Westland/Ramos Reach of the Umatilla River

Engineering Feasibility Study and Preliminary Channel Design

FINAL REPORT

prepared for

Westland Irrigation District

January 28, 2000

HARZA

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Prepared for:
Westland Irrigation District

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EXECUTIVE SUMMARY

This study was commissioned by the Westland Irrigation District (WID) in response to requests from the U.S. Bureau of Reclamation (USBR), other resource agencies, and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) to determine the engineering feasibility and cost estimate for implementing a plan for river restoration that would provide significant benefits to anadromous fish.

The pilot habitat restoration project is in a 7,000 foot-long reach of the Umatilla River near Echo, Oregon. Two low head irrigation diversion dams approximately bound the project reach. A key element of the restoration plan is to notch the dams to ensure the lasting stability of the reconstructed channel by providing the river a single, defined point of entry through the dams.

A primary objective of this study is to assess the engineering feasibility of notching the dams to provide a stable channel form and function for the specific benefit of significantly improving fish habitat, while mitigating adverse effects to landowners and fish habitat from flood flows. The feasibility study would also ensure that notching of the dams and placement of grade control structures would maintain diversion capacity to the Westland and Feed ditches.

Irrigation districts, agencies and landowners were interviewed to gather existing information on diversion operations, facilities design, and to solicit concerns that may have a bearing in consideration of preliminary design. Site visits and surveys were made to characterize channel morphology and collect dimensions and elevations on facility structures such as diversion dams, headworks and fish ladders.

Functional design criteria were developed for the channel and diversion structures. Drawings and design dimensions were used to quantify requirements for instream natural stability structures; to identify riparian treatment areas; to quantify target fish benefits such as habitat units, habitat quality parameters, and channel morphology; and to identify flood-prone areas. Design criteria for the diversion dams were developed to ensure that diversions retain their capability to meet diversion requirements as well as or better than the existing diversion; to provide unrestricted upstream and downstream fish passage for both juvenile and adult target species between the minimum and maximum design flows; to improve ability of diversion to pass bedload downstream to minimize deposition of bedload material around the diversion dam and intake headworks; and, consequently, reduce the level of operations and maintenance required at the diversion. The key element in meeting these goals is the use of “W” rock weirs for diversion and grade control.

This study also developed a 5-year plan outline to monitor implementation and effectiveness based on the tenets of adaptive management.

Planning level cost estimates were estimated using known unit and lump sum costs from similar types of projects, the Means 1999 Heavy Construction Cost Data, and standard engineering practice for planning level cost estimates. Total project costs were estimated at $3.8 million, assuming 20 percent construction contingency, 3 percent annual O&M, and engineering, permitting, and administration cost calculated at 25 percent of the construction cost. Costs (millions) included $0.175 for general, $2.0 for channel construction (excavation, embankment, rock structures, and dam notching), $0.2 for riparian construction, and $0.275 for monitoring.

1. INTRODUCTION

1.1 Purpose

This study was conducted as part of the U.S. Bureau of Reclamation (USBR) stipulations in the 1999 Temporary Water services Contract between the Westland Irrigation District (WID) and the USBR. The study was commissioned by the WID in response to requests from resource agencies and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) to determine the engineering feasibility and cost of implementing a plan for river restoration that would provide significant benefits to anadromous fish.

1.2 Project Background and Goals

A plan for a pilot habitat restoration project for a reach of the Umatilla River near Echo, Oregon was developed in the fall of 1998 and finalized in the spring of 1999. The reach is approximately bounded by the Westland and Feed Canal dams, and in the plan is referred to as the Westland/Ramos stream reach. The Westland dam is operated by WID, and the Hermiston Irrigation District (HID) operates the Feed Canal dam. Drawing 1 displays the location map and project area.

The plan was generated and submitted by the Harza Engineering Company under a contract with the Westland Irrigation District (WID). Consultation for the plan was also made with Mr. John Ramos (a property owner within the project reach), the CTUIR, and the USBR. The development of a draft plan for a pilot restoration project was one of the stipulations in the 1998 Temporary Water Services Contract between the WID and USBR. This contract stipulated that WID provide a draft plan that would:

a) Result in significant benefits to fish,

b) Show specific objectives tied to specific benefits to fish,

c) Document a scientifically based analysis explaining how the project will achieve each of its fish objectives,

d) Include a monitoring plan to determine if the project's fish objectives are met; and

e) Identify potential sources of funding for the project.

The overall purpose of the Westland/Ramos project restoration plan (the Plan) was to provide significant benefits to anadromous fish. An analysis of existing conditions for fish habitat, channel form and function, and riparian resources were used to identify limiting factors to fish. In turn, limiting factors were used to identify fish enhancement opportunities. The most important opportunity identified was the potential to provide high quality habitat for anadromous salmonids. This potential could be met by restoring diverse physical and biological features to the river. The longevity of those features could be prolonged, if not assured, by establishing a stable channel form.

The Plan identified that the morphologic form of the Umatilla River through the project reach is limited in its ability to provide stable, functional fish habitat. Presently, the channel is out of equilibrium, characterized by a high width to depth ratio across and preceding the diversion dams, low sinuosity, and by a plan-form morphology that does not provide complex fish habitat. The high width to depth ratio is caused by the river's attempts to adjust laterally around the diversion dams and sediment that has accumulated behind the structures. The high width to depth ratio, which is maintained by a cycle of lateral incision, bank instability, and loss of mature riparian cover, has also reduced the river's capacity to transport its bedload through the reach.

Consequently, accumulation of sediment above the dams and through the reach has caused impaired instream fish habitat due to:

- Channel shifting and split flow;
- Loss of instream habitat complexity;
- Shallow seasonal low flow water depth and elevated water temperature;
- Increased stress on the near-bank region, with subsequent loss of riparian vegetation and cropland through lateral incision; and,
- Losses of instream cover due to loss of riparian vegetation.

Additionally, landowners and irrigation districts incur maintenance and operations costs for their constant efforts to repair damage caused by bank erosion and flooding.

The Plan identified that restoration of fish habitat would necessarily require a stable channel form and functional riparian ecosystem. A stable channel is one that enables the stream, over time, to transport the flow and sediment of its watershed without aggrading or degrading while maintaining its dimensions, pattern and profile (Rosgen 1996). Opportunities to stabilize the project channel would center on reducing the width to depth ratio, increasing bedload transport capacity, reducing aggradation, using in-stream structures to direct velocity away from banks and reduce stress on the banks, increasing habitat complexity, and rehabilitating the riparian zone.

To meet these restoration goals, the Plan presented four alternatives for habitat restoration. Each of the four Plan alternatives offered a different approach to stabilizing the stream channel, managing gravel, improving riparian buffer width and complexity, reducing water temperatures, and increasing instream habitat complexity. The alternatives were designed to meet the conditions stipulated by the USBR in the 1998 Temporary Water Services Contract. Implementation of any one of the four alternatives was also intended to address the needs of WID and HID for maintaining a reliable water supply to their members. Two of the four proposed alternatives would require alterations to one or both of the diversion dams located at the upstream and downstream ends of the project reach. Proposed alterations to dams included either removal or notching.

WID, USBR and CTUIR concurred in advancing the process to implement a pilot project through an engineering feasibility study focused on Plan Alternative 2. This alternative is intended to meet the requirements of the habitat restoration plan by notching the dams and constructing a stable river channel based on natural stability concepts. Notching the dams is recommended to ensure the lasting stability of the reconstructed channel by providing the river a single, defined point of entry through the dams.

The notching alternative would provide significant benefits to fish by ensuring the maintenance of a stable channel design based on natural stability concepts. Ensuring a stable channel also provides benefits to landowners by reducing channel shifts that cause loss of land and by reducing flood-related impacts on crops. This treatment of the dams is also projected to be less costly than complete dam removal, because only a portion of the dams would be affected and because much less instream channel modification would be required upstream of the Feed Dam. Following notching, the sediment wedge upstream of the dams would be utilized as flood plain. Annual costs to maintain diversion would likely be reduced because irrigation districts would expend less time and effort in gravel maintenance; bedload that would normally accumulate behind the dams would be flushed through the dam and reconstructed channel.

Upon successful completion of this feasibility study, development of the project would likely proceed through six subsequent phases. The first of these phases would include consultation with landowners to procure riparian easements, identification of and application for funding, and identification of required permits, timeline and costs. The second phase would include implementation of the monitoring plan, beginning with collection of baseline biological and physical data. The third phase would include preliminary design and permit compliance review. The fourth phase would include final design and construction documents. The fifth phase would include construction services consisting of construction contract procurement and construction management. The sixth phase would involve on going monitoring and evaluation of the project, data analyses, and information feedback used in modifications and maintenance of project features.

1.3 Project Objectives

A primary objective of this study is to assess the engineering feasibility of the preferred restoration alternative (Plan Alternative 2) to provide a stable channel form and function for the specific benefit of significantly improving fish habitat, while mitigating adverse effects to landowners and fish habitat from flood flows. The feasibility study would also ensure that notching of the dams and placement of grade control structures would maintain diversion capacity to the Westland and Feed ditches. Notching the dams is recommended to ensure that a stable channel form is maintained through the reach. A stable channel form is required to ensure significant benefits to fish. A stable channel form would include increased sinuosity, reduced width to depth ratio, and stable banks enhanced by riparian vegetation utilizing native species. Benefits to fish include significantly greater habitat type complexity (e.g., pools, riffles and side channels) and significantly greater habitat quality (e.g., effective cover, diversity of cover type, and food availability).

A second study objective is to provide accurate estimates of project costs for the feasible design alternative. These costs include estimates of design, construction, monitoring, easement acquisition, and project maintenance.

A third study objective is to facilitate agreement between WID, HID, USBR, CTUIR, Oregon Department of Fish and Wildlife (ODFW), other resource agencies, and adjacent property owners for acceptance of implementing the preferred restoration alternative. WID, landowners, and resource agencies must be assured that the functional designs developed in the report will satisfy resource agency requirements to significantly benefit fish, and that structural and channel designs are constructable, dependable, maintainable, and will function as desired at the lowest cost possible.

1.4 Data Collection

Harza collected and reviewed existing information and gathered baseline data for analysis of existing conditions to aid in development of proposed design and improvements to channel resources and diversion facilities.

Harza coordinated with irrigation districts and agencies to collect and review available information on diversion operations and facility design, which included engineering design of existing diversion dams, irrigation intakes, fish ladders and screens, and their relative elevations. Interviews were made with project maintenance staff and USBR engineers. Copies of current and historical aerial photographs were obtained from USDA Farm Services Agency (Pendleton). Other background material included a floodplain study made by the Corps of Engineers (USACE) for the Umatilla River in the Echo vicinity (USACE 1974), and various resource reports made by CTUIR, ODFW, and USBR, which are cited in the following sections.

Harza also met with owners of property adjacent to the project reach in order to review project status and perceived project benefits to landowners, as well as to derive landowner concerns that may be important in consideration of preliminary design.

Collection of baseline data for channel morphology and diversion facilities was made in late July of 1999. Surveys were made to verify facility dimensions and elevations relative to a common datum. A local surveyor (William R. Wells, PLS) performed surveys using a GPS-based system. The channel was surveyed for cross sections, longitudinal profile, and plan form. This data was used to derive bankfull width and depth elevations, floodprone elevations, bed features, sinuosity, meander width ratio, and energy slope. This data was also used in the derivation of the proposed stable channel design. Surveys on facilities included: typical cross-sections near canal entrances; surveys on head-gate structures (including depth of sluice gates, control limits, and overall dimensions); elevations and dimensions on the diversion dams and fish ladders; and forebay, tail-water, and ladder pool water surface elevations and water depths at the time of survey.

2. PROJECT SETTING

The project area lies within the Walla Walla Plain of the Columbia Plateau physiographic province. This area is composed primarily of horizontal layers of lava that have a surface expression of level plateaus and rolling hills. Climate within the study area is characterized as semi-arid mid-latitude steppe with moderate summers. Temperatures range between less than 0°F to more than 100°F, with a mean temperature of approximately 53°F (USACE 1974). The dryness in the region is reflected in the vegetation composition of a dominant grassland/shrubland community.

Average annual precipitation is about ten inches, with over 80 percent occurring as winter snow and spring rain. Peak runoff occurs in late spring as convective rainstorms melt foothill and mountain snowpacks. From analysis of peak flood data from the Yoakum gauging station (approximate river mile (RM) 38) for the period 1948 to 1998, combined with field-determined bankfull stage and developed cross section, the bankfull discharge for the Umatilla River in this reach is about 3,500 to 3,700 cfs, with a recurrence interval of about 1.25 years (see hydrology data in Appendix B).

Presently, much of the river is disconnected from its floodplain. Intensive land uses within the floodplain have led to dramatic changes in waterway characteristics since settlement of the basin in the 1800's. Stream channelizing, diking of floodplains, streambank riprapping, and elimination of riparian vegetation have altered the natural channel form and function. The loss of stream channel meander within the valley due to channelization and diking has accelerated runoff velocity due to an increase in surface gradient.

Drawing 1 displays the location map and project area. The project reach extends approximately from 1,000 feet upstream of the Feed dam to 700 feet downstream of the Westland dam. Also shown on Drawing 1 are plat lines obtained from the Umatilla County Assessor's Office. Table 2.1-1 lists tax lot number, legal reference number, and owner name.

Table 2.1-1. Landowners in the project area.

Map Lot Number	Legal Reference Number	Name
7100	291-335	Spike, Robert and Suzanne
7200	R230-1531 and 1538	Holeman, Rolland L. and Toni K. (agents)
7300	342-218	Cunha, Joe Jr., Antone, Manuel and Alfred
7500	R261-1668	Ramos, Charles Joseph and John Brinker
7600	R261-1668	Ramos, Charles Joseph and John Brinker
7800	R261-1668	Ramos, Charles Joseph and John Brinker
9300	R4-485	Holeman, Rolland L. and Toni K. (agents)

Obtained May 17, 1999 from Umatilla County Assessors Office, map from T3N R29E.W.M.

3. EXISTING CONDITIONS

3.1 Hydrology

Daily streamflow data was collected for Umatilla River and canal stream gauges in the project vicinity (Table 3.1-1). Data was obtained from the Oregon Department of Water Resources web site and the local Watermaster's office.

Table 3.1-1. Stream gauges in the project vicinity.

Gauge number	Name	Period of Record (and Water Years Used in Analysis)
14026000 (YOKO)	Umatilla River at Yoakum	1904-1998 (1948-1998)
14027000 (FURO)	Furnish Canal near Echo	1926-1988 (1948-1988)
14026897	Furnish Canal above Crayne-Lisle Canal	1993-1998 (partial record 1993, 1994-1995, 1997-1998)
14029000 (FCEO)	Feed Canal near Echo	1926-1997 (1948-1997)
14029900 (UMUO)	Umatilla River below Feed Canal	1993-1998 (partial record 1993, 1994-1998)
14030500 (WESO)	Western Land Canal near Echo	1926-1998 (1948-1998)
14031050 (UMDO)	Umatilla River at I-84 near Stanfield	1993-1998 (1993-1998)

Daily flows were entered into a spreadsheet and used to calculate exceedence values for each month as well as on an annual basis. Exceedence flows refer to the percent of the days that river flows are above a given value. In other words, if the November 80 percent exceedence flow is 240 cfs, it means that for 80 percent of the November days analyzed, flows were 240 cfs or greater, and for 20 percent of the days flows were less than 240 cfs.

Two periods were analyzed for each gauge: the period of record (listed in Table 3.1-1) and the 1948-1998 period to reflect more current land and water uses in the basin. Data for all gauges except YOKO (Umatilla River at Yoakum) are provisional, and may not be complete and accurate. Data for the YOKO gauge until 1991 was published by USGS, and was attributed an accuracy rating of "good" for the record.

In addition to the daily flow analysis, peak flows at the Umatilla River at Yoakum were collected and used to calculate flood frequency values using a standard computer package (HECEXE). This package follows the guidelines of the Guidelines for Determining Flood Flow Frequency (US Water Resources Council, Bulletin 17B, September 1981).

Results from this analysis are displayed graphically in Appendix B, Hydrology Data. Results are also used and referenced within the following report sections.

3.2 Channel Morphology and Riparian Habitat

3.2.1 Channel Morphology

The Umatilla River through the project reach flows west-northwest in a moderately broad valley with gentle, down-valley elevation relief (Valley Type VIII, Rosgen 1996). In profile, the valley slope is about 0.0024 and the water surface slope is about 0.002. The valley width ranges from about one-quarter to one-half mile, and is controlled by generally flat-laying lava buttes that rise more than 200 feet above the valley floor. The valley floor is predominantly comprised of alluvial terraces and floodplains. These depositional landforms are capable of producing a high sediment supply. Undisturbed rivers in this valley type are typically characterized by meandering channels that are only slightly entrenched, meaning that they have access to a broad floodplain. Presently, cropland occupies terraces that were once floodplains.

Soils that have developed in the valley were built by the river, which deposited silt as floodwater spilled out of its channel and flowed over the valley floodplain. Soils within the project area are predominantly Xerofluvent Series and Yakima silt loam, with slopes varying from zero to three percent (USDA SCS 1988). The Xerofluvent soils are located within the active floodplain through the project reach, are poorly to excessively drained, and have variable water holding capacity. Surface layers range from loamy sand to very cobbly loam or silt loam; subsurface layers range from extremely gravelly or cobbly sand to very cobbly or gravelly loam.

Yakima silt loam is located on low terraces in the project reach, and so are more rarely flooded than Xerofluvents. These soils are deep and well drained. Surface layers are typically silt loams. Subsurface layers vary from silt loam to gravelly loamy sand and sand.

Within the annual floodplain soils range from barren riverwash to vegetated sandy and gravelly alluvium. These soils typically have had little time to develop because of the continual reworking of the alluvial deposits by floodwater. Riparian establishment within the existing annual floodplain is not likely due to the continual reworking of gravelly substrate.

Drawings 2 and 3 display plan views of the upstream and downstream portions of the project reach. The channel through the project reach is laterally constrained on the left bank by a terrace that extends about 2,600 feet downstream from the Feed Canal dam, and by about 2,600 feet of basalt bluff along the lower portion upstream of the Westland dam. The right bank below the Feed Canal dam is riprapped for some 600 feet. The remainder of the right bank is bermed to some extent to prevent flooding of cropland.

Flow into the reach spills across the entire length of the Feed Canal dam. Alternating point and mid-channel bars characterize the in-channel depositional features. Some bars have developed on the downstream ends of outside meander bends. Chute cut-offs have developed across bars. Similar depositional patterns that include broad, large accumulations of gravel have formed above the Feed Canal dam and below the Westland dam.

Through the reach, as well as upstream and downstream of the dams, the channel is characterized by a high width to depth ratio, low sinuosity, an irregular and truncated meander pattern, and split flow. The width to depth ratio, measured at the bankfull stage, is 48. Sinuosity, the ratio of stream length to down-valley distance, is about 1.03. The irregular and truncated meander pattern is due to features that confine the channel laterally. Meander length is about 2,200 feet with a radius of curvature of about 1,028 feet. The channel belt width is about 260 feet. The floodprone width varies between about 250 and 550 feet. The floodprone width is defined at an elevation that is twice the maximum bankfull depth (Rosgen 1996). Discharge at this stage is roughly equivalent to the 50-year flood of about 20,000 cfs (Appendix B).

Channel stability overall is poor, characterized by high sediment deposition, continuous channel shifts, and high to very high streambank erosion potential. Near-vertical banks comprised of non-cohesive gravel and silt characterize the high erosion potential, along with low surface protection afforded by organic debris or rooted stock, low to moderate root depth and root density, and high to extreme shear stress from river flow. About 3,000 feet of banks showed signs of recent scour.

3.2.2 Riparian Habitat

Riparian habitat in the study reach can be characterized as a narrow and fragmented band of vegetation. Adjacent land use is agricultural (irrigated alfalfa hay, cattle grazing), with the exception of approximately 2,600 linear feet along the left bank, which runs along the base of a basalt wall and then slopes to undeveloped shrub-steppe habitat.

The width of the riparian corridor varies from 0 to about 200 feet. Approximately 2,400 feet along the right bank (47 percent of the reach), and 900 feet along the left bank (18 percent of the reach) are shaded by riparian trees and/or shrubs. During the afternoon, the steep basalt bluff progressively shades an additional 2,600 feet along the left bank.

Where the riparian corridor is widest, it is densely vegetated and structural diversity is high. Dominant trees include cottonwood (*Populus trichocarpa*) and alder (*Alnus rubra*), ranging from seedling/sapling size to mature individuals with diameters of 24"-30" at breast height for cottonwood and 16"-18" for alder. The most common shrub species along the riverbank are coyote willow (*Salix exigua*) and whiplash willow (*Salix asiandra* var. *caudata*). Chokecherry (*Prunus virginiana*) and blue elderberry (*Sambucus cerulea*) are present in the tall shrub layer, but small amounts of wood rose (*Rosa woodsii*) and several patches of Himalayan blackberry (*Rubus discolor*) were also observed.

On gravel bars and along the banks where soils are droughty cobble/gravel, the most common forbs and grasses are weedy species, typical of disturbed sites. White sweet clover (*Melilotus alba*), common burdock (*Arctium minus*), common mullein (*Verbascum thapsis*) and gumweed (*Grindelia* species) are common forbs. A variety of other forbs that could not be identified at this time of year are present. The noxious weed yellow starthistle (*Centaurea solstitialis*) is scattered on recently-deposited gravel bars. Cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*) are also common noxious weeds.

Where soils are relatively deep, the most common herbaceous species is reed canarygrass (*Phalaris arundinacea*), and barnyard grass (*Echinocloa crusgalli*) is scattered. A very low percentage of the herbaceous layer appears to be represented by native plants, although a few native grasses, such as bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), needle-and-thread (*Achnatherum* species) and Great Basin wildrye (*Elymus cinereus*), are present.

Wetland species noted on the channel banks and gravel bars include cattails (*Typha latifolia*), small-fruited bulrush (*Scirpus microcarpus),* sedges (*Carex* species), needle spikerush (*Eleocharis* *acicularis)* and smartweed (*Polygonum persicaria*). Aquatic plants were observed in shallow and/or slower-moving stream sections. These plants include elodea (*Elodea canadensis*), leafy pondweed (*Potamogeton foliosus*), Mexican water-fern (*Azolla mexicana*), watercress (*Rorippa nasturtium-aquaticum*), and duckweeds (*Lemna minor, Spirodela polyrhiza*).

Habitat Function

Under optimal conditions, riparian vegetation contributes to bank stability through the development of root structure that holds soils, leaf surface that intercepts rainfall, and groundcover that protects soils from sheet erosion and gullying. Riparian vegetation also contributes to protection of water quality by taking up nutrients, filtering pollutants, and settling out and storing sediments. In the arid west, riparian vegetation is especially important in providing shade to maintain cool water temperatures and supporting surface flows during the summer through groundwater discharge. Streamside plants also provide overhanging cover for fish. Their roots add to instream habitat diversity, and the litter and insects that fall from them provide a forage base for many species. Each one of these factors - bank stability, water quality, water quantity, cover and forage - is an important component of fish habitat. In the project area, the ability of riparian vegetation to provide these components is limited by the narrow width and fragmentation of the riparian corridor.

Bank Stability

Bank erosion was observed along approximately 600 feet of the left bank, where cattle have access to the river, trees and shrubs have been removed, and agricultural practices are conducted to the top of the bank. The 18-24" A-horizon in these 1-5 foot vertical banks appears loamier, with a higher moisture-retention capacity, than the underlying cobble/gravel.

Vertical banks from 2 to 4 feet high were observed along approximately 2,000 feet of the right bank, where recent flood events have resulted in erosion into the floodplain. Exposed soils are primarily loose, cobbly loam and sandy loam, with some areas of Yakima silt loam that are not so excessively drained.

Water Quality/Water Quantity

The lower Umatilla River is designated as water-quality limited by high summer temperatures, as well as by turbidity in the spring and summer and flow modification (ODEQ 1998). Low summer and fall flows, combined with a high width to depth ratio and loss of shading vegetation, almost certainly contribute to high temperatures.

Approximately half the reach is shaded to some extent, but several factors reduce the capability of existing riparian vegetation to provide adequate shade. In several places, the main channel has shifted or split. These shifts, together with the development of wide gravel bars, has separated the river from established riparian vegetation. Existing trees and shrubs continue to provide shade to these abandoned or side channels. In other places, erosion has removed riparian vegetation along the main channel.

The existing riparian zone provides a minimal buffer between the river and adjacent land use, in terms of taking up nutrients, filtering pollutants that might otherwise enter the river, and settling out and storing sediments. Also, because of narrow width and fragmentation, the riparian buffer is limited in its ability to moderate flood flows by slowing flood peaks, providing overbank floodway, or storing water, acting as a sponge to take up water during high flows and releasing it slowly during low flows.

Fish Habitat

As described above, trees or shrubs that could provide overhanging cover, leaf litter, and associated insect production are absent along approximately half the project reach, or have become separated from the main channel by deposition of gravel bars. The largest gravel bars in the project reach are of recent origin, and do not currently support shrubs or trees that contribute to cover or provision of prey items.

3.3 Fish Habitat and Limiting Factors

During summer months, high water temperature and low streamflow are the primary factor limiting production of anadromous salmonids in the lower Umatilla River basin below the Westland dam. From July through September the reach between Three Mile Dam (RM 3) and Stanfield Dam (approximate RM 33) can become de-watered, creating a barrier to the upstream and downstream migration of both adult and juvenile salmonids. Water temperatures in this portion of the river can also exceed the upper lethal limit for salmonids (ODFW 1986).

The Umatilla trap and haul program was implemented to provide both adult and juvenile fish passage through the lower 30 miles of the river (CTUIR and ODFW 1997). As a result of this program, Three Mile Dam is now the major fish collection and counting point for all adult anadromous salmonids returning to the Umatilla River. The Westland Dam facility, located at the downstream end of this project's study reach, is the major fish collection and counting point for outmigrating juvenile salmonids.

At the Three Mile Dam facility, adult fish are collected and transported upstream when river flows are projected to be less than 150 cfs at Dillon within 30 days. When projected flows are higher than 150 cfs at Dillon, fish are released immediately above Three Mile Dam. Transported fall chinook and coho are released at Barnhardt (RM 42). Spring chinook and summer steelhead collected prior to May 15 (or until flow drops below 150 cfs at Pendleton) are transported and released at either Barnhardt or Nolin (RM 33). After May 15, or when flows drop below 150 cfs, releases of spring chinook and summer steelhead alternate between Thornhollow (RM 73.5) and Imeques (RM 80) (CTUIR and ODFW 1997).

At the Westland Dam facility, downstream migrants are collected and transported downstream whenever flow conditions in the river are projected to be below 150 cfs at Dillon within 10 days. All transported juveniles are released at the Umatilla boat ramp (CTUIR and ODFW 1997).

Today, fall chinook and coho use the lower 50 miles of the Umatilla River for adult migration, pre-spawning holding, spawning, incubation, rearing, and juvenile migration at various times of the year. Spring chinook and summer steelhead use the reach primarily for adult migration, rearing, and juvenile migration (pers. comm. C. Contor, CTUIR Fisheries Biologist, October 1998). Specific life history information regarding the timing of each species and life stage in the lower 50 miles of the Umatilla River is presented in Figure 3.4-1 (Feed Canal Diversion Event Timing Chart) and Figure 3.4-2 (Westland Diversion Event Timing Chart).

While low flows and high water temperatures are likely to be the primary limiting factors throughout the lower Umatilla river from mid-May through mid-September, the reach between Westland Dam and Feed Canal Dam has the potential to provide quality anadromous salmonid habitat throughout the year. Based on our assessment of existing fish habitat conditions, anadromous fish production in the study reach is limited by a lack of habitat complexity (Table 3.3-1). Long monotypic glides and short riffles that provide very little to no cover dominate the reach. Presently, few pools and no off-channel rearing habitats exist in the reach. While the reach appears to contain an adequate amount of quality spawning gravel, large cobbles and boulders are extremely rare. Stable large woody debris (LWD) is also limited.

Table 3.3-1. Summary of potential factors limiting to anadromous salmonid production (by life stage) in the Umatilla River between RM 27.8 and 28.8.

Life Stage	**Observed or Potential Limiting Factors**
Upstream Migration of Adults	The reach lacks instream cover including: deep pools, LWD, submerged objects, and undercut banks. Passage conditions are not ideal, although dams are equipped with fish ladders.
Spawning	Gravel quantity and quality does not appear to be a limiting factor in the reach. However, the existing channel lacks the transition areas between pools and riffles. Instream cover is also limited.
Egg Incubation	Existing gravel appears to be relatively free of fine sediment. However, channel shifts can strand redds and bedload movement can scour redds.
Freshwater Rearing	***Food Availability:*** Data describing macroinvertebrate production in the reach is lacking, but production could benefit from an enhanced riparian area. Out-of-stream sources of organic matter (i.e. leaves from riparian plants) may be limited by the relatively narrow riparian zone through the reach. Retained organic detritus is also limited due to the lack of pools. ***Dissolved Oxygen and Turbidity:*** Dissolved Oxygen for salmonid spawning did not meet ODEQ listing criteria (from mouth to Speare Canyon). Turbidity during spring and summer is limiting (303(d) List) due to rate of increase. ***Channel Morphology:*** The reach lacks a diverse mixture of habitat types. Glides and riffles were the only habitat types observed in the reach. Deep pools and quality off-channel habitat do not exist. The lack of pools in the reach is due to a lack of large channel forming features (including LWD, boulders, and bedrock outcrops), low sinuosity, and insufficient channel capacity to transport its bedload through the reach. ***Instream Cover:*** Cover in the form of LWD, undercut banks, cobble and boulder substrate, water depth and turbulence, and aquatic vegetation is limited to only about 10 percent of the wetted habitat area. This is well below optimal levels.
Seaward Migration	Same as freshwater rearing.

3.4 Diversions and Operations

3.4.1 HID Feed Canal Diversion

The Feed Canal Diversion is a USBR project and is managed by the HID to deliver water from the Umatilla River to Cold Springs Reservoir via the Feed Canal for use by HID. The Feed Canal Diversion is a component of the East Division of the Umatilla Project. The East Division is essentially the HID. Besides the Feed Canal Diversion, the East Division includes the Cold Springs

Dam and Reservoir, the Maxwell Diversion Dam and Canal, and miscellaneous distribution system facilities. However, these other facilities are not directly related to this Project.

The Feed Canal Diversion includes the following facilities: the diversion dam, the headworks, the canal, the fishscreens and bypass, and the check and wasteway structures (see Drawing 4). The Feed Canal Diversion Dam was constructed in 1907 and is located on the Umatilla River at approximately RM 29 from its confluence with the Columbia River. The dam is composed of an approximately 400-foot overflow spillway and an approximately 700-foot earth embankment wing. The spillway has a concrete crest and a timber and rock crib spillway apron. In order to provide the capability to divert design flows during low river flow, the spillway crest was raised in 1991 with the addition of wood planks to its present day approximate crest EL. 656.8.

In 1989, a vertical slot fishladder was constructed on the overflow weir. The fishladder contains a total of three slotted weirs. During our site visit on July 20, 1999, the headwater-tailwater difference at the dam was estimated to be at least 6 feet. This would effectively result in at least a 2-foot average hydraulic drop through each slot. Resource agency criteria (NMFS, ODFW) stipulate a maximum hydraulic step of 1 foot for upstream fish passage facilities.

The canal headworks are located at the right abutment of the overflow spillway. The concrete headworks structure includes eight slide gates, each measuring 6.25-feet wide with a maximum opening height of 21-inches. All the gates are automated. A trashrack is located just upstream of the headgates.

The Feed Canal itself is an earth-lined channel approximately 25 miles in length. The canal was constructed in 1907 and enlarged to a capacity of 350 cfs between 1913 and 1917. Since its enlargement, the canal's capacity has gradually decreased to approximately 220 cfs due to sedimentation and erosion. The canal runs roughly parallel to the river for about 8 miles before turning northeast to the Cold Springs Reservoir. The canal section between the headworks and the check and wasteway structure is generally trapezoidal in section with an approximately 35-foot bottom width and 1 to 1 sideslopes.

The fishscreen and bypass facilities are located in the canal approximately 700-feet downstream of the headworks. Because they didn't meet federal and state screen criteria at the time, the original 1973 fish screen facilities were replaced in 1989 with the current fishscreen and bypass facilities. The new screens were designed to meet 1988 criteria, including a maximum normal velocity of 0.5 fps at the 245-cfs design flow (USBR 1988b). The screens are angled at 20 degrees from the canal centerline. There are ten drum screens total, each measuring 5-foot in diameter by 12-feet long. An approximately 300-foot long, 30-inch diameter bypass pipe returns juvenile migrants to the river approximately 600-feet downstream of the dam.

3.4.2 HID Water Rights, Target Instream Flows and Current Operation

HID's senior water right to withdraw 350 cfs from the Umatilla River dates back to 1905 (pers. comm., Chuck Wilcox, HID Manager, November 16, 1998). However, the current canal design flow is 245 cfs, and diversions rarely exceed 220 cfs due to canal capacity limitations (pers. comm., Wilcox 1998; and pers. comm., Paul Gregory, USBR, January 5, 2000). In 1988 the USBR published recommended target flows for the Umatilla River below the Feed Canal Dam as part of a report to assist in anadromous fish recovery (USBR 1988a). These target flows are illustrated in

Figure 3.4-1 (Feed Canal Diversion Event Timing Chart) along with target species run timing and historical flow data for the Umatilla River (YOKO Gauge: 1948-1998).

To maintain access to the fish ladder near the canal intake structure, HID is permitted to use machinery in the water to clear gravel accumulations. Variable quantities of gravel are moved on an annual basis, but excavation is restricted to the area near the fish passage facility. HID typically pushes gravel to armor the channel banks, or removes the gravel from the channel with an excavator. Reportedly, gravel has never been moved to the downstream side of the dam (pers. comm., Chuck Wilcox, HID Manager, November 16, 1998).

3.4.3 Westland Canal Diversion

The Westland Canal Diversion is managed by the WID to divert water from the Umatilla River for delivery to WID and others along the system. The dam was completed and diversion commenced in 1903. The WID diversion includes the following facilities: diversion dam, canal headworks, vertical slot fish ladder, canal, fish screen and fish handling facilities, and check and wasteway structures (see Drawing 5). The Westland Dam is located on the Umatilla River at approximately RM 28 from its confluence with the Columbia River. The concrete dam is approximately 295 feet in length with an approximate crest EL. 640.8. During low flow conditions, the headwater/tailwater difference is roughly 4 feet. An approximately 40-foot low flow notch with crest elevation 638.8 is located adjacent to the left abutment. During low flow periods, a flashboard system is deployed in the notch to maintain forebay water surface elevations for desired diversion flows.

The canal headworks are located at the left abutment, adjacent to the low flow notch. The concrete headworks include 6 slidegates with automated controls. A trashrack is located in front of the headgates.

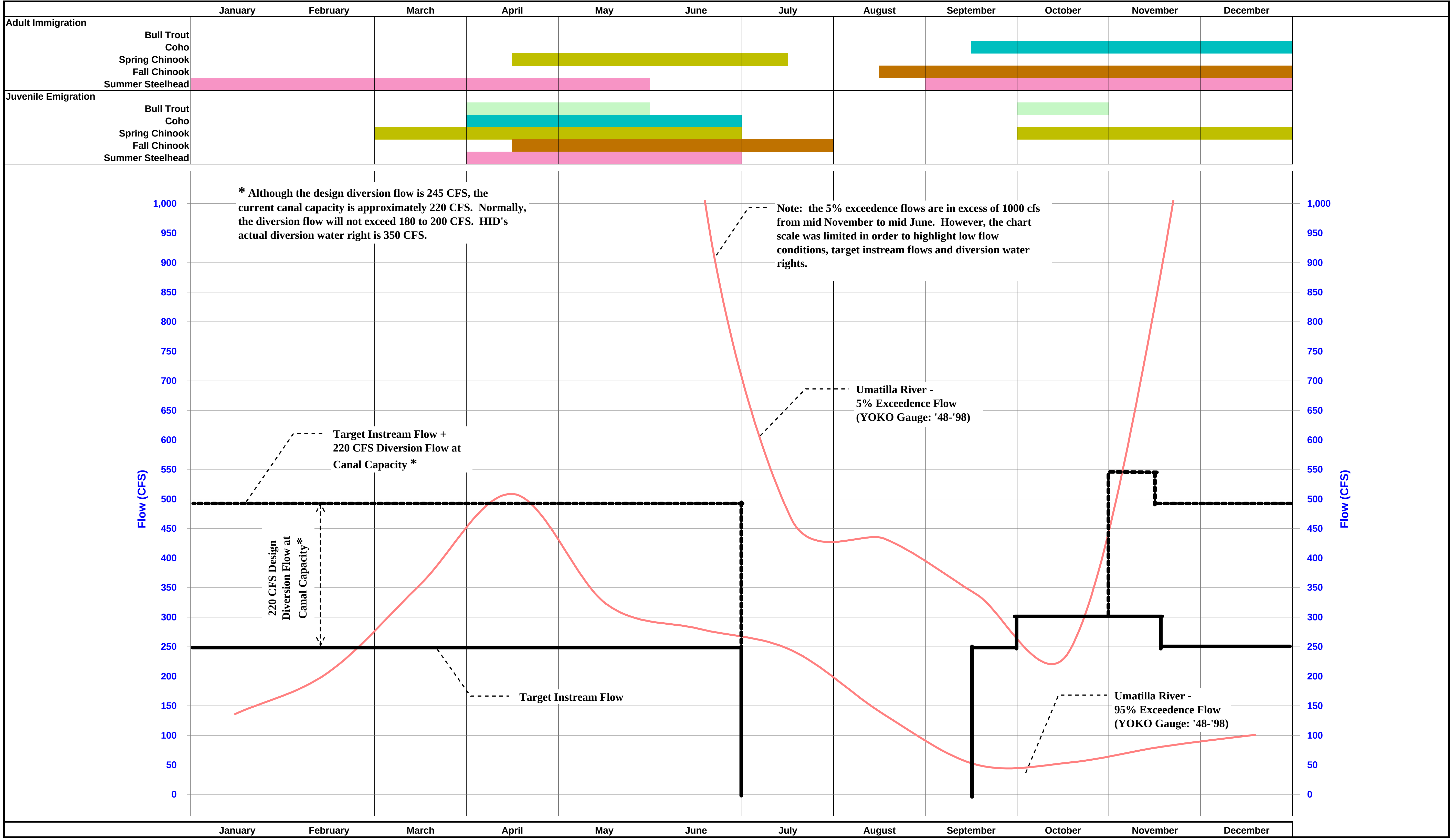
The vertical slot fishladder is located on the dam crest approximately 60 feet from the left abutment of the dam. The ladder was constructed in 1990 to replace an older concrete fishway located approximately 100 feet from the right abutment. The concrete vertical slot ladder includes an entrance structure with four entrance gates, seven vertical slot weirs, and an auxiliary attraction water channel. Both the ladder's exit and the auxiliary water intake are protected with trashracks. A footbridge provides access to the ladder from the left abutment.

The fish screen and fish handling facilities were designed and constructed at the same time as the vertical slot fish ladder. These facilities are located in the canal between approximately 200 and 600 feet downstream of the canal headworks. The check and wasteway structures are located approximately 2,100 feet downstream of the canal headworks.

While the Westland canal, the fish screen and fish handling facilities, and the check and wasteway structures are important components of the WID diversion, their operation should not be affected by the proposed modifications. Therefore, they do not pertain directly to the design component of this project. However, it will be necessary to ensure that the proposed modifications will provide the necessary water surface elevations at the headworks to meet WID diversion requirements and fish screening criteria.

Fish Passage on Umatilla River @ Feed Canal Diversion

Run Timing & Monthly Flows



* Although the design diversion flow is 245 CFS, the current canal capacity is approximately 220 CFS. Normally, the diversion flow will not exceed 180 to 200 CFS. HID's actual diversion water right is 350 CFS.

Note: the 5% exceedence flows are in excess of 1000 cfs from mid November to mid June. However, the chart scale was limited in order to highlight low flow conditions, target instream flows and diversion water rights.

P:/15227/Design/Feed Canal Timing 3: Timing
4/10/01 @ 10:04 AM

Figure 3.4.1

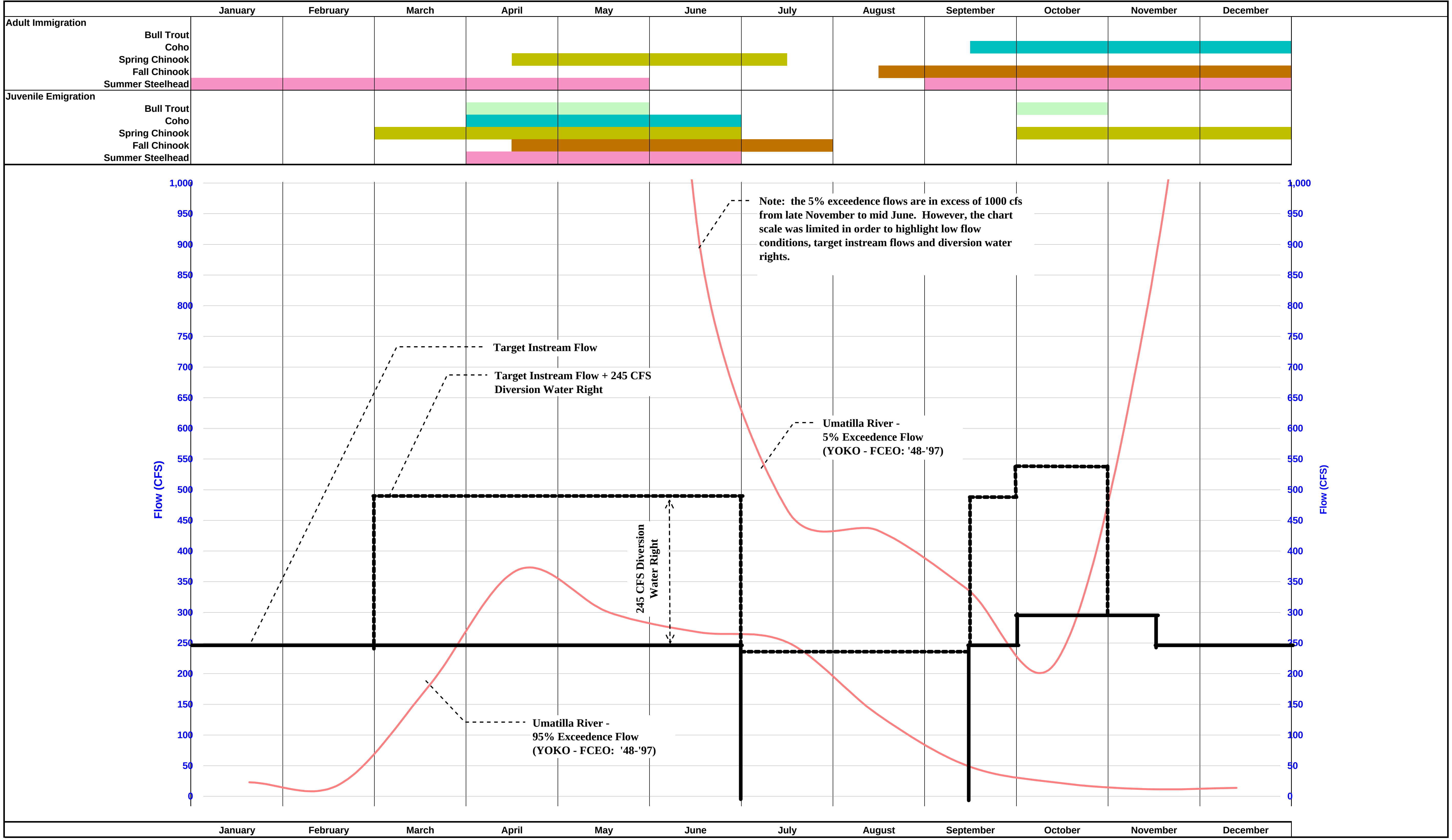
3.4.4 WID Water Rights, Target Instream Flows and Current Operation

WID began delivering water in 1903. WID diverts approximately 245 cfs between March 1st and October 31st. WID has an additional right to divert 60 cfs for a Recharge Project beginning November 1st, or when water is available in the Umatilla River in excess of 500 cfs (pers. comm., Dolly Ashbeck, WID District Manager, letter dated November 10, 1998). In 1988 the USBR published recommended target flows for the Umatilla River below the Feed Canal Dam as part of a report to assist in anadromous fish recovery (USBR 1988a). Historical flow data for the Umatilla River below the Feed Canal dam (YOKO Gauge minus FCEO Gauge: 1948-1997) are illustrated in Figure 3.4-2 (Westland Diversion Event Timing Chart) along with target species run timing and target instream flows.

WID has the authority to remove and relocate gravel 100 feet upstream and downstream from the points of diversion. This work is done during minimal river flow when fish are not present. WID currently removes the gravel from the front of their intake gates. Normally a portion of this dredged gravel is used to construct a pushup berm on the northeast bank of the river to divert water from the river toward the intake gates (pers. comm., Dolly Ashbeck, WID District Manager, letter dated November 10, 1998).

Fish Passage on Umatilla River @ Westland Diversion

Run Timing & Monthly Flows



Note: the 5% exceedence flows are in excess of 1000 cfs from late November to mid June. However, the chart scale was limited in order to highlight low flow conditions, target instream flows and diversion water rights.

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Figure 3.4.2

4. FUNCTIONAL DESIGN ALTERNATIVES

This section describes design goals, criteria and considerations for the proposed channel and riparian resources, and for the functional design alternative at Feed Canal diversion dam and at the Westland diversion dam. The functional design alternatives presented in this section were made to test the feasibility of notching the diversion dams as a critical requirement for restoring and maintaining a stable channel to provide significant benefits to fish.

4.1 Functional Design Alternative for Channel Restoration

Data analysis of the survey of channel morphology and facilities, aerial photos and flood study (USACE 1974), along with dimensionless ratios extrapolated from reference data, were used to prepare dimensions and layout for a preliminary stable channel design. Drawings and design dimensions were used to quantify requirements for instream natural stability structures; to identify riparian treatment areas; to quantify target fish benefits such as habitat units, habitat quality parameters, and channel morphology; and to identify flood-prone areas.

Section 4.1 presents design goals, criteria and considerations, and proposed channel modifications for the preliminary channel restoration design. Drawings 6 and 7 display in plan form the proposed preliminary design, along with the proposed riparian treatment. The riparian restoration plan is presented in Section 4.2.

4.1.1 Design Goals

The primary design goal for the Umatilla River through the project reach is to restore its channel to a stable form, function and biological condition that would provide significant benefits to fish. Target benefits include substantially greater habitat diversity for rearing and spawning, greater water depth during periods of low flow, increased instream cover, improved water quality, and enhanced fish passage. In addition, a stable channel would help establish and maintain functional riparian vegetation to provide shade and overhanging cover.

Other important goals are to maintain diversion capacity at the Feed Canal and Westland diversions to meet diversion requirements, and to reduce adverse effects to landowners and fish habitat from flood flows and lateral incision.

4.1.2 Design Criteria and Considerations

A stable channel is one that enables the stream, over time, to transport the flow and sediment of its watershed without long-term aggradation or degradation, while maintaining its dimensions, pattern and profile (Rosgen 1996). Opportunities to stabilize the project channel center on reducing the width to depth ratio, and recreating a natural channel geometry that contains a low flow channel, floodplain and terrace. The new channel form would further be maintained by the use of instream natural stability structures that provide grade control and protection for banks against erosive flow stresses. In addition, this treatment is designed to accelerate riparian establishment, as well as provide instream cover for fish.

Several important criteria were considered for the proposed design. First, the principal causes of channel disequilibrium needed to be identified. Channel disequilibrium in the project reach is caused principally by instream channel structures (the dams) and by historical land use practices that have reduced the river's natural tendency to meander. As a consequence, sediment deposition in the channel between the dams and preceding the Feed dam accounts for the high width to depth ratio as the local upstream slope is reduced and the river attempts to adjust laterally. In addition, the river spills over the full width of the Feed dam crest, even at low flow, so that the channel below the dam is unstable. Hence, increasing bedload transport capacity and reducing aggradation are also important considerations.

A second criterion considered for the proposed channel design required matching the appropriate channel type to the valley type. Two candidate channel types are appropriate for the project reach in this valley setting: a "C4" or a "B4c" channel type (Rosgen 1996; pers. comm., Dave Rosgen, October 1998 and October 1999). In general, the C4 stream type is a low gradient, meandering, gravel dominated, point-bar, riffle/pool, alluvial channel with a broad, well-defined floodplain. The B4c stream type is a low gradient, gravel dominated, riffle/pool channel with a moderately entrenched channel within a moderate floodplain. A B4c channel type was selected for this project for the following reasons.

- Bc channel types have lower width to depth ratios than do C channel types. A lower width to depth ratio is preferable in this project to increase water depth during periods of low flow. Deeper water during low flow provides more cover for fish as well as providing beneficial affects to water temperature. Less wetted width implies greater opportunity for shading provided by riparian vegetation to mitigate water temperature.
- The lower width to depth ratio of the Bc channel also provides more energy for bedload transport, as depth (as well as slope) is a critical component of shear stress.
- The Bc channel type is less sinuous, and so does not require as wide a meander width as does a C channel. This is an important consideration where meander width is constrained by topography and land use.
- The C channel type, having greater sinuosity, would require both a greater amount of structural control to fix its position between the diversion control points, and riparian treatment for a longer stream length.
- The greater sinuosity that is required of a C channel would reduce the energy gradient. Since bedload transport capacity and elimination of lateral migration are important considerations to the design of this stable channel, a Bc channel type would maximize channel gradient.

A third criterion considered for the preliminary channel design was the characterization of the bankfull discharge. The bankfull discharge is related to channel dimensions such as width and depth, and channel patterns such as meander length, radius of curvature, belt width, meander width ratio and amplitude. The bankfull discharge also represents the upper level of the range of channel-forming flows that transport the bulk of the available sediment over time.

Other considerations for the preliminary channel design include:

- Adequate provision of a flood prone area width for flood flows. This width is designed to (approximately) accommodate the 50-year flood (about 20,000 cfs in the project area).

- Maximum use of existing mature riparian vegetation. In the interest of benefits to fish habitat from woody debris, leaf litter, shade, and bank stability, the plan form of the proposed channel should take advantage of existing rooted stock.
- Robust grade control and training structures at the upstream end of the project reach. The transition from the untreated channel that lacks stability or natural control into the treated channel must be assured. Likewise, grade control is critical for the diversion structures.

4.1.3 Proposed Modifications

Variables used in assessing the morphology of the existing and proposed channels are displayed in Table 4.1-1. Also displayed are the ranges of reference values for a B4c channel type (Rosgen 1996). The range in values from the reference channel type are generally applicable for the preliminary design, but will need to be verified for a stable B4c reference channel within the geophysiographic province of the project reach before the project goes to final design.

A series of calculations were performed to derive the bankfull dimensions in cross section, plan and profile of the proposed design. The first step in preliminary design was to derive the bankfull discharge. Bankfull dimensions were derived from a cross section that was measured in a control reach downstream of the Yoakum gauge (RM ~ 38). Water surface elevations were compared with the staff gauge at the station, and the bankfull elevations were calibrated with the stage/discharge records. From this survey the bankfull discharge was estimated at about 3,700 cfs, with a return interval of 1.25 years. The bankfull cross-sectional area at the site was 543 feet^2. These values were considered as representative of the project reach as no appreciable inflow from tributaries occurs between there and the Yoakum gauge.

Cross Section Dimensions

The proposed bankfull width of the design channel was calculated from the relationship of the square root of the product of the cross-sectional area by the reference width to depth ratio (14). Bankfull mean depth and maximum depth were calculated for average riffle morphology. Wetted perimeter, hydraulic radius, and average flow velocity were then computed. Average velocity was approximated from the continuity equation (discharge = cross-section area times velocity).

Indicators of bankfull elevation in the project reach included tops of point bars, stain lines on rock, and vegetative trim lines. Existing bankfull elevations (and areas) derived from this exercise and reported in Table 4.1-1 are suspect. This is because average velocity of the bankfull flow in the project reach is greater than the velocity computed for the proposed channel, yet more boundary resistance is indicated by the greater width and shallower depth of the existing channel. Because the proposed channel area value (543 square feet) was derived from calibration at a gauge station, this value is carried through the derivation of values for the proposed design.

The flood prone area width was derived using an entrenchment ratio of 2.2, which is the upper end of the range of values for B4c channel types. The entrenchment ratio is calculated as the width of the flood prone area divided by the channel bankfull width. This flood prone area width is the width at an elevation of twice the maximum bankfull depth, which roughly corresponds with the 50-year flood. For the project area, the 50-year flood is about 20,000 cfs (Appendix B). This width is treated as a minimum value (the flood prone area width can be greater than 191 feet). Representative cross section data are shown in Drawing 8. The locations of these cross sections are shown in Drawings 2 and 3. A detail of typical design sections for pool, glide and riffle morphology are shown in Drawing 11.

Table 4.1-1. Morphological characteristics of the existing and proposed channel through the project reach.

	Variable (measured for the bankfull condition except as indicated by "*")	**Existing Channel Value**	**Proposed Channel Value**	**Reference Value (B4c Channel Type)**
	discharge[1/] (cfs)	3,700	3,700	
Cross Section	area (sq. ft)	435	543	
	width (ft)	144	87	
	average depth (ft)	3.0	6.2	
	width/depth ratio	48	14	12 – 16
	maximum depth (ft)	5.6	8.1	
	width of flood-prone area[2/]	340	191	1.8 – 2.2 times bankfull width
	entrenchment ratio[3/]	2.4	2.2	1.4 – 2.2
	wetted perimeter (ft)	140	99.4	
	hydraulic radius (ft)	3.1	5.5	
	average velocity (ft / sec)	8.5	6.8	
Profile	average water slope*	0.0021	0.0023	valley slope / sinuosity
	bankfull slope	0.0025	0.0023	
	average riffle slope*	0.0030	0.0041	
	ratio of riffle slope to average slope	1.45	1.8	1.5 – 2.0 times average
	maximum riffle depth (ft)	5.4	8.1	
	ratio of riffle maximum depth to bankfull depth	1.8	1.3	1.2 – 1.4
	average pool slope*	0.0009	0.0005	
	ratio of pool slope to average slope	0.41	0.21	0.2 times average
	maximum pool depth (ft)	8.65	18	
	ratio of maximum pool depth to bankfull depth	2.9	3	2.5 – 3.5
Plan	meander wavelength (ft)	2,204	950	8 – 12 times bankfull width
	radius of curvature (ft)	1,028	350	3 – 5 times bankfull width
	meander width ratio (belt width/bankfull width)	1.8	4	
	ratio of meander wave-length to bankfull width	15.3	10.9	8 – 12 times bankfull width
	sinuosity (ft/ft)	1.03	1.2	
	arc length (ft)	1,133	570	
	belt width (ft)	260	365	

[1/] Bankfull discharge obtained by calibration of developed cross-section with field-determined bankfull stage and flood flow hydrograph at the Yoakum gauge (USGS Gauge 14026000). Recurrence interval is 1.25 years.

[2/] Width of flood prone area calculated as elevation at twice the maximum bankfull depth in riffle cross-sections (see Drawing 8 for typical sections).

[3/] Entrenchment ratio (Rosgen 1996) calculated as [width of flood prone area] / [width at bankfull flow]. This index value describes the degree of vertical containment of the river channel. Values less than 1.4 indicate very narrow flood planes; values greater than 2.2 indicate channels with very broad and well defined flood planes.

Plan Dimensions

The bankfull width value (87 feet) was used with reference values to calculate meander wavelength and radius of curvature through the meander. The meander wavelength is twice the pool to pool spacing, which for a B4c channel is in the range of 4 to 5 times the bankfull width. Values were used that provided a design plan form that generally fit within the existing channel flood prone area.

A sinusoidal curve was drawn on graph paper using the proposed channel dimensions for belt width, meander wavelength, and radius of curvature. The curve was then scaled and laid over an orthophoto of the project area. Diversion headgates and topographic features dictated control over the placement of the channel at the upstream and downstream ends. To the extent possible, existing vegetation was utilized, especially at the outside of meander bends where velocity would be greatest.

Profile Dimensions

Average slopes of water and bankfull elevations, and depths of habitat features, were calculated from survey data for the existing channel. For the proposed channel, average water and bankfull slopes were calculated as the difference in bed elevation between the upstream and downstream dams after notching, divided by the length of the new channel. Reference values were then used to derive riffle slope and depth, and pool slope and depth.

Another calculation was made for critical shear stress in order to derive required minimum bankfull depth of riffles to move bedload. Sediment sizes used in calculations were estimated for channel and point bar substrate, and modified based on particle size distributions derived from Wolman (1954) pebble counts at the Yoakum gauge. Calculations demonstrated that a minimum riffle slope of 0.004 would be required to move the bedload at a minimum bankfull depth of 6.1 feet. These preliminary calculations support the selection of the B4c design channel type; a C channel type would have a shallower bankfull depth and / or lower slope, and under project constraints might not have the competence to transport the particle sizes. Constraints include “fixing” the channel position to prevent lateral incision so that diversion can be maintained and so that land presently in production is not threatened.

Natural Stability Structures

Drawings 6 and 7 show the placement of natural stability structures (W rock weirs, cross vanes and J-hook vanes) that provide three functions essential to the channel design. These structures provide grade control, they function as velocity training structures to deflect the thalweg toward the center of the channel and protect against bank scour, and they provide cover for fish by creating turbulence and deep backwater eddies. Drawing 12 shows cartoons of these structures and their dimensions in plan and section. Function of the structures is also discussed in Sections 4.2 and 4.3.

Target Fish Benefits

Table 4.1-2 displays the comparison of existing and proposed habitat types at the bankfull stage in the project reach between the Feed and Westland dams. While total wetted surface area of the proposed channel is less than existing, the quantity and quality of habitat is significantly improved. The design morphology shows significantly improved complexity in the ratio of pool and riffle habitat. Both pool and riffle habitats are greater, and glide habitat is greatly diminished. Water depths and water widths are also significantly improved.

Table 4.1-2. Comparison of existing and proposed habitat types at the bankfull stage in the Umatilla River between the Westland and Feed Dams.

Habitat Type	Total Surface Area (sq. ft)		Percent Composition		Average Width[1] (ft)		Average Depth[1] (ft)	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
Pool	20,145	268,782	3.3	49	133	90	7.0	8.3
Riffle	124,307	279,753	20.5	51	147	87	3.5	6.2
Glide[2]	461,083		76.1		141		3.0	
Total	605,535	548,535	100.0	100	142	88	3.2	6.2

[1] Average width and depth dimensions under existing conditions computed from cross section data; totals of widths and depths are averages weighted by percent composition.

[2] Specific glide habitat is not identified for the proposed channel, but is included with pool habitat as part of the pool tail-out.

Another component of the channel design is construction of about 550 feet of side channel, shown on Drawing 6 on the right bank downstream of the Feed dam. The intent of this side channel is to provide off-channel spawning and rearing habitat. It is also a design option for the fish bypass pipe returning from the fish screens in Feed Canal.

4.2 Riparian Restoration Plan

The primary objective of the riparian restoration plan is to improve habitat quality for anadromous fish. For this reason, planting recommendations are focused on measures to stabilize streambanks, protect water quality, and provide shade and overhanging cover.

The recommendations provided below are based on the preliminary project design; planting specifications will need to be carefully matched to the contours of the new channel and predicted hydrologic and hydraulic characteristics of the construction reach. This should be completed at the earliest opportunity, to allow time for locating and permitting salvage sites, contract-growing, and nursery orders. Construction scheduling should be reviewed, so that planting can be timed to maximize survival. However, in addition to these planned activities (final design, specifications, scheduling), a habitat restoration specialist will need to be on-site during construction, so that the planting plan can be adapted to conditions encountered as construction progresses.

Stock Sources

It is anticipated that plant materials, including rooted stock and cuttings, can be obtained from several sources. These include contract-growing by adjacent landowners, salvage sites within the project reach, or borrow areas within the lower Umatilla watershed. If the amount of material needed is more than can be obtained through these sources, plant stock should be ordered from nurseries as close as possible to the project reach, to ensure that plants are well-adapted to site conditions. Sources of stock should be determined as soon as possible, to provide adequate time for on-site or contract growing.

Prior to construction and planting, a habitat biologist should clearly flag areas where salvage is to be permitted (as well as clearly flagging native vegetation to be retained). Rooted stock that is to be salvaged on-site or obtained from adjacent landowners can be scalped, a method that results in the least disturbance to the soil/root matrix. A front-end loader can be used to excavate soil and plants, and move them immediately to the proper location. Both rooted stock and cuttings should be protected from desiccation and planted as soon as possible after they are obtained.

Bank Treatments and Floodplain Plantings

Native willows develop the type of root structure that will help to stabilize soils, have stem densities that would add channel roughness and help to slow flood flows, and their growth habit would provide overhanging cover and shade to the stream. Coyote willow (*Salix exigua*) rooted stock is recommended for packing around vanes, W-weirs, boulder/rootwad bank treatments, and along the outsides of meander bends. Cuttings and live stakes of coyote willow can also be used to fill in between bank structures. Cuttings and stakes must be cleanly cut, tamped into the soil to ensure contact with water during low-flow periods of the year, and clipped back to a minimum of 6 inches. Cuttings and stakes should be installed on 18-24 inch centers.

Information provided by CTUIR staff indicates that arroyo willow (*S. lasiolepis*) and whiplash willow (*S. lasiandra var. caudata*) do well on upper banks and farther distances from the water (J. Ebaugh, CTUIR, pers. comm. December 7, 1998). Rooted stock is preferred, and should be planted on 3-foot centers.

Cottonwood (*Populus trichocarpa*) and alder (*Alnus rubra*) are recommended for planting in the floodplain at the lowest elevations. Rooted stock (seedling/sapling size) is preferred. Farther from the water, inclusion of species such as chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier alnifolia*), hawthorn (*Crataegus douglasii*), blue elderberry (*Sambucus cerulea*), oceanspray (*Holodiscus discolor*), and snowberry (*Symphoricarpos albus*), in addition to cottonwood and alder, would increase diversity in the riparian plant community. These should also be planted as rooted stock.

To provide rapid groundcover, an erosion control seed mix is recommended in most areas disturbed by construction. Seed mixes should be composed of native species where possible.

Size and Spacing

The planting groups described below should be refined in consultation with the WID, CTUIR and NRCS.

Bank Protection at Outside Meander Bends				
Common Name	***Scientific Name***	**Stock**	**Size**	**Spacing**
Coyote willow	*Salix exigua*	rootstock, contract grown and on-site salvage	up to 4” dbh	packed
Coyote willow	*Salix exigua*	cuttings, contract grown and on-site salvage	48”-60” length, ½”-1” diameter	18-24” OC

Bank Protection at Inside Meander Bends					
Common Name	***Scientific Name***	**Percent**	**Stock**	**Size**	**Spacing**
Coyote willow	*Salix exigua*	50	cuttings	48”-60” length, ½”-1” diameter	18”-24” OC
Arroyo willow	*Salix lasiolepis*	25	cuttings	48”-60” length, ½”-1” diameter	18”-24” OC
Whiplash willow	*Salix lasiandra var. caudata*	25	cuttings	48”-60” length, ½”-1” diameter	18”-24” OC

Lower-Elevation Floodplain					
Common Name	***Scientific Name***	**Percent**	**Stock**	**Size**	**Spacing**
Arroyo willow	*Salix lasiolepis*	20	rooted	2’-3’	3’-6’ OC
Whiplash willow	*Salix lasiandra var. caudata*	20	rooted	2’-3’	3’-6’ OC
Cottonwood	*Populus trichocarpa*	50	rooted	3’-4’	9’-12’ OC
Alder	*Alnus rubra, A. rhombifolia*	10	rooted	3’-4’	9’-12’ OC

Higher-Elevation Floodplain					
Common Name	***Scientific Name***	**Percent**	**Stock**	**Size**	**Spacing**
Cottonwood	*Populus trichocarpa*	50	rooted	3’-4’	9’-12’ OC
Alder	*Alnus rubra, A. rhombifolia*	25	rooted	3’-4’	9’-12’ OC
Chokecherry	*Prunus virginiana*	5	rooted	2’-3’	6’-9’ OC
Serviceberry	*Amelanchier alnifolia*	5	rooted	2’-3’	3’-4’ OC
Blue elderberry	*Sambucus cerulea*	5	rooted	2’-3’	3’-4’ OC
Snowberry	*Symphoricarpos albus*	5	rooted	18”-24”	3’-4’ OC
Rose	*Rosa woodsii*	5	rooted	18”-24”	3’-4’ OC

Maintenance

Maintenance activities will need to include irrigation, protection from browse damage, and replanting if plant survival does not meet agreed-upon performance standards. New plantings will require irrigation during the first two years following project implementation. Irrigation water could be supplied from the Umatilla River through use of pumps and a rainbird-type sprinkler system. Fencing along a portion of the left bank would prevent cattle from browsing and/or trampling plantings. Vexar tubing would be effective in protecting new plantings from both cattle and wildlife, but would not prevent trampling of seeded areas.

One of the most important elements of the maintenance program will be control of invasive weeds. Noxious weeds, including yellow star thistle (*Centaurea solstitialis*) and Russian thistle (*Salsola kali*) in particular, are common throughout the project area. Soil preparation (i.e., repeated plowing-fallow cycles, herbicide treatment) should be considered, and regular control measures will be especially important during the first three to five years following construction. Over time, native trees and shrubs will create shaded conditions that are not conducive to the spread of herbaceous invaders. An overall weed control strategy should be coordinated with the landowners, CTUIR and the Umatilla County Noxious Weed Control Board.

4.3 Functional Design Alternative – Feed Canal Dam

4.3.1 Design Goals

- Ensure Feed Canal Diversion retains capability to meet diversion requirements as well as or better than the existing diversion.
- Provide unrestricted upstream and downstream fish passage for both juvenile and adult target species between the minimum and maximum design flows.
- Improve ability of diversion to pass bedload downstream to minimize deposition of bedload material around the diversion dam and intake headworks.
- And, consequently, reduce level of operations and maintenance required at the diversion.

4.3.2 Design Criteria and Considerations

- Design River Flows - The 95 percent and 5 percent monthly exceedence flows for the Umatilla River at the Feed Canal Diversion were selected as the minimum and maximum design flows respectively (See Figure 3.4.1, Feed Canal Diversion Event Timing Chart). These exceedence flows were determined from analysis of daily stream flow data on the Umatilla River at the Yoakum gauge (USGS Gage 14026000, YOKO) (See Section 3.1, Hydrology). To reflect relatively recent changes in the basin, only the last 50 years of record were used.

  The 95 percent and 5 percent monthly exceedence flows are typical design flows for fish passage projects in the Pacific Northwest. This criteria provides a reasonable low-to-high flow design range that allow fish movement under normal flow conditions, as fish do not normally migrate actively or effectively during extreme flow conditions.

- Design Diversion Flow – 245 cfs - (Bernie Meskimen, Project Construction Engineer, USBR, Memo – Feed Canal Corrective Work, September 13, 1991). The existing fish screens are designed to operate between 210 cfs and 270 cfs (70 percent and 90 percent submergence respectively). Current canal capacity is estimated to be approximately 220 cfs (pers. comm., Paul Gregory, USBR, January 5, 2000). As with the design river flows, historical 5 percent and 95 percent monthly exceedence flows for the gauge on the Feed Canal near Echo (USGS gauge 14029000, FCEO) were determined for the last 50 years of record (Appendix B).
- Design Forebay Level – WSEL 656.5 - (Bernie Meskimen, Project Construction Engineer, USBR, Memo – Feed Canal Corrective Work, September 13, 1991). The design water surface elevation to achieve the design diversion flow of 245 cfs.
- Headworks Structure IE 654.2 - The surveyed invert elevation of the floor slab for the headgates at the Feed Canal headworks structure (surveyed July 1999).

4.3.3 Proposed Modifications

Notch Dam – Notching the dam crest creates a defined channel through the dam. Presently, the channel's approach to the dams can change over time, even season to season. Sediment carried by the river is trapped behind the dam face, creating a broad sediment wedge, locally elevating the channel bed. The river responds by shifting its channel, and thereby changing its approach to the dam. Hence, the channel below the dam is not stable and can vary in time and space. With a notch in the dam, the river channel is fixed in its approach through the dam. In turn, the channel immediately below the dam is fixed, and design and implementation of channel-stabilizing efforts below the dams are far more likely to succeed.

Notching the dam first requires that the crest elevation across the entire length of the dam approximates the level of the sediment wedge behind the dam. Next, the dam is notched to the design dimensions of average bankfull width and depth, which were calculated for the stable channel form at 87 feet and 6.2 feet respectively. Grade control will be achieved with instream structures such as W-weirs and cross vanes (see Drawing 12). Following construction and installation of the upstream grade control weir, the channel is allowed to headcut its way to equilibrium upstream.

W-Weir Diversion – To compensate for notching the dam, a W-Weir is proposed as the alternative structure to provide diversion flows for the Feed Canal. The W-Weir diversion would include a W-Weir, an "in-river" diversion channel, and a sluice gate (See Drawings 6 and 9). Because the low point(s) on the crest of W-Weirs are set at the same elevation of the riverbed, it necessarily would be located upstream of the Feed Canal Diversion to still provide the required forebay level at the diversion headworks. The W-Weir would also act as a grade control structure.

At the time of this report, no stage-discharge rating curves or equations were available for W-Weirs. Therefore, it was assumed that a W-Weir could be conservatively approximated using V-Notch weir equations. Assuming the 245 cfs design diversion flow and 250 cfs required minimum instream flow, it was estimated that a minimum crest elevation of approximately 655 would provide the required forebay WSEL 656.5 at the diversion headworks. The W-Weir structure would be located approximately 600 feet upstream of the Feed Canal Dam. This location will be where the anticipated "natural thalweg" of the river will be at approximately El. 655.

(In the original scope of work, it was proposed that HEC-RAS be used to hydraulically model the proposed changes to the dam and river. It was since determined that this model would be inappropriate. HEC-RAS is a one-dimensional, gradually varied flow model, whereas flow through the proposed W-Weir, dam notch, and other instream structures would in reality be three-dimensional, rapidly varied flow.)

Because the low-points of the W-Weir would be set at the "natural thalweg" of the river, there consequently would not be a physical barrier to upstream migration. Although core velocities through the W-Weir may exceed the swimming capabilities of upstream migrants during high flows, the cross-sectional velocity gradient of W-Weirs is characteristically steep. Therefore, perimeter velocities would remain low and navigable by the target species. (A study by B. Rosgen (unpublished) compared vertical velocity profiles through a W-rock weir, a rock vane, and a control cross section that had no rock structures. The study showed that the W-weir had the highest maximum velocity and higher mean velocity than the control, but created deep backwater eddies in which fish could "hold.").

An “in-river” diversion channel would connect the W-Weir to the headworks, effectively extending the Feed Canal upstream to the W-Weir. The diversion channel would be created by constructing a berm parallel to the right bank of the river between the W-Weir and the diversion headworks. Assuming normal flow conditions, a depth of 2.3 feet and negligible backwater effects at the headworks, it was estimated that a trapezoidal channel with a 30-foot bottom width, 1.5:1 sideslopes, and a 0.0013 channel slope will have the capacity for the 245 cfs design diversion flow.

A sluice gate would be located at the downstream end of diversion channel, adjacent to the left abutment of the headworks structure. The sluice gate would allow for removal of accumulated bedload material in the vicinity of the headworks. This would be accomplished by opening the sluice gate to increase flow velocities upstream and consequently flush sediment deposited in front of the headworks. The funneling effect of the tapered diversion channel along the headworks would also help increase velocities as flow approaches the sluice gate during sluicing operations (see Drawing 9). The gate would also add an additional means of flow and water surface control at the headgates.

4.4 Functional Design Alternative – Westland Diversion

4.4.1 Design Goals

- Ensure that Westland Diversion retains its capability to meet diversion requirements as well as or better than the existing diversion.
- Provide unrestricted upstream and downstream fish passage for both juvenile and adult target species between the minimum and maximum design flows.
- Ensure the existing fish ladder will effectively operate between the minimum and maximum design flows.
- Improve the ability of the diversion to pass bedload downstream to minimize deposition of bedload material around the diversion dam, intake headworks, and fish ladder.
- And, consequently, reduce level of operations and maintenance required at the diversion.

4.4.2 Design Criteria and Considerations

- <u>Design River Flows</u> - The 95 percent and 5 percent monthly exceedence flows for the Umatilla River at the Westland Diversion were selected as the minimum and maximum design flows respectively (See Figure 3.4-2, Westland Diversion Event Timing Chart). These exceedence flows were determined from analysis of the difference in the daily stream flow data on the Umatilla River at the Yoakum gauge (USGS Gage 14026000, YOKO) (See Section 3.1, Hydrology) and the gauge on the Feed Canal near Echo (USGS gauge 14029000, FCEO). In other words, the FCEO daily flows were subtracted from the YOKO daily flows to synthesize a period of record at the Westland Dam. To reflect relatively recent changes in the basin, only the last 50 years of record were used (See Section 3.1, Hydrology).
- <u>Design Diversion Flow – 245 cfs</u> - As with the design river flows, historical 5 percent and 95 percent monthly exceedence flows for the gauge on the Westland Canal near Echo (WESO gauge No. 14030500) were determined for the last 50 years of record (Appendix B).

4.4.3 Proposed Modifications

The dam would be notched to approximately IE 636 between the left abutment and the existing fishladder and also for 30 feet on the right side of the ladder (see Drawings 7 and 10). This would be approximately 1.1 foot lower than the headworks IE 637.1. The remaining dam crest would be raised approximately 0.75 feet to EL 642, which is the proposed design bankfull elevation. It was estimated that the combination of notching the dam and raising the remaining dam crest would not reduce the overall capacity of the dam to pass high flows. Therefore, it is assumed that no additional diking on the riverbanks near the dam would be required.

The proposed notch would be outfitted with a new flashboard system on either side of the fish ladder to maintain the necessary forebay levels for required diversion flows.

5. MONITORING PLAN FOR FISH AND FISH HABITAT, CHANNEL MORPHOLOGY, AND RIPARIAN RESOURCES

5.1 Introduction

One of the tasks outlined in the proposed Westland Irrigation District (WID) study is to consult with CTUIR, ODFW, USBR, and other resource agencies in the development of a plan to monitor the implementation and effectiveness of the Westland/Ramos restoration project. Implementation and effectiveness are two key components of the project certification process, a tool which has been employed in the evaluation of numerous fish facilities in the Columbia Basin (Carlson and Costello, 1997). Implementation monitoring is used to assess whether projects are constructed as designed. Effectiveness monitoring is used to measure project performance. If monitoring indicates that a project is not performing as designed, then remedies to the problem are sought. Further, if monitoring shows no significant improvement in key parameters, adaptations to the project and to other future projects need to be developed. This is a basic tenet of adaptive management.

For the Westland/Ramos restoration project, implementation monitoring will address construction of the habitat and channel treatments. Effectiveness monitoring will help to identify maintenance requirements and any design modifications that may be needed. The monitoring plan includes the following elements:

A. Objectives and strategies;

B. Identification of critical biological and physical attributes and associated parameters or measurements for evaluating project performance;

C. Sampling designs, methods, and schedules for data collection, data analysis and reporting;

D. Estimates of annual costs.

Each of these elements is addressed in more detail in the following sections. However, a final plan that includes specific methods, performance standards and maintenance requirements will need to be completed following consultation with the resource management agencies, CTUIR, and other stakeholders after the project design has been finalized.

5.2 Monitoring Objectives and Strategies

The objectives of the monitoring plan are to:

- Provide an accurate characterization of a baseline condition for the in-channel and riparian resources at a level of precision and detail suitable for performance monitoring.
- Provide statistically valid information that documents changes and trends in habitat unit distribution, abundance, and quality.
- Conduct the monitoring activity over a time span that will fully document the performance and effectiveness of the treatments (riparian and in-channel).
- Establish concrete standards for parametric measurement of each attribute (physical and biological), so that project performance can be adequately evaluated for use in future

restoration efforts within the Umatilla River watershed and elsewhere (Adaptive Management).

Monitoring strategies will concentrate on measurements and comparisons of stream habitat attributes relative to baseline conditions in the project area (treated reach) and relative to those parameters in the stream reach (untreated) immediately upstream of the project area. Under current conditions, low flows and high water temperatures appear to be the primary limiting factors during July through October in the river reach between the Westland and Feed Canal dams. However, this reach has the potential to provide quality anadromous salmonid habitat year-round.

Based on recent assessments of fish habitat conditions, the lack of habitat complexity limits anadromous fish production in the study reach (Table 5.2-1). Long monotypic glides and short riffles that provide very little to no cover dominate the reach. Currently, no off-channel rearing areas and few pool habitats exist in the reach. While the reach appears to contain an adequate amount of quality spawning gravel, large cobbles and boulders are extremely rare. Large, stable LWD is also limited.

Table 5.2-1. Summary of potential factors limiting anadromous salmonid production (by life stage) in the Umatilla River between the Westland and Feed dams.

Life Stage	Observed or Potential Limiting Factors
Upstream Migration of Adults	The reach lacks instream cover including: deep pools, LWD, submerged objects, and undercut banks. Passage conditions are not ideal, although dams are equipped with fish ladders.
Spawning	Gravel quantity and quality does not appear to be a limiting factor in the reach. However, the existing channel lacks the transition areas between pools and riffles. Instream cover is also limited.
Egg Incubation	Existing gravel appears to be relatively free of fine sediment. However, channel shifts can strand redds and bedload movement can scour out and/or fill-in salmon redds.
Freshwater Rearing	***Food Availability:*** Data describing macroinvertebrate production in the reach is lacking, but production could benefit from an enhanced riparian area. Out-of-stream sources of organic matter (i.e. leaves from riparian plants) may be limited by the relatively narrow riparian zone through the reach. Retained organic detritus is also limited due to the lack of pools. ***Dissolved Oxygen and Turbidity:*** Dissolved Oxygen for salmonid spawning did not meet ODEQ listing criteria (from mouth to Speare Canyon). Turbidity during spring and summer is limiting (303(d) List) due to rate of increase. ***Channel Morphology:*** The reach lacks a diverse mixture of habitat types. Glides and riffles were the dominant habitat types observed in the reach in 1998 and 1999. Deep pools and quality off-channel habit do not exist. The lack of pools in the reach is due to a lack of large channel forming features (including LWD, boulders, and bedrock outcrops), and due to insufficient channel capacity to transport its bedload through the reach. ***Instream Cover:*** Cover in the form of LWD, undercut banks, cobble and boulder substrate, water depth and turbulence, and aquatic vegetation is limited to only about 10 percent of the wetted habitat area. This is well below optimal levels.
Seaward Migration	Same as freshwater rearing.

The restoration plan is designed to improve habitat for anadromous fish by addressing these limiting factors. In-channel treatments within the project area include:

- Restoration of channel and flood plain areas to reduce the width-to-depth ratio and provide a stable channel form in plan, profile, and dimension;
- Construction of in-channel grade control structures (W-weirs, cross vanes, and J-hook vanes) that also function to protect erodible banks and provide fish habitat;
- Placement of anchored root wads to enhance fish habitat; and
- Reconstruction and treatment of raw or eroding banks with established sod mats to minimize effects of scour.

The in-channel treatments to this reach are expected to benefit anadromous salmonid populations by:

- Increasing habitat type diversity (creating pool habitat for rearing and holding);
- Increasing the amount of available cover (LWD, depth, and turbulence);
- Stabilizing the existing channel and reducing the potential for future problems;
- Minimizing the deposition of fine sediment;
- Concentrating the flow during low-flow periods of the year;
- Increasing D.O. levels through increased turbulence;
- Reducing summer water temperature by decreasing the wetted width (surface area) and increasing the depth of the channel; and
- Providing low velocity areas (pools) to retain organic detritus for macroinvertebrate production.

Riparian treatments to this reach will include tree and shrub plantings, and grass/reed introductions, especially within reconstructed bank areas. Further options include livestock exclusion areas, remote watering structures, and fencing projects. The riparian treatments to this reach are expected to benefit anadromous salmonid populations by:

- Increasing the amount of instream cover in the form of overhanging vegetation, and future inputs of LWD;
- Further stabilizing the reconstructed stream channel and banks;
- Reducing inputs of solar radiation (reducing temperatures);
- Increasing inputs of organic material for macroinvertebrate production;
- Enhancing the production of terrestrial insects as a food source;
- Reducing nutrient enrichment via livestock waste; and,
- Reducing or eliminating trampling of banks by livestock.

5.3 Biological and Physical Attributes to be Monitored

Tables 5.3-1 and 5.3-2 summarize the biological and physical attributes that will be monitored, the reasons why each is important, and the methods and schedule for monitoring. Monitoring methods are discussed in more detail in Section 5.4 (Methods and Procedures)

Table 5.3-1. Attributes, objectives, methods, and sampling frequency for monitoring in-channel treatments and fish habitat quality.

Attribute	Objective	Methodology	Frequency
Vertical channel stability	Determine whether the channel is vertically stable; determine rate, magnitude, and direction of vertical change.	Establish and measure permanently monumented cross-sections on each of at least a riffle and pool segment. Include floodplain, terrace, and active channel. In establishing cross section, include installation of toe pin and scour chain. Provide vicinity map, detailed site map, and upstream and downstream photographs.	Annually, during low flow conditions.
Lateral stability	Determine the rate of lateral migration due to bank erosion; determine rate, magnitude, and direction of lateral change.	Install bank pins at sites established for vertical stability (at pools on outside bend of meanders and in straight riffle reaches).	Annually, during low flow conditions, and periodically following a 2-year storm.
Bed material size distribution	Observe shifts in bed material size distributions.	Measure using Wolman (1954) pebble count method in transects established for vertical stability.	Annually, during low flow conditions.
Wetted channel width to depth ratio.	Determine if river flows are becoming concentrated into a narrower and deeper channel during low flow conditions.	Establish a permanent transect to monitor wetted width and depth over time.	Annually, during low flow conditions.
Percent habitat type by area and volume as well as pool quality.	Determine whether the habitat improvement structures have increased habitat type diversity over time. Determine the quality of created pool habitat. (Residual Pool Depth).	Inventory fish habitat in the study reach using guidelines presented in USFS (1995), Moore et al. (1993), or similar methodology.	Annually, during low flow conditions.
Percent total in-stream cover and cover type.	Determine if habitat improvement structures (in-channel and riparian improvements) are providing useable cover for anadromous fish populations.	As part of the habitat surveys, determine percent useable cover for each habitat unit and total cover for the entire survey reach (USFS 1995).	Annually, during low flow conditions.
Percent area and rating of the quantity and quality of all substrate types.	Determine if habitat improvement structures are creating diverse substrate types. Are substrate types changing over time?	As part of the habitat surveys, estimate percent substrate type for representative habitat units (riffle/pool tailouts) in the survey reach.	Annually, during low flow conditions.

Table 5.3-1. Attributes, objectives, methods, and sampling frequency for monitoring in-channel treatments and fish habitat quality (continued).

Attribute	Objective	Methodology	Frequency
Macro-invertebrate diversity and relative abundance	Determine if habitat improvement structures are creating diverse habitat types for other macro-invertebrate groups (species diversity) and to which overall abundance is increasing.	Sample various habitat units (pools vs. riffles) for macroinvertebrate diversity and abundance using kick nets and/or Surber sampler (ABA 1996).	Annually, during low flow conditions.
Fish species and lifestage presence and relative abundance.	Determine effectiveness of restoration activities on fish populations.	Monitor fish spawning activity and fingerling production in the survey reach. Spawning surveys and juvenile snorkel surveys (or electro-fisher sampling).	Annually or biannually during low flow conditions and periods of adult spawning.

Table 5.3-2. Attributes, objectives, methods and sampling frequency for monitoring riparian habitat treatments.

Attribute	Objective	Methodology	Frequency
All plantings	Determine stability of bioengineered features and overall success of revegetation efforts, especially in relation to potential to provide shade.	Visual inspection of entire reach; photo-documentation at permanently established photo-points.	Visual inspections monthly and ASAP after 2-yr. or greater storm event during Year 1; Photos quarterly during Year 1; then annually in October
Willow fascines and brush layers	Determine percent survival, percent cover; identify maintenance (e.g., irrigation, protection from animal damage, disease, competition from weedy invasive plants) and/or replacement needs.	Visual estimates of survival and stem density for each layer for each 100-foot segment of planted reach; calculate trends on each subsequent visit.	Quarterly in Year 1; then annually in October
Cuttings, live-stakes and rooted stock	Determine percent survival, percent cover; identify maintenance and/or replacement needs.	Mark 10 percent of planted material using color-coded metal stakes. Use total of live marked plants in relation to number of original marked plants to determine percent survival on each subsequent visit.	Quarterly in Year 1; then annually in October
Seeding/sod	Determine percent cover; identify maintenance and/or replacement needs.	Mark permanent plots to cover minimum 1 percent of planted area; estimate percent cover; note plant condition, note noxious weeds on each subsequent visit.	Quarterly in Year 1; then annually in October

5.4 Methods and Procedures

5.4.1 Channel Characteristics

Channel monitoring methods include collection of specific measurements and photographs in order to evaluate changes to channel stability. Measurements are made using standard survey methodology to document vertical stability, lateral stability, and bed material distribution.

Vertical Stability

This method employs the use of permanently monumented cross-sections located on at least a riffle and pool segment of a reach. An elevation benchmark for the cross-section is located on a stable site above the active channel. The profile of the stream cross-section is measured from the intercept of the rod with a tape line leveled from the benchmark. Distance and elevation are read at the intercept of the rod with tape. Major features to measure include left and right benchmark, terraces, bankfull elevations, edges of water, channel configuration across the bed, thalweg, and inner berm features. Cross sections are plotted for each measurement event and compared to previous cross-sections.

Lateral Stability

This method is used to determine the rate and magnitude of bank erosion. Erosion rates can be expressed in feet per year, cubic yards per year, or total tons per stream reach. Two or three bank pins are installed horizontally on the outside of meander bends and in representative straight reaches through riffles at permanently monumented cross sections. Pins should be 1/2” to 5/8” in diameter and four to five feet in length. The distance between the end of the pins and the banks are measured. Data is plotted to display the bank profile for each survey, and compared with previous surveys annually or following storms. The mean erosion or deposition rates are then computed.

Bed Material Size Distribution

A pebble count method (e.g., Wolman 1954) is used at permanently established transects during low flow. Existing and departures of a frequency of particle size distributions are obtained by measuring 100 particles from bed material at riffles and pools. Distribution frequencies are compared to previous distributions.

5.4.2 Fish and Fish Habitat

Habitat Surveys

Stream habitat surveys can be used to inventory specific habitat types based on established methodologies, i.e. USFS (1995), Pleus et al. (1999), Moore et al. (1993). These surveys are designed to objectively quantify fish habitat available to juvenile salmonids during the low flow season. Attributes to be measured in the survey methodology are:

- Percent habitat type by area and volume as well as a measure of pool quality.
- Wetted channel width to depth ratios.
- Percent total in-stream cover and cover type.

- Percent area and rating of the quantity and quality of all substrate types (Pebble Count methodology, Wolman 1954, or Riffle Stability Index methodology, Kappesser 1993).
- Condition of habitat improvement structures.

Procedure

A two-person crew equipped with a hip chain and stadia rod, identifying discrete habitat units (pool, riffle, glide, cascade), then measuring length and width of each unit, average depth (maximum and tail crest depths for pools), and a percent estimate and typing of any cover components (vegetation, undercut banks, depth, turbulence, LWD) within the unit. Photo points will also be established to document recovery visually. Estimated time for each of the reaches, treated and untreated, one day each; two day total during late summer.

Macroinvertebrate Sampling

Macroinvertebrate sampling is used to quantify biomass and quality of stream prey items available to juvenile salmonids. Macroinvertebrate community structure can also be used to evaluate inputs and processing of fine and course particulate organic matter (FPOM and CPOM), i.e. leaf litter, woody debris, and other vegetative matter.

Procedure

A two-person crew equipped with a kick-net and collection jars (with a 50 percent alcohol solution), will sample using the 3 habitat sampling protocol developed by ABA (1996) wherever possible. The three-habitat protocol involves acquiring samples in a consistent manner from erosional, margin, and detritus habitats.

Erosional Habitat Sample

Semi-quantitative method using a kick-net to acquire a composite sample from 5 stations in representative erosional microhabitats (riffles, glides, cascades, chutes, etc.) within a study reach. The total area sampled at each sample station is approximately one square meter. A kick-net with 500 micron mesh is operated much like a Surber sampler. A brush is used to remove invertebrates from armor layer rocks, then underlying sediments are thoroughly stirred to a depth of 5-10 centimeters.

Margin Habitat

This is a non-random, semi-quantitative sample that targets “best available” cobble microhabitats along slack or slow-water areas of the stream margin. Twenty cobbles are selected from varied locations on the margin. Invertebrates are scrubbed and washed from these cobbles to obtain the margin sample (500 micron mesh employed).

Detritus (CPOM) Habitat

“Best available” detrital accumulations are sampled to determine the extent of the shredder (large particle detritivores) community at a site. A gallon of the most biologically active detrital material is taken from a variety of points in a study reach.

Six to ten sample areas for each of the sample reaches (treated vs. untreated) will be sampled. Estimated time to sample each of the reaches, treated and untreated, two days each; four days total during late summer. Samples will be sent to ABA for analysis.

Fish Species and Abundance

Because of the varied impacts to salmon production throughout all life stages, it is extremely difficult to quantify any increased fish production due solely to habitat improvement. For this project, it is more productive to document changes in the physical stream habitat. Fish use can be documented during certain critical periods, such as summer low-flow or spawning periods, but these measures are relative to overall production in the basin.

Procedure

Conduct spawning ground surveys for fall chinook, coho, and steelhead in both the treated project area, and the "control" region immediately upstream. Summer low flow habitat use by juvenile coho and steelhead can be measured via snorkel surveys or electrofish sampling, then comparing year to year variability and fish use within the treated versus control reach upstream.

5.4.3 Riparian Habitat

Riparian habitat monitoring methods include a broad-level check on the success of plantings using permanent photo points, and the collection of more detailed numerical data for each type of revegetation measure. In addition to estimates of survival, monitoring will be used to identify signs of desiccation, disease, insect or animal damage. It will be especially important to document the presence, abundance and distribution of noxious weeds. Results of the surveys will be used to document progress toward performance standards determined by WID, ODFW, CTUIR, and USBR.

Photo Documentation

Photo documentation provides a rapid and easily-repeated check on the success of plantings over time.

Procedure

Permanent photo points will be established immediately following planting, by installing and marking metal fence posts at 500-foot intervals along each bank, with photo points on each bank offset to provide coverage at 250-foot intervals. Photos will be taken in each cardinal direction at each photo point by focusing on a staff gauge or survey rod held 20 feet from the camera. This arbitrary distance will standardize information collected at each photo point during each survey effort, but additional photos will be needed, at varying focus distances, to record plant growth and density.

Bank Treatment Surveys

Bank revetments, vanes and W-weirs are critical elements of the channel design, and the success of plantings associated with these structures will be an important factor in establishing and maintaining channel stability.

Procedure

Due to the effect of planting success on overall project success, survival of willows installed as protection for outside meander bends will be monitored at each site where the treatment is used, rather than selecting a subsample for numerical assessment. A metal stake will be installed at the upstream and downstream end of each treated site. Each site will be divided into 50-foot segments using a hipchain. Percent survival along each segment will be estimated. General condition of the plantings, including notes regarding vigor, flowering, fruiting, and suckering, will be recorded.

Flagged Plant Counts and Transect Surveys

Approximately 25 acres of the floodplain along the reconfigured channel will be planted with cuttings, live-stakes and rooted stock of native trees and shrubs. Depending on soil/substrate characteristics, seeding with a native grass/forb mix is also recommended. Two approaches can be used to evaluate planting success in these areas. Flagged plant counts provide a determination of survival. Transect surveys using methods developed by Horner and Raedeke (1989) can be used to collect more detailed information about planting success, natural revegetation, and potential invasion of noxious weeds, but are more time-consuming, and therefore more expensive to perform.

Procedures

The total area to be planted will be divided into 10 planting sites. For flagged plant counts, 10 percent of the plants installed at each site will be marked at the time of planting, using color-coded flagging to identify species. During monitoring surveys, the marked plants will be classified as: live, stressed, tip die-back, basal sprouts, not found, apparently dead, and dead. The total of live marked plants in relation to the number of original marked plants will be used to calculate percent survival (within each site and through the project reach) on each monitoring visit. In addition to survival, information about condition will be used to help determine maintenance needs (irrigation, pesticide treatment, browse protection). Recruitment and colonization by volunteer species will be also be evaluated.

For transect surveys, a baseline parallel to the river will be established for each site. A minimum of four transects will be laid out perpendicular to the baseline, extending from the ordinary high water mark through the planted area to the landward edge of the site. Along each transect, permanent plots measuring 10 feet by 10 feet will be established, and a metal stake will be installed at plot center. The interval between plots will be determined in part by the number of transects established, with the objective being to establish a minimum of 40 plots per planting site. Within these 10 foot by 10 foot plots, 5 foot by 5 foot plots will be established to estimate herbaceous cover. Canopy coverage of each species in each tree/shrub plot and each herbaceous plot will be recorded as a coverage class (Daubenmire 1959). This approach is recommended in order to minimize variability between observers and monitoring events, while maintaining a standardized approach. Each species encountered in a sample plot will be recorded by coverage class, as shown below (Table 5.4-1), in order of dominance. The coverage of bare ground will also be recorded.

Table 5.4-1. Estimation of canopy coverage by class.

Coverage Class	Range of Coverage	Midpoint of Range
1	0-5%	2.5%
2	6-25%	15%
3	26-50%	37.5%
4	51-75%	62.5%
5	76-95%	85%
6	96-100%	97.5%

Calculation of canopy coverage for each species is converted from the coverage class to a percentage by first adding the midpoint values for each species on the plot, and then dividing the sum by the number of plots examined.

At a minimum, five years of monitoring are recommended. During the first year, a visual inspection will be conducted at monthly intervals and immediately following 2-year or greater flood events, primarily to identify maintenance needs, such as irrigation or browse control. Monitoring using photo documentation and numerical assessment will be conducted at 3-month intervals (January, April, July, October), and immediately following 2-year or greater flood events, during the first and second years following planting. Monitoring will be conducted annually in October during the third, fourth and fifth years after planting.

The results of the monthly visual inspection during the first year will be provided by telephone to the Project Manager within one week following the inspection. Brief quarterly reports will be submitted to the Project Manager within one week following each monitoring event. These reports will include 1) maintenance activities conducted during the previous quarter; 2) survival and percent cover data; 3) additional problems identified; and 4) recommended treatments. Color photos and field notes will be included as appendices.

Annual reports will be submitted to the Project Manager by December 1st. Results for each type of planting will be numerically analyzed, described and summarized. Color photos and field notes will be included as appendices.

5.5 Annual Costs

Costs associated with the proposed monitoring plan will primarily reflect the cost of labor to conduct the monitoring. Therefore, an estimate of labor hours is provided. For total project cost estimating purposes (Section 6), we have assumed a rate of $70 per hour. The labor hour estimates shown below (Table 5.5-1) should be considered initial predictions. Frequency and timing of visits should be modified, if necessary, based on the results of monitoring during the first two years.

The estimates shown in Table 5.5-1 are based on the assumption that monitoring activities would be conducted by biologists and scientists who are trained and experienced in river morphology, fisheries and fish habitat sampling and analysis, and vegetation measurement and riparian restoration techniques. Costs could be substantially reduced if qualified local personnel (e.g., Pendleton, Hermiston, Echo) are employed for the monitoring effort.

Table 5.5-1. Estimated labor hours, by year and task, to complete a 5-year monitoring plan.

Year	Task	Field Work	Data Analysis	Reporting	Total
1	Channel	96	52	40	188
	Fish	240	160	80	480
	Riparian	248	80	98	426
	Subtotal	584	292	218	1,094
2	Channel	48	24	32	104
	Fish	240	160	80	480
	Riparian	96	32	72	200
	Subtotal	384	216	184	784
3	Channel	48	24	32	104
	Fish	240	160	80	480
	Riparian	24	8	40	72
	Subtotal	312	192	152	656
4	Channel	80	40	32	152
	Fish	240	160	80	480
	Riparian	48	16	40	104
	Subtotal	368	216	152	736
5	Channel	48	24	32	104
	Fish	240	160	80	480
	Riparian	24	8	40	72
	Subtotal	312	192	152	656
Total Hours		**1,960**	**1,108**	**858**	**3,926**

* Hours for channel and riparian monitoring in years 1 and 4 assume occurrence of a 1.25-year or greater flood event, which would require an additional monitoring visit.

Estimated labor hours reflect the assumption that monitoring of channel, fish, and riparian attributes would be conducted independently. However, overall costs could be substantially reduced if travel costs are shared between resource areas.

5.6 Recommendations

As described in the introduction to this monitoring plan, a final plan will be developed in consultation with the WID and the fisheries resource agencies (CTUIR and ODFW). The plan will include a framework and process (information feedback ‘loop’) for deriving and analyzing parametric measurements, generating conclusions, supporting decisions, and implementing actions relative to the project performance. Parametric measurements of physical and biological attributes will be used for evaluating the performance of project in-channel and riparian treatments. Information derived from the performance evaluation will generally be used for the following actions:

- Determination and implementation of project operation and maintenance requirements,
- Adaptation of design components for improved project performance, and
- Transference of technology to the design of future projects.

6. COST ESTIMATES

Planning level costs, detailed in Table 6-1 for the channel modifications, are subtotaled to show:

- Construction cost with a 20 percent contingency; engineering, permitting, and administration cost calculated at 25 percent of the construction cost.
- Total project cost.
- Monitoring plan cost.
- Operation and maintenance costs estimated at 3 percent annually of the total project cost.

These costs were estimated using known unit and lump sum costs from similar types of projects, the Means 1999 Heavy Construction Cost Data, and standard engineering practice for planning level cost estimates. The total construction cost calculated for the project at this level is based on our best estimate of the quantities of the major items required for the project. Quantities, such as cubic yards (CY) of excavation and embankment materials, were conservatively calculated from very limited survey data. As these estimates are very coarse, caution should be exercised in using them for comparison purposes with similar types of projects that have been implemented.

At this stage in the planning process, the cost of constructing the proposed channel alignment is the major component, which would primarily be the earthwork involved in forming the new channel. The rock channel structures are also a major cost component of the design. Along with concrete demolition of the existing dam structures for the proposed channel notch, the channel construction and materials are over half the capital cost of construction. As the design progresses to the next level, the details will be more defined, and costs will be based on more specific quantities.

The general category includes mobilization, care and diversion of water, and site restoration. Mobilization costs are estimated to be roughly 10 percent of the construction cost subtotal. Care and diversion of water will depend on the permitting requirements for the instream work, which are difficult to estimate accurately at this time. Site restoration includes costs for regrading access roads, regrading and revegetating construction staging areas, and general cleanup after construction.

Costs estimated for riparian construction include vegetation enhancements along the channel boundaries and within the flood prone area, root wads and large woody debris.

The 20 percent contingency applied to the construction subtotal is an estimate of unknown costs of materials and construction, which may or may not change with more detail at the next level of design. The monitoring plan would take place for five years after construction is complete. At the end of the five-year period, the effectiveness of the new channel alignment and enhancements will be evaluated, and a report will be compiled with recommendations for any modifications necessary. The 3 percent annual cost of operation and maintenance is applied to the Project Total. It includes an estimate of the time and materials for sediment removal, mainly at the Feed Canal dam, but also the Westland dam. Costs also include the installation and removal of the low flow flashboards at the Westland dam, and possible vegetation and slope maintenance along the channel boundaries.

Table 6-1. Planning level cost estimate.

Item	Quantity	Unit	Unit Cost	Cost
General				**$ 175,000**
Mobilization	1	LS	$ 100,000	$ 100,000
Care and Diversion of Water	1	LS	$ 60,000	$ 60,000
Site Restoration	1	LS	$ 15,000	$ 15,000
Channel Construction				**$ 1,847,000**
Excavation	97,400	CY	$ 10	$ 974,000
Embankment	99,000	CY	$ 7	$ 693,000
Channel Structures	6,200	TON	$ 29	$ 179,800
Diversion Modifications				**$ 156,000**
Diversion Structures	4,000	TON	$ 29	$ 116,000
Dam Notch Demolition	1	LS	$ 40,000	$ 40,000
Riparian Construction				**$ 200,000**
Revegetation	25	Acre	$ 8,000	$ 200,000
Construction Subtotal				**$ 2,378,000**
Construction Contingencies (20%)				$ 476,000
SUBTOTAL, CONSTRUCTION COSTS				$ 2,854,000
Engineering, Permitting and Administration (25% of Construction)				$ 714,000
Sub Total Project Cost				**$ 3,568,000**
Monitoring (5 years)				$ 275,000
PROJECT TOTAL				**$ 3,840,000**
Operation & Maintenance @ 3% Annually				**$ 115,000**

7. RECOMMENDATIONS

A conservative approach was taken to ensure that notching the Feed and Westland dams and constructing a stable channel form is feasible, and would provide significant benefits to fish, maintain diversion capacity to the Westland and Feed canals, and reduce adverse flow effects on landowners and fish habitat.

Upon successful completion of this feasibility study, development of the project would likely proceed through six subsequent phases:

- Consultation with landowners to procure riparian easements, identification of and application for funding, and identification of required permits, timeline and costs.
- Implementation of the monitoring plan, beginning with collection of baseline biological and physical data;
- Preliminary design and permit compliance review;
- Final design and construction documents;
- Construction services consisting of construction contract procurement and construction management; and,
- On-going monitoring and evaluation of the project, data analyses, and information feedback used in modifications and maintenance of project features.

Another important, early action may be to investigate any probable effects on the reach through Echo downstream of the project. This investigation might include a thorough analysis of aerial photo documentation over as long a record as is available; analysis of flood events and timing; interviews with long-time residents, and interviews with state or federal transportation departments for any history of damage to roads or bridges associated with flood magnitude.

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Drawings