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Water Consulting, Inc.

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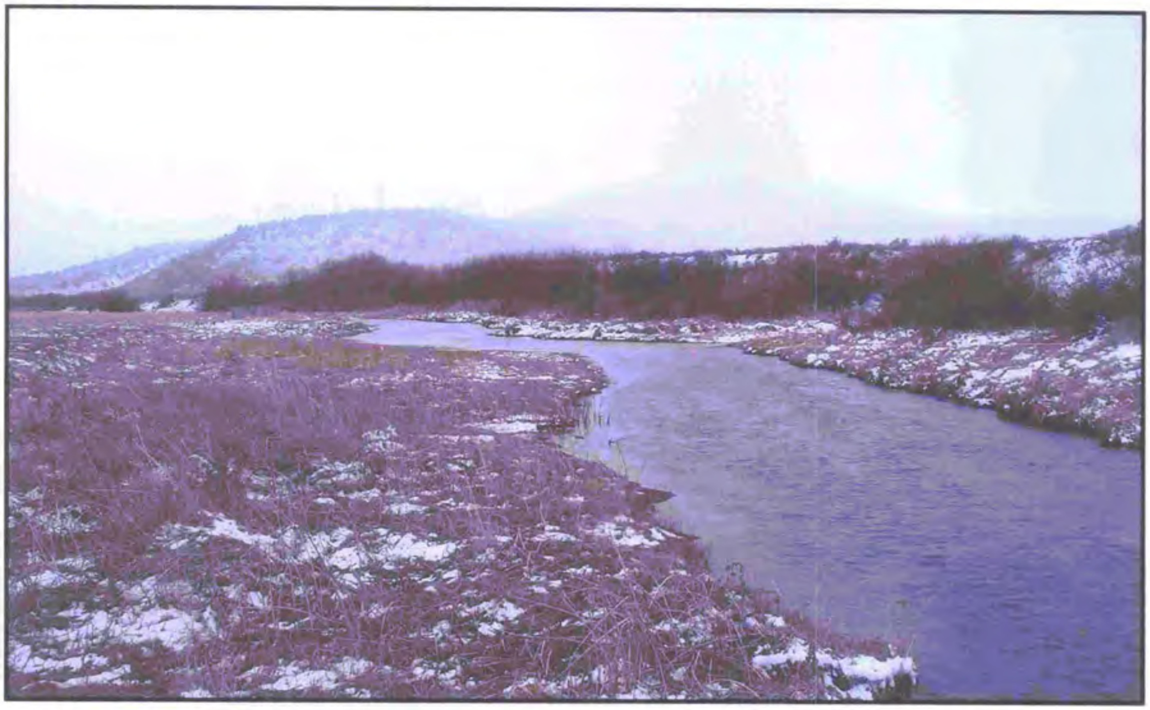
ANDERSON SPRING CREEK RESTORATION PROJECT DESIGN REPORT



Prepared for:

U.S. Fish & Wildlife Service
6610 Washburn Way
Klamath Falls, Oregon 97603

Prepared by:

Water Consulting, Inc.
P.O. Box 981
Hamilton, Montana 59840

WCI Project No. 02-012

May 31, 2002

HAMILTON & WHITEFISH
MONTANA

Water Consulting, Inc.
120 South Fifth Street, Suite 201
P.O. Box 981
Hamilton, MT 59840
Office: (406) 363-2828
Fax: (406) 363-5322

&

Water Consulting, Inc.
576 Spokane Avenue
Whitefish, MT 59937
Office: (406) 862-2234
Fax: (406) 862-2182

Web Site: www.waterconsulting.com
E-Mail: wci@waterconsulting.com

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1.0 INTRODUCTION

The Klamath Falls office of the U.S. Fish and Wildlife Service has retained Water Consulting, Inc. (WCI) to design and supervise the construction of the Anderson Spring Creek Restoration Project near Beatty, Oregon. Anderson Spring is a low elevation tributary to the Sprague River and historically provided spawning habitat for federally endangered shortnose sucker, *Chasmistes brevirostris*, and Lost River sucker, *Deltistes luxatus*. In March 2002, WCI completed a total station survey and fish habitat assessment to evaluate existing channel and floodplain conditions. Field data were compiled and analyzed to develop a stream restoration design that will include constructing a low width/depth ratio, sinuous two-stage channel with improved stability and riparian habitat conditions. The restored channel is expected to improve the quantity and quality of available habitat for all life-stages of the focus sucker species as well as salmonids inhabiting Anderson Spring Creek.

1.1 PROJECT GOALS AND OBJECTIVES

In November 2001, the State of Oregon Department of Environmental Quality (DEQ) prepared the Draft Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) report. The TMDL established water quality and restoration goals for streams and lakes of the Upper Klamath Lake drainage. One of the primary intents of the TMDL was to identify the causes and sources of water quality impairment and to promote a strategy for achieving water quality standards through planned water quality improvement efforts.

The Sprague River was identified as impaired on the 1998 Oregon 303(d) list for temperature, dissolved oxygen, pH, and habitat modifications. In light of these impairments, the following restoration goals have been developed for restoring Anderson Spring Creek:

- Reduce in-stream sources of sediment and bank erosion by incorporating stabilization techniques that function naturally with the stream and decrease the amount of stress on the banks,
- Establish the proper plan view, longitudinal, and cross-sectional channel dimensions,
- Reconnect abandoned floodplains to reduce in-stream energy, attenuate flood flows, and provide for late season release of water,
- Improve the structure and composition of riparian communities, and
- Increase the availability of complex fish habitat, particularly for native species.

The Anderson Spring Creek Restoration Project is intended to parallel the efforts of the State of Oregon DEQ in reducing the pollutants of concern through applied stream restoration. The design objectives are intended to reduce the pollutants of concern and facilitate attainment of water quality standards for the Sprague River and Upper Klamath Lake following project implementation.

2.0 PROJECT LOCATION

Anderson Spring Creek is a low elevation spring-fed stream tributary to the Sprague River located northeast of Beatty, Oregon and approximately 40 miles northeast of Klamath Falls, Oregon (Figure 1). The spring creek originates southeast of the project area in a series of perennial groundwater contact springs. Flowing northwest, Anderson Spring Creek is influenced by both groundwater contact springs and surface water inputs. The stream flows beneath the OC&E trail bridge and adjacent to the trail through the project area.

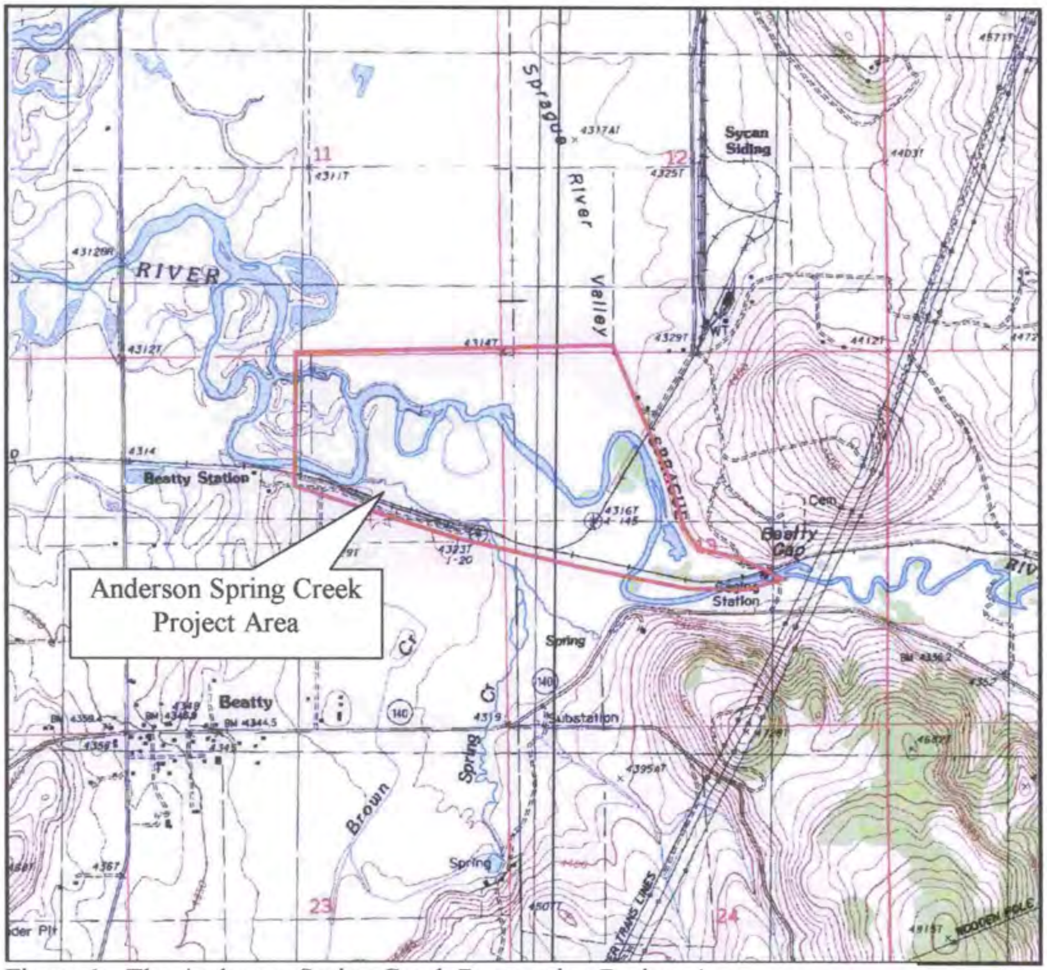


Figure 1: The Anderson Spring Creek Restoration Project Area.

3.0 EXISTING CONDITIONS

Anderson Spring Creek is currently functioning below its potential in terms of fishery production and channel stability. The existing channel has been subjected to straightening, direct vegetation removal, and intensive livestock grazing that have collectively displaced the vegetation community types historically present in the project reach. The resulting over-widened channel currently provides minimal in-stream habitat for the focus fish species. Elevated summer stream temperatures, poor bank stability, and inadequate fish habitat, have reduced the fisheries habitat value of Anderson Spring Creek.

Though currently functioning below its potential, Anderson Spring Creek has responded in a positive manner to reduced grazing pressure over the past two years. Field evidence indicates that the channel is in the process of narrowing due to the deposition of fine sediments and subsequent encroachment of vegetation along the channel margins. Over time, the channel would be expected to naturally narrow and deepen to the proper cross-section configuration. However, even with these processes occurring, the existing channel pattern would likely not improve for a considerable period of time. The proposed restoration design will accelerate the development of the proper channel dimensions, profile, and pattern and facilitate recovery of critical fish habitat for the focus sucker species.

3.1 FISH HABITAT ASSESSMENT METHODS

WCI completed a fish habitat assessment in the Anderson Spring Creek project reach in February 2002. Typically, fish habitat assessments are completed in the project area and a paired reference reach to evaluate stream and fish habitat departure from potential conditions. Due to the lack of reference reach conditions in the project area and surrounding vicinity of Beatty, a fish habitat assessment was only completed in the project reach. However, WCI supplemented the design fish habitat and channel dimensions with reference reach information collected from spring creeks in western Montana and Idaho displaying similar morphology and watershed characteristics.

The fish habitat assessment protocol, modified from Simonson et al. (1994), relied on both detailed cross-section surveys and more generalized reach-level habitat quantifications. A survey laser and measuring tapes were used to measure the channel dimensions and profile. Three Wolman pebble counts were completed in the project area to characterize channel bed particle size distribution. Three discharge measurements were also completed to estimate stream flow contribution from two tributary spring creeks located in the project area. A digital camera was used to photograph the cross-sections and stream channel for design purposes and for long-term effectiveness monitoring of the restoration project.

The field assessment included the collection of the following data:

- Representative pebble counts
- Surveyed channel and floodplain cross-sections every two to three bankfull channel widths
- Quantification of habitat characteristics within one bankfull channel width centered on each cross-section
- Quantification of channel habitat units
- Photo points of each cross-section location

The collected data were synthesized to yield the following information:

- Channel width (mean, standard deviation)
- Channel depth (mean, standard deviation)
- Longitudinal profile based on cross-section measurements
- Total habitat areas
- Pool tailout depths

3.2 FISH HABITAT ASSESSMENT RESULTS

Fourteen cross-sections were surveyed in the project area. Eleven cross-sections captured riffle/glide habitat units, as these habitats dominated the project area. Three cross-sections were located to capture the two pools in the project reach. The dominance of riffle/glide habitat and the low pool frequency reflects the poor fish habitat condition of the spring creek.

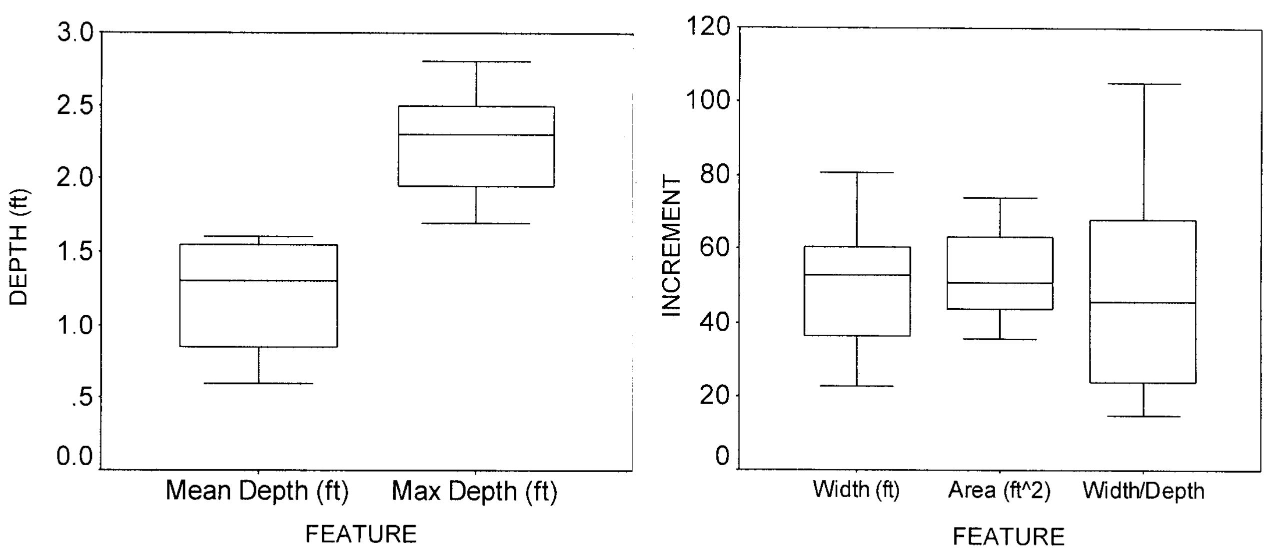


Figure 2: Box plots illustrating the bankfull channel metrics for the riffle cross-sections measured on Anderson Spring Creek (n = 11).

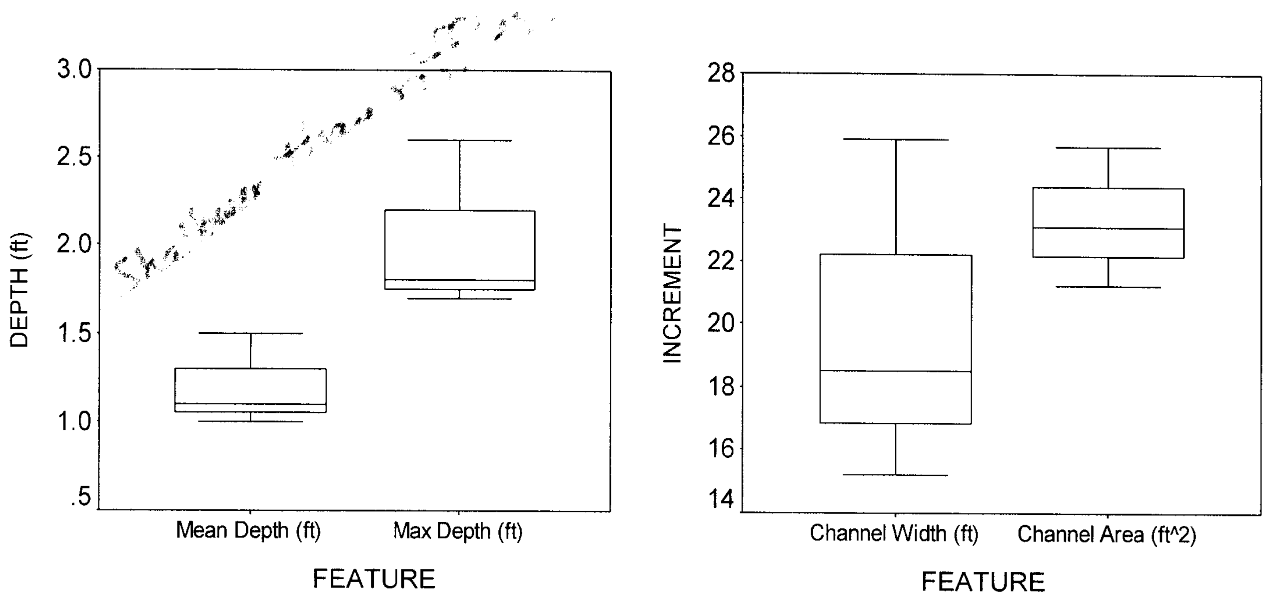


Figure 3: Box plots illustrating the bankfull channel metrics for the [redacted] cross-sections measured on Anderson Spring Creek ([redacted]).

Secondary fish habitat including woody debris, water surface turbulence, and vegetation cover were also evaluated at each cross-section. These categories were assessed in an area measuring one-bankfull width (40 feet) centered on each cross-section.

Table 1: The occurrence of water surface turbulence at each cross-section surveyed on Anderson Spring Creek.

			Turbulence				
Cross-section	Station	Pool/Riffle	<5%	5-10%	11-40%	41-75%	>75%
1	0+00	Riffle			X		
2	0+33	Pool	X				
3	1+50	Riffle	X				
4	3+00	Riffle	X				
5	4+50	Riffle	X				
6	6+00	Riffle	X				
7	7+50	Riffle	X				
8	9+18	Riffle			X		
9	9+50	Riffle			X		
10	10+50	Riffle	X				
11	12+00	Run/Pool	X				
12	12+87	Pool	X				
13	13+40	Riffle			X		
14	15+00	Riffle		X			

Table 2: The occurrence of woody debris, vegetation, and undercut banks at each cross-section surveyed on Anderson Spring Creek.

			LWD (cm)						
Cross-section	Station	Pool/Riffle	1-5	6-10	11-50	>51	RWD	% Veg	Undercut Bank (ft)
1	0+00	Riffle	SWD Jam Covering 24% of Channel						1.2
2	0+33	Pool		20				25%	
3	1+50	Riffle						20%	0.5
4	3+00	Riffle		30				<10%	
5	4+50	Riffle		1				40%	
6	6+00	Riffle	1					20%	
7	7+50	Riffle	1	5				30%	
8	9+18	Riffle						20%	0.5
9	9+50	Riffle	2					20%	0.5
10	10+50	Riffle					2	10%	
11	12+00	Run/Pool	20					10%	
12	12+87	Pool	20	1				<10%	
13	13+40	Riffle	4					20%	
14	15+00	Riffle		15	2				0.4

Reach level assessments were also completed to quantify the habitat volume in the project reach. In a stable Rosgen E/C stream type, pools typically comprise approximately 40 percent to 50 percent of the overall channel length. However, we determined that only 14 percent of Anderson Spring Creek provides pool habitat. The following tables provide reach level channel habitat information.

Table 3: Pools surveyed on Anderson Spring Creek.

Channel Habitat Number	Station	Max Depth	Ave Depth	Max Length	Ave Width	Tailout Max Depth	Habitat Volume (ft^3)
1	0-75	2.8	0.8	75	23	1.2	1,380
2	1180-1310	2.7	1.5	130	20	1.4	3,900
Average		2.8	1.2	102.5	21.5	1.3	

Table 4: Riffle/glides surveyed on Anderson Spring Creek.

Channel Habitat Number	Station	Max Depth	Ave Depth	Max Length	Ave Width	Habitat Volume (ft^3)
1	75-1180	1.8	0.7	1,105	20	15,470
2	1310-1500	1.6	0.9	190	16	2,736
Average		1.7	0.8	647.5	18.0	

The longitudinal profile illustrates the low pool frequency in the project reach (Figure 4). Two primary pools were located at the beginning, and towards the bottom of the project reach. The remainder of the project area was characterized by low gradient riffle/glide habitat.

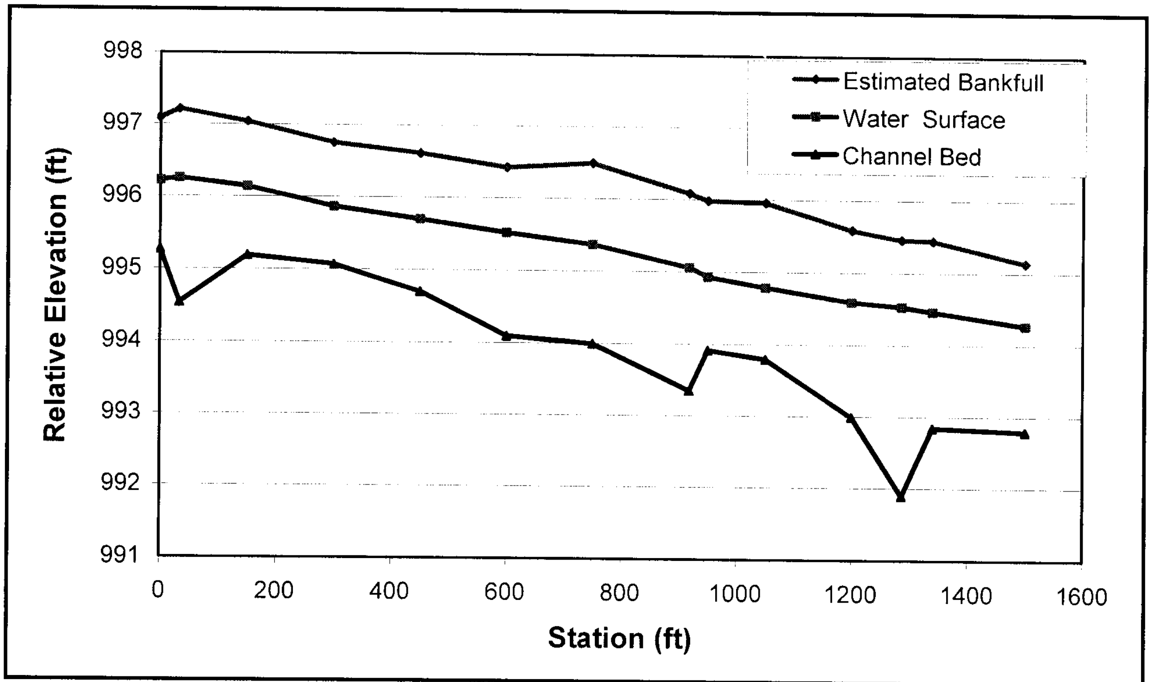


Figure 4: The Anderson Spring Creek project area longitudinal profile.

3.3 LIMITING FACTORS DISCUSSION

Fish habitat in the project reach is currently functioning below its potential. Historically, the spring creek was likely a narrow, sinuous channel with dense riparian vegetation typical of a Rosgen E4 stream type (Rosgen 1996). The narrow, deep spring creek would have provided cool water refuge to fish during the summer when the larger Sprague River was warmer. The riparian vegetation would have shaded the stream, provided aquatic and riparian habitat, and contributed woody debris to the channel. Intensive agriculture and grazing in the 20th century converted the spring creek to a straightened over-widened channel lacking habitat complexity. Existing riparian vegetation is generally mature or senescent along much of the project reach. The lack of woody vegetation recruitment suggests the long-term impact of livestock on the riparian community. Wetter portions of the floodplain that are influenced by upland springs support a greater diversity of vegetation age classes. This may suggest that livestock were less inclined to graze on the wetter southern side of the project site and preferred the drier northern side of the spring creek for grazing. The following section describes specific factors limiting fish habitat use in the project area.

3.3.1 Channel Morphology

As previously stated, the existing channel morphology deviates significantly from the likely historical condition. The infrequency of deep, complex pools reduces the amount of adult fish holding water in the project area. Deep pools maintain lower water temperatures, provide cover from predators, and offer a diversity of flows that may be used by feeding and resting fish.

The nearly homogenous low gradient riffle/glide habitat does not offer the diversity of habitat that would be expected in a stable Rosgen E4 stream type. This stream type is characterized primarily by run and pool habitats. Riffles are not a typical feature of stable E4 stream types. A diverse channel morphology provides the range of habitats required by all age classes of the focus species.

3.3.2 Fine Sediment

Fine sediment deposition in the channel has reduced the value of Anderson Spring Creek for spawning, refugia, and juvenile rearing for the focus fish species. Fine sediment is contributed to the stream predominantly through lateral bank migration, bank failure, and upland runoff, and impairs water quality, fish habitat, and aquatic macro-invertebrate communities. Currently, excessive sediment deposition has resulted in channel aggradation and accelerated rates of lateral channel migration and subsequent channel widening. Fine sediment (particles ≤ 2.0 mm) currently constitutes on average 36 percent (Range of three samples: 22 percent to 44 percent) of channel material, resulting in high embeddedness of larger gravels that provide porous living space for aquatic macroinvertebrates and important spawning and over-wintering habitat for shortnose suckers, Lost River suckers, and salmonids.

Fine sediment deposition will continue to be a limiting factor until the channel width narrows and greater shear stresses are produced to transport the fine particles that now deposit in the channel.

3.3.3 Structural Habitat

Structural habitat is critical for increasing channel complexity. Riparian vegetation and the woody debris that the shrubs contribute to the creek once provided complex lateral channel margin structural habitat in Anderson Spring Creek. The conversion from a shrub-dominated riparian habitat community to a more simplified grass community has reduced the bank stability and recruitment of small diameter woody debris to the channel.

3.3.4 Riparian Vegetation

The past long-term grazing management was detrimental to the health and vigor of the riparian communities. Simplified riparian habitat conditions have negatively affected the stream condition by reducing channel complexity, bank integrity, and stream shading.

The riparian community is recovering from the past grazing regime and will continue to be shaped and modified by beaver herbivory. The riparian condition is expected to improve through natural colonization and continued beaver activities. Proposed willow sprigging and containerized stock planting will speed the recovery of the riparian community and improve the community diversity in the project reach.

3.3.5 Limiting Factors Summary

High quality aquatic habitat in the Anderson Spring Creek is currently limited. The creek may have been at one time a spawning tributary for the focus sucker species and red band trout. Existing fine sediment deposition and overall channel condition are not conducive to sucker spawning requirements. However, observed unidentified fish using deep pools upstream of the project reach suggest that the creek does provide valuable deep water habitat. With the removal of livestock, vigorous vegetation growth on the floodplain, and abundant spring sources, recovery of Anderson Spring Creek is a realistic goal.

4.0 POTENTIAL CHANNEL CONDITIONS

Tributary spring creeks provide areas of coldwater refuge and protection from large piscivores that prefer the larger mainstream rivers. As such, the primary goals are to reestablish the proper meander pattern typical of low gradient (<0.01) stream channels, while incorporating natural bank stabilization treatments that provide complex habitat units. Currently, with the exception of a few areas along the stream corridor, the spring creek lacks quality, complex habitat including deep pools, overhead cover, large woody debris, and suitable spawning areas (e.g. pool tailouts). In order to improve habitat, bank stability, and channel complexity, a restoration plan that incorporates the following objectives has been developed.

- Construct a stable, self-maintaining Rosgen E4 and C4 channel that is able to transport sediment without adversely impacting vertical and lateral channel stability,
- Incorporate habitat structures, constructed of native materials, to restore critical spawning, rearing, and over-wintering habitats for native endangered species and species of special concern in the Sprague River basin,
- Minimize construction costs by incorporating balanced cut-fill construction and native on-site materials including vegetation transplants, sod mats, soil, and trees, and
- Maintain off-channel open water wetlands for the benefit of waterfowl and other wetland dependent species.

The potential condition of Anderson Spring Creek is a single threaded, meandering, riffle-run-pool dominated stream type with a broad riparian floodplain vegetated with mature shrub species including willow and alder. The restoration plan includes balanced cut and fill construction to minimize end-hauling costs and fill disposal. Mature transplants will be taken from on-site locations to minimize revegetation costs, efficiently use available material, and incorporate vegetation that has evolved to the site-specific conditions of the project area. Fish habitat structures will be constructed to improve the retention of spawning gravels and promote the channel hydraulics typical of spawning glide and riffle habitat units. Large woody debris structures will be used for meander stabilization, to increase lateral channel margin complexity, and to provide areas for juvenile rearing and adult/juvenile over-wintering. Concerning the endangered suckers, the channel margin complexity is expected to benefit juveniles prior to out-migrating to the Sprague River.

5.0 DESIGN CHANNEL DIMENSIONS

A two-stage channel consisting of a natural channel to carry the normal annual flows and a floodplain to convey the flood events is proposed. In order for the channel to maintain itself over item (transport sediment, debris, and stream flow), through normal runoff events, it must have a consistent, specific cross-sectional area. The width/depth ratio and other hydraulic parameters are balanced with the gradient to provide enough sediment transport capacity to mobilize the available sediment. For the channel to maintain the designed cross-sectional area during flood events, it must have a sufficient floodplain so that all flows are not confined within the bankfull channel.

This two-stage channel design will mitigate existing in-stream sediment sources. Given the correct channel shape, meander, gradient, and floodplain, the creek will be able to transport sediment and flow more efficiently. Accelerated lateral stream migration and sediment supply will be reduced by incorporating bank stabilization techniques that function naturally with the channel.

The restoration design emphasizes fish habitat and spawning areas favored by the endangered suckers and salmonids that are expected to use the spring creek. Preferable spawning locations will be created by constructing the proper riffle-pool channel profile. Fish habitat and grade control structures will also improve the quality and retention of spawning gravels in the project reach.

5.1 METHODS

Two methods were used to generate the design channel dimensions. First, WCI surveyed the channel and floodplain in the project reach to characterize existing conditions and determine the degree of geomorphic departure from potential conditions. The survey included the collection of channel cross-sections and a continuous longitudinal profile to document the existing channel and floodplain conditions, including thalweg elevations, bankfull features, and low terraces. Cross-sections were located to measure both stable and impaired channel reaches. Stable reaches typically had lower width/depth ratios, higher quality in-channel fish habitat, and were hydrologically connected to the adjacent floodplain. Conversely, impaired reaches were characterized by higher width/depth ratios, accelerated lateral erosion rates, improper plan forms, extensive fine sediment deposition, and poor in-channel fish habitat.

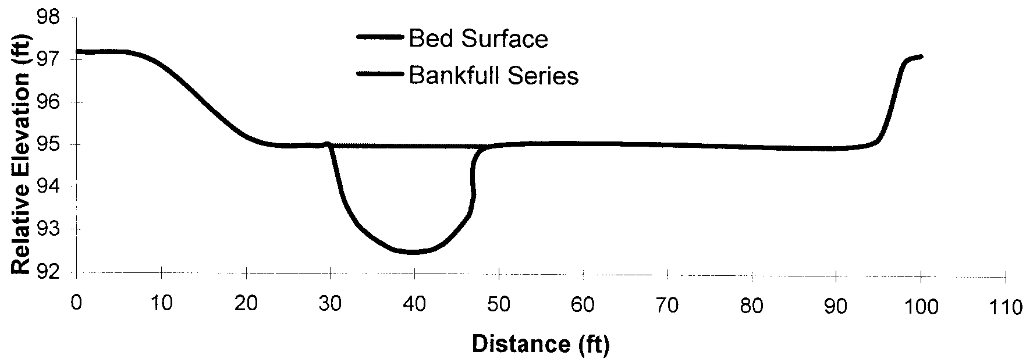
Secondly, due to the lack of contiguous, stable channel conditions in the project area, WCI incorporated data from a proprietary stream reference reach database to evaluate and determine the channel dimensions. Dimensionless ratio hydraulic geometry was applied to the design dimensions to develop specific values for pool, riffle, run, and longitudinal profile dimensions.

The proposed channel design dimensions were modeled in WinXSPro to determine the bankfull channel capacity and sediment transport properties. Flow measurements completed in the field were used to calibrate the hydraulic model and refine the bankfull discharge estimate. Table 5 includes the typical (impaired), stable, and design channel dimensions for the Anderson Spring Creek project site. Figure 5 illustrates the proposed typical riffle and pool cross-sections for the Anderson Spring Creek.

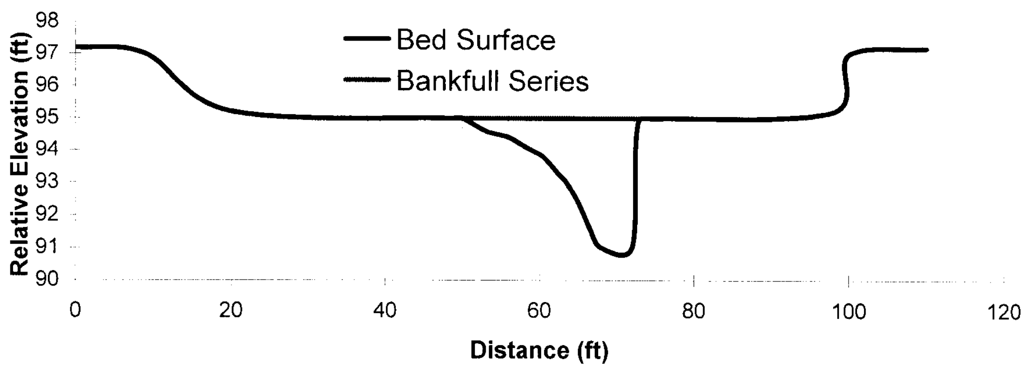
Table 5: Typical, reference, and proposed design channel dimensions for Anderson Spring Creek. Mean Value (Range)

Feature	Typical	Reference	Design
Cross-sectional Area (ft^2)	51	36	36
Bankfull Width (ft)	64	23	19
Mean Depth (ft)	0.8	1.6	1.9
Max. Depth (riffle) (ft)	2.4	2.8	2.5
Max Depth (pool) (ft)	2.7	3.9	4.7
Width/ Depth Ratio	50 to 80	15	10
Channel Length (ft)	2,030		2,883
Sinuosity	1.1		1.4
Slope	0.0013		0.0009
Meander Length (ft)			150 (115 - 230)
Radius Curvature (ft)			75 (38 - 115)
Belt Width (ft)			150 (70 - 245)
Floodplain Width (ft)			[redacted] minimum

Proposed Typical Riffle Cross-Section



Proposed Typical Pool Cross-Section



Feature	Width (ft)	Channel Area (ft^2)	Mean Depth (ft)	Max Depth (ft)	Hydraulic Radius (ft)	Width/Depth Ratio
Riffle XS	19.0	35.5	1.9	2.5	1.8	10
Pool XS	23.0	41.9	1.8	4.0	1.6	13

Figure 5: The proposed typical riffle and pool cross-sections for the outlet channel restoration project. Note the vertical exaggeration in both cross-sections.

6.0 FISH HABITAT, BANK STABILIZATION, AND GRADE CONTROL STRUCTURES

Fish habitat, bank stabilization, and grade control structures will be necessary for maintaining the design channel dimensions, fish habitat, and channel-floodplain stability until the riparian community recovers from past grazing.

To maintain the design channel dimensions and pattern, bank stabilization and grade control structures will be installed during channel construction. Habitat structures will be constructed using native materials and will be designed to mimic naturally occurring habitat arrays found in stable stream reaches. For Anderson Spring Creek, logs, rootwads, other woody material, rock, and vegetation transplants will be used to build the fish habitat structures. The proposed structures have been successfully employed in a range of streams throughout Montana, Idaho, Utah, and Colorado. WCI has monitored excellent fish population responses to the proposed structures on other low gradient streams similar to Anderson Spring Creek.

The proposed structures for streambank stabilization and grade control include bank placed rootwad revetments, high-stage deflector logs, log vanes, log weirs, and cobble patches (Figure 6). Revetment structures including rootwads and trees typically have a lifespan of between 15 and 20 years. The intent of these wood structures is to provide short-term interim protection and habitat until mature, stabilizing vegetation becomes established on streambank and floodplain areas. Woody debris provides native complex habitat with a relatively long lifespan over the entire range of flows. Proper placement of woody debris in the channel will improve channel stability in addition to habitat quality.

Figure 6.1: A log weir provides fish habitat and directs the thalweg towards the center of the channel, reducing lateral bank erosion and sediment contributions.

Figure 6.2: Finger bars are effective for narrowing over-widened channels. These structures require minimal fill material and create off-channel pond habitats. Off-channel habitats may benefit juvenile shortnose and Lost River suckers out-migrating from Anderson Spring Creek. The ponds also benefit waterfowl.

Figure 6.3: Bank stabilization/fish habitat structures are constructed with native materials including rootwads, deflector logs, and vegetation. Structures span from the scour depth to the bankfull elevation. Structure complexity benefits all age-classes of the target fish species. Young-of-year and juveniles use interstitial spaces while adults inhabit the deep scour pools that are formed around the rootwads.

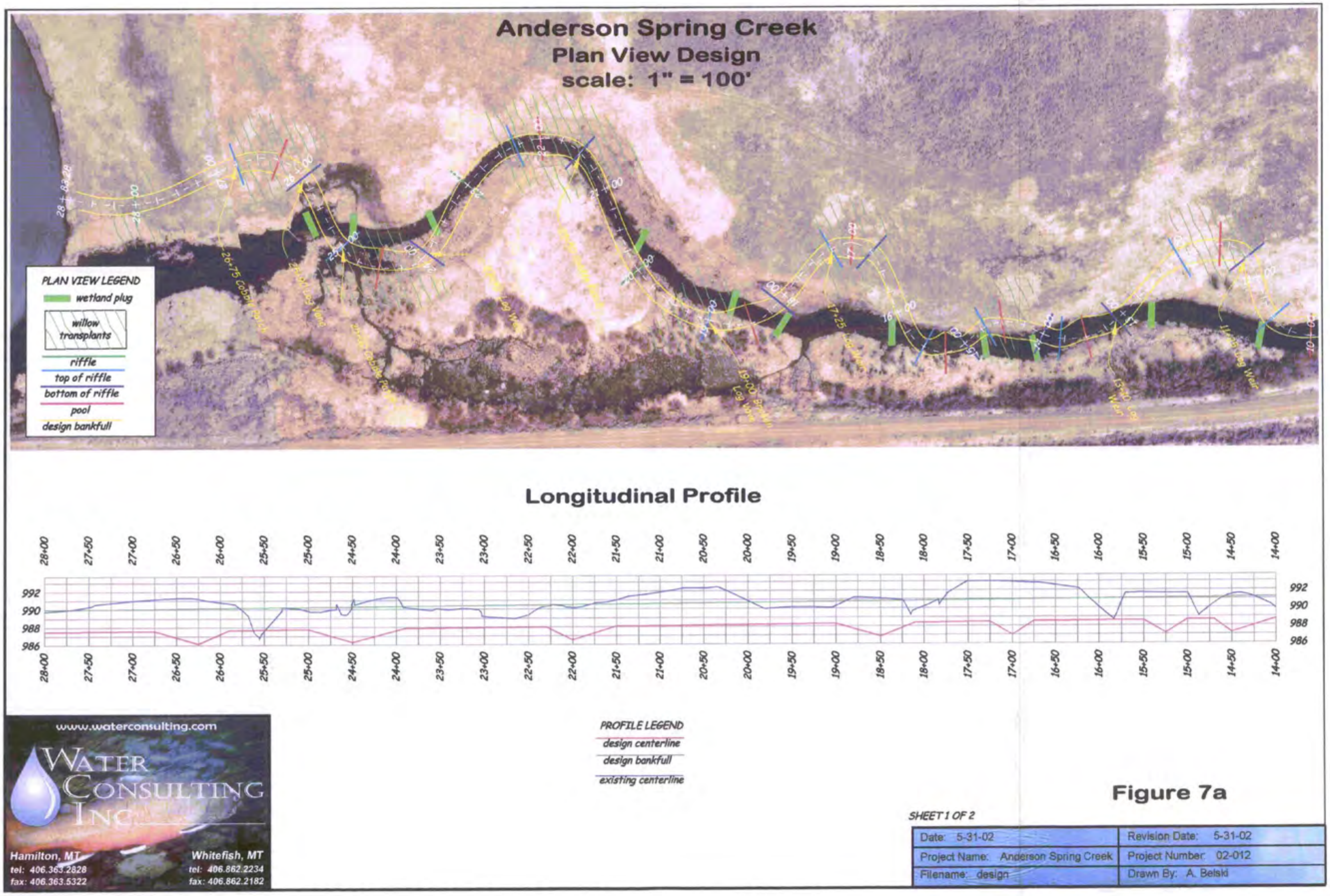
Figure 6.4: Constructed floodplains are necessary for narrowing over-widened channels. Fill material is used to narrow the channel. Sod and willow transplants speed the stabilization and recovery of the constructed floodplain. The narrowed channel improves sediment transport, flow conveyance, stream temperatures, and fish habitat condition.

7.0 RESTORATION PLAN OVERVIEW

The restored Anderson Spring Creek will be a self-maintaining channel capable of conveying the range of flows and transporting the sediment made available by the watershed (Figure 7). The channel restoration design accounts for two primary tributary spring creeks that influence Anderson Spring Creek. Portions of the tributary spring creeks will be relocated to accommodate the designed channel location.

The restored channel will improve fish habitat, channel stability, and stream-floodplain connectivity. Fish habitat will be improved for all age classes of the primary species of special concern. The designed riffle-pool channel profile provides deep pools for larger adult fish, especially important during low water periods and adverse seasonal conditions. Young-of-year and juvenile fish are also expected to benefit from the diverse habitat features. The shallow channel margins, complex woody debris, and overhanging vegetation will provide protected living space for young individuals. Bank stabilization and grade control structures will further increase the habitat area in the project reach. These structures increase the number of flows paths for feeding and resting stations, provide cover from predators, and create refugia during high and low flow events.

Because the channel will be built to the proper dimensions, pattern, and profile, the restored channel will be more stable and capable of transporting the available sediment.



Anderson Spring Creek
Plan View Design
scale: 1" = 100'
PLAN VIEW LEGEND
wetland plug
willow transplants
riffle
top of riffle
bottom of riffle
pool
design bankfull
Longitudinal Profile
992
990
988
986
28+00
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design bankfull
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www.waterconsulting.com
WATER CONSULTING INC.
Hamilton, MT
tel: 406.363.2828
fax: 406.363.5322
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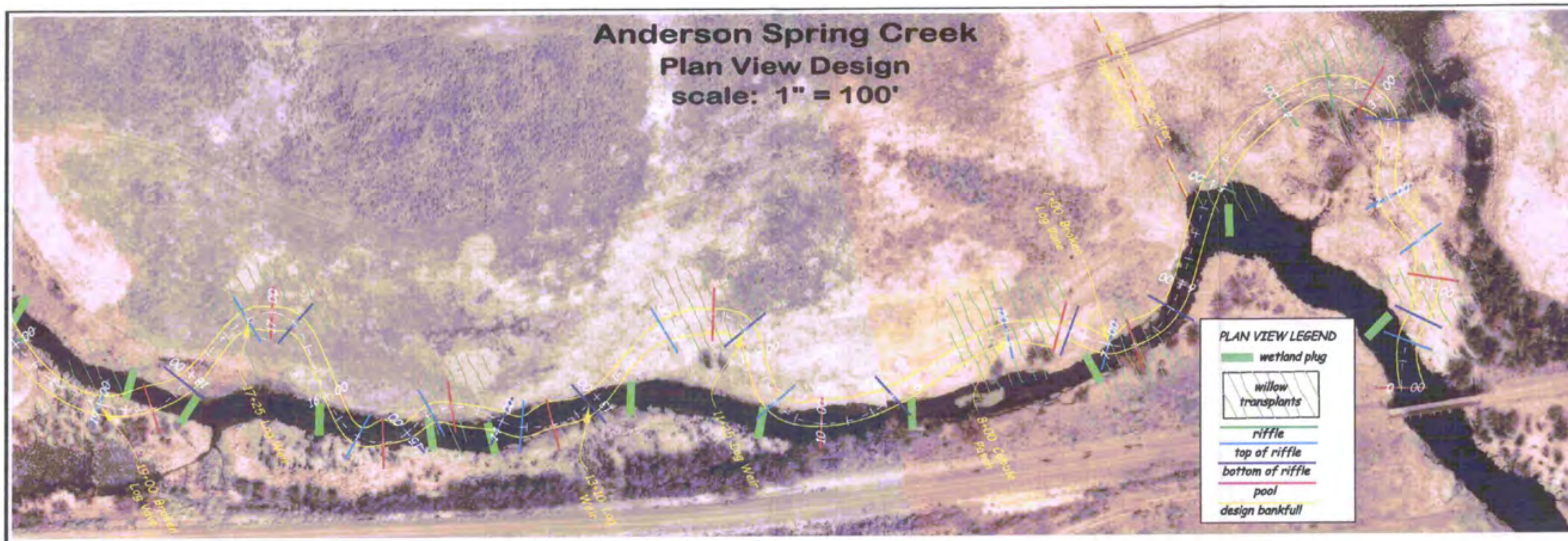
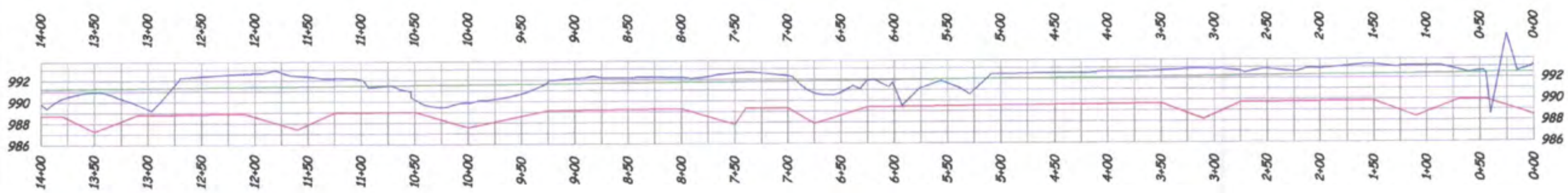
fax: 406.862.2182
Figure 7a
SHEET 1 OF 2
Date: 5-31-02
Revision Date: 5-31-02
Project Name: Anderson Spring Creek
Project Number: 02-012
Filename: design
Drawn By: A. Belski



Longitudinal Profile



PROFILE LEGEND
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Figure 7b

SHEET 2 OF 2

Date: 5-31-02	Revision Date: 5-31-02
Project Name: Anderson Spring Creek	Project Number: 02-012
Filename: design	Drawn By: A. Belski

Because the channel will be built to the proper dimensions, pattern, and profile, the restored channel will be more stable and capable of transporting the available sediment load. By increasing the stream competency, the channel will maintain its cross-sectional area, maintain more diverse fish habitat, and interact with the adjacent floodplain more frequently. Revegetating the near channel area will improve the long-term success of the restoration project. Revegetation efforts will improve bank stability, fish habitat, and provide future woody debris to the spring creek.

Stream-floodplain interactions reduce in-stream shear stress, increase fine sediment deposition on the floodplain, and improve the riparian community condition. The designed channel will be constructed to the proper bankfull dimensions so that a flow event with an approximate 1.8 to 2 year recurrence interval will access the floodplain. Maintaining stream-floodplain connectivity assures long-term channel stability, vegetation diversity, and sediment transport efficiency.

Wetland plugs and finger bars will be constructed to separate the reconstructed and existing channel (see Figure 6.2). These features will be constructed using fill material and harvested sod mats. Mature willow transplants will be used to stabilize each of the wetland plugs. Additional shrub planting and sprigging will improve plug integrity and speed the integration of the plugs with the surrounding floodplain. Finger bars will be constructed where the existing channel is greatly over-widened and filling the entire channel would require a significant amount of fill material. Finger bars effectively reduce the cross-sectional channel area and provide off-channel aquatic habitat for waterfowl and juvenile fish. Wetland plugs and finger bars will increase the habitat diversity and channel stability in the project reach.

WCI has recently invested in a new technology that improves planting efficiency and plant survival. Attached to an excavator, the revegetation equipment requires minimal labor and is capable of rapidly planting a large area with native species. Plantings will include both native containerized stock and cuttings taken from the project area. Using the revegetating equipment is preferable over manual labor from both cost and plant success perspectives.

8.0 EQUIPMENT SPECIFICATIONS

This project will require a small excavator, a mid-size front-end loader, and a standard dump truck. As with all stream restoration projects, equipment will be free of all oil, hydraulic fluid, and diesel fuel leaks. To guarantee that only clean equipment is used on-site, equipment should be new or well maintained. To prevent invasion of noxious weeds, it is recommended that all equipment be power washed and cleaned prior to mobilization into the project area. This requirement is important due to the degree of exposed and disturbed soils anticipated during and for a short period following project construction.

8.1 EXCAVATOR

This project will require either one or two excavators based on the projected time frame. If two excavators are selected, one excavator should be a Komatsu 200 class (CAT 320) excavator and the second should be a Komatsu 150 class excavator. If only one excavator is to be used, it should be a Komatsu 200 class. Excavators must be equipped with hydraulic thumbs. Two excavators on-site would improve project efficiency and maintain lower implementation costs.

8.2 LOADER

A Komatsu 320 (CAT 938) is the appropriate loader for this project, although a larger loader could be used. The bucket should be approximately 3 yd^3 and must have a grapple capable of transporting trees and rootwads. The loader must also have off-road tires in good condition.

8.3 DUMP TRUCK

Materials gathering, transport, and distribution of materials for this project will require one standard 10 yd^3 dump truck. Some truck time will be reduced since it will be necessary for the loader to distribute materials to portions of the project area.

9.0 REQUIRED MATERIALS

Vegetation transplants, rock, woody debris, and fill material will be required to complete the Anderson Spring Creek restoration project (Table 6). These materials will be used to construct the proper bank and fish habitat/stabilization structures. Excavated material will be used on-site as necessary to narrow the over-widened channel. Extra fill material that cannot be used on-site will be transported and spoiled outside of the project area. The required mature willow transplants and sod mats will be harvested from within or in close proximity to the project area. Since few mature trees are located in the project area, some trees may need to be acquired from off-site.

Table 6: The estimated number of structures and vegetation for the Anderson Spring Creek Restoration Project.

Structure	Number	Total Rock (yd^3)	Total Rootwads	Total Whole Logs
Gravel Bars	4	0	0	0
Mature Willow Transplants	185	0	0	0
Log Vane	1	2	0	1
Log Weir	4	8	0	8
Broken Log Vane	2	4	0	4
Rootwad Revetment	1	2	2	0
Deflector Logs	20	0	0	30
Wetland Plugs	14	0	0	0
Additional Plants/Whips	300	0	0	0
Total Structures*	32	16	2	43

*: Does not include mature willow transplants or other plants/whips.

10.0 IMPLEMENTATION PLAN

Project construction should follow a defined schedule for the completion of the new channel. All materials should be gathered and distributed on-site in piles along the proposed channel. Stockpiled materials should include all rocks, rootwads, deflector logs, and habitat logs. Mature willow transplants will be harvested as needed to improve transplant survival.

The channel restoration work will proceed in three phases. First, a clear water bypass channel will be constructed to reduce construction-related turbidity. The bypass channel will begin at Station 05+00 and extend across the low terrace to the historic oxbow meander of the main Sprague River located north of the project area. The bypass channel will be designed to convey the existing flow to minimize the amount of disturbed area across the low terrace. By reducing the amount of surface water in the channel during construction, discharge of turbid construction water to the Sprague River will be greatly reduced. Additional trash pumps and Best Management Practices (BMPs) may be deployed in the project area to reduce construction related turbidity.

The second phase will include rough and fine channel and floodplain shaping from the OC&E trail bridge downstream to the confluence with the main Sprague River. During rough shaping, the operator will excavate the pattern and approximate profile and channel dimensions. In places, the existing low terrace will be excavated to the appropriate bankfull elevation to establish the proper bank height ratios and to increase the floodplain acreage in the project reach. Fine channel shaping will include refining the channel cross-section dimensions and positioning fish habitat/stabilization structures. The front-end loader will assist with transporting structure materials and harvesting mature willow shrubs for transplanting in the project reach. A majority of the whole shrub transplants will be gathered from the historic oxbow meander of the Sprague River located north of the Anderson Spring Creek. The operator will minimize the period of time between shrub harvest and transplanting to increase survival success.

The third phase will include constructing the remaining wetland plugs. Wetland plugs will be placed on the upstream and downstream ends of the existing channel segments. Wetland plugs will be installed at the floodplain elevation and serve as off-channel, shallow open water wetland. Sod mats harvested during the second phase of construction will be placed on the fill materials to create wetland plugs. Additional mature willow shrubs will be transplanted on the wetland plugs to improve their integrity and resistance to scour. Containerized plants and whips will also be installed during this phase.

Depending on the water levels in the channel during construction, new channel construction may be completed incrementally. A floodplain plug will be left in place to isolate each new channel segment from the existing channel. This will reduce turbidity in the existing channel during construction in the event of significant groundwater upwelling.

Following successful completion of Phases 1-3, the diverted water will be diverted into the new channel from the clear water bypass channel. At this time, observation of structure and channel function may require fine-tuning channel dimensions and individual structures. The bypass channel will be filled to the pre-construction elevation and seeded once the water is diverted into the restored channel.

11.0 PROPOSED BUDGET

Please refer to Appendix A for the proposed budget.

12.0 SUMMARY

The proposed channel design is expected to create a more stable stream capable of conveying the flows and transporting the sediment made available by the watershed. The improved channel and floodplain conditions are expected to be self-maintaining. Constructed fish habitat, bank stabilization, along with the reconstructed channel profile, will increase the fish habitat diversity in the project reach. The proposed channel design is expected to benefit the endangered Lost River sucker and shortnose sucker populations in the Sprague River. Other species in the Sprague River fish community including trout may also benefit from the proposed channel restoration project. In addition to expected fish population responses, we expect the channel modifications will reduce fine sediment load and water temperatures in both Anderson Spring Creek and the Sprague River.

References Cited

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO. USLC Catalog No. 96-60962.365.

Simonson, T.D., J. Lyons, and P.D. Kanehl. 1994. Quantifying fish habitat in streams: transect spacing, sample size, and a proposed framework. North American Journal of Fisheries Management 14: 607-615.

APPENDIX A

Anderson Spring Creek Restoration Project Budget

WCI TASKS AND COSTS

Task	Cost/Day	Project Number of Days	Project Total Cost	Notes
Layout and Construction Oversight				
WCI Design Layout				
WCI Hydrologist/Fisheries Biologist	$600	2	$1,200	Channel Staking
WCI Professional Surveyor	$600	2	$1,200	Channel Staking
WCI Construction Oversight				
WCI Hydrologist/Fisheries Biologist	$600	15	$9,120	WCI oversight for 80% of excavator time
WCI Senior Hydrologist	$750	5	$3,750	WCI oversight for 80% of excavator time
Per Diem	$50	24	$1,200	With WCI Trailer on-site, more if hotel accoms.
Plane Tickets	$330	2	$660	Tickets for Surveyor and Senior Hydrologist
Staff Travel Time (Half Rate)	$480	2	$960	
Round Trip Mileage (approx. 2200 mi roundtrip)	$770	1	$770	Mileage from Hamilton to job site
Staff Travel Time (Half Rate)	$480	2	$960	
Layout and Construction Oversight			**$18,860**	

OPERATOR TASKS AND COSTS

Task	Cost/Day	Project Number of Days	Project Total Cost	Notes
Equipment Mobilization / Demobilization	$3,300	1.0	$3,300	Cost for 200 Excavator, Front End Loader, and Dump Truck
Materials Collection, Sorting, Distributing				
Equipment				
Komatsu 200	$1,000	2.0	$2,000	Sort materials
Cat 966 End Loader 3 yd bucket	$1,000	2.0	$2,000	Collect and tram materials
Dump Truck	$550	2.0	$1,100	Collect and tram materials
Construct Diversion Channel				
Equipment				
Komatsu 200	$1,000	1.0	$1,000	Diversion channel to work in dry conditions
Cat 966 End Loader 3 yd bucket	$1,000	1.0	$1,000	

Task	Cost/Day	Project Number of Days	Project Total Cost	Notes
<u>Channel/Floodplain Rough Shaping</u>				
Equipment				
Komatsu 200	$1,000	6.0	$6,000	Generate fill to narrow channel/reduce floodplain elevation
Cat 966 End Loader 3 yd bucket	$1,000	6.0	$6,000	Haul cut and fill materials
<u>Fine Channel Shaping</u>				
Equipment				
Komatsu 200	$1,000	5.0	$5,000	Fine channel shaping
Cat 966 End Loader 3 yd bucket	$1,000	5.0	$5,000	Transport fill materials and willow transplants
Dump Truck	$550	4.0	$2,200	Transport fill materials and willow transplants
<u>Fish Habitat, Bank Stabilization, Grade Control</u>				
Equipment				
Komatsu 200	$1,000	2.0	$2,000	Build structures
Cat 966 End Loader 3 yd bucket	$1,000	2.0	$2,000	Supply materials and transport willow transplants
<u>Floodplain Plugs and Additional Willow Transplants</u>				
Equipment				
Komatsu 200	$1,000	2.0	$2,000	Complete floodplain plugs and willow tranplants
Cat 966 End Loader 3 yd bucket	$1,000	2.0	$2,000	Complete floodplain plugs and willow tranplants
<u>Reclaim Diversion Channel</u>				
Equipment				
Komatsu 200	$1,000	1.0	$1,000	Fill diversion ditch and reclaim area
Cat 966 End Loader 3 yd bucket	$1,000	1.0	$1,000	Fill diversion ditch and reclaim area
Per Diem	$50	34.0	$1,700	

WCI Costs Summary

Design Layout			$2,400	
Construction Oversight			$12,870	
Per Diem			$1,200	
Plane Tickets			$960	
Mileage			$770	
Total WCI Cost			**$18,200**	

Operator Costs Summary

Estimated Equipment Costs				
Komatsu 200		19.0	$19,000	
Cat 966 End Loader 3 yd bucket		19.0	$19,000	
End Dump Truck		6.0	$3,300	
Per Diem		34.0	$1,700	
Mobilization Costs			$3,300	
Total Equipment Cost			**$46,300**	

Material Costs Summary

Rock	$35/yd3	16 yd3	$560	
Whole Trees	$100/Tree	13 Trees	$1,300	Deflector logs may be acquired from the USFS for nominal cost
Rootwads	$100/Rootwad	2 Rootwads	$200	
Containerized Stock	$8/plant installed	100 Plants	$800	
Whips	$3/cutting installed	200 Whips	$600	
Total Materials Cost			**$3,460**	

Cost for Anderson Spring Creek Restoration Project	**$67,960**	
Approximate Cost per Lineal Foot (3000 ft)	**$23**	