Bunchgrass (ft) | Upland Bunchgrass (ft) | Other (ft) |
| Greenline #1 | 1,050 | 822 | 168 | | 60 |
| Greenline #1, transect #1 | 100 | 33 | 35 | | channel width 32 ft |
| Greenline #1, transect #2 | 85 | 32 | 30 | | channel width 23 ft |
| Greenline #2 | 930 | 890 | 40 | | 0 |
| Greenline #2, transect #1 | 87 | 23 | 17 | | channel width 20 ft, bare ground 7 ft, rushes 20 ft |
| Greenline #2, transect #2 | 117 | 46 | | 45 | channel width 26 ft |
| Greenline #3 | 871 | 811 | 60 | | |
| Greenline #3, transect #1 | 96 | 36 | | 25 | channel width 18 ft, bare ground 14 ft |
| Greenline #3, transect #2 | 100 | 54 | 28 | | channel width 18 ft |
| Greenline #3, transect #3 | 84 | 46 | 12 | 9 | channel width 17 ft |


*Figure 6.8-4: Photo of the riparian zone in the project area showing the dominance of reed canary grass along the greenline in this reach of the river Reed canary grass has vegetated the channel banks, which shows a reduction of the impact on the channel from cattle grazing, but has out competed native species.*

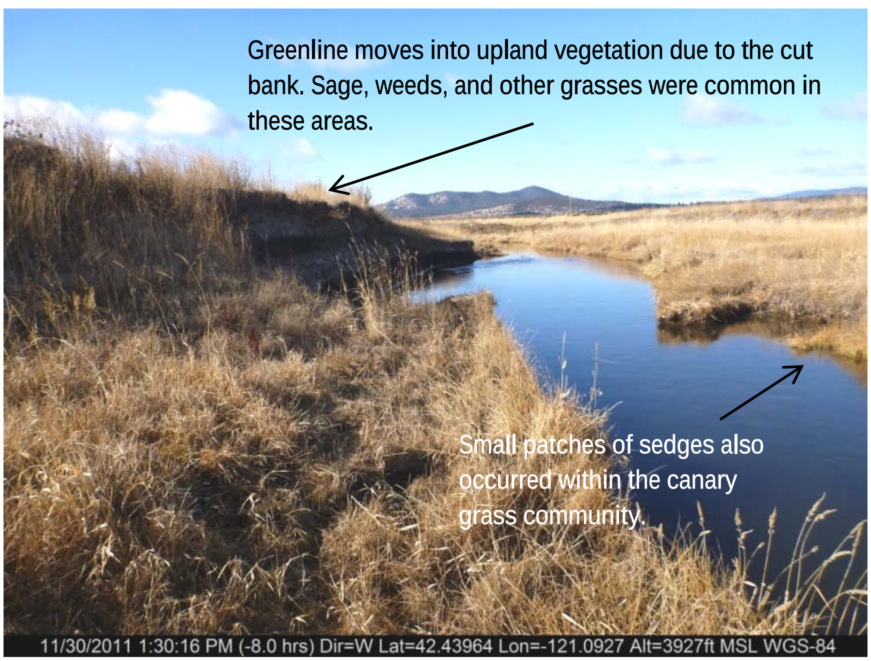



*Figure 6.8-5: Photo showing typical vegetation, still dominated by reed canary grass on the lower bench, but with other components present on the greenline due to erosion within the leveed channel.*

Our post-project evaluation of this site showed that excluding cattle from grazing the riparian corridor can increase the abundance of vegetation in the corridor. However, without vegetation management prescriptions, non-native species can dominate the vegetation communities that become established. Vegetation management prescriptions or planting of woody vegetation may be required to establish willows or other woody species in the riparian corridor. To quantify the change in vegetation and evaluate the success of different vegetation management prescriptions, greenline and vegetation composition surveys should be conducted and repeated during post project monitoring.

#### 6.8.6.2.2 Bank Erosion Evaluation

The Grazing conceptual model predicts that degraded banks will recover after cattle are removed from the riparian corridor. To evaluate the performance of this project with respect to channel bank conditions, we conducted a channel bank erosion evaluation. Without a bank condition assessment of pre-project conditions, we were unable to quantify the change in bank condition after two years of cattle exclusion. However, our analysis did indicate that eroded banks still comprise a significant portion of the channel length (Table 6.8-2 and Figure 6.8-6). This finding highlights the importance of considering all potentially applicable conceptual models in the planning and implementation of river restoration projects. For the goals and objectives of this project, the Channel Confinement conceptual model should have been considered as channel confinement is likely the dominant influence on channel bank condition. This conceptual model predicts that channel confinement will incise and erode the channel banks (Figure 6.8-7), and eventually lead to the formation of inset floodplain surfaces within the area confined by the levees (Figure 6.8-8) and continued bank erosion. Utilization of the Channel Confinement conceptual model, which predicts channel incision and widening, during project design could have resulted in a design that moved the fence line further back from channel bends or incorporated secondary channels isolated from the channel by breaching or setting back levees.

Our bank erosion assessment covered both banks of the channel for the first mile upstream of the Camp Six Road Bridge (Figure 6.8-6). We identified fifteen bank erosion sites along 5,485 feet of river with total bank length of 10,970 feet. The fifteen bank erosion sites we identified totaled 3,776 feet in length, which is 69% of the channel length and 34% of the total bank length (Table 6.8-2). Future bank erosion assessments would be useful in determining the background amount of bank erosion in the Sprague River system, as bank erosion is a common feature in meandering, low gradient river systems.

*Table 6.8-2: Summary of Bank Erosion Sites*

| | |
|---|---|
| Total Bank Length (ft) | 10,970 |
| Total Channel Length (ft) | 5,485 |
| Total Channel Bank Length Classified as Eroding (ft) | 3,776 |
| Percent of Channel Classified as Eroding | 69% |
| Percent of Channel Bank Classified as Eroding | 34% |

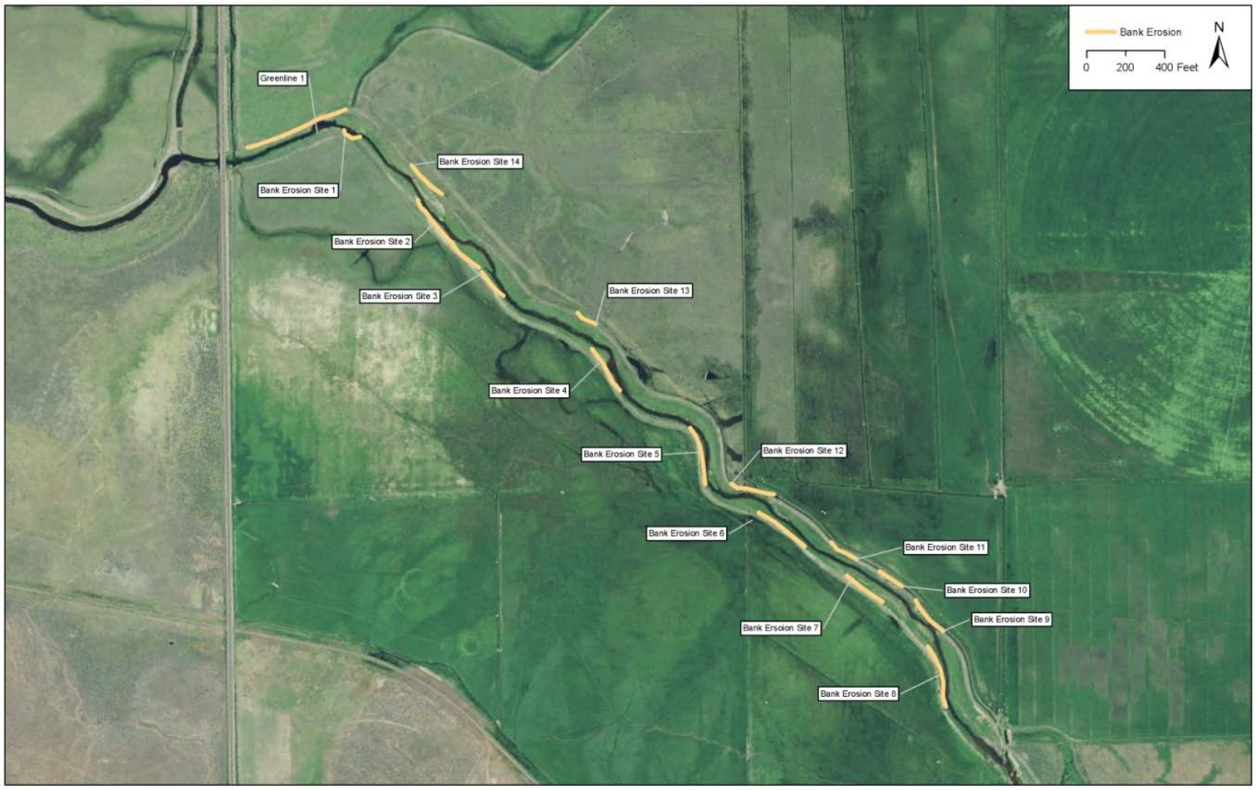



*Figure 6.8-6: Bank erosion sites identified during post project appraisal.*


*Figure 6.8-7: Bank erosion on an outside bend of the channel where eroded material has been transported downstream*


*Figure 6.8-8: Bank erosion on the inside bend of the channel where eroded material has formed a lower surface that has been colonized by grass.*

### 6.8.6.2.3 Historical Aerial Photograph Evaluation

We reviewed historical aerial photographs to assess the changes before and after the project and to identify channel, riparian, and floodplain changes trends at the site. The historical photographs from 1953 to 2009 (Figure 6.8-9) were all taken after levee construction; however, the 1953 photo shows remnant secondary channels in the project reach that were disconnected by the levees. Multiple islands are visible in the 1995 to 2009 aerial photos, and the channel is meandering within the narrow levee corridor during this period.

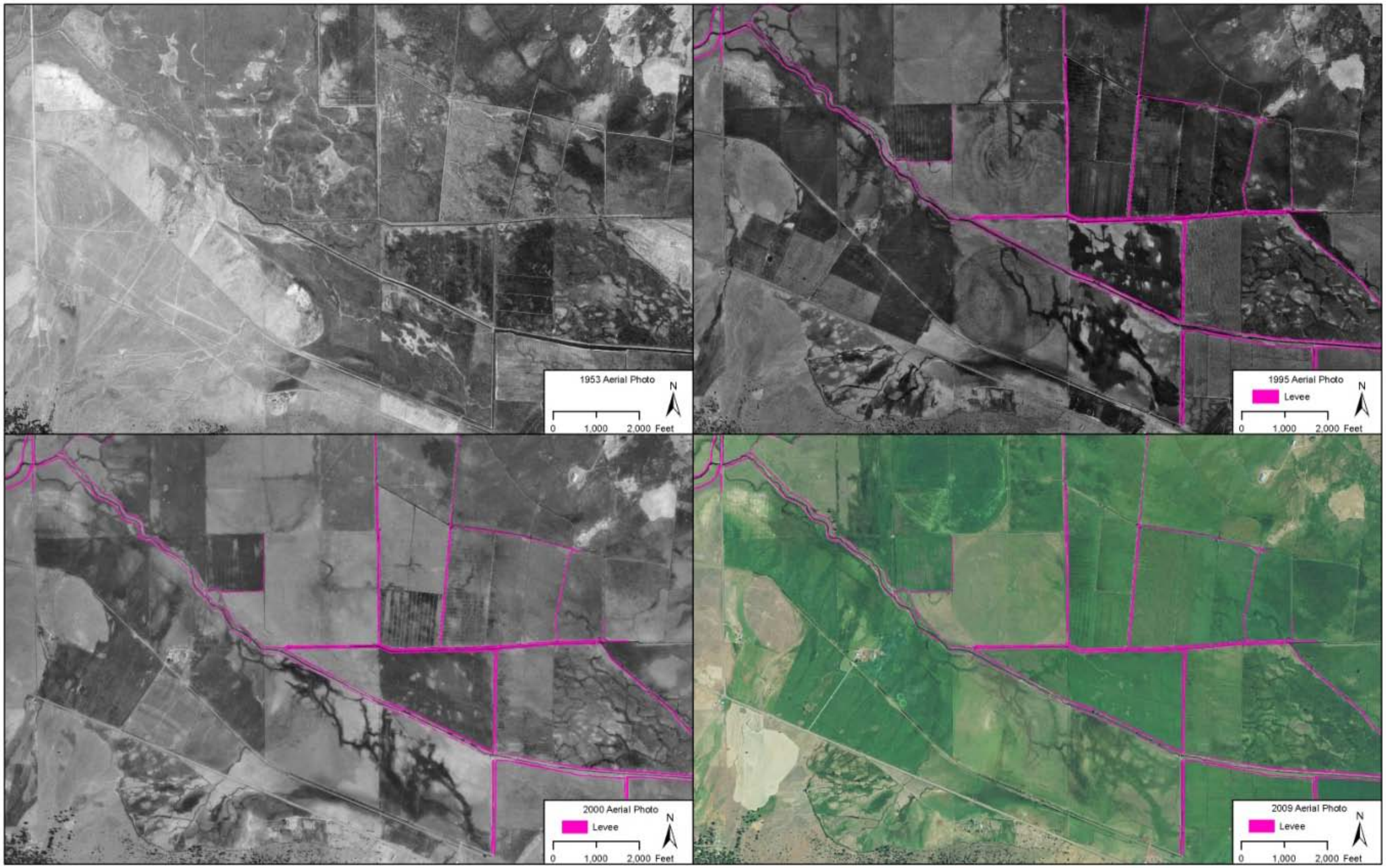



*Figure 6.8-9: Comparison of historical aerial photographs from 1953, 1995, 2000, and 2009 showing levee locations from 2000.*

### 6.8.7 PPA Lessons Learned

Based on our review of project documents, our field observations and measurements, and our PPA, we identified a variety of useful lessons from the South Fork Sprague River project at the site and basin scale. Table 6.8-3 presents a summary of lessons learned at the site and basin scale by restoration project life-cycle phase.

*Table 6.8-3: Summary of key lessons learned from the South Fork Sprague River Project*

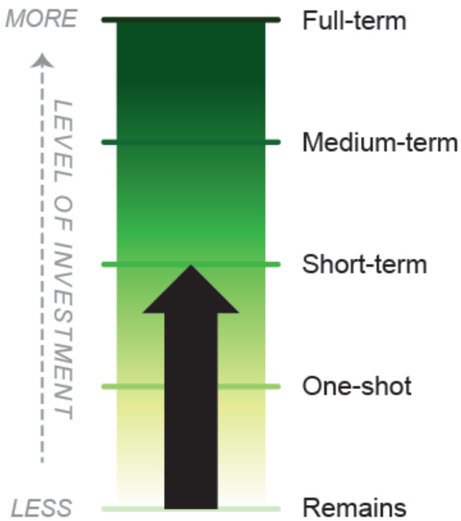
| Restoration Project Life-cycle Phase | Scale for Lesson | Lessons Learned |
|---|---|---|
| Pre-Project – Goals/objectives, Planning, Data Collection, Analysis | Site-specific | Collect pre-project and as-built baseline data to allow quantitative evaluation of project performance and more accurate assessment against project success criteria. |
| | | Develop vegetation management plan to reduce amount of non-native species as fencing has resulted in regeneration of predominately non-native species. |
| | | Use all applicable conceptual models for the site to inform goals/objectives. |
| | Site-specific and basinwide | Establishment of native vegetation requires predator control, vegetation management, and analysis of groundwater, and surface water hydrology for native species to colonize the riparian corridor. |
| | | Fencing alone may not stop bank erosion and sedimentation as reach scale geomorphic processes may continue bank erosion (i.e. channel adjustment from levee construction). |
| Design | Site-specific | Setback fences at channel bends to account for migration/bank erosion and include secondary channels in the riparian corridor. |
| | | Include design features to prevent cattle on adjacent properties from crossing fence lines (fence to the low water line, use barb wire, reinforce fence posts with rail road ties). |
| Implementation | Site-specific | GPS/Survey as-built features (fences, watering station, water gap) to monitor and inventory features constructed. |
| | | Plan construction when ground is dry (after wet and irrigation seasons) to avoid delays in construction schedule. |
| | | Use flash or rotational cattle grazing in the riparian corridor to help control non-native vegetation species such as star thistle and young reed canary grass to avoid spraying herbicide. Cattle preference for non-native species is life stage dependent and may limit the usefulness of cattle grazing for non-native species control in the riparian corridor. |
| Monitoring | Site-specific and basinwide | Conduct vegetation and geomorphic (cross sections and longitudinal profile) monitoring to assess project success and adaptively manage the project. |
| | | Standardize monitoring data so that monitoring can be replicated from the data in the report appendix or on a data DVD required in monitoring reports (all photos and surveys should be georeferenced). |
| General | Site-specific | Incorporate levee setback into restoration actions to reconnect the floodplain to the channel and reduce channel incision and bank erosion from channel confinement from the levees. |
| | Basinwide | Provide incentives for land owners to implement restoration projects that help with grazing or cattle management to encourage more land owners to participate in restoration programs. |
| | | Vegetation regeneration creates a buffer strip in the riparian corridor that decreases fine sediment and nutrient input into the channel that improves basin wide water quality. |

At the project site scale, we learned that relatively minor changes to the planning, design, implementation, and monitoring of this project could have improved its overall performance. Consideration of all relevant conceptual models would have improved the development of measurable objectives and perhaps expanded the scope of the project to address channel confinement in addition to grazing.

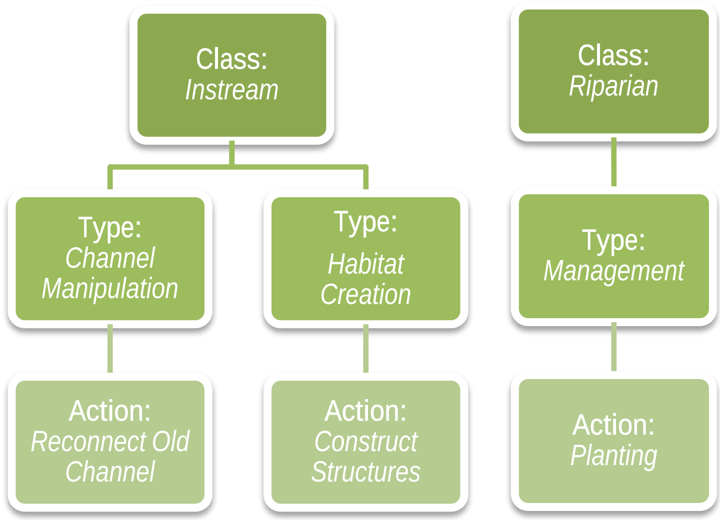
We also learned from this PPA that the project contributes incrementally to the basin wide goal of providing more normative geomorphic, sediment transport, and biological processes that create riparian conditions and variability that better supports native riparian plant communities and biota in the Upper Klamath Basin. However, additional work appears to be required at this site to maximize the basinwide benefits possible with the site scale changes of this project.

## 6.9 Bailey Flat Project – North Fork Sprague (Upper Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**




### 6.9.1 PPA Synopsis

We selected this project to provide a PPA case-study of reconnection of a historical channel combined with fish structure placement and riparian planting (Site 1). We categorized this PPA as short term based on data availability and the period of pre- and post-project monitoring. This project also included bank protection and bank erosion elements (Sites 2-6), but our PPA focused on the historical channel reconnection, fish habitat structures, and riparian planting (Site 1) aspects of the project because access to the bank protection elements was limited. The Bailey Flat project fits both the instream and riparian classes, with channel manipulation, habitat creation, and management project types. Our PPA of this project was informed by the ***Channel Simplification*** and ***Grazing*** conceptual models.

The project documents that we reviewed for this PPA listed both site specific goals (e.g. reconnecting the channelized reach with the floodplain/marsh surface and abandoning the straightened channel) and basin wide goals (e.g. improving habitat conditions for salmonids and other fishes of the Sprague River). These goals were supported by objectives that were also both site specific (e.g. creating overhead cover using riparian vegetation, undercut banks, and large woody debris features) and basin wide (e.g. improving water quality with regard to pollutants, water temperature, and suspended fine sediments). We conducted our PPA of this project by evaluating design documentation and one year of post-project monitoring data, to which we added a second year of channel survey data, two pebble counts, and photo point observations. The primary lesson learned from this project was that additional analysis should be undertaken during design to estimate channel response to greater than bankfull discharge. This project was for the most part successful and if repeated elsewhere in the Sprague River Basin, this project type could improve spawning habitat conditions for salmonids.

### 6.9.2 Site Conditions

This project is located in the upper watershed of the Sprague River Basin on the North Fork Sprague River (Figure 6.9-1), about 8 miles upstream of the confluence with the South Fork Sprague River. The project reach is located in an alluvial valley bottom that is about 6,500 ft long and ranges from 350 to 800 ft wide. Between 1940 and 1995 about 2,200 feet of the downstream half of the reach was straightened and relocated along the valley's north western edge. Levees were constructed to contain flood flows and isolate the channel from the valley wetlands and pasture. The relocated channel was steeper in slope than the historical channel and is a source of chronic bank erosion (Balance, 2009). The project included reconstruction of the historical channel by reoccupying about 2,000 ft of remnant channels within the valley bottom (OWEB, 2011). The reach serves as habitat for salmonids, suckers, and other fishes including the federally threatened Bull Trout (Balance 2009). The project channel reduces the channel slope from 0.0068 to 0.0044 ft/ft, which is just slightly lower than the reference reach slope upstream of the project.

The restored channel was designed to inundate the floodplain at flows greater than 400 cfs, which is between the 1.5 and 2.0-year recurrence interval discharge for the North Fork Sprague River. Balance (2009) empirically developed the flood frequency analysis from USGS gages at the North Fork of the Sprague River near Bly, Oregon (Gage # 11495800) and the Sprague River near Beatty, Oregon (Gage # 11497500). The new channel width of 35 feet was based on the width of the remnant channel and the reference reach. The channel was designed to alternate between pools and riffles, and LWD was placed to protect banks, reduce flow energy, create pools, and enhance channel complexity. The constructed banks were sloped and vegetated to provide stability and promote bank undercutting for fish cover and habitat. At the downstream confluence of the new channel with the old channel, the channel was kept open to provide backwater habitat. Material excavated from the new channel was used to plug the straightened channel and create floodplain wetlands or off-channel ponds (OWEB, 2011). Two cattle crossings were also installed (Figure 6.9-1).

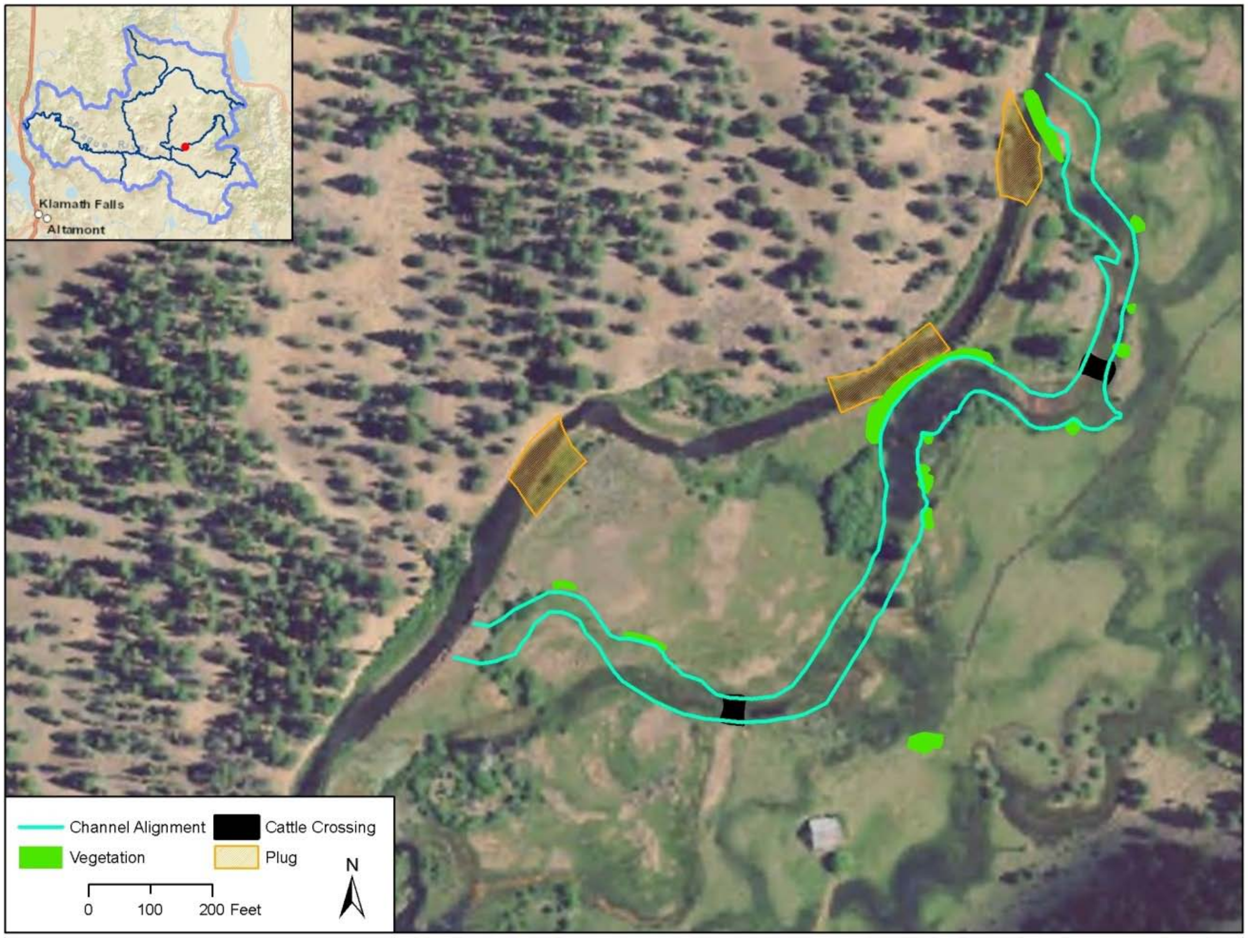



*Figure 6.9-1:The Bailey Flat Project on the North Fork Sprague River, approximately 8 miles upstream of the confluence with the South Fork Sprague River. The base aerial photograph from 2009 shows the pre-project condition. The project relocated the channel from the straightened reach along the edge of the valley to remnant channels.*

### 6.9.3 Success Criteria

The documentation we reviewed for this project cited a wide range of site specific and basin scale goals and objectives. General site scale goals included improving habitat conditions for salmonids and other fishes, restoring hydrologic and geomorphic function within the project reach, and reducing bank erosion. Specific site goals included reconnecting the channelized reach with the floodplain/marsh surface and abandoning the straightened channel, increasing the number, size, and depth of pool habitats, creating overhead cover using riparian vegetation, undercut banks, and large woody debris features, re-establishing riparian vegetation to stabilize banks, provide overhead cover, and temperature control, reducing sedimentation to promote loose, clean, well-oxygenated gravels suitable for spawning, creating slow-moving backwaters for rearing and high-flow refuge, and increasing overall channel complexity (Balance 2009). Basin-wide goals included restoring habitat values for the fishery and other native species and improving water quality with regard to pollutants, water temperature, and suspended fine sediments. These objectives mostly align with the objectives identified and discussed for these classes and types of projects in the Organizational Framework in Section 3.1 of this report.

### 6.9.4 Project Timeline

The origins of this project are not clearly described in the project documentation. The oldest document we found in the project folder was the 2008 US Army Corps of Engineers (USACE) Joint Permit Application and electrofishing results from 2008. The USACE application states that the purpose and need for relocating the channel that was diked against the hillside to provide additional livestock grazing area the project was that,

"*the straightened river lost connectivity with its floodplain, and has very high velocities, especially during spring flow. This has degraded fish habitat. In order to improve fish habitat and river function in this reach of river, the owners have partnered along with the US Fish and Wildlife Service and Oregon Watershed Enhancement Board to reconstruct a portion of the historic channel, and to provide fish habitat enhancement structures throughout the reach.*"

A technical workplan was developed by Balance Hydrologics, Inc. in 2008 and the foundational document for this project is the Balance design and implementation memorandum from June, 2009. This document provides the project objectives and design of basis. Balance developed a design discharge empirically from gage data and discusses the rational for the selection of the design meander wavelength and amplitude. Further design rational is documented for the channel profile, channel geometry, channel habitat complexity, former channel abandonment, and the implementation process. The general restoration approach proposed in this document was to reoccupy a remnant channel with similar channel geometry and alignment to a reference reach upstream. Channel excavation directed by Balance began August 2009 and continued through September 2010. Shortly after the project was completed an as-built survey was conducted by Balance in October, 2010 that included a longitudinal profile of the relocated channel and twelve cross sections. Staff from the USFWS took digital photographs on April 19, 2011 at a discharge of 331 cfs and on May 16, 2011 at 413 cfs after the annual daily average peak flow of 745 cfs on May 14, 2011. However, discharge at the Oregon Department of Water Resources gage (gage # 11495900) located upstream of the site was measured at closer to 1,200 cfs, but this measurement may be an error as it is not included with the downloadable data for the site. This measurement was 300 cfs (40%) higher than any other measurements in the record for this gage, and was likely the result of some error at the gage. Finally, we completed channel geometry and longitudinal profile surveys, pebble counts, and establishment of photographic monitoring locations on July 27, 2011 in support of this PPA.

### 6.9.5 Relevant Conceptual Models

The ***channel simplification*** conceptual model guided our PPA of this project. The channel simplification conceptual model describes how reversal of channelization is typically expected to create more natural instream conditions and dynamics (see Section 3.2 for more details on conceptual models). The goals and objectives of the Bailey Flat project suggest that the project proponents and designers were aware of the typical changes predicted by this conceptual model for the implemented actions. Restoring a historical channel alignment decreases the channel slope, which reduces stream velocity. These changes can lead to improved habitat conditions for fish and reduce bank erosion that can be a chronic source of fine sediment to the channel. Specifically, the project designers attempted to restore not only the historical channel alignment, but also the channel profile with the grading and excavation of riffle and pool sequences.

### 6.9.6 Post Project Appraisal

#### *6.9.6.1 Methods*

The Project Framework introduced in Section 3.1 lists several metrics that could be used to evaluate the performance of this type of project relative to its goals and objectives. The availability of monitoring data for this project was better than for most of the other sites we evaluated for this project, and using the Downs and Kondolf (2002) PPA rating system we characterized the project's monitoring investment as short term. Still, ideally, a more complete suite of assessment methods would be applied to future similar projects so that more can be learned as those projects evolve through time. We collected monitoring data in July 2011 that included comparing twelve as-built and current cross sections, as-built and current longitudinal profile, and historical and current aerial photos (Figure 6.9-2). We also collected additional data to be used as baseline data for future monitoring efforts including two pebble counts to document bed material composition and ground photograph monitoring points at the twelve as-built cross section locations.

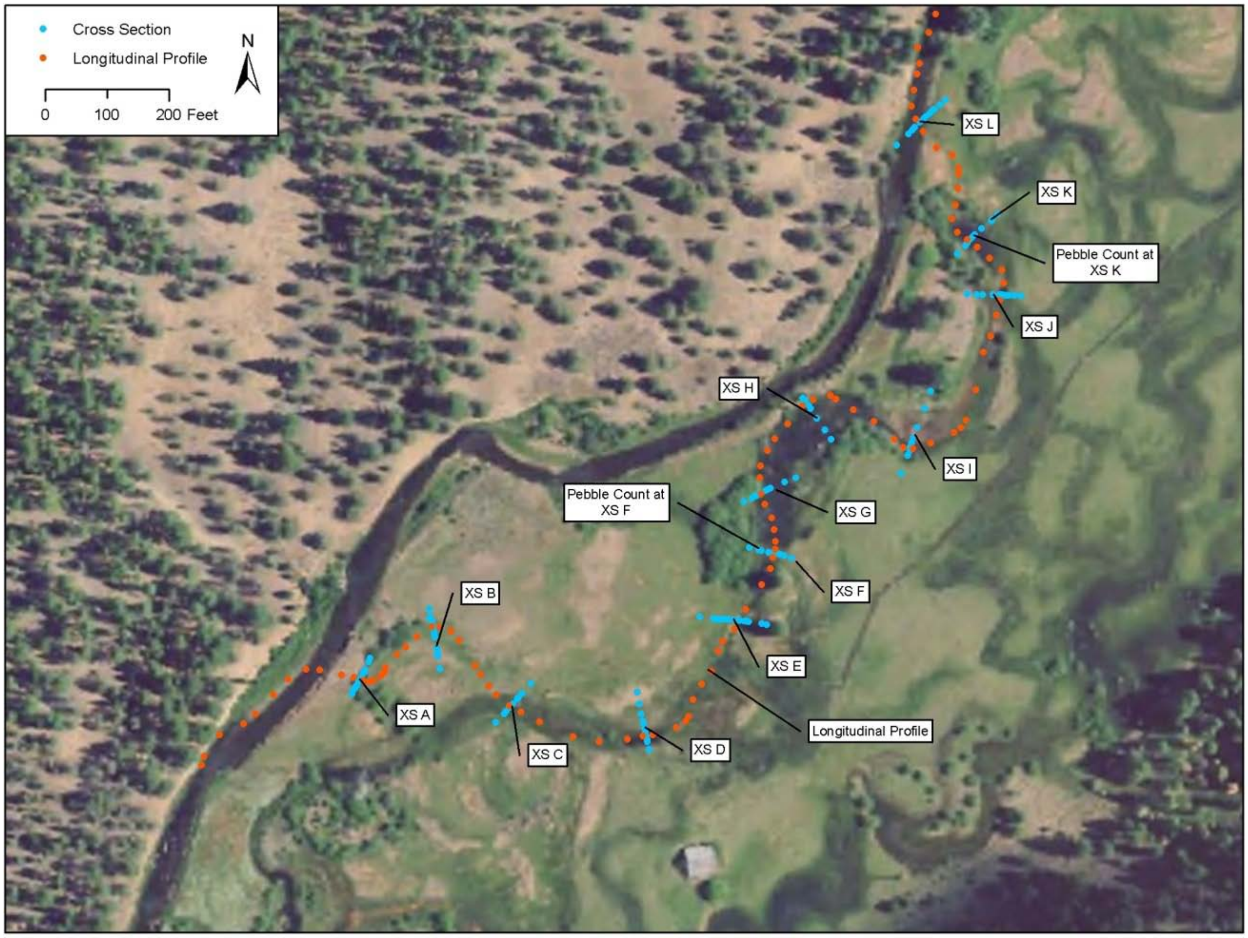



*Figure 6.9-2: Location of channel cross sections, longitudinal profile, and pebble counts used to evaluate instream changes between 2010 and 2011.*

### *6.9.6.2 Results*

#### 6.9.6.2.1 Historical Aerial Photo Comparisons

We reviewed historical aerial photographs to assess the changes before and after the project and to identify trends in channel change at the site. Our review of the historical photographs from 1953 to 2009 (Figure 6.9-3) shows many changes to the channel and floodplain. The channel alignment was significantly altered between 1953 and 1995. The historical channel is highly sinuous in 1953, while in 1995 it is much straighter. The remnant channels in the 1995 and later aerial photographs contain the historical channel in the 1953 aerial photograph. The upstream quarter of the channel occupies the same alignment in all the aerial photographs, while the downstream extent of the channel in 1953 and 1995 converges farther downstream. We also identified a change in upland vegetation composition and density between the 1953 and 1995 aerial photographs. Likely the increase in trees in the uplands is a result of fire suppression over the last half century or the regeneration of timber after logging in the early 1900s.

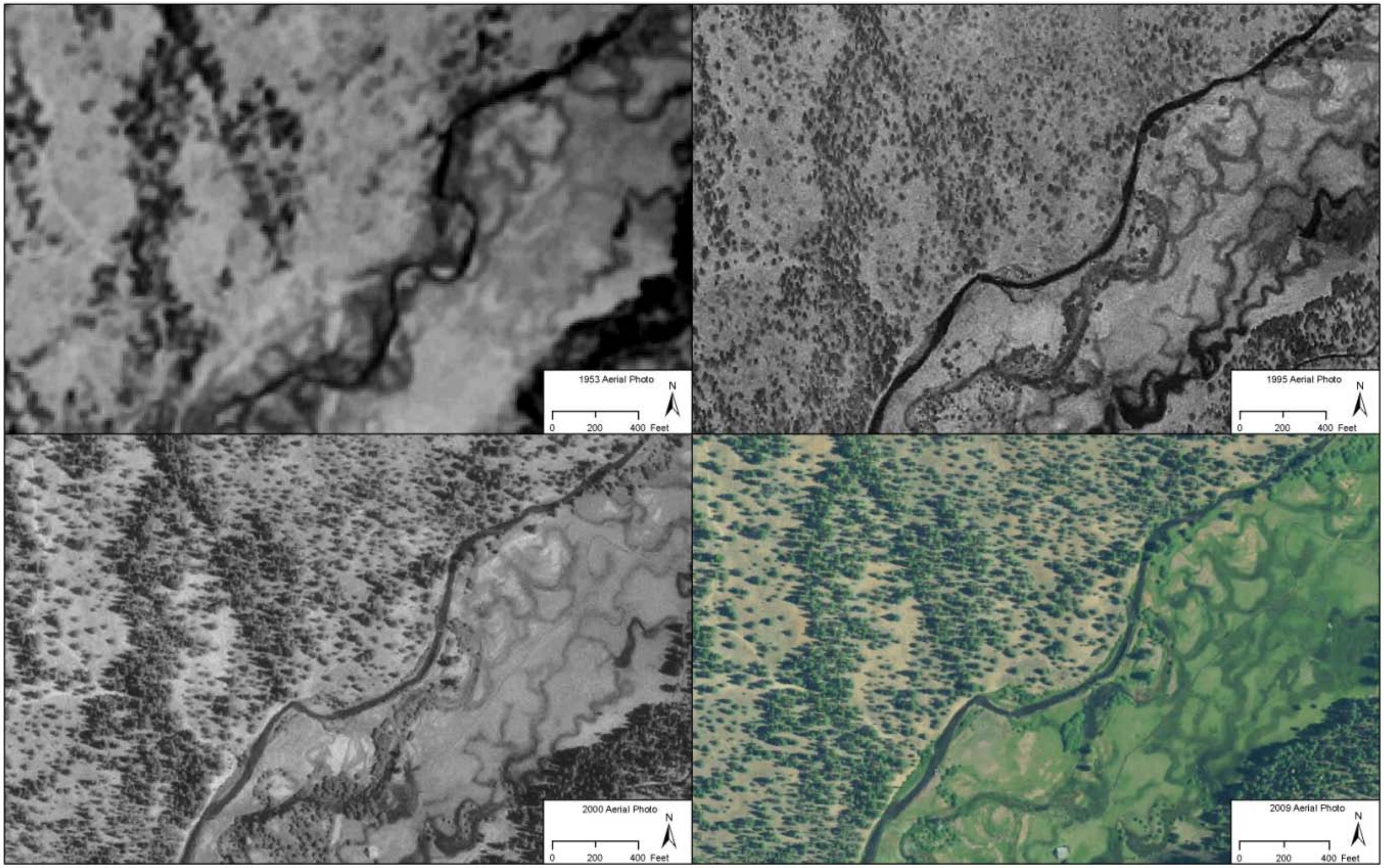



*Figure 6.9-3: Comparison of historical aerial photographs from 1953, 1995, 2000, and 2009 of the project site. The 1953 aerial photograph shows the original channel location before it was moved the toe of the north side of the valley.*

#### 6.9.6.2.2 Channel Geometry

Twelve as-built cross sections were surveyed by Balance Hydrologics, Inc. in October, 2010 using a relative survey referenced to a benchmark. Cross sections end pins were monuments with wooden stakes and elevations from the Balance survey were adjusted to GPS elevations collected by the USFWS in 2010. We relocated the wooden cross section end pins and re-surveyed the twelve cross sections. We plotted both cross sections and compared the changes in channel geometry. Figure 6.9-4 and Figure 6.9-5 illustrate the range of change in channel geometry between the two surveys. The highest daily average discharge between the two survey dates was 745 cfs on May 14, 2011 from the North Fork Sprague River USGS gage, which was greater than the estimated 2-year event of 494 cfs (Balance 2009). The May 14, 2011 flow was greater than the design flow and overtopped the channel banks and spilled onto the floodplain.

The plotted comparisons of the 2010 as-built cross sections and our 2011 cross sections in the downstream portion of the reach show that the channel adjusted after the bankfull flow in May 2011. Cross sections B and F remained stable, while cross sections A, C, D, and E experienced deposition in the thalweg. Cross sections A, D, and E show the most change, with cross section A eroding bank material and sections D and E building point bars. The general trends in the change in the cross sections in the downstream portion of the project reach show the channel depositing material at the thalweg and building point bars. The downstream most cross section experienced erosion that may be related to the transition back into the existing channel.

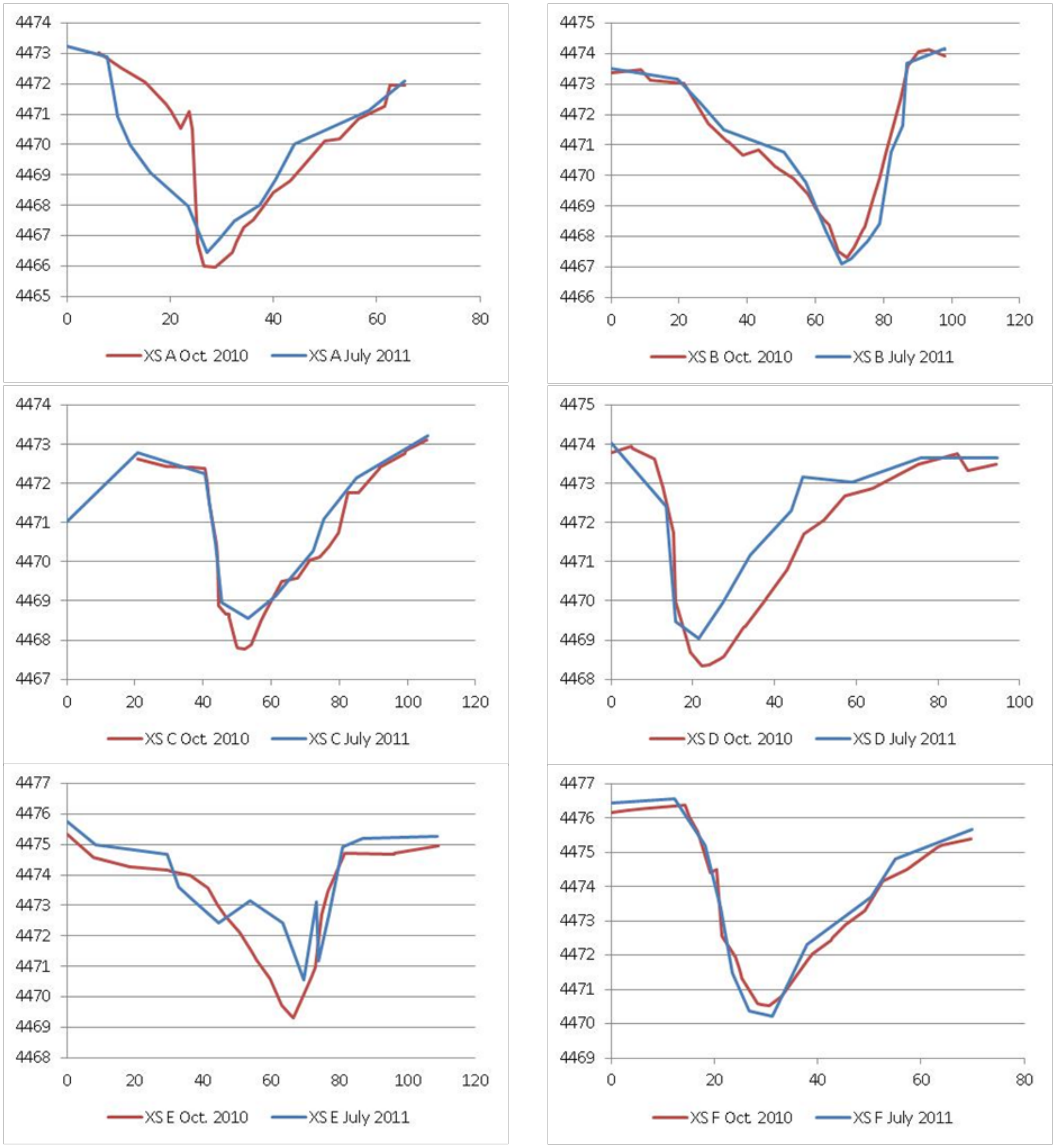



*Figure 6.9-4: Comparison of 2010 as-built cross section and our 2011 cross sections A through F. The locations of the cross sections are identified in Figure 6.9-2.*

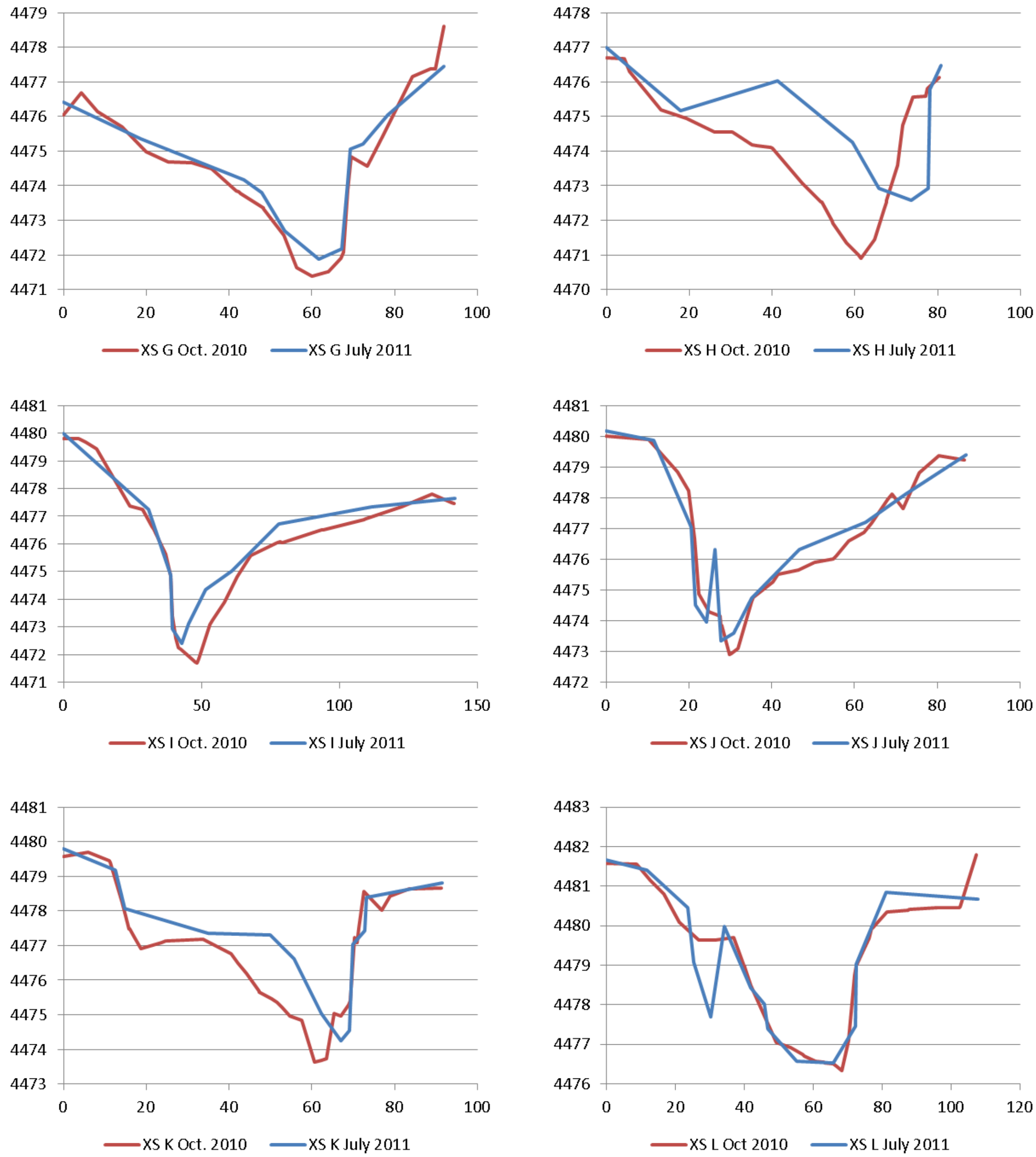



*Figure 6.9-5: Comparison of the 2010 as-built channel cross section and our 2011 cross sections G through L. The locations of the cross sections are identified in Figure 6.9-2.*

The plotted comparisons of the 2010 as-built cross sections and our 2011 cross sections in the upstream portion of the reach show that the channel adjusted after a greater than bankfull flow between the two surveys. The bed elevation increased in all of the upstream cross sections, except for cross section L which experienced no change in the thalweg elevation. Cross section L was the only cross section to experience downcutting on the channel bench. Cross sections H, I, and K show the most change, primarily point bar formation. Cross Section H also eroded the inside bank of the channel, while the other cross sections showed little to no bank erosion. Similar to the downstream portion of the project reach, the general trends we observed in the cross sections in the upstream portion of the project reach were sediment deposition in the thalweg and formation of point bars. If these trends continue, the objective of creating pool riffle sequences may not be met if the channel longitudinal profile flattens and becomes a long run. Currently the pools have just filled slightly and could be scoured during the next peak flow event.

###### 6.9.6.2.3 Longitudinal Profile

We surveyed a longitudinal profile as part of our PPA for this project in July 2011 and plotted our profile with the Balance longitudinal profile from October 2010 in Figure 6.9-6. The channel experienced overbank flow on May 14, 2011, midway through the period between our survey and the Balance survey. Often channel forming or bankfull discharges alter the longitudinal profile as material is scoured and deposited in the channel. Riparian vegetation planted after construction had not established by the time of the large peak flow in May 2011 and root systems were not yet sufficiently developed to stabilize banks.

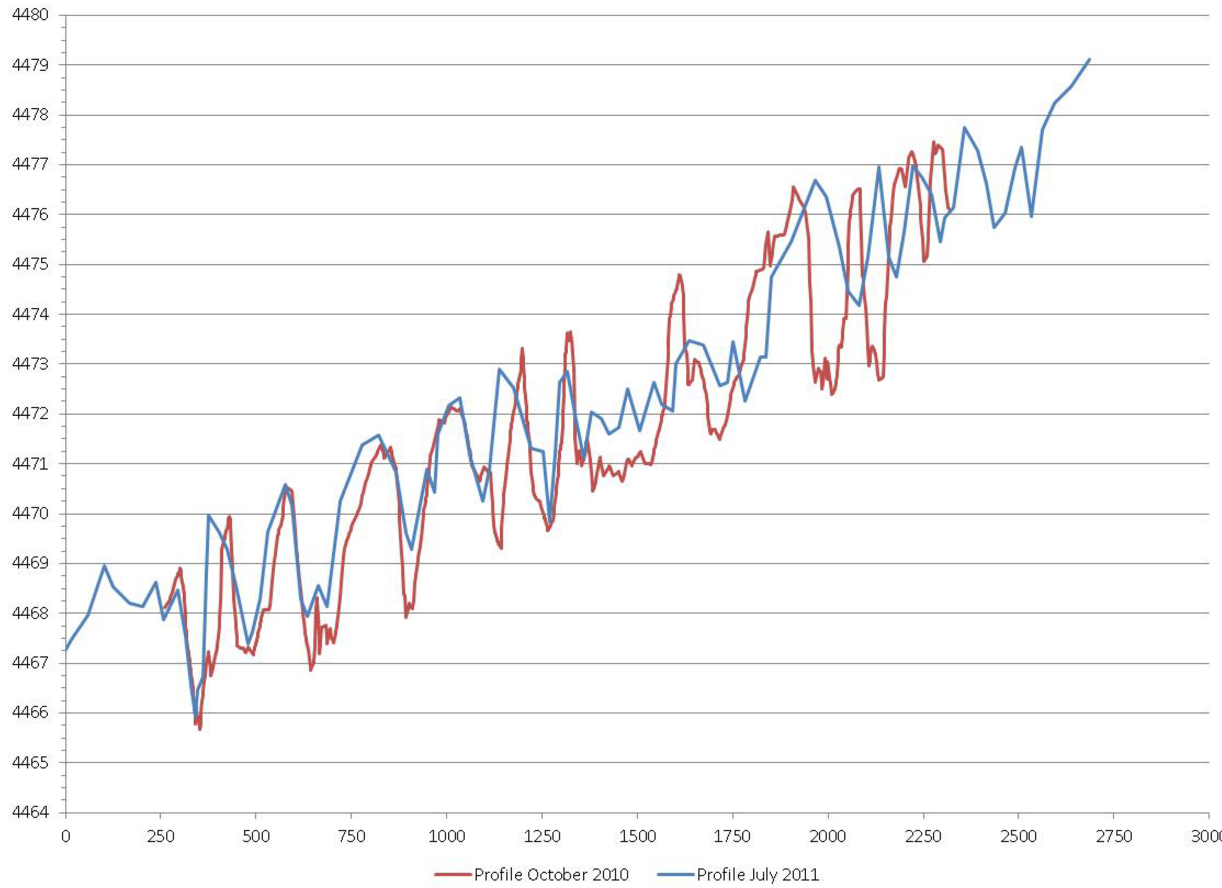



*Figure 6.9-6: Comparison of longitudinal profiles surveyed in July 2010, by Balance Hydrologics, Inc. and in October 2011 as part of this study. The comparison shows that the channel adjusted to a greater than bankfull discharge by depositing material in the pools.*

Our comparison of the two longitudinal profiles shows that there has been some longitudinal migration of channel features and sediment deposition in pools. Towards the upstream extent of the reach, the offset could be due to differences in survey methods. We identified transport of bed material from the riffle at station 1600 to the run downstream by comparing the profiles. Our comparison of the profiles shows that the pools at stations 700, 900, 1100, 1200, 1700, 2000, and 2100 experienced sediment deposition. Longitudinal monitoring should be continued at the site to help determine if the channel is readjusting its bed elevation in pools or if sediment is being stored until a larger flow scours pools. In general, the channel maintained the riffle pool sequence established in the Balance design, but the elevation differences between the riffles and pools decreased.

#### 6.9.6.2.4 Bed Material Composition

We conducted two pebble counts at Cross Section K and F (Figure 6.9-2) to characterize the channel bed surface composition. The pebble count we conducted at cross section K is located in the upstream extent of the relocated channel and the pebble count at cross section F is located in the middle of the relocated channel reach. We determined that the $D_{50}$ for pebble count F was 91 mm and the $D_{50}$ for pebble count K was 38 mm. We plotted the size distribution for the two pebble counts in Figure 6.9-7 and classified the bed as very coarse gravel at cross section K and cobble at cross section F. Cross section K has gravels suitable for salmonid spawning, but the $D_{50}$ for cross section F is larger than all but very large fish can move to build redds (Kondolf 2000). The larger gravel size at cross section K may be attributed to transport of finer bed material downstream as the riffle at station 2050 in Figure 6.9-6 was scoured.

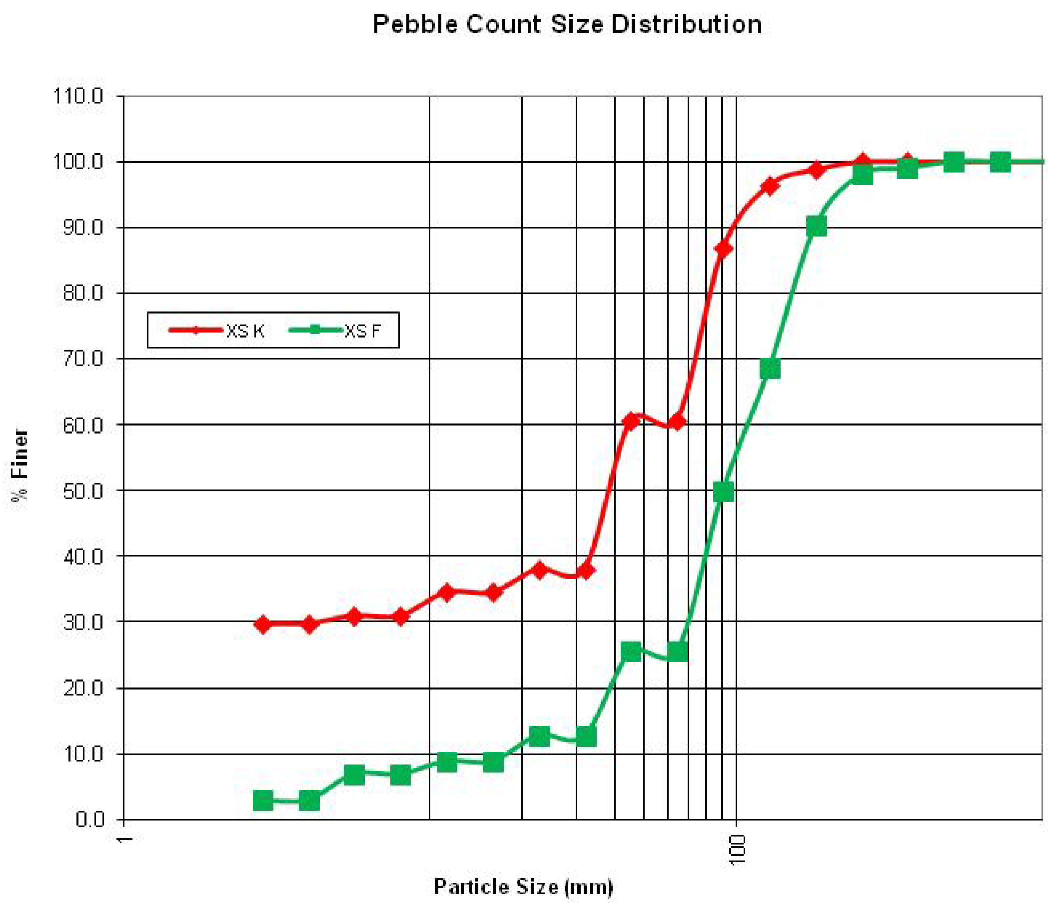



*Figure 6.9-7 Pebble count size distributions plots for the pebble counts we conducted at cross section K and F.*

### 6.9.6.2.5 Ground Photograph Monitoring Points

We established ground photographic monitoring locations at each cross section end pin and the thalweg (deepest part) of the channel. We took digital photographs looking upstream, across the channel, and downstream from each cross section end pin. From the channel thalweg, we took digital photographs looking upstream and downstream and towards both banks. We collected GPS waypoints at each digital photograph and used software to write the GPS coordinates, date, and time on each photograph. We exported the coordinates and the file name of each photograph to a GIS shapefile and incorporated the shapefile into the SPPAMS for the project. Digital photographs are included the data DVD with the project. Future monitoring should include revisiting the photo points we established. Figure 6.9-8 shows cross section H, which is likely to change over time as the point bar on the inside of the bend continues to build from material eroded from the outside bank of the bend.


*Figure 6.9-8 Looking upstream (upper left photo) showing bank erosion on the outside bank (upper right photo) and formation of a point bar on the inside of the channel (lower center photo). Photos taken at cross section H, illustrating active channel bank migration.*

### 6.9.7 PPA Lessons Learned

Based on our review of project documents, our field observations and measurements, and our completed PPA, we identified a variety of useful lessons from the Bailey Flat project at the site and basin scale. Table 6.9-1 summarizes lessons learned from this project by restoration project life-cycle phase.

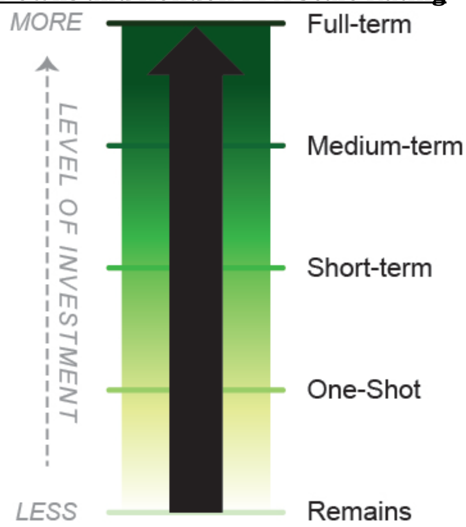
*Table 6.9-1: Summary of key lessons learned from the Bailey Flat Project*

| **Stream Restoration Project Life-cycle Phase** | **Scale for Lesson** | **Lessons Learned** |
|---|---|---|
| Pre-Project (goal and objective setting, planning, data collection, analysis) | Site-specific | Conduct more detailed analysis of channel scour and sediment mobilization to maximize the potential of the channel design to be stable under high flows. |
| | | Include fish specific monitoring to assess improvements to habitat. |
| | Site-specific and basinwide | At the basin scale channel relocation that matches the historical channel slope and sinuosity should reduce bank erosion compared to straightened reaches, but sediment input to the system may be increased while the new channel adjusts. |
| Design | Site-specific | Incorporate discussion of expected channel adjustment after construction and determine thresholds for adaptive management to maintain channel condition. |
| Implementation | Site-specific | Excavate and re-plant on-site vegetation on the same day to reduce mortality from vegetation drying out while stockpiled. |
| | | Install cages around willows to reduce mortality from beavers. |
| | | Include LWD debris structures, vegetation planting, and other project features in as-built survey to assess success during monitoring. |
| | Site-specific and Basinwide | Plant vegetation early in project to maximize the growing season. |
| Monitoring | Site-specific and Basinwide | Require monitoring report that includes documentation of the datums and benchmarks so that monitoring can be replicated and conducted by different agencies or consultants. |
| | | Include coordinates with cross sections and longitudinal profiles and the processed data (not just station and elevation) so that the surveys can be revisited for future monitoring. |
| General | Site-specific | Include fish monitoring metrics to assess habitat improvement goals. |
| | | Match monitoring plan with goals and objectives of the project so that monitoring can be used to assess project success. |

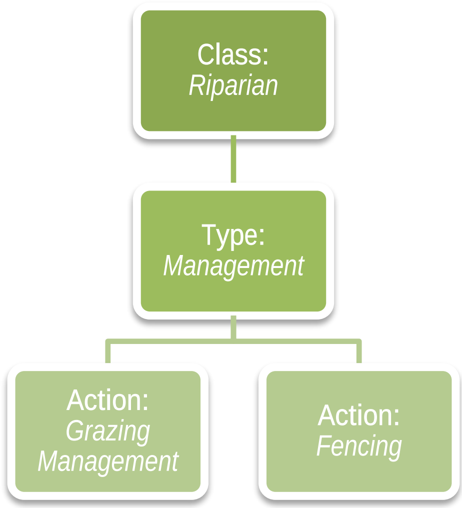
We learned that additional design analysis should have been conducted for sediment transport and scour and deposition in the channel. The channel experienced a greater than bankfull event within the first year of construction and many of the pools were partially filled with sediment. Cross sections also experienced deposition. The design documentation doesn't include discussion of the potential channel adjustment or thresholds for adaptive management actions. Further, monitoring is required to determine if the channel has adjusted the bed elevation or if designed pool and riffle sequences are unsustainable in this reach. The Bailey Flat project could improve the quality and quantity of spawning habitat in the Sprague River Basin. Monitoring metrics should include red counts, pebble counts, and fish population surveys.

## 6.10 Long Creek Project (Upper Sycan Watershed)

**Downs and Kondolf PPA Scale Rating**




**Project Class, Type(s), and Action(s)**




### 6.10.1 PPA Synopsis

We selected this project for PPA to provide a case-study of grazing management and livestock fencing. Additional projects on Long Creek included brook trout removal and fish barrier removal, but we focused this PPA on the grazing management activities. The Long Creek project is in the riparian class of stream restoration projects with management types of actions. Our PPA of this project was informed by the ***Grazing*** conceptual model. We conducted this PPA by reviewing and integrating the research of Carolyn Doehring, Zan Rubin, and Rashmi Sahai summarized in a document titled *Effects of a livestock exclosure on channel morphology and vegetation along Long Creek in Lake County, Oregon* (2011), which included comparisons of a series of pre- and post-project channel cross-sections and photographs along monumented transects, spanning the period between 1990 to 2011. Additionally, we integrated monitoring studies and documentation on restoration objectives and actions provided by The Nature Conservancy. Finally, we visited the site, verified the accuracy of the cross-section monuments, and performed historical aerial photography analyses. We categorized this PPA as "full-term" because of its long period of monitoring, however this project did lack documented site-specific success criteria for the grazing management project. However, site-specific success criteria was developed for the brook trout removal and fish barrier removal projects, which are not part of this PPA. The primary lessons learned from this project include the following:

- In the short term (10 years), substantial changes to channel morphology did not occur as a result of riparian management actions. We expect that more substantial changes will occur over the long term (50 years) as re-established vegetation begins to exert more control of natural geomorphic processes.
- Riparian management actions resulted in a substantial increase in riparian vegetation growth over the 20 year monitoring period. Although additional data (including the survival, density, composition, and diversity of plant communities and species) needs to be collected to quantify the associated ecological benefits, the results of this PPA demonstrate that these actions

provide a relatively high level of benefit to the local riparian ecosystem for relatively low planning, design, and implementation costs.

### 6.10.2 Site Conditions

Long Creek, a tributary to the Sycan River, is located in the headwaters of the Sprague River Basin and drains into the Sycan Marsh in western Lake County, Oregon (Figure 6.10-1). The Long Creek watershed encompasses 41 square miles upstream of the confluence with the Sycan River. Long Creek historically diverged into three channels before entering Sycan Marsh. To manage irrigation deliveries, Long Creek water was diverted into the North Fork for irrigation, and the South Fork of Long Creek no longer received flow. In 2008, a change in water rights allowed The Nature Conservancy (TNC) to rewater the South Fork, which now carries approximately 60% of the Long Creek discharge to Sycan Marsh. Long Creek is the last remaining of three historic bull trout (*Salvelinus confluentus*) spawning streams within the Sycan Marsh tributaries (Doehring et al. 2011). Threats to Bull Trout in the Sycan watershed from abiotic factors were identified by Craig Bienz (2008) and are listed from greatest to lowest: (1) diminished connectivity, (2) altered riparian vegetation (higher stream temperatures), (3) altered channel morphology, and (4) altered hydrologic regime. Extensive livestock grazing in the lower reaches of Long Creek occurred during the 1900's, before TNC acquired 9.6 km along Long Creek and implemented passive restoration through decreased livestock grazing in 1995 and total exclusion starting in 1999 (Doehring et al. 2011; pers. comm. with C. Bienz, The Nature Conservancy, 2011). Historically, riparian and wetland systems in this area did not receive extensive ungulate grazing. The degree to which livestock had access to the channel, and impacted the streambanks and channel of Long Creek, or the riparian, floodplain, and wetland ecosystems in the river corridor as a result of grazing has not been determined.

### 6.10.3 Success Criteria

Success criteria for the Long Creek project are excerpted from several studies and reports provided by The Nature Conservancy in regards to their monitoring and restoration of the Long Creek project site. As noted by Craig Bienz of TNC (pers. com. 2012), “restoration projects [in Long Creek] are consistent with federal recovery plan objectives and state stream restoration methods.” These goals and objectives are mostly derived from documents that describe restoration actions (barrier removal and brook trout eradication) that occurred on the project site more than five years after livestock exclusion occurred. At that time, the primary restoration project objective was to increase bull trout distribution, population size, and life history types through increased habitat, and increase connectivity within the stream network. We were not able to locate documentation of the original grazing management and fencing project, or records of specific project intent, goals, or objectives from TNC. However, based upon the Doehring et al (2011) research effort, as well as use of our Grazing conceptual model, we can surmise that project goals and objectives likely included the restoration of riparian habitats in the project area, including restoring the extent and quality of riparian habitat, and increasing riparian vegetation growth. Pre-project photographs of the channel provide evidence that livestock did access the channel at the project site, thus additional project goals and objectives should address the passive restoration of channel morphology, including decreased livestock trampling of streambanks and preventing / reducing sediment inputs derived from bank erosion and channel adjustment.

### 6.10.4 Project Timeline

The Nature Conservancy implemented reduced livestock grazing along this reach in 1996 and excluded cattle from the riparian area in 1999. Prior to these projects, TNC established monuments and surveyed twelve cross-sections of the mainstem Long Creek and adjacent floodplains in 1990. During and after project implementation, TNC repeated some of the cross section surveys in 1996, 2002, and 2003. From 2002-2007, daily water temperatures were recorded at Long Creek at the Sycan Marsh Preserve. In 2003, benthic macroinvertebrate surveys were conducted along Long Creek. Starting sometime prior to 2005 until 2008, TNC conducted additional restoration actions on Long Creek, including instream barrier removal at two locations and brook trout capture and eradication (Bienz 2008) in fish traps (it should be noted that these additional restoration actions are not evaluated as part of this PPA). During three sampling events in 2010 and 2011, TNC conducted water quality testing at upstream and downstream locations along the Long Creek project site. Also in 2011, TNC completed a lodgepole pine harvest on the project site. In September 2011, we visited the site, took photographs, and recorded observations on geomorphic and riparian vegetation conditions. In October 2011, Doehring, Rubin, and Sahai surveyed channel cross sections and took photographs at seven of the monumented transects and compared their 2011 surveys to previous surveys conducted since 1990.

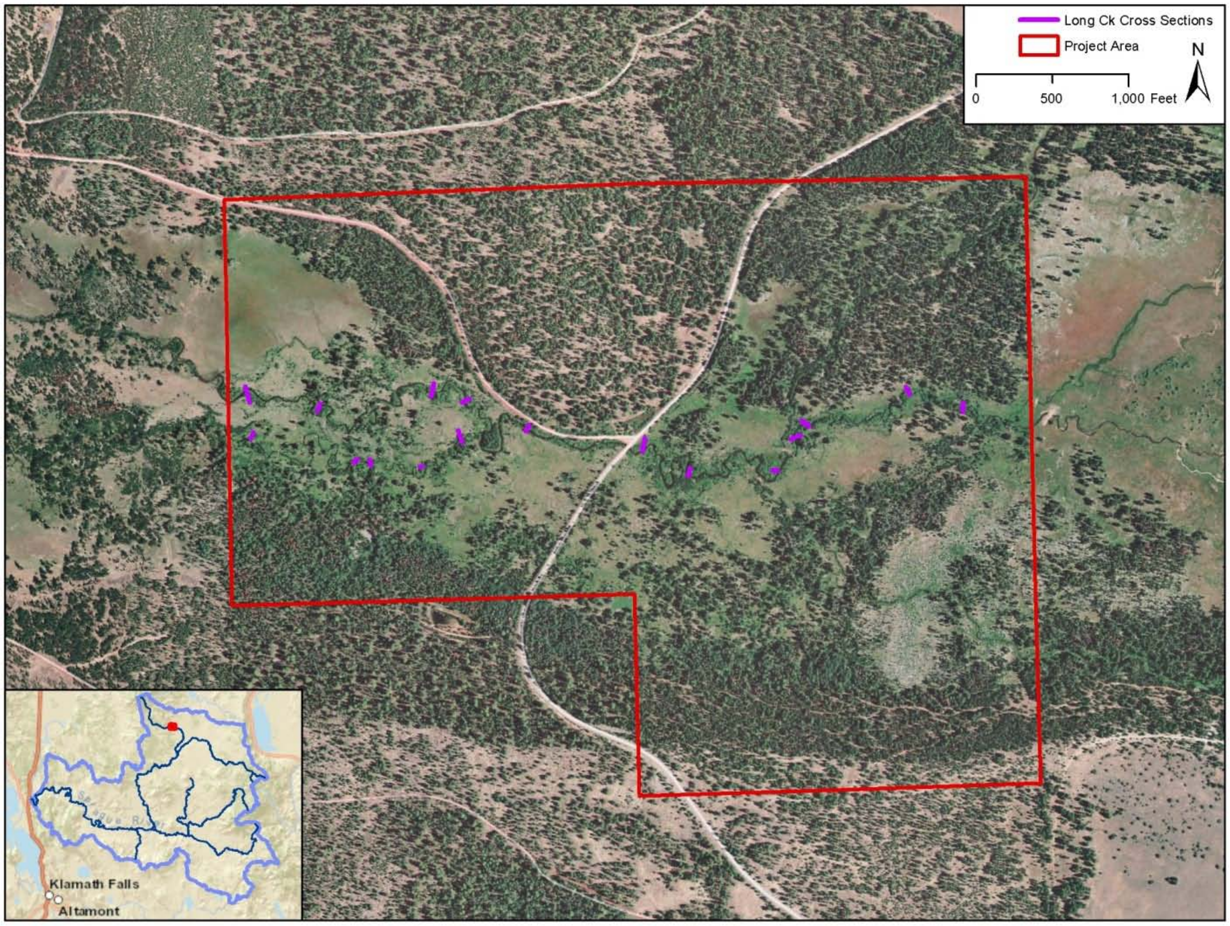



*Figure 6.10-1: Long Creek project site 2009 aerial photograph, showing the channel network, project area where riparian management actions were implemented, and channel cross-sections. The exact location of the livestock exclusion fencing has not been mapped.*

### 6.10.5 Relevant Conceptual Models

The ***grazing*** conceptual model guided our PPA of this project. The grazing conceptual model describes how changes in livestock grazing and planting of native vegetation are typically expected to create more natural riparian conditions (see Section 3.2 for more details on conceptual models). Exclusion of grazing from areas prone to scour and erosion and reestablishment of native riparian vegetation are proven approaches to restoring more natural riparian conditions, and improving local geomorphic and aquatic habitat conditions. Because we were unable to locate documentation of specific project goals and objectives, it was impossible for us to evaluate project performance against site-specific success criteria. However, the conceptual model gives us an adequate framework to evaluate “idealized” goals and objectives for this type of project.

### 6.10.6 Post Project Appraisal

#### *6.10.6.1 Methods*

The Organizational Framework (in Section 3.1) lists several metrics that could be used to evaluate the performance of this type of project relative to its assumed goals and objectives. These include:

- Primarily, the sampling of vegetation species presence and abundance in the riparian zone, and diversity and fish and macroinvertebrates during times of inundation to determine colonization by and succession of riparian and aquatic species.
- Topographic surveys, soil mapping and subsurface boring, groundwater levels, peak flow inundation depths, hydraulic modeling output, and the quantification of density and extent of large wood, vegetation, root structure, and other forms of riparian cover to determine geomorphic processes (erosion, deposition, and scour) driving the creation of more complex and diverse channel and riparian habitat.
- Water quality monitoring (temperature, dissolved oxygen, and nutrients) to determine temperature buffering and nutrient sequestration in the channel and riparian areas.

The availability and completeness of monitoring data for this project was mixed. The trend of vegetation reestablishment has been monitored using comparative photography at monumented locations over a 20-year period of time, which allows a qualitative assessment of revegetation rates, but does not specifically measure riparian vegetation density, composition, or diversity, which would have allowed a more quantitative evaluation of riparian habitat change in response to grazing management and exclusion. The long term set of resurveyed cross-sections allows a comparative evaluation of changes in channel geometry at the study reaches pre-project, and for more than 10 years post-project, allowing a preliminary assessment of channel adjustments as a result of riparian management actions. To gain a more thorough understanding of channel bed elevations and geomorphic trends through the study reach, cross section monitoring data could have been supplemented with repeat longitudinal profiles. Some longitudinal profiles have been conducted by TNC, but the data had not been processed by the date of this report. Streamflows have been measured at two locations on Long Creek from October 1992 to September 2002, and April 1996 to December 2004, respectively.

Additional post-project monitoring conducted by TNC at or near the project site is referenced here, but was not included in our PPA because no pre-project or baseline data was available. Water quality monitoring was conducted by TNC on November 3, 2010, May 26, 2011, and August 3, 2011 at two places along the Long Creek as part of a larger Sycan Basin water quality sampling effort (Bienz and Wong 2011). The water quality sampling sites on Long Creek are located in the middle of the project site and over a mile downstream of the site. Water quality samples include measurements of nitrogen and phosphorous, water temperature, dissolved oxygen (DO) concentration, pH, and conductivity. Additionally, water temperature data collected by TNC exists for Long Creek from 2002 – 2007. Macroinvertebrate sampling occurred along the project reach in 2003, providing indications of water quality and general aquatic ecosystem health. Additionally, redband trout biomass has been annually measured in Long Creek by TNC starting in 2000.

We relied heavily on data and analyses completed by Doehring et al (2011) to draw conclusions about changes to channel geometry and riparian habitat. Post-project studies by TNC on water quality parameters, benthic macroinvertebrates, and discharge provide additional data on how the aquatic, riparian, and floodplain ecosystems are performing. Without pre-project baseline data, we were unable to compare the current conditions to show improvements in water quality or benthic macroinvertebrates. As result, we focused our analysis on changes in channel cross section and qualitative comparisons of riparian vegetation.

### *6.10.6.2 Results*

#### 6.10.6.2.1 Channel Geometry

The Doehring et al (2011) study focused on seven cross-sections in the study reach (Figure 6.10-2; Table 6.10-1). Figure 6.10-3 and Figure 6.10-4 are reproduced from their report and show the changes in channel geometry through time in the project area.

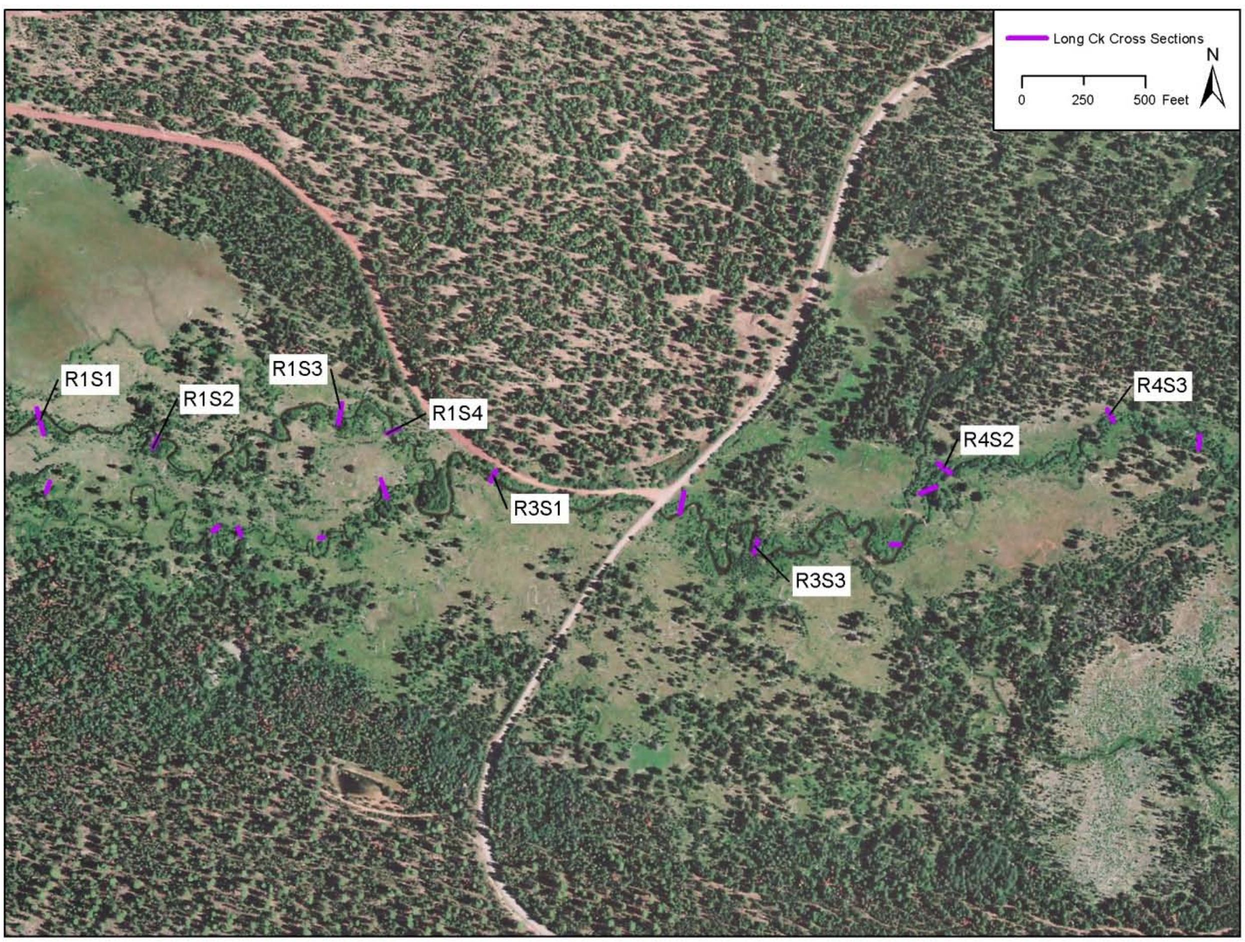



*Figure 6.10-2: Locations of comparative channel cross-sections used for this PPA*

*Table 6.10-1: Long Creek cross-section sites and data availability*

| | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| Site | 1990 | 1995 | 1996 | 2002 | 2003 | 2008 | 2011 |
| R1S1 | X P | | P | X | P | P | X P |
| R1S2 | P | P | | | P | P | P |
| R1S3 | P | P | | | X P | P | X P |
| R1S4 | P | P | | | P | P | P |
| R3S1 | P | P | X | X | P | P | P |
| R3S3 | X | | X | X | | | |
| R4S2 | X P | P | X | X | P | P | X P |
| R4S3 | X P | P | X | X | P | P | X P |

*Note: X = cross-section survey data available*
*P = photo monitoring survey data available*

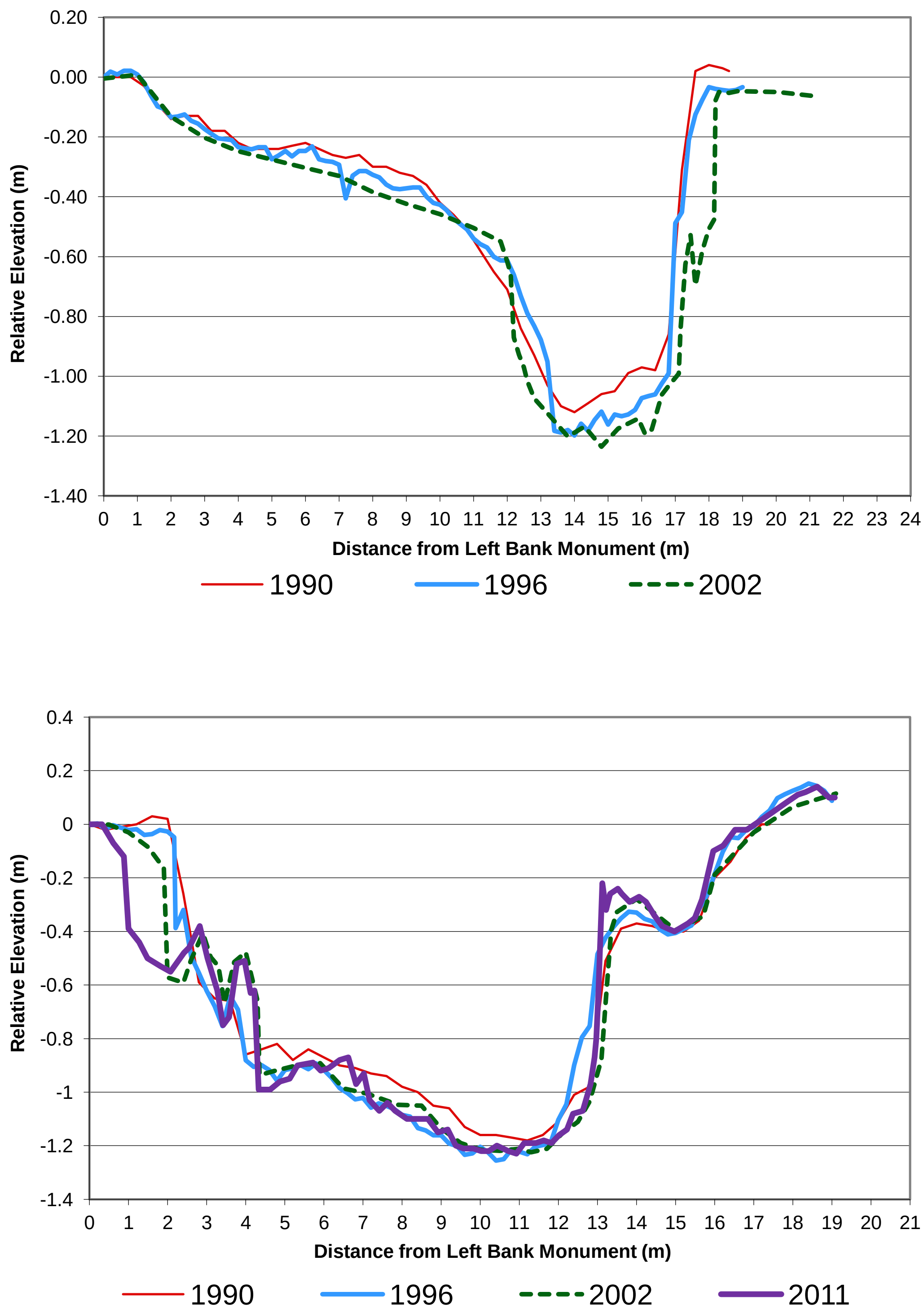
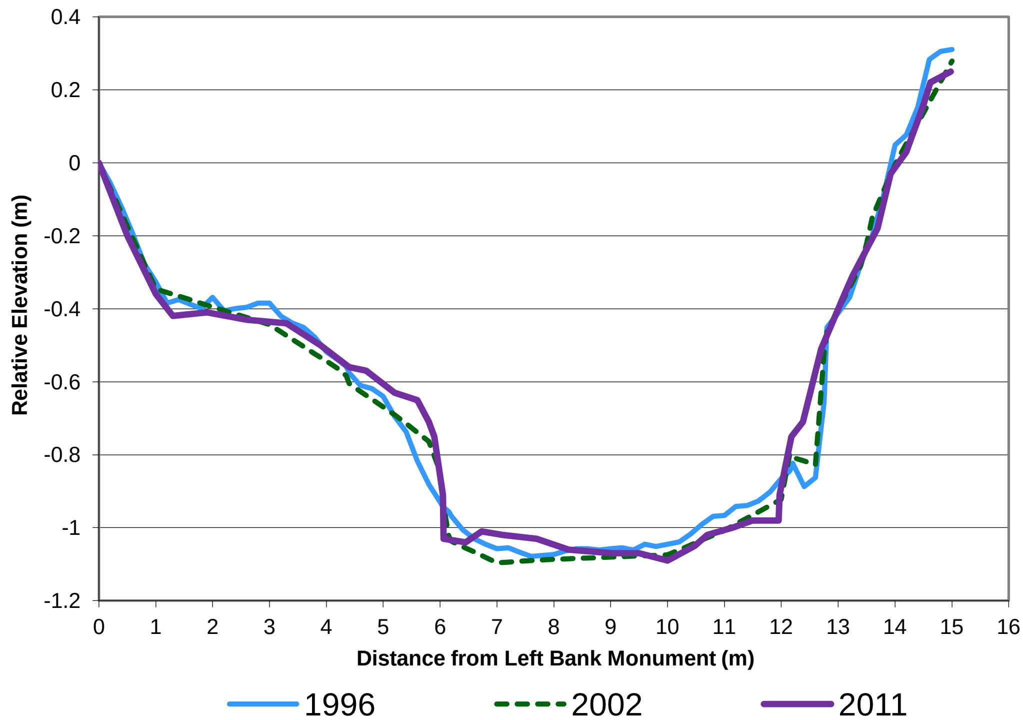



*Figure 6.10-3: Cross-section Reach 3 Section 3 (top) and cross-section Reach 4 Section 2 (bottom) showing minor channel widening and incision since 1990 (Source: Doehring et al 2011).*



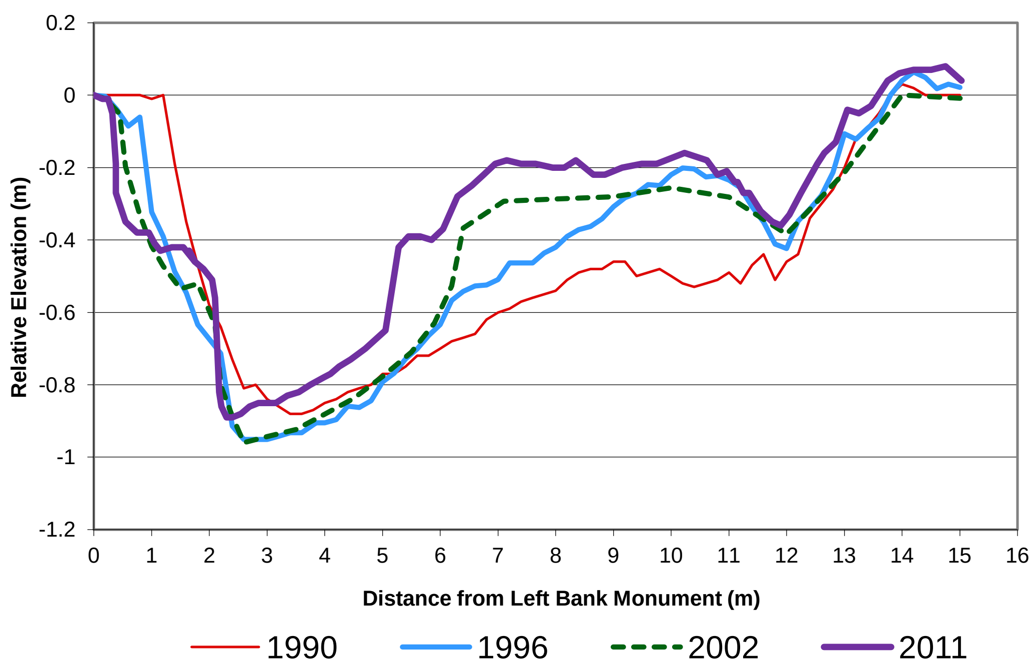




*Figure 6.10-4: Cross-sections Reach 3 Section 1 (top) and Reach 4 Section 3 (bottom) showing minor channel narrowing (Source: Doehring et al 2011).*

The results of the channel cross-section monitoring show that four cross-sections had measurable channel change. Two of the four cross-sections demonstrated widening and incision (Figure 6.10-3):

- Reach 3 Section 3 - downcut 0.2m and widened by 0.8m from 1990 to 2002
- Reach 4 Section 2 - downcut 0.1m (10% change) and widened 1.4m (10% change)

The other two cross-sections demonstrated channel narrowing (Figure 6.10-4):

- Reach 3 Section 1 - narrowed from 7.6m to 7.1m (10% change) from 1996 to 2011, but bed elevation and channel depth remained the same
- Reach 4 Section 3 - in 1990 the channel was 7.2m wide and 0.4m deep, by 2011 the channel had deepened to 0.7m (75% change) and narrowed to 6.5m (10% change)

The remaining two monitoring cross-sections did not show significant channel change during the monitoring period.

Doehring et al (2011) report “no consistent trend in channel morphology” changes, and attribute the lower than expected changes in channel morphology (narrowing) to the small amount of time for changes to occur (11 years since exclusion), and cite research that shows that older exclosures often demonstrate more pronounced morphological changes than younger exclosures (Kondolf 1993, McDowell and Magilligan 1997). The rate of channel change is dependent on hydrologic and sediment transport conditions in the watershed.

Hydrologic records, provided by TNC, of Long Creek exist from a USFS gage that operated for 10 years from October 1, 1992 to September 31, 2002 (Figure 6.10-5), and another gage that operated from April 21, 1996 to December 29, 2003 (Figure 6.10-6). The exact locations of these gages on Long Creek were not supplied for this analysis. The gage data shows that the largest flows occurred in May 1993 (174 cfs on the USFS gage), January 1997 (229 cfs), and May 1999 (203 cfs) on the other gage. The reach experienced the highest flows in this short period of record during the period of cattle grazing at the project site. A longer flow record would help us determine the effect these flows had on the geomorphology of Long Creek. The Sycan River gage was discontinued after 1991, and the Sprague River at Chiloquin gage is the closest gage with a long term record. The Chiloquin gage provides a relevant flow record, and we used this as a proxy for flows in the Sycan watershed, including Long Creek. The Sprague River at Chiloquin has only had one large flow event since 1999 (when the livestock exclosure project was completed by TNC on Long Creek), which occurred in 2006 and was approximately a 5-year flow event. The lack of large floods during this period could partially explain the relatively low rate of change to channel morphology following livestock exclosure and riparian management actions.

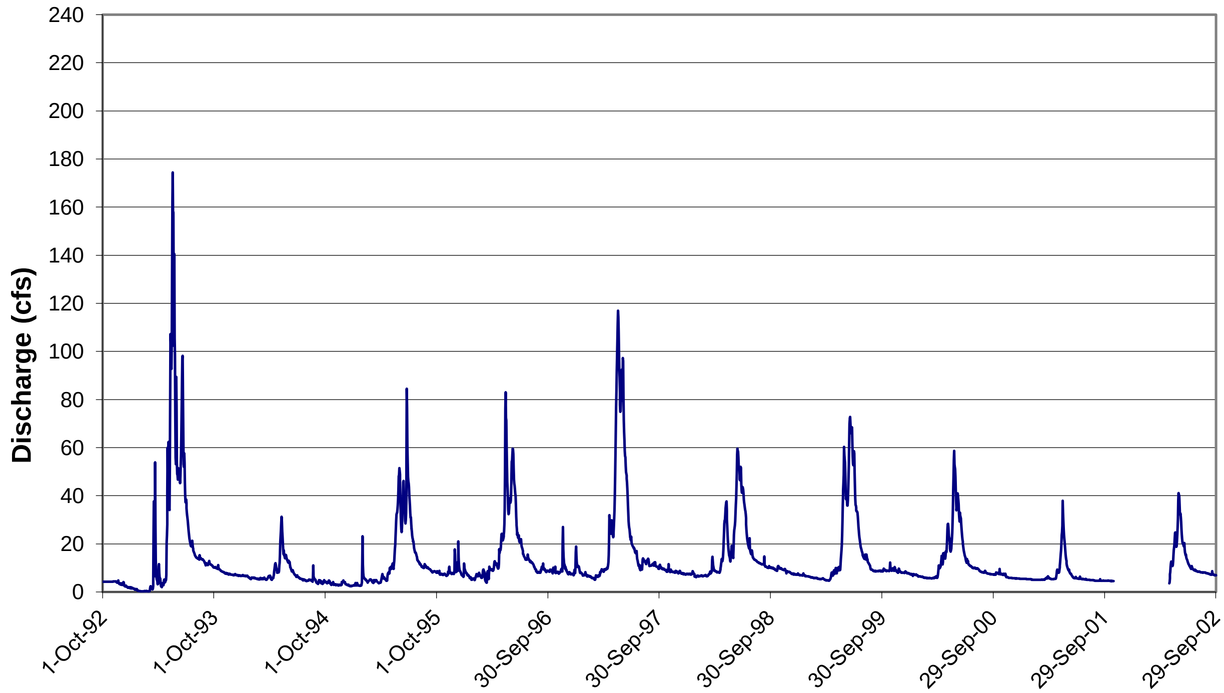



*Figure 6.10-5: Streamflow record for Long Creek, USFS data, unknown location*

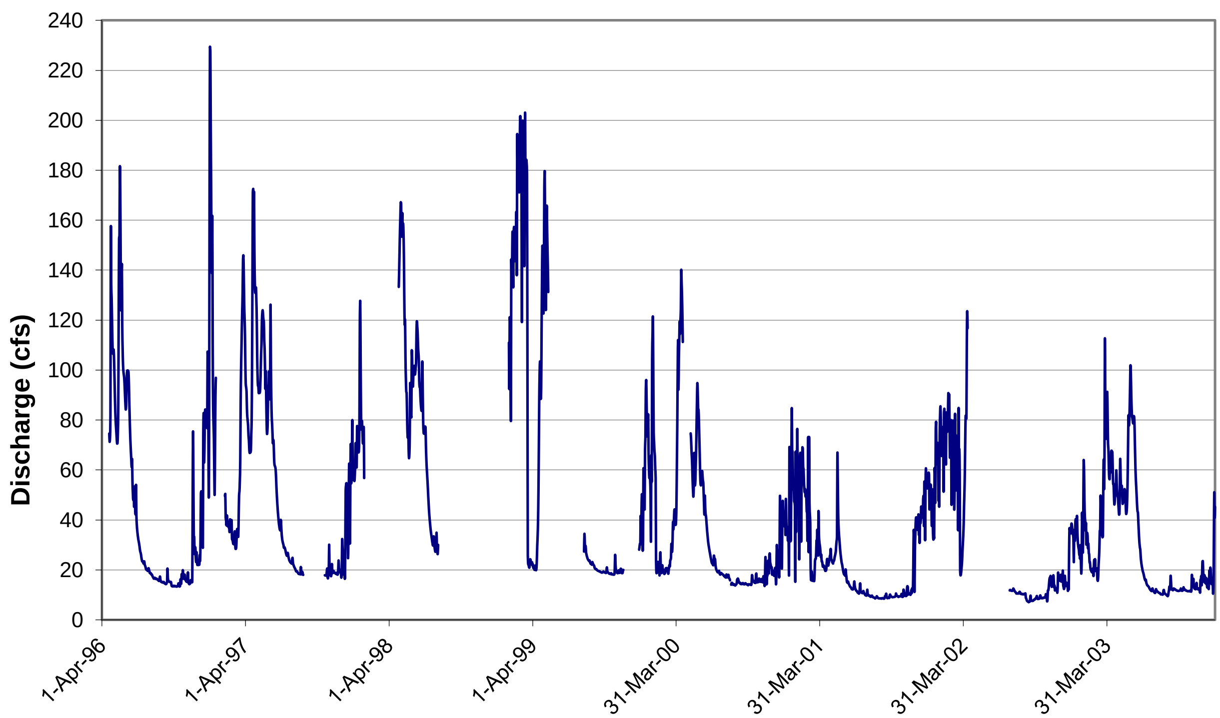



*Figure 6.10-6: Streamflow record for Long Creek, unknown location*

Finally, Doehring et al (2011) note that extensive beaver activity in the lower reaches of Long Creek may have significantly affected the channel geometry and planform, and may be a significant contributing factor to channel morphology in those areas.

#### 6.10.6.2.2 Riparian Habitat Conditions

Photo-monitoring at cross-sections R1S1, R1S2, R1S3, R1S4, R3S1, R4S2, and R4S4 shows that the extent of low-lying riparian vegetation, including willows and alders, increased substantially from 1990 (nine years before livestock exclusion) to 2011 (eleven years after livestock exclusion) within all sampled reaches. This is demonstrated in Figure 6.10-7, which shows vegetative reestablishment along Long Creek at station R1S1 between 1990 and 2011, and Figure 6.10-8, which shows a time series of photos at station R4S3.


*Figure 6.10-7: Photo-monitoring series at station R1S1, near the upstream extent of the project site, showing riparian revegetation from 1990 to 2011 looking downstream (top) and upstream (bottom) from the channel cross-section (Source: Doehring et al 2011).*


*Figure 6.10-8: Photo-monitoring series at station R4S3, near the downstream extent of the project site, showing riparian revegetation from 1990 to 2011 along several different aspects of the channel cross-section (Source: Doehring et al 2011).*

These photo-monitoring series show the following trends:

- From 1990 to 1996, a period when there were changes in the timing and intensity of livestock grazing, there is an overall increase in riparian vegetation
- From 1996 to 2003, willow density increased
- 2011 photos show a marked increase in native riparian willows and upland conifers along the channel banks

Figure 6.10-10 is a historical aerial photo sequence of the project site from 1953 to 2009, showing similar channel planform and sinuosity, but large increases in riparian vegetation establishment over that time period, especially between 2000 and 2009.

This period also showed an increase in conifer growth, specifically Lodgepole pine (*Pinus contorta*), in the riparian areas. Lodgepole pine trees tend to establish quickly in valley bottom areas that have been disturbed. The presence of these species is not necessarily desirable, since they consume large amounts of water leading to drier conditions in the riparian zone, and potentially causing a positive feedback of additional lodgepole establishment. This could ultimately direct the ecosystem towards a drier, more pine-dominated trajectory than the historical conditions along Long Creek (Doehring et al 2011). To address this issue, TNC initiated a lodgepole harvest along the valley bottom areas within the Long Creek project site, which was completed in December 2012 (Figure 6.10-9; pers. comm. with C. Bienz, The Nature Conservancy, 2012). Prescribed fire will be applied in the fall of 2013 to further restore riparian forest structure through the Long Creek corridor.

*Figure 6.10-9: Picture illustrating lodgepole harvest that TNC completed in 2011. This picture is of Coyote Creek, but similar conditions exist at Long Creek (Craig Bienz 2012).*

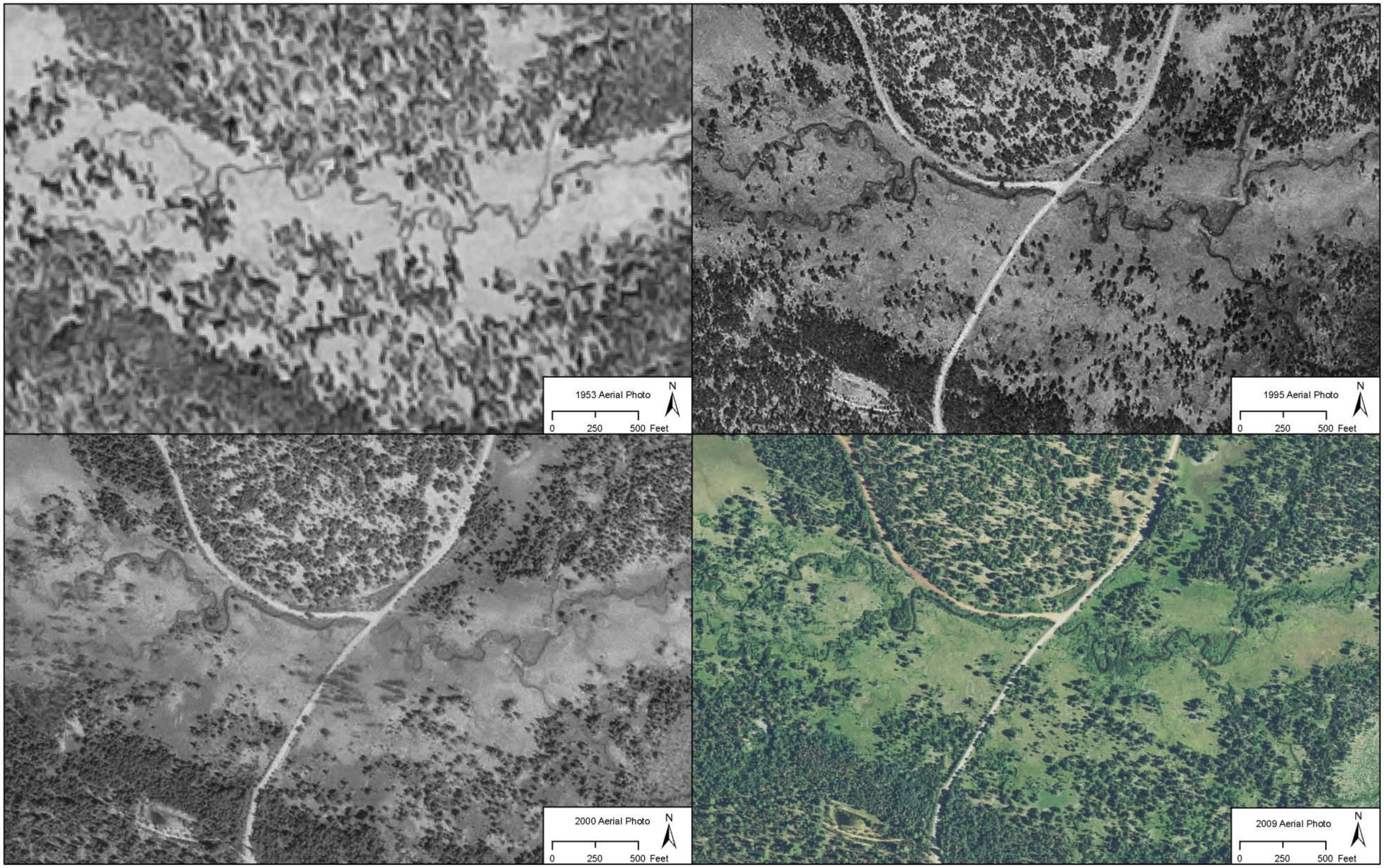



*Figure 6.10-10: Historical aerial photo comparison of the Long Creek project site. Aerial photographs from years 1953 (top left), 1995 (top right), 2000 (bottom left), 2009 (bottom right).*

### 6.10.7 PPA Lessons Learned

This grazing management and exclusion project did not result in substantial changes to channel morphology. Channel morphology may improve in the future as a result of livestock exclusion, but we are uncertain about the likely rate of that change. We suspect it will be related to hydrology, and that a single large peak flow could cause significant channel change over a short period. Additionally, beaver activity in some reaches of Long Creek may be a significant driver for channel form and function.

In contrast, the Long Creek project did result in an overall increase in riparian vegetation extent and density along the Long Creek channel where livestock were excluded and riparian management was implemented. In these areas, some invasive / undesirable vegetation such as lodgepole pine have colonized. Recent forestry management actions such a lodgepole pine harvesting and future prescribed burning are examples of the continued active management of the Long Creek site, as a result of lessons learned from post-project monitoring.

Doehring et al (2011) provide the following additional lessons learned from their study:

- Beaver can increase the rate of change for channel and riparian systems, and may be beneficial for restoration in some portions of the Sprague River Basin. Future projects should consider including beavers as part of an adaptive management strategy for controlling lodgepole pine and recovering the hydrologic dynamic that likely existed prior to grazing.
- Future monitoring efforts should ensure the permanence of survey monuments and set survey monuments away from existing channel banks with sufficient distance to anticipate any future channel migration. The orientation of the cross-sectional location across the channel should be noted as dense vegetative growth over time can obstruct relocation. Alternatively, more modern surveying techniques such as survey grade GPS could be used to establish the true longitude and latitude of recorded elevations along channel cross sections.

Given the relatively low level of effort needed to plan, design, implement, and fund these types of riparian management projects in relation to the potential benefits of a restored riparian ecosystem, the primary lesson from this project is that grazing management and exclusion is a very effective way to restore riparian vegetation and improve riparian habitat conditions.

Table 6.10-2 summarizes the lessons learned relative to the typical phases in the life cycle of stream restoration projects.

*Table 6.10-2: Summary of key lessons learned from the Long Creek Project*

| Stream Restoration Project Life-cycle Phase | Scale for Lesson | Lessons Learned |
|---|---|---|
| Pre-Project (goal and objective setting, planning, data collection, analysis) | Site-specific | Develop specific project goals and objectives, even for low investment restoration actions such as riparian management. |
| Design | Site-specific | Designing active riparian plantings as part of a riparian management and restoration strategy can greatly increase the success of the project by reducing the likelihood for invasive / undesirable vegetation establishment. |
| | | Design should consider active recruiting of beaver. |
| Implementation | Site-specific | At the site scale, regular maintenance should occur to prevent lodgepole takeover of the riparian areas. |
| | Basinwide | At the basin scale, implementation should anticipate possible unwanted species and manage them. |
| Monitoring | Site-specific | More specific attention to obtaining relevant pre- and post-project monitoring data (in this case, longitudinal profile surveys, more detailed riparian vegetation surveys, and fish and/or macroinvertebrate surveys). |
| | Site-specific | At the basin scale, monitoring strategies should be tailored to the location of a project within the watershed; different approaches will be required in the upper headwaters than in the lowland areas. |
| General | Site-specific | The project did result in an overall increase in riparian vegetation growth along the Long Creek channel, including the re-establishment of willow and alder species.1 |
| | | In the short term (10 years), this project did not result in substantial changes to channel morphology as a result of riparian management actions. |
| | | For riparian management projects, there is a relatively high level of benefit to the riparian ecosystems for relatively low planning, design, and implementation costs. |
| | Site-specific and Basinwide | For riparian grazing management projects, which tend to be less "design oriented" than other more structural restoration projects, pre-project goal and objective setting, planning, data collection, and analysis is still very important, and can greatly improve the value of a PPA and subsequent lessons learned for future projects. |

# 7 Conclusions and Recommendations

## 7.1 Introduction

This project is a testament to the professionalism and integrity of the stream restoration community in the Sprague River Basin. While our findings leave no doubt that stream restoration practices in the basin could be improved in the future, the ongoing planning, design, implementation, and monitoring efforts in the basin are commendable and have resulted in an extremely valuable foundation upon which future stream restoration efforts can be built. Our primary conclusion and recommendation, which is described in detail in the following sections, is that a systematic approach to all phases of the stream restoration life cycle is needed to guide and prioritize all of the stream restoration work that is being and will continue to be implemented. Our recommendation would almost certainly be the same for any watershed where diverse and extensive stream restoration activities are taking place to improve conditions for the species that depend on these habitats.

The preceding chapters of this report summarize the work completed by the Evaluation Team (ET) and the Evaluation Team Assistance Group (ETAG) with the assistance of the Core Team (CT) and Advisory Team (AT) to extract as much information and as many useful lessons learned from an extremely complex database spanning a wide range of stream restoration activities. Our intent with this chapter is to concisely summarize our findings in a way that stream restoration practitioners in the basin can use to inform their ongoing and future work. We have attempted to do this by directly addressing the three key objectives of this project, which are as follows:

1) Assess the performance of selected projects in the basin with respect to their stated success criteria
2) Assess the potential of the project types and actions used in the Sprague River Basin to collectively achieve basin wide goals
3) Provide guidance for planning and implementation (including monitoring) of future projects in the basin to maximize the potential to achieve basin wide goals

## 7.2 Selected Project Performance

The preceding chapter includes PPAs of ten selected projects in the basin that span a wide range of project classes, types, and actions. The reader should refer to these case studies for detailed observations and lessons learned from each site, especially when attempting to apply lessons learned from these PPAs to ongoing or new projects in the basin. Here we present a rolled up assessment of the performance of each project with respect to its stated success criteria and success criteria that would be considered appropriate for a given project type or action based on the state of the art in stream restoration. Our intent is not to oversimplify our findings from each PPA or to “pass judgment” on any given project. Rather, our intent is to provide a concise summary of what has and has not worked in the basin, and the rationale behind our finding for each project.

Table 7.2-1 lists each of the ten projects for which we have completed detailed PPAs. We have scored each project on a scale of -1 to +1, with a score of -1 signifying that the project failed to satisfy most or all of its success criteria, a score of 1 signifying that the project satisfied some of its success criteria but not others and did not consider all critical processes, and a score of +1 signifying that the project satisfied most or all of its success criteria.

*Table 7.2-1: Sprague River Basin restoration project performance*

| **Project Name** | **Stream** | **Location in the Watershed** | **Score** | **Rationale** |
|---|---|---|---|---|
| Nine Mile Road | Sprague River | Lower | **1** | ***Meander cutoff plugs*** are stable and restore local channel sinuosity. Uncertainty surrounding temporal and spatial trends of meander cutoff and creation and the benefits of habitat in cutoff meander bends, combined with unexpected changes in restored meander bends reduces the magnitude and certainty benefits attributed to meander cutoff plugging. |
| Southside Levee Breach | Sprague River | Lower | **+1** | ***Levee breaching*** effectively restores hydraulic connectivity between river channel and floodplain, provides access to fish and other organisms, and contributes to increased vegetation diversity and abundance. ***Grazing management*** contributes to increased vegetation diversity and abundance. Better understanding of breach hydraulics and sediment transport is needed to prevent fish passage problems. |
| Nimrod River Park | Sprague River | Middle | **1** | ***Wetland creation*** has improved inundated floodplain habitat and grazing management (fencing) has resulted in more stable streambanks. Meander cutoff plugging has redirected flows into the meander bend and created backwater habitat. Woody riparian vegetation has not colonized the site and vegetation is dominated by non-native species, reducing habitat value in constructed wetlands. Vegetation management required to fully satisfy vegetation success criteria. Uncertainty surrounding temporal and spatial trends of meander cutoff and creation and the benefits of habitat in cutoff meander bends, combined with unexpected changes in restored meander bends reduces the magnitude and certainty of benefits attributed to meander cutoff plugging. |

| Project Name | Stream | Location in the Watershed | Score | Rationale |
|---|---|---|---|---|
| Whisky Creek | Sprague River | Middle | 1 | ***Grazing management*** achieved revegetation and bank stabilization goals. However, non-native vegetation dominates species composition and desired woody vegetation has not colonized the site. ***Spring protection*** has yielded enhanced spring habitat, but ***spring reconnection*** has not been sustainable. Active management of vegetation and spring connectivity required to fully satisfy all success criteria. |
| Sycan River | Sycan River | Sycan | 1 | ***Grazing management*** achieved revegetation and bank stabilization goals. However, non-native vegetation dominates species composition and desired woody vegetation has not colonized the site. Vegetation management required to fully satisfy all success criteria. |
| Beatty Station | Sprague River | Middle | 1 | ***Meander cutoff plugs*** are stable and restore local channel sinuosity. Uncertainty surrounding temporal and spatial trends of meander cutoff and creation and the benefits of habitat in cutoff meander bends, combined with unexpected changes in restored meander bends reduces the magnitude and certainty of benefits attributed to meander cutoff plugging. |
| Five Mile Creek | Five Mile Creek | Upper | +1 | ***Constructed bypass channel*** successfully provided improved fish passage. Improper weir design has already been corrected. Short term failure to establish woody riparian vegetation not caused by failure to recognize fundamental processes and can be corrected with minimal effort. |
| South Fork Sprague River | S. Fork Sprague River | Upper | 1 | ***Grazing management*** achieved revegetation goals. However, non-native vegetation dominates species composition. Further, because other site disturbances (e.g. levees and disconnection of secondary channels) were not addressed as part of this project, undesirable erosion still occurs. Vegetation management and consideration of other controlling processes required to fully satisfy all success criteria. |
| Bailey Flat | North Fork Sprague River | Upper | +1 | ***Reoccupied historical channels*** achieved improvements in instream and riparian habitat and addressed chronic erosion. Initial channel adjustments and current instability of vegetation not caused by failure to recognize fundamental processes and should establish a dynamic equilibrium over time without further intervention. |
| Long Creek | Long Creek | Sycan Marsh | 1 | ***Exclusion of grazing*** has facilitated riparian revegetation, however, lodge pole pines have outcompeted more desirable species and channel geometry has not adjusted as expected. Ongoing vegetation management is needed to achieve desired vegetation community composition. |

The value of the information contained in Table 7.2-1 is that it provides a basis from which stream restoration practitioners in the basin can communicate about how specific projects and actions are performing, the key lessons from each project that should be applied to future similar projects, and the project-specific issues that should be addressed in the ongoing management of these completed projects.

## 7.3 Potential of Restoration Project Types and Actions

In this section we extrapolate lessons learned from selected projects for which we completed PPAs to provide an assessment of the relative potential of different project types and actions to contribute to the achievement of the basin wide goal for the Sprague River. As presented by project class in Table 7.3-1, the basin wide goal is to:

*“maintain, create, improve, and restore more normative hydrologic, geomorphic, and sediment transport processes that create instream, riparian, floodplain, and spring conditions and variability that better supports target and/or native aquatic plant communities and biota.”*

Table 7.3-1 lists the project classes, types, and actions that have been and will likely continue to be implemented in the Sprague River Basin, summarizes the number of PPAs we completed in this study that provided lessons learned for each project type, assigns a high, moderate, or low magnitude and certainty of benefit of achieving site-specific or basinwide goals, level of effort in terms of design and construction for each project type based on our findings from the PPAs, and finally an estimate of the total number of projects from each project type that have been implemented in the basin. The purpose of this table is to provide stream restoration practitioners in the basin with a concise guide to assist in the planning and decision-making about the relative value of implementing a new project of a given type in the basin, and the need for additional studies to resolve uncertainties about certain project types before additional projects of that type are implemented. For example, for project types with high magnitude and certainty of benefits and low level of effort and/or number implemented in the basin (e.g. floodplain reconnection), more projects of this type should be strongly considered. Conversely, for project types with low or unknown magnitude and certainty of benefits and high level of effort and/or total number implemented in the basin (e.g. meander bend cutoff plugging), additional study should be conducted before additional projects are considered, or implementation of the project type should be discontinued.

*Table 7.3-1: Assessment of the relative potential of different project types and actions to contribute to the achievement of the basin wide goal for the Sprague River*

| Class | Type | Action(s) | # of PPAs | Benefit: Magnitude | Benefit: Certainty | Level of Effort | Projects in Basin |
|---|---|---|---|---|---|---|---|
| Instream | Channel Manipulation | Create new channel, reconnect old channel, prevent / reverse meander bend cutoff | 6 | H/?* | H/?* | H/H* | M/M* |
| | Habitat Creation | Construct structure | 2 | M | H | L | M |
| | Flow Augmentation | Reduce diversion rate | 0 | ? | ? | ? | L |
| | Fish Passage Improvement | Construct bypass channel(s), install or modify culvert(s) | 1 | H | M | H | L |
| | | Screen diversion(s) | 1 | H | H | M | M |
| Riparian | Management | Construct fences, change grazing management, plant vegetation | 8 | H | M | L | H |
| | Expansion | Remove levee(s), create new channels | 1 | H | H | L | L |
| Floodplain | Reconnection | Remove levees, excavate new connection from floodplain to channel through riparian area | 2 | H | H | L | L |
| | Modification | Restore floodplain topography, excavate wetland(s) | 1 | M | H | H | H |
| | Management | Change grazing management, plant vegetation, construct fence(s) | 1 | H | M | L | L |
| Spring | Reconnection | Excavate new channel(s), install or modify culverts | 1 | L | M | M | M |
| | Enhancement | Excavate, recontour | 0 | L | H | L | L |
| | Management | Plant vegetation, construct fence(s), add gravel or other suitable substrate | 1 | L | H | L | L |

** Instream channel manipulations were given a split score because this project type included both channel creation and reconnection and meander bend cutoffs.*

## 7.4 Guidance for Future Projects

Our guidance for future stream restoration projects in the Sprague River Basin consists of three simple components:

1) ***Implement a structured monitoring and adaptive management program.*** This recommendation is to ensure that monitoring is made integral with project implementation, and that it be systematic, consistent, and persistent through time. This will require a change in standard operating procedures for stream restoration practitioners in the basin. Without such a change, learning and true adaptive management from investments in post project monitoring will remain elusive.

2) ***Establish standard monitoring and data management methods.*** The lessons learned in each of our 10 PPAs provide detailed suggestions regarding monitoring and data management methods. In general,  list monitoring metrics and assessment methods tied to objectives and processes addressed by specific restoration actions. We recommend referring to this table in the development of monitoring plans for all future restoration projects. Lastly, stream restoration practitioners in the Sprague River Basin must develop a central standardized data storage system to house all relevant data on past and future restoration projects.

3) ***Use the tools and lessons learned contained in this report to guide future restoration projects in the basin.*** When embarking upon a new project to address impacts from some disturbance in the Sprague River Basin, restoration practitioners should begin by identifying and understanding the appropriate conceptual model describing the processes and linkages of most importance. Based on this understanding, practitioners should then consult to guide development of project objectives and actions as well as monitoring metrics and assessment methods to maximize the potential for project specific success and contribution to achievement of basin wide goals.

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