RECLAMATION

Managing Water in the West

SRH-2009-47

River Spanning Rock Structures Field Investigations 2008

Pacific Northwest Region

U.S. Department of the Interior
Bureau of Reclamation

December 2009

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover Photo: View of rock weir on Entiat River taken on October 27, 2008.

River Spanning Rock Structures Field Investigations 2008

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Peer Review Certification: This document has been peer reviewed per guidelines established by the Technical Service Center and is believed to be in accordance with the service agreement and standards of the profession.

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Bureau of Reclamation

December 2009

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Introduction

Reclamation has initiated a multi-faceted research effort to develop design criteria for river spanning rock structures. Ongoing research consists of three primary components:

1. Field investigations of river spanning rock structure performance,
2. Physical modeling in a laboratory setting, and
3. Numerical modeling of hydraulics resulting from the presence of river spanning rock structures.

From October 23, 2008 to October 29, 2008, 17 rock weirs and 3 rock ramps were visited throughout the Pacific Northwest region as part of the field investigations component. Survey data, bed material information, and qualitative habitat evaluations were collected at each structure. The data is used in a quantitative analysis, trying to capture ranges of specific design parameters and link the measured parameters to possible failure mechanisms. Figure 1 shows the general locations of the structures.

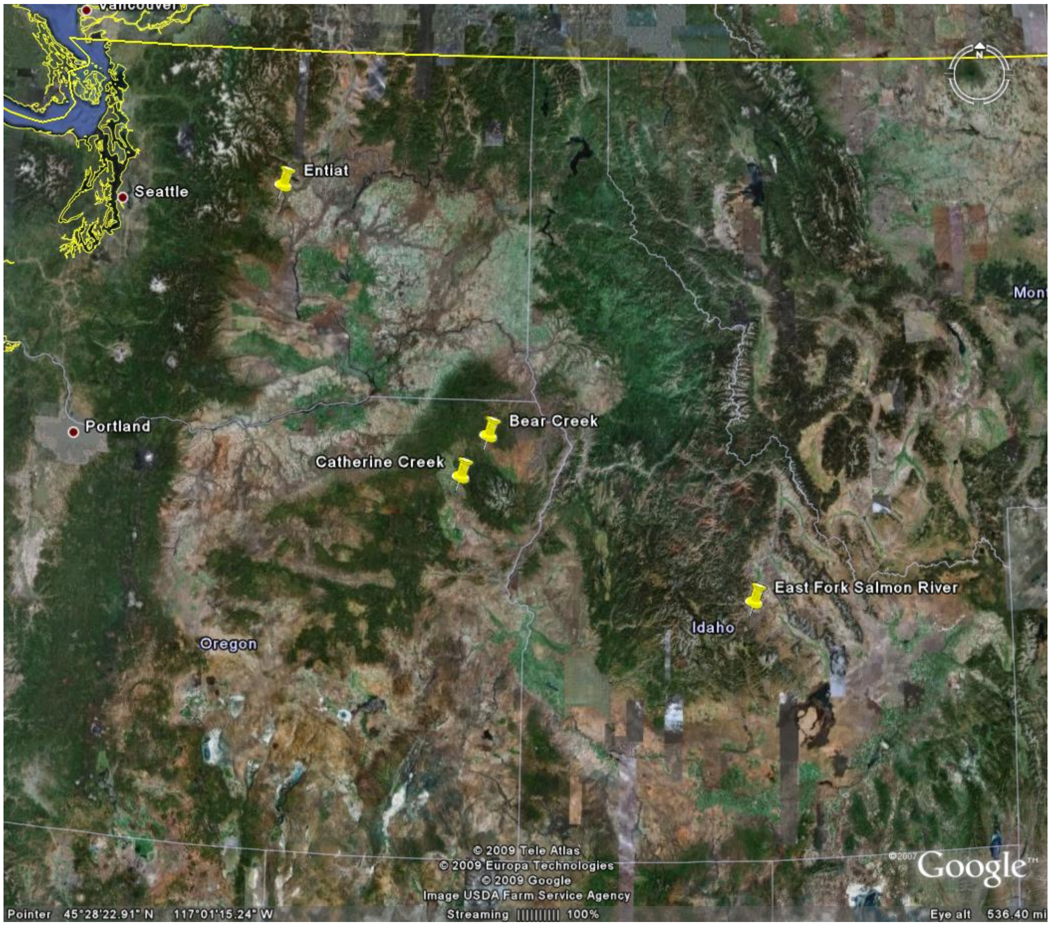

Figure 1. General location of structure sites.

River spanning loose-rock structures are used in channels for a variety of purposes ranging from grade control to habitat complexity. The most common objectives in implementing these structures in rivers are to provide sufficient head for irrigation diversion without creating migration barriers for fish, to increase channel bed and bank stability, and to improve habitat features for targeted fish species. Plan and profile views of a typical A-weir rock structure are shown in Figure 2 and Figure 3, respectively.

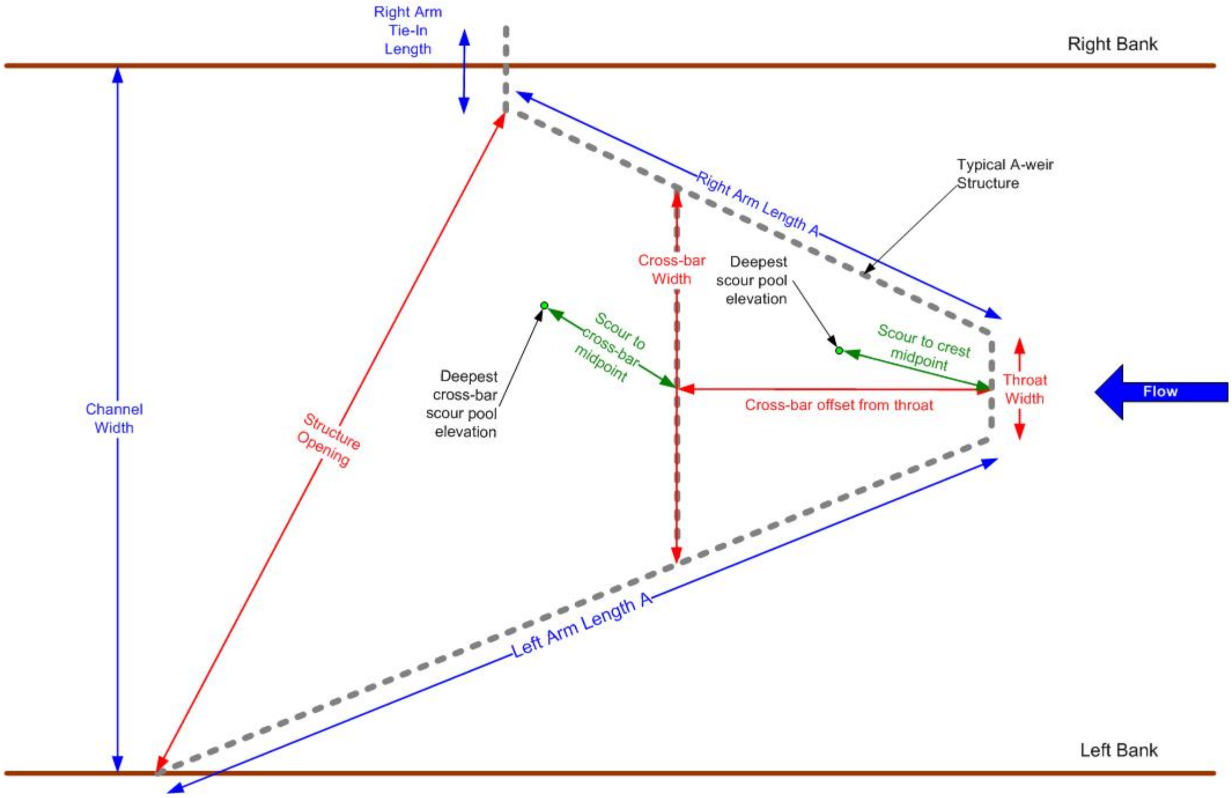

Figure 2. Plan view schematic of a typical A-weir river spanning rock structure.

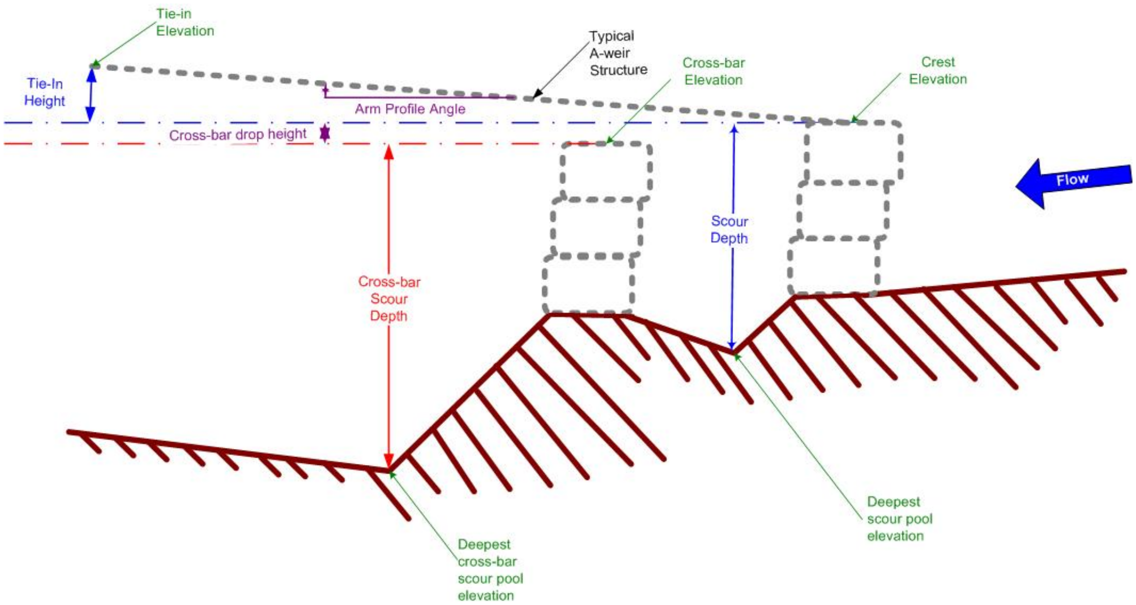

Figure 3. Profile schematic of a typical A-weir river spanning rock structure.

The structure locations surveyed were:

- East Fork Salmon River near Stanley, ID
  - 1 V-weir rock ramp: EF 7-8
  - 1 A-weir: EF 10-11
  - 1 rock ramp: EF 17
- Salmon River near Stanley, ID
  - 1 rock ramp
- Bear Creek near Wallowa, OR
  - 4 U-weirs: B, D1, D2, and D3
- Catherine Creek near Union, OR
  - Hempe Hutchensen
    - 3 U-weirs: HH1, HH2, and HH3
  - Swackhammer
    - 1 U-weir
    - 1 W-weir
- Entiat River near Entiat, WA
  - 3 U-weirs: RM 3.1, RM 3.2, and RM 3.4
  - 2 A-weirs: RM 4.6, and RM 5.1
- Chewuck River near Winthrop, WA
  - 1 rock ramp: Fulton Dam
  - 1 rock ramp: Chewuck

The rock weirs on the East Fork Salmon, Bear Creek, Catherine Creek, and 3 of the Entiat River rock weirs had been visited previously in 2005. These sites were revisited to collect additional missing survey information such as bank lines and bed elevations and to have a local biologist evaluate the habitat being provided; a local biologist came to every site investigation except for the visits to Salmon River and Catherine Creek.

Biologists were requested to provide written feedback on the structures. The feedback has been included in this report where it was provided. The biologists examined the rock weirs for present fish use, added habitat, and potential improvements that could be made to increase fish use.

The following sections describe each location, observations on the structure integrity, data collected, and a summary of the habitat evaluation. Comparisons were also made between the 2005 and 2008 observations where applicable. The habitat forms that each local biologist completed are attached in the appendix.

East Fork Salmon River, Structure 7-8

Metadata

Conducted by: Elaina Holburn, Chris Holmquist-Johnson, Kendra Russell, and Kent Collins
Structure Type: V-weir
Location: NAD83 State Plane Idaho Central (feet)

- Northing: 1560182
- Easting: 905232
- HUC: 17060201

Description: V-weir to provide sufficient head for irrigation diversion structure.
Construction Date: 1998
Initial Site Visit: July, 2005
Second Data Collection Visit: October, 2008

Background

This structure was originally designated as a V-weir rock ramp following the initial 2005 site visit because of the ramping of smaller, angular rock material upstream and downstream of the crest of the weir. However, the structure functions as a normal rock-weir with a greater amount of smaller sized constituent rocks. The weir was designed and constructed by NRCS in 1998. The purpose of the structure is to provide sufficient head for an adjacent irrigation diversion while maintaining fish passage. Since the construction of the weir, several minor adjustments are believed to have occurred (Brian Hamilton, personal communication, 10/23/09).

Data Collection

Data collected during the October 2008 site visit included topographic surveys of the structures and surrounding features (e.g. banks, scour pools, thalweg), bed material samples, structure rock size measurements, and qualitative information related to vegetation, bank condition, and structure performance. Despite attempts to acquire information from local biologists, no information on the habitat value of the structure was provided.

Survey Data

Surveys of the structure were collected in 2005 and again in 2008 to document current structure conditions and surrounding topographic features including bank lines, channel thalweg, scour pools, and adjacent bed topography. Data collected at the East Fork 7-8 site are illustrated in Figure 4.

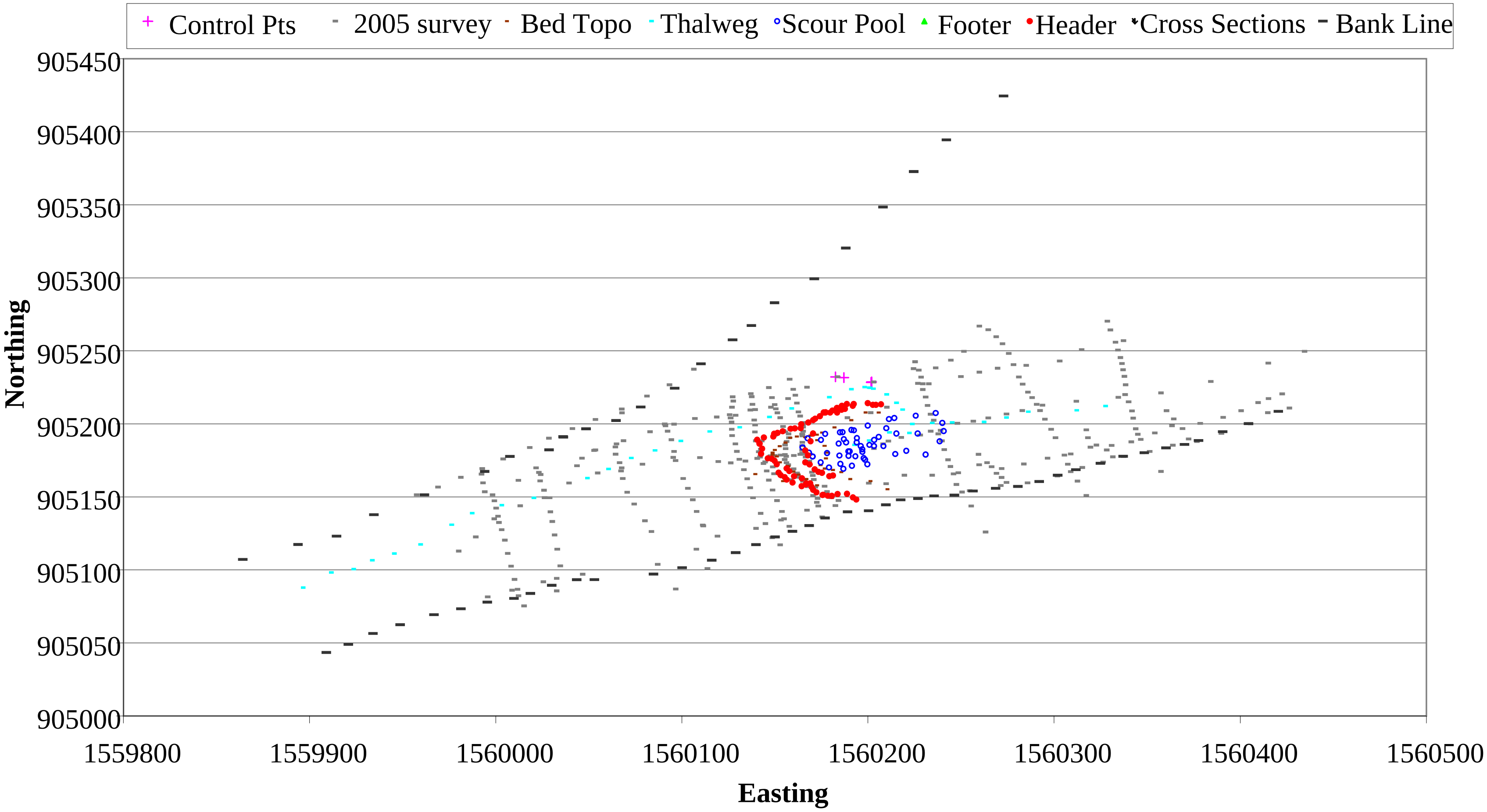

Figure 4. Survey data collected for East Fork Salmon Structure EF 7-8.

Structure Condition

Structure EF 7-8 is located in a system with a high sediment load, but has mostly maintained its structural integrity over the last 10 years likely due to its location in a fairly straight section of channel that is not associated with active deposition or lateral channel migration. Several years of photographs are available to evaluate changes to the structure between 2003 and 2008. However, there was some mobilization of member rocks that occurred between 1998 and 2003 that are not visible in the photographs. The displacement that has occurred appears to be associated with sliding and rolling of some of the smaller constituent rocks and/or geotechnical slumping of some of the footer rocks (footers) and subsequent mobilization of the header rocks (headers). Figure 5 illustrates mobilization in several of the header rocks along the throat and arms of the structure by April 2004. By October 2008, even more of these rocks have mobilized (Figure 6), and backfill along the left arm of the structure has either been mobilized or additional large rock was placed to protect the irrigation ditch. It is unclear if the design intentionally created a ramp-like feature on the downstream end of the structure or if rocks have been mobilized to this area, creating a sloped ramp.

High flows have maintained a large scour pool downstream of the structure (maximum depth of 3 feet), as evidenced in Figure 7 and Figure 8. Some larger headers have slumped into the scour pool. Material in the bed of the pool appeared coarser than the material upstream of the structure. Sands were present around the fringes of the scour pool and in associated eddies.

While the structure continues to provide sufficient head for diversion, maintenance of the berm directing flow into the irrigation ditch is apparent in Figure 9 through Figure 12. As sediment settles in the lower velocity zones of the irrigation diversion, the guide berm is extended further upstream to maintain head. During high flow, some of this sediment may be flushed through the system, but additional clearing of the irrigation channel just upstream of the diversion structure appears necessary in addition to extension of a push-up berm. To avoid in-channel work during critical life stages for endangered species, the irrigation canal upstream of the diversion structure may be modified to sluice more sediment under high flows. Potential options include retrofitting the current diversion structure to provide a sluicing mechanism or installing a stable sluicing structure through the structure arm that can be activated under higher flows and shut off during low flows. One of many options may provide a solution to the sediment deposition issue; however, the hydraulics associated with a U- or V-weir shape induce low velocity zones, prone to higher rates of sediment deposition, along the structure arms and against the banks and concentrate flows to the center of the channel. For designs of river spanning rock structures associated with diversions, other types of structures (e.g. rock ramps) may better meet irrigation needs without requiring as much maintenance.

Figure 5. East Fork Salmon EF 7-8 on April 2004. Note smaller material along the left arm of structure.

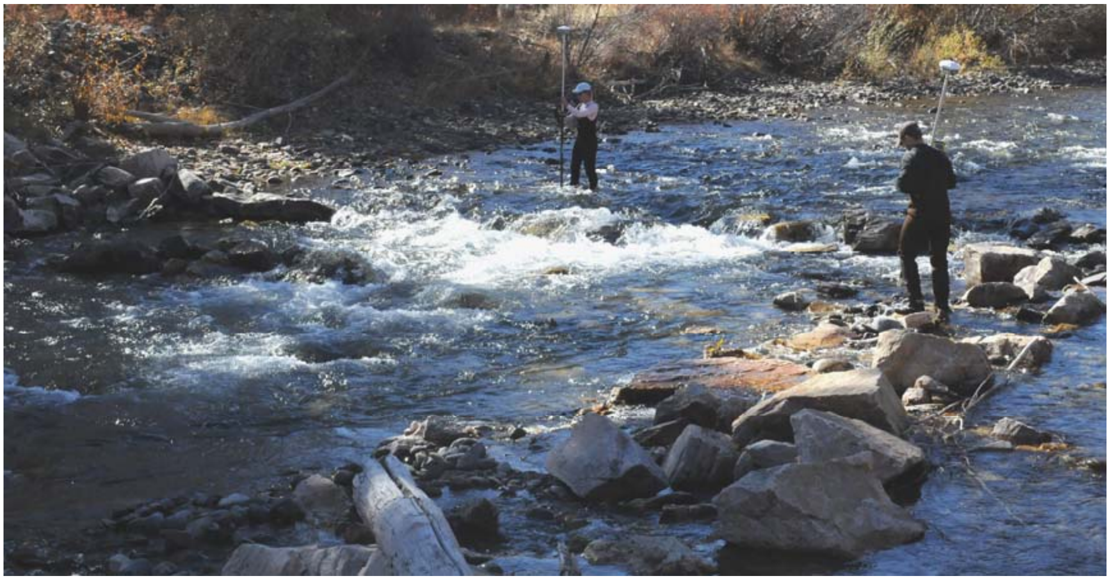

Figure 6. East Fork Salmon EF 7-8 on October 2008. Smaller material seen in Figure 5 is no longer present along the left arm and flow is conveyed through seeps from the irrigation canal to the river.

Figure 7. Looking down across the top of the East Fork Salmon EF 7-8 structure in May 2003. Note the lack of a berm extending upstream of the structure.

Figure 8. Looking across the East Fork Salmon EF 7-8 structure in May 2005.

Figure 9. Looking upstream at the East Fork Salmon EF 7-8 structure in March 2003. Loose woody debris has piled up along the diversion channel and structure.

Figure 10. Looking upstream at the East Fork Salmon EF 7-8 structure in February 2006. Notice the berm extending upstream of the structure to guide flow toward the diversion gate.

Figure 11. Looking upstream at the East Fork Salmon EF 7-8 structure in September 2007. The berm has been extended well beyond the head of the structure. Also, note seepage through the left arm of the structure.

Figure 12. Looking upstream at the East Fork Salmon EF 7-8 structure in October 2008. Remnants of the berm from the previous year are visible.

Rock Size

A representation of the size of material used to construct the structure was measured. Because of the angular nature of the rocks in this structure, the width (parallel to flow) of the rocks was measured along the structure arms and throat to represent average rock size. An attempt was made to measure headers and footers, but not all rocks could be measured due to being partially buried or absent. Rocks comprising the right structure arm and throat were similar in size. However, the rocks protecting the irrigation diversion along the left arm of the structure were substantially larger. The average size of rocks making up the structure is depicted in Table 1.

Table 1. Average size of rock measured in each East Fork Salmon EF 7-8 structure feature.

	Left Arm (cm)	Throat (cm)	Right arm (cm)
EF 7-8	60	39	39

Bed Material

Representative bed material gradations within the reach were obtained through pebble counts. Two pebble counts were performed using traditional Wolman methodology. The first (EF 7-8_01) was collected on a gravel bar downstream from the structure. The second (EF 7-8_02) was collected in the channel upstream from the structure. Resulting gradations are shown in Table 2, Figure 13, and Figure 14.

Table 2. Particle size distribution (mm) obtained from pebble counts located upstream and downstream from East Fork Salmon EF 7-8 structure.

Name of Sample	Fines <6 mm	D16	D35	D50	D84	D95	% Bedrock	Note
EF 7-8_01	0%	35	53	69	108	147	0%	Downstream Gravel Bar
EF 7-8_02	0%	34	48	55	88	118	0%	Upstream Channel

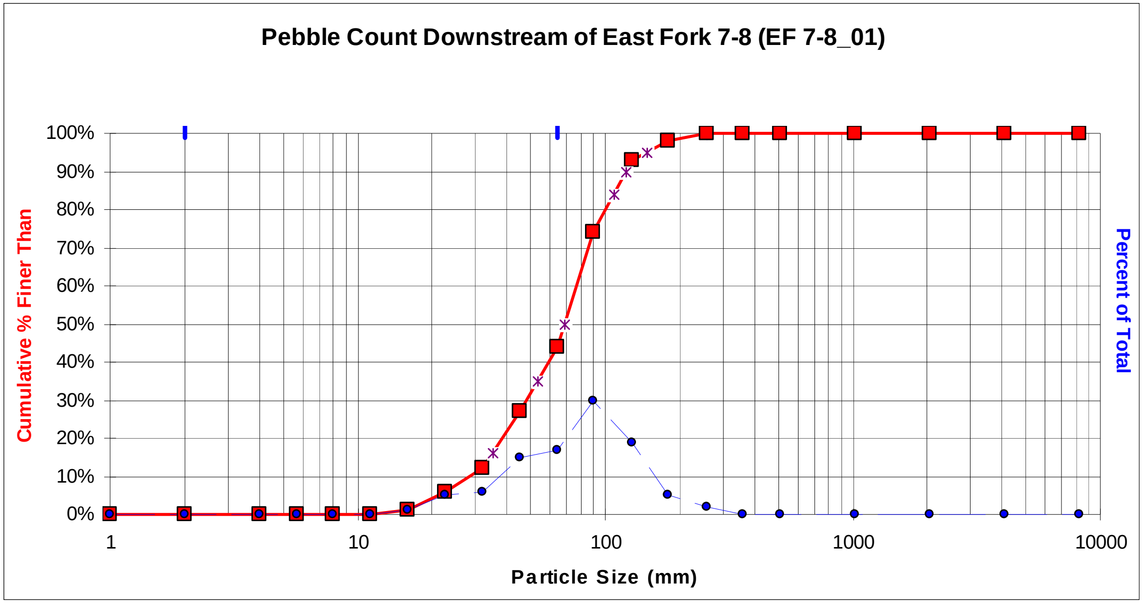

Figure 13. Grain size distribution from pebble count EF 7-8_01 at East Fork Salmon EF 7-8.

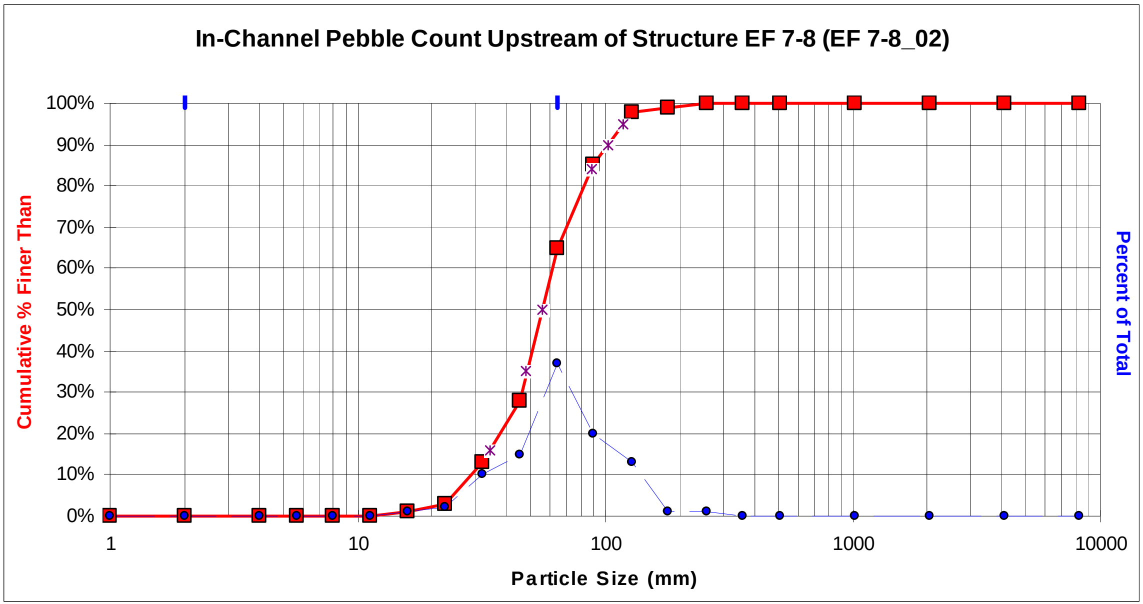

Figure 14. Grain size distribution from pebble count EF 7-8_02 at East Fork Salmon EF 7-8.

Vegetation

Both banks surrounding EF 7-8 are fairly well vegetated with varying densities along the channel embankment. The right bank is composed of a mix of woody trees, grasses, and shrubs, while the left bank is dominated by smaller trees and shrubs. Riprap is present along the channel banks at the structure location. The right arm is tied in to the riprap, which covers the right bank. The left arm is tied in to the diversion gate and irrigation canal. Immediately downstream from the structure, a series of non-river spanning rock structures are present in efforts of protecting the right bank from erosion (Figure 15).

Figure 15. Several rock structures along right bank downstream from East Fork Salmon EF 7-8 structure (October 2008).

Conclusions

Structure EF 7-8 is performing its intended function, but only with regular maintenance to mitigate for sediment deposition upstream of the structure and through the irrigation diversion channel upstream from the irrigation structure. The maintenance appears to entail clearing of the irrigation channel upstream from the structure and/or creating a push-up berm extending longitudinally upstream from the left arm of the structure. Despite a high sediment load and movement of material, the structure is still considered to have mostly maintained its structural integrity. The ramp-like nature of the structure appears to be assisting in its permanence. However, some of the smaller material used in construction has become mobilized during high flow events. The absence of a few headers and dislodged or misaligned footers along the crest combined with the presence of large boulders in the scour pool indicate that some slumping of the footers has occurred, which resulted in mobilization of the headers. A large scour pool is located downstream of the structure but is not currently scouring beneath or undermining the structure. The integrity of the structure is impacted by the ramping or layering of material along the structure slope as opposed to a sharp drop. Although the structure does have maintenance issues associated with the diversion canal, the current state provides some guidance as to structure design for longevity since it has persisted over the last ten years without major modifications and through several high flow events (estimated high flow experienced by the structure is a 30-year storm event). The structure is located in a relatively straight, non-depositional section of the channel between two meander bends, which likely supports its persistence.

East Fork Salmon River, Structure 10-11

Metadata

Conducted by: Elaina Holburn, Chris Holmquist-Johnson, Kendra Russell, and Kent Collins
Structure Type: A-weir
Location: NAD83 State Plane Idaho Central (feet)

- Northing: 903394
- Easting: 1544416
- HUC: 17060201

Description: Double drop rock weir for irrigation diversion
Construction Date: 2003
Initial Site Visit: July, 2005
Second Data Collection Visit: October, 2008

Background

This structure was designed and constructed in 2003 by Reclamation. Historically, the land owners would push up a berm from the bed of the river extending longitudinally upstream to direct flow to the irrigation diversion (Figure 16 and Figure 17). The purpose of the structure was to provide sufficient head for the adjacent irrigation diversion while maintaining fish passage and eliminating the need to use a push-up berm. The structure was designed with a metal T plate along the structure arms and crossbar (Figure 18). A scour pool was excavated downstream of the structure and between the structure throat and cross-bar. The rock weir spans approximately 2/3 of the channel with the irrigation diversion channel spanning the remaining 1/3 of the total channel width. Prior to installation, a large, mid-channel gravel bar was forming between the irrigation canal and the low flow channel. Since construction, the irrigation diversion and structure have experienced substantial ice formation, high flows, large wood and gravel deposition, and bed and bank erosion.

Figure 16. Looking upstream at the berm that was pushed up on a regular basis to guide flow to the diversion prior to installation of the A-weir at East Fork Salmon EF 10-11.

Figure 17. Looking downstream across the berm and the channel prior to installation of the A-weir at East Fork Salmon EF 10-11.

Figure 18. Metal plate installed along the structure cross bar and left arm at East Fork Salmon EF 10-11.

Data Collection

Data collected during the October 2008 site visit included topographic surveys of the structures and surrounding features (e.g. banks, scour pools, thalweg), bed material samples, structure rock size measurements, and qualitative information related to vegetation, bank condition, and structure performance. Despite attempts to acquire information from local biologists, no information on the habitat value of the structure was provided.

Survey Data

A survey of the structure was collected in 2008 to document current conditions and surrounding topographic features, including the bank lines, channel thalweg, scour pools, and adjacent bed topography. Due to high depths and velocities in the scour pool, this topographic feature could not be completely mapped. Data collected at the East Fork 10-11 site are illustrated in Figure 19.

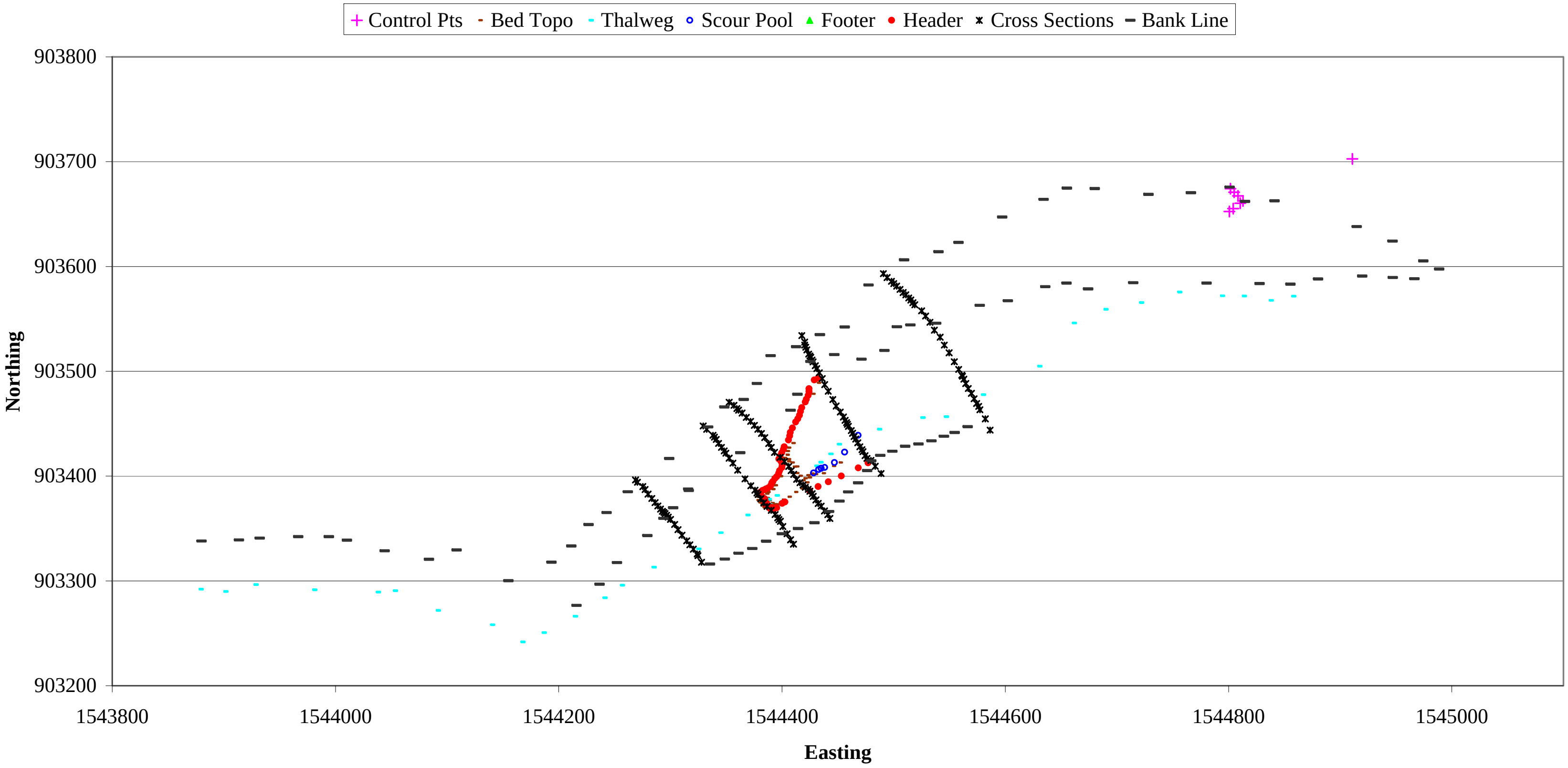

Figure 19. Survey data collected at East Fork Salmon EF 10-11 on October, 2008.

Structure Condition

Structure EF 10-11 is located in a system with a high sediment load. The structure is located just downstream from a geologic constriction of the channel where bedrock was noted in the bed of the channel. Just upstream from the structure, the valley changes from a more confined configuration upstream to a slightly wider valley with a low surrounding surface across which the channel likely migrated historically (in geologic time). The structure currently is not meeting fish passage criteria regarding jump height and velocity. Since installation of the rock weir, the channel downstream from the structure has eroded at least one foot vertically and widened substantially (up to 10 feet) due to erosion along the right bank. The irrigation canal has filled with sediment, and the land owners have returned to using a push-up berm to meet diversion requirements. Figure 20 through Figure 22 provide evidence of structure changes since construction in August of 2003 to October 2008. Although the structure is still intact, the metal plate is now exposed in several locations and some of the headers have moved into the deep scour pools (Figure 23). The metal plate provides a hard point in the river and strongly influences the structure’s persistence. The drop over the throat is currently greater than 2.5 feet, and the drop over the cross bar greater than 4 feet.

The geomorphology of this reach of the river controls the sediment transport through the location of the rock weir. The relatively narrow reach upstream transports sediment to the wider reach in the vicinity of the irrigation diversion, where velocities are reduced and gravels and cobbles may settle. This process is evidenced through a review of ground photos at the site prior to installation of the A-weir. Prior to installation, a mid-channel gravel bar appeared to have been forming upstream from the current location of the structure between the channel and the push-up berm (Figure 24). During high flows, material from this gravel bar may have been mobilized and conveyed downstream along with the smaller material in the push-up berm. Detailed evaluation of historical aerial photos in this reach could help determine if the wider channel and depositional zone present today is part of the natural river process or if it was initiated by the anthropogenic activities associated with the irrigation diversion.

The hydraulics associated with the A-weir inherently induces low velocity zones along the structure arms. The installation of the structure supported the continued development of the gravel bar along the left arm of the structure, which gained substantial rock and organic material during the 2006 high flows (Figure 25). This has resulted in complete burial of the left arm of the structure and flow being limited to a confined throat (with high velocities), which forces flow against the downstream right bank. Material settling in the gravel bar resulted in a sediment deprived condition just downstream from the structure (similar to a dam) and caused local erosion of the channel bed and banks (Figure 26 through Figure 28). Several small rills and channels have formed through the gravel bar, none of which conveys sufficient flow to mobilize the deposited gravels and cobbles.

To alleviate current issues with the structure, multiple options may be considered. To reduce sediment deposition within the irrigation canal, modifications may be made to sluice more sediment under high flows. One method for accomplishing this is to install a stable sluicing structure through the arm of the rock weir that can be activated under higher flows and shut off during low flows. Such a design would require sufficiently high velocities though the irrigation canal to transport the material through the sluicing structure. Alternatively, several notches could be made through the left arm of the structure and the irrigation diversion embankment to allow flow and sediment to be conveyed through the structure. One or multiple secondary flow paths through the gravel bar and left arm of the structure that become activated under medium flows would allow more flow over the structure arm, reduce velocities in the throat, and increase sediment transport along the left side of the channel. However, these options may require some maintenance to keep the channels free of sediment.

In its current state, the A-weir is not capable of maintaining the irrigation head alone due to sediment deposition upstream and in the canal. A push-up berm is maintained by the land owner to guide flow to the diversion channel. Potential short-term fixes would be to excavate the diversion canal and extend a more stable (larger rock) berm longitudinally upstream. This option may require annual maintenance during critical life stages of salmonids.

The most difficult problem, however, is in dealing with the current structure without causing adverse impacts to the diversion canal. The metal plate and large boulders are creating a stable point in an actively migrating location. Allowing the channel to migrate into the right bank of the channel is not a problem (from a river process perspective) as long as the left side of the channel does not become abandoned or completely filled with sediment, thereby cutting off access to the diversion. This appears to be the current trend of the channel based on the time series of photographs. If lateral migration of the right bank becomes a social or political constraint, bank stabilization measures could be taken to eliminate lateral migration at this location. This would not necessarily change the depositional zone along the left bank upstream from the structure however. Removing the metal plates and filling the drops with large boulders to create a ramp through the current structure would alleviate the fish passage jump height problems. However, the throat of the structure may need to be widened to reduce velocities through the confined width and potentially encourage more sediment transport through the structure. Prior to any modifications, it is recommended that a fluvial geomorphologist visit the site to evaluate the stability of the surrounding surfaces and determine the tools needed to adequately assess potential solutions.

Figure 20. East Fork Salmon EF 10-11 just after construction in August 2003.

Figure 21. East Fork Salmon EF 10-11 in July 2005. Note depositional zone upstream from structure on right side of the photo (left bank)

Figure 22. East Fork Salmon EF 10-11 in October 2008. Note significant change in drop height since construction, mobilization of larger boulders, and excessive deposition upstream of structure.

Figure 23. Exposed metal support along East Fork Salmon EF 10-11 structure cross bar (October 2008).

Figure 24. Gravel bar formation between the channel and the irrigation diversion prior to construction of East Fork Salmon EF 10-11 (February 2002).

Figure 25. Looking upstream from where the left arm of the East Fork Salmon EF 10-11structure lies buried under large gravel bar and large woody debris (October 2008).

Figure 26. East Fork Salmon EF 10-11 in May 2005. Note initial bank erosion along right bank.

Figure 27. East Fork Salmon EF 10-11 in July 2005. Increased erosion in visible following spring run off.

Figure 28. East Fork Salmon EF 10-11 in October 2008. Erosion has resulted in destabilization of structure tie-in.

Rock Size

A representation of the size of material used to construct the structure was measured. Because of the angular nature of the rocks in this structure, the width (parallel to flow) of the rocks was measured along the structure arms and throat to represent average rock size. An attempt was made to measure headers and footers, but not all rocks could be measured due to being partially buried or absent; rocks in the left arm of the structure were buried by a large gravel bar and were immeasurable. The average size of rocks making up the structure is depicted in Table 3.

Table 3. Average size of rock measured for each East Fork Salmon EF 10-11 structure feature (cm). * indicates that average is only based on two measurements.

	Throat (cm)	Right Arm (cm)	Cross Bar (cm)
EF 10-11	53	47	*59

Bed Material

Representative bed material gradations within the reach were obtained through pebble counts. Two pebble counts were performed using traditional Wolman methodology. The first (EF 10-11_01) was collected in the channel bed downstream from the structure. The second (EF 10-11_02) was collected in the channel bed upstream from the structure. Resulting gradations are shown in Table 4, Figure 29, and Figure 30.

Table 4. Particle size distribution (mm) obtained from pebble counts located upstream and downstream from East Fork Salmon EF 10-11 structure.

Name of Sample	Fines <6 mm	D16	D35	D50	D84	D95	% Bedrock	Note
EF 10-11_01	0%	35	49	62	121	159	0%	Downstream Channel
EF 10-11_02	0%	40	58	74	119	154	0%	Upstream Channel

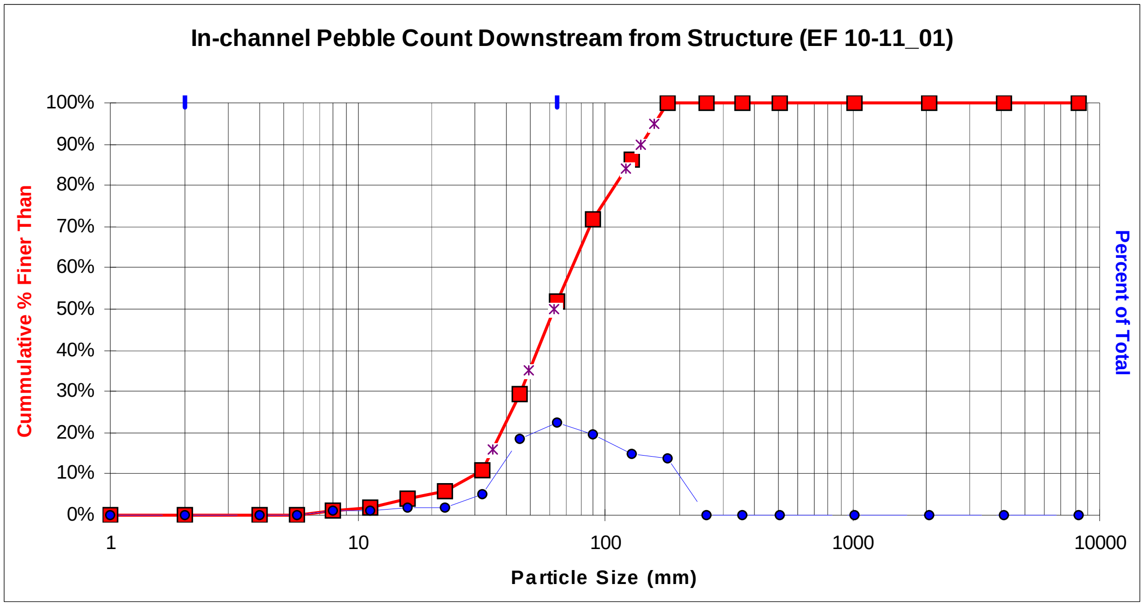

Figure 29. Grain size distribution from pebble count EF 10-11_01 at East Fork Salmon EF 10-11.

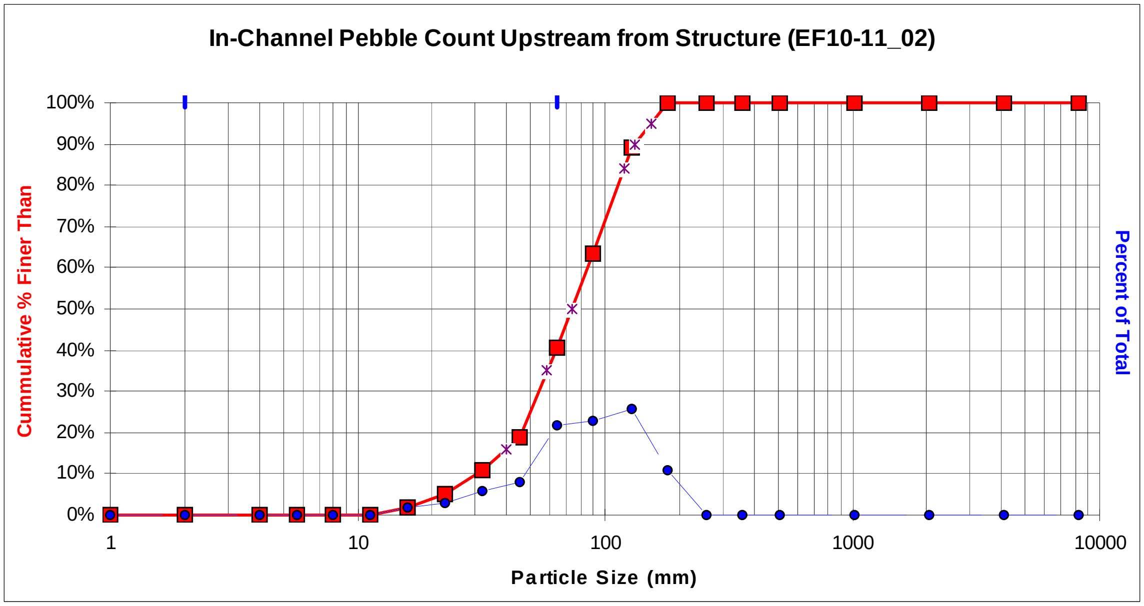

Figure 30. Grain size distribution from pebble count EF 10-11_02 at East Fork Salmon EF 10-11.

Vegetation

Banks are comprised of a highly erodible matrix of sand and gravel. Vegetation in the vicinity of the structures varied in density and type, ranging from woody trees and shrubs to open areas and grasses. In the location of the structure and just downstream, the right bank was not vegetated and has recently experience substantial erosion. The left bank of the channel near the structure also consists primarily of grasses and some shrubs established on an easily erodible sand/gravel matrix. The right arm was tied into the top of the right bank, and the left arm was tied into the irrigation canal and gravel bar at the time of the data collection site visit.

Conclusions

From a stability standpoint, EF 10-11 has persisted over the last 5 years through ice formation, high flows, and high sediment loads. The highest flow experienced by the structure is estimated to have a 30-year return interval. However, many of the rocks have been mobilized into the downstream scour pool, leaving the metal T plate exposed along the left arm and cross bar in several locations. The metal plate has provided added stability to the structure as evidenced in it persistence despite major channel changes downstream. Although the intention of EF 10-11 was to eliminate the need for a push-up berm and annual in-channel work during critical life stages of salmonids, the installation of the structure has led to increased deposition along the left arm and in the irrigation channel upstream from the diversion. The location of a large gravel bar has forced flow through a smaller area of the structure than the original design intended, and now forces flow into the right bank of the downstream channel. Deposition of material above the structure and increased velocities through the structure throat has resulted in increased bank erosion of the right bank and channel bed just downstream from the structure. The drops over the throat and cross bar have become great enough to hinder fish passage. Several potential solutions to the existing structure are possible to eliminate fish passage problems and alleviate sediment deposition upstream of the structure and in the irrigation channel. However, the irrigation channel upstream of the diversion will likely require continued maintenance.

Geomorphic processes, including sediment transport and lateral channel migration, control the channel response to the placement of the structure. Channel adjustment to the structure includes depositing sediment at the head of the irrigation diversion channel at a faster rate, thereby forcing flows and channel position to the right side of the floodplain. The best alternative for reducing the sediment deposition upstream and maintaining fish passage appears to include (1) modifying the current structure to create a ramp with a wider throat than currently exists to spread more flow over a greater area of the channel, (2) providing a sluicing mechanism and a pathway to the main channel to convey sediment deposited in the irrigation canal, and (3) extending a more stable berm upstream and performing annual maintenance within the remaining depositional zones of the canal (avoiding critical salmonid life stages).

Bear Creek

Metadata

Conducted by:
Chris Holmquist-Johnson, Kent Collins, Elaina Holburn, and Kendra Russell
Oregon Department of Fish and Wildlife: Brad Smith

Structure Type: 4 U-Weirs (1 at Site B, 3 at Site D)
Location, US state plane NAD83, Oregon North 3601, Geoid03 (see Figure 31)

- Northing: 707790
- Easting: 8957827
- HUC 17060105

Description: Site B is immediately upstream of Upper Diamond Lane bridge and site D is located upstream of the Bear Creek Rd bridge in Wallowa, OR. Site C is between site B and site D and was not surveyed during the field investigations.
Construction Date: 1999
Initial site visit on September 19, 2006
Data collection conducted on September 20, 2006 and October 25, 2008

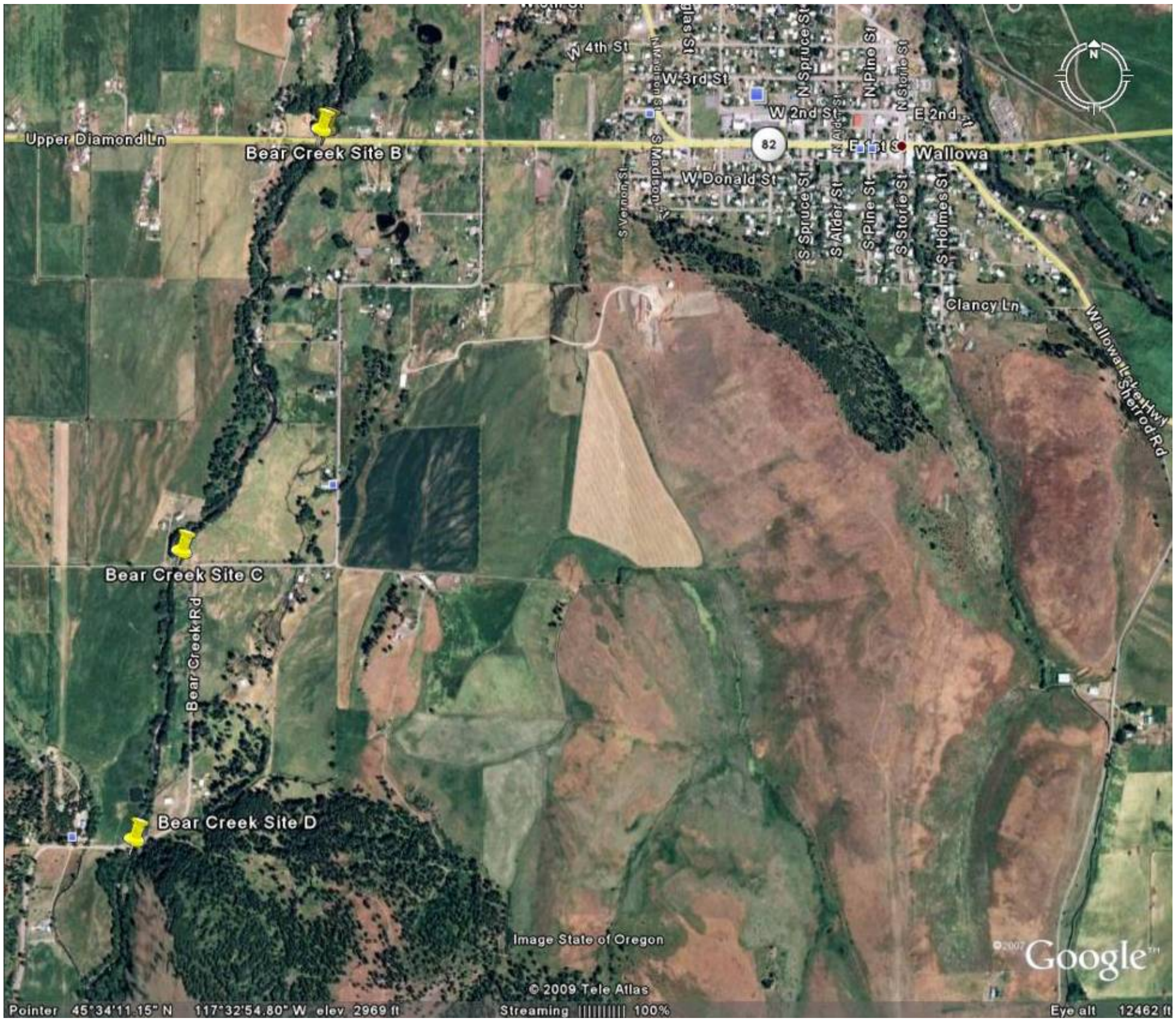

Figure 31. Overview of 4 U-weirs located on Bear Creek

Background

Background information was provided by Darrell Dyke from Reclamation's Grande Ronde area office. Brad Smith with the Oregon Department of Fish and Wildlife met Reclamation staff on October 25, 2008 to tour the site and provide information pertaining to fish habitat at each of the structures (habitat assessment forms completed by Mr. Smith are included at the end of this report).

Bear Creek was originally a flat, broad, shallow channel which was thought to provide inadequate fish passage (Dyke personal communication, 2006). As a result, in 1999 a 2.5 mile long channel reconstruction project using cross vanes (river spanning rock structures) and large woody debris (LWD) was designed to concentrate the flow in the center of the channel and create depth diversity. The project was designed by a private engineer, Frank Reckendorf. Tom Smith from the NRCS was the inspector. Structure stability and fish passage is still an issue but no adjustments are planned. Minor maintenance has occurred but stability is still an issue. Available background data includes:

- Construction Drawings (Paper File)
- Original Channel Survey (NRCS has copies)
- Field Photos (NRCS, Tom Smith)
- Flow Record: USGS gaging station: #13330500 Bear Creek near Wallowa, OR downstream ~2 miles from study site (see Figure 32)

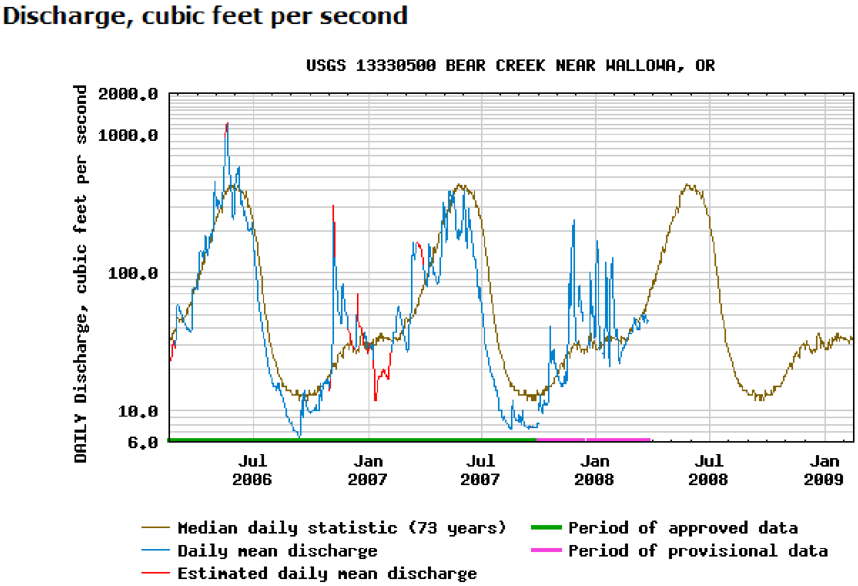

Figure 32. Flow record at USGS gaging station #13330500 Bear Creek near Wallowa, OR.

2006.09.20 Data collection included:

- Qualitative evaluation and photo documentation
- Handheld tape and rangefinder measurements of structure and channel (RTK GPS satellite coverage was not available at time of site visit)

2008.10.25 Data collection included:

- Qualitative evaluation and photo documentation
- RTK Survey of Structure and Channel
- Geo-referenced coordinates for future monitoring surveys
- Biological assessment survey for determining habitat value of river spanning rock structures

The structures are believed to have functioned well prior to a 1,300 ft^3/s flow in May 2006 which moved header and footer rocks and filled in the middle of the channel upstream of the structures. Additional high flows in May 2007 and November 2007 appear to have caused additional movement of the header rocks.

Data Collection

Data collected during the October 2008 site visit included topographic surveys of the structures and surrounding features (Figure 33 and Figure 34; e.g. banks, scour pools, thalweg), bed material samples, structure rock size measurements, and qualitative information related to vegetation, bank condition, and structure performance. Information on the habitat value of the structure was provided by Brad Smith with the Oregon Department of Fish and Wildlife. Due to time constrictions, structure D4 was not included in the GPS survey but was included in the habitat value survey.

Survey Data

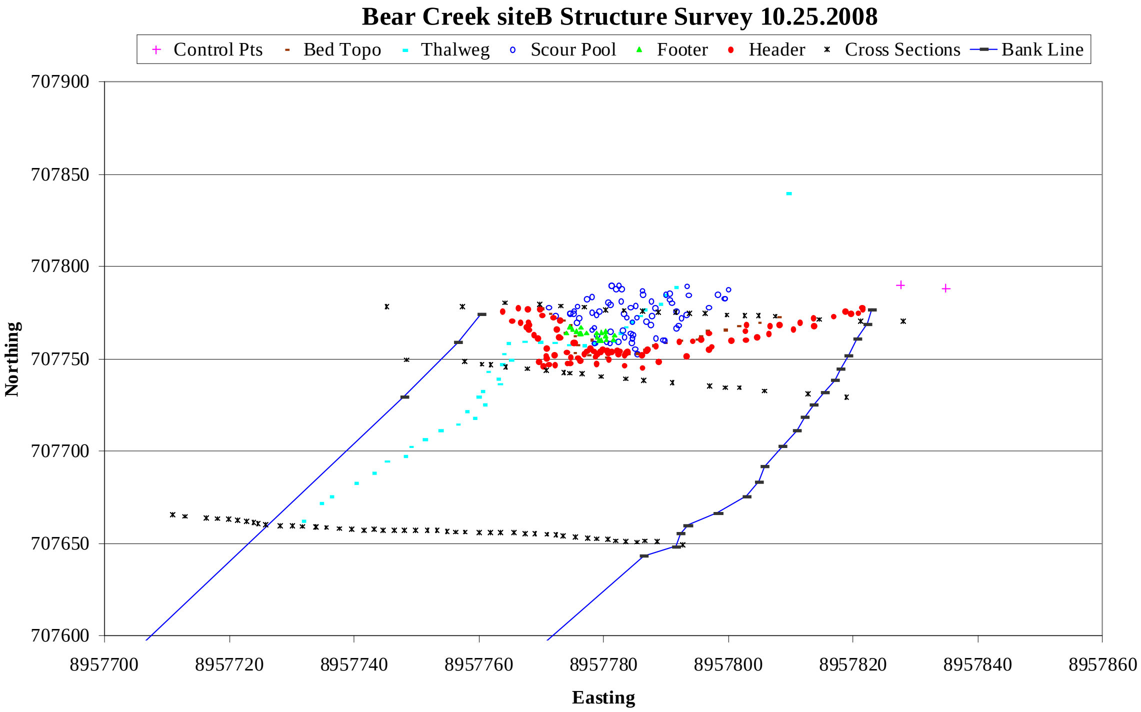

Figure 33. Survey Data collected at Bear Creek site B in October, 2008.

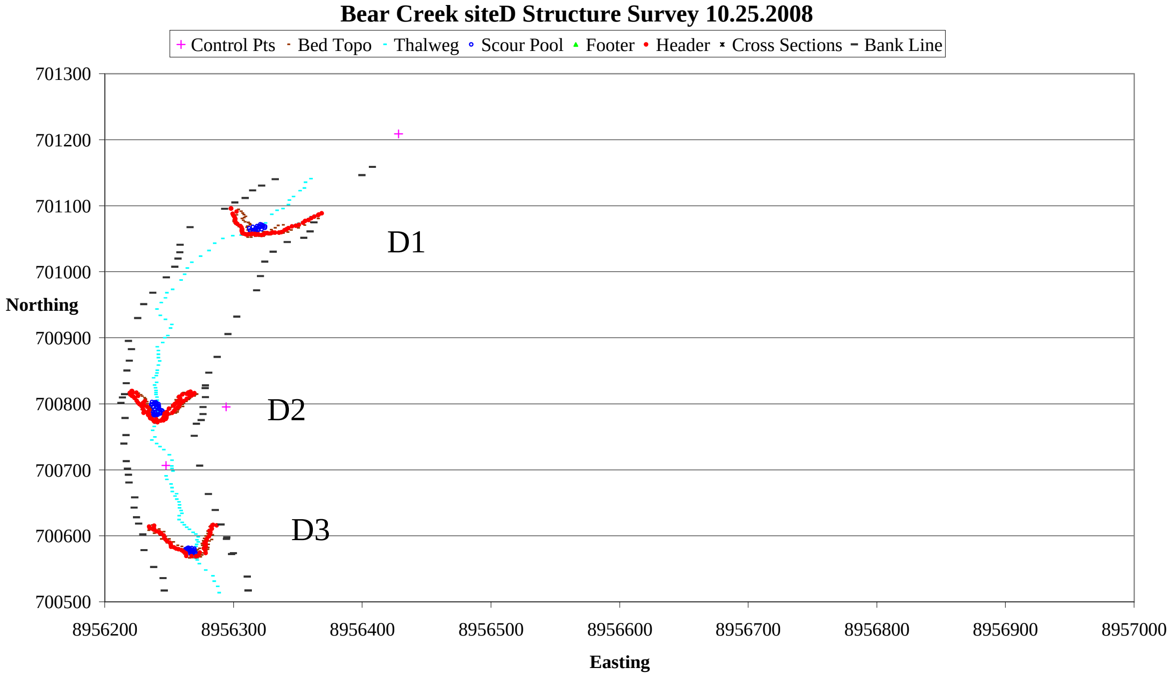

Figure 34. Survey data collected at Bear Creek site D1 in October, 2008.

Structure Condition

Photo documentation from September 19-20, 2006 and October 25, 2008 recorded the state of the weirs and documented processes including qualitative channel conditions, rock motion and mechanism, and deposition upstream of the structures. The river planform consists of a mostly straight reach with very slight bends. Hydraulic influences consist of a bridge at the downstream end of each site (site B, C, and D). At the discharge during the field visit, effects from the bridges did not appear to propagate upstream into the weirs. Figure 35 shows the downstream most structure at Site B, which has experienced excessive rock movement on the left arm. Figure 36 shows the downstream most structure (D1) at site D, which experienced rock movement along both the left and right arms. Multiple low flow jets of water are present through the throats of both structures and along the left arms as a result of the rock movement.

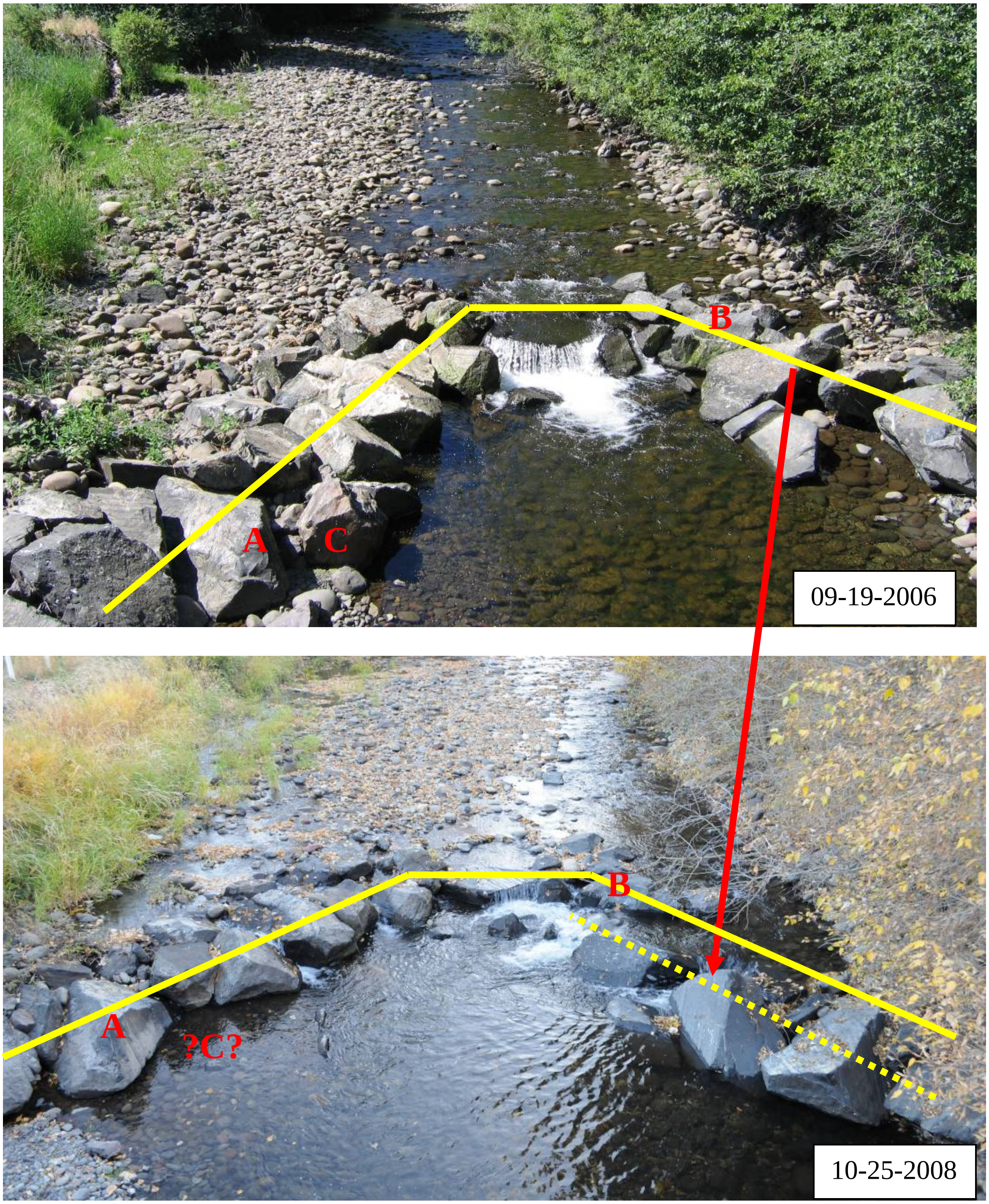

Figure 35. Bear Creek Site B U-Weir Looking Upstream showing rock movement along the left arm.

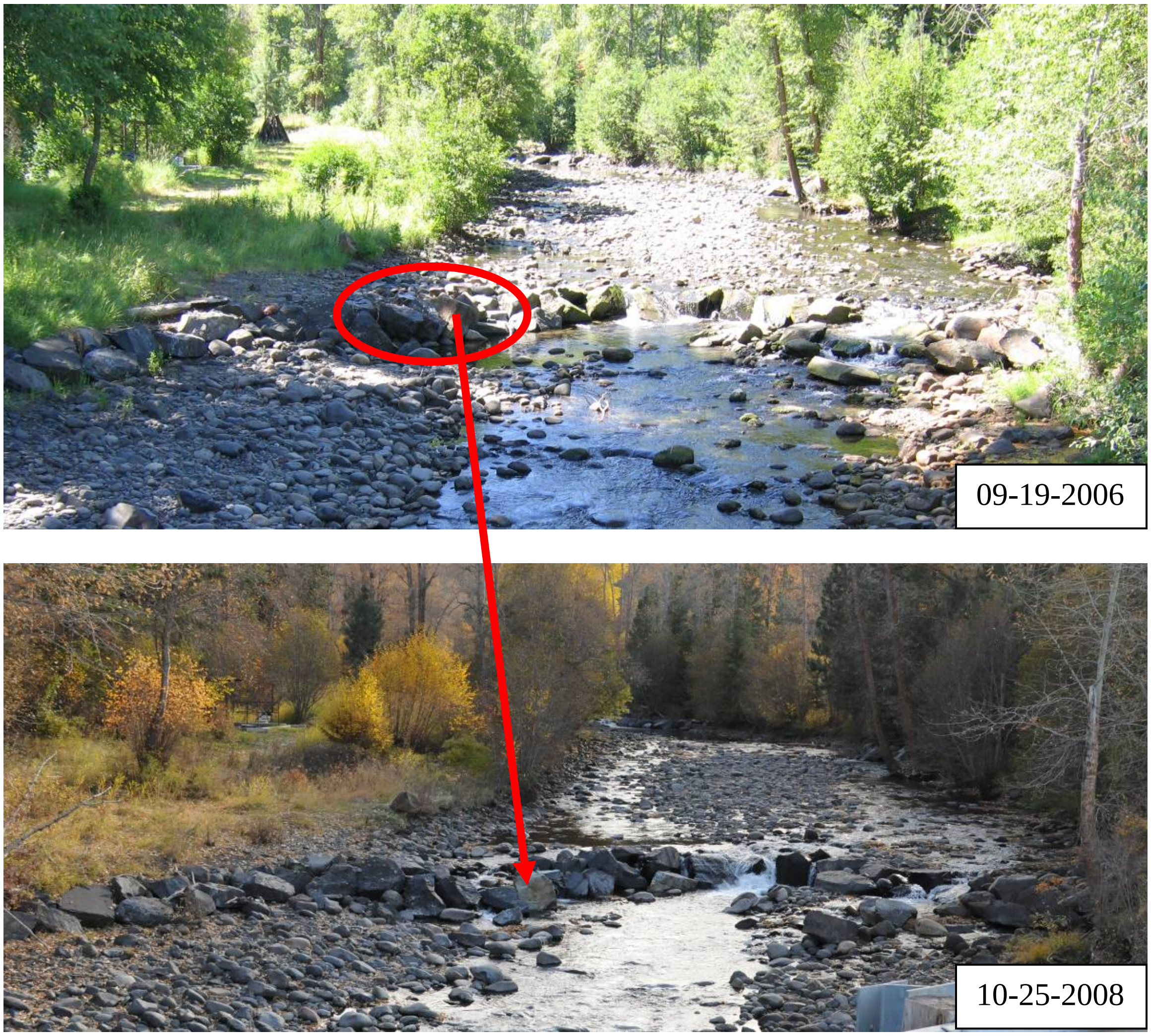

Figure 36. Bear Creek Site D1 U-Weir Looking Upstream displaying rock movement along both arms.

Header rocks in the throat and arms of all the structures appear to have moved just downstream of the originally constructed positions, with structures B and D1 exemplified in Figure 37 and Figure 38, respectively. Footer rocks are visible and appear to have shifted forward (downstream) from their original position. Construction plans called for symmetrical structures so the current alignments likely resulted from motion after installation. Misalignment in plan, reoriented rocks, and visibly protruding footers indicate motion. Incipient motion would not be expected to alter the footers. Movement is likely due to geotechnical slumping of the footer when the scour pool depth exceeded the depth of the footer. Incipient motion would be expected to move the header rocks farther downstream while geotechnical slumping might explain the current positions. Material was naturally deposited upstream of the structure arms to within approximately one foot of the top elevation of the structure in most locations. The formation of gravel bars upstream of the structures and filling along the structure arms indicates a significant sediment load in the system. Large mid-channel bars upstream of structures B and D1 are likely formed due to backwater impacts of the bridge and subsequent settling of gravels and cobbles under high flows. These bar formations upstream of structures B and D1 have resulted in a split flow condition such that the flow is concentrated along the left and right banks. At higher flows, this may cause the flow to be directed more towards the arms of the structures resulting in more flow over the arms and additional scour downstream. This may be the cause of the rock movement seen along the arms of each of the structures. Increasing the depth of the foundation (footer rocks) along the arms of the structure may help provide scour protection and reduce the slumping of the footer rocks into the scour hole.

Figure 37. Hypothesized Locations of the Original Header Rocks at Bear Creek site B1.

Figure 38. Hypothesized Locations of the Original Header Rocks at Bear Creek site D1.

Scour pools were not pre-excavated during construction but do appear to have been hydraulically formed during the high flows, with some deposition in the center of the channel and some scour below each of the arms at each of the structures. Material in the scour pools consisted of large cobbles and small boulders, Figure 39.

Figure 39. Bed Material in Scour Pool at Bear Creek site B.

Rock Size

Rock size was measured to obtain a representation of the size of material used to construct each structure. Because of the angular nature of the rocks in the structure, the depth (vertical) and width (parallel to flow) of the rocks was measured along the structure arms and throat to represent average rock size. An attempt was made to measure headers and footers, but all rocks could not be measured due to being partially buried or absent. Rocks comprising the structure arms and throat were similar in size at each structure. The average size of rocks in the arms and throats for each structure are depicted in Table 5.

Table 5. Average size of rock measured in each Bear Creek structure (cm)

location	Arm Width (cm)	Arm Depth (cm)	Throat Width (cm)	Throat Depth (cm)
B1	80	54	73	56
D1	75	52	70	60
D2	88	63	84	60
D3	99	69	85	81
D4	93	47	102	42

Bed Material

The substrate consists of a deep alluvium absent of bedrock. Visible channel material appeared to range from small cobble to small boulders with no noticeable difference between upstream, downstream, or pool gradations. The structures appear to be constructed on riffle features. Bed particles were relatively clean and loose. Representative bed material within the reach was obtained through pebble counts. One pebble count was performed using traditional Wolman methodology and was collected in the channel upstream from structure D1 (Wolman, 1954). The gradations developed from the pebble count is shown in Table 6 and Figure 40.

Table 6. Particle size distribution (mm) obtained from pebble count located upstream of Bear Creek site D1.

Sample	Fines <6 mm	D16	D35	D50	D84	D95	% Bedrock	Note
Distribution (mm)	0%	39.4	64.5	85.3	246.6	349.7	0%	Upstream Channel

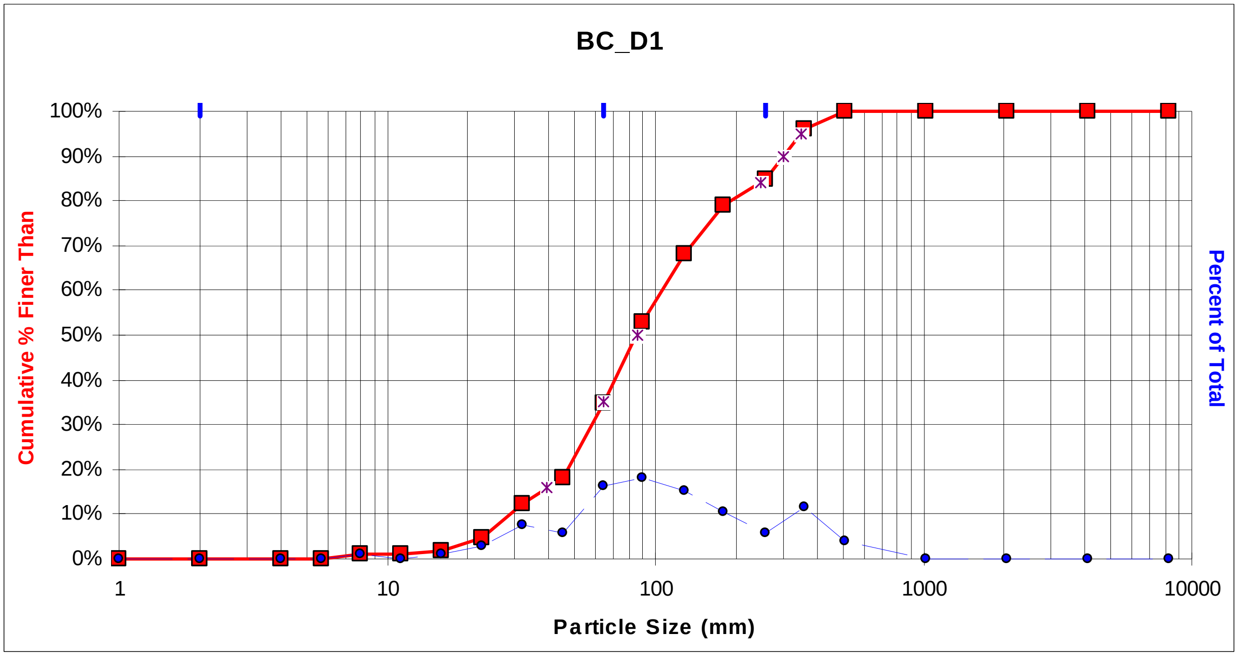

Figure 40. Grain size distribution from pebble count at Bear Creek site D1.

Conclusions

Structures B and D1-4 appear to be performing their intended functions of increasing fish passage and narrowing the channel. Based on mobility, the structures are considered to only be partially intact since a substantial amount of motion of the structural material has occurred. A few headers were absent along the crest and large boulders were present in the scour pool and downstream of the arms. Slumping of footers also occurred, which likely resulted in mobilization of the headers. Displaced header rocks were located and accounted for immediately downstream. Incipient motion was deemed less likely as a failure mechanism since the footer rocks had shifted. Incipient motion would most likely result in the header rocks being displaced and the footers rocks remaining level and undisturbed compared to the slumping case where the footers are found to be slightly displaced from their original position and tilted/rotated in either the upstream or downstream direction.

Sediment filled some portions of the scour pool and the areas upstream of the arms suggesting significant motion of bed material; the clean, loose particles support this conclusion. Pool depth was maintained downstream of the arms where the header rocks remained in their original location.

While the structures appear to have increased sinuosity and bar building in the channel, fish passage is still of great concern. At low flows, the drop over the throat of the structures is close to or greater than the minimum passage for juveniles. Due to the slumping of the structure material along the arms, localized fish passage is available through the voids that would otherwise have blocked passage. Since the goals of these structures were to increase sinuosity, bar formation, pool habitat, and fish passage, the mobility of the structures is not as much of a concern as if their purpose was for maintaining a specified water elevation for irrigation diversion. To the contrary, as stated above, the mobility of the structures has actually allowed fish passage where it may not have been otherwise. Information pertaining to the specific habitat value at each of the structures is provided in the appendix.

Catherine Creek – Swackhammer

Metadata

Conducted by: Elaina Holburn, Chris Holmquist-Johnson, Kendra Russell, and Kent Collins
Structure Types: W-weir and U-weir
Location: Catherine Creek, located in the Town of Union, Oregon

- NAD83 State Plane Oregon North (feet)
- Northing: 573547.899
- Easting: 8883332.809
- HUC: 17060104

Description: W-weir and U-weir are located just downstream from multi-drop concrete weir. W-weir is approximately 200 feet upstream from U-weir.
Construction Date: July 2005
Initial Site Visit: July 2005
Data Collection Visit: October 26, 2008

Background

Darrell Dyke with Reclamation and Lyle Kukenbeker with Grande Ronde Model Watershed Program provided background descriptions of the Swackhammer project. Swackhammer was initially constructed as a 3 pool concrete drop structure in 1995 to aid fish passage across a low-head irrigation dam. Several fixes have occurred since then, including the addition of 2 drops in the concrete structure, a U-weir, W-weir, and two J-hooks.

The W-weir was designed by Reclamation and constructed in 2005. The purpose of the structure was to direct flow away from the eroding right bank and narrow the flow conveyance area. Although the structure was originally planned to be a J-hook, the design was changed based on biological input from USFWS requesting the design of a secondary channel across the right arm (looking downstream) that would convey 30% of the flow and provide backwater habitat. The W-weir was sited at the location of a large mid-channel gravel bar. This bar was excavated prior to construction of the W-weir. In addition, several rootwads were installed along the right bank of the secondary channel to further protect the bank from lateral channel migration and erosion.

The U-weir, located approximately 200 feet downstream from the W-weir, was also designed by Reclamation in 2005 with the purposes of providing grade control and protecting vegetation along the right bank. The U-weir has not been maintained since its original construction.

Data Collection

Data collected during the October 2008 site visit included topographic surveys of the structures and surrounding features (e.g. banks, scour pools, thalweg), bed material samples, a flow estimate, structure rock size measurements, and qualitative information related to vegetation, bank condition, and structure performance. Information on the habitat value of the structure was provided by Lyle Kukenbecker with the Grande Ronde Model Watershed Program.

Survey Data

Surveys of the structures were collected to document current conditions of the structures and surrounding topographic features, including the bank lines, channel thalweg, scour pools, and adjacent bed topography. Topographic data collected at the Swackhammer site are illustrated in Figure 41.

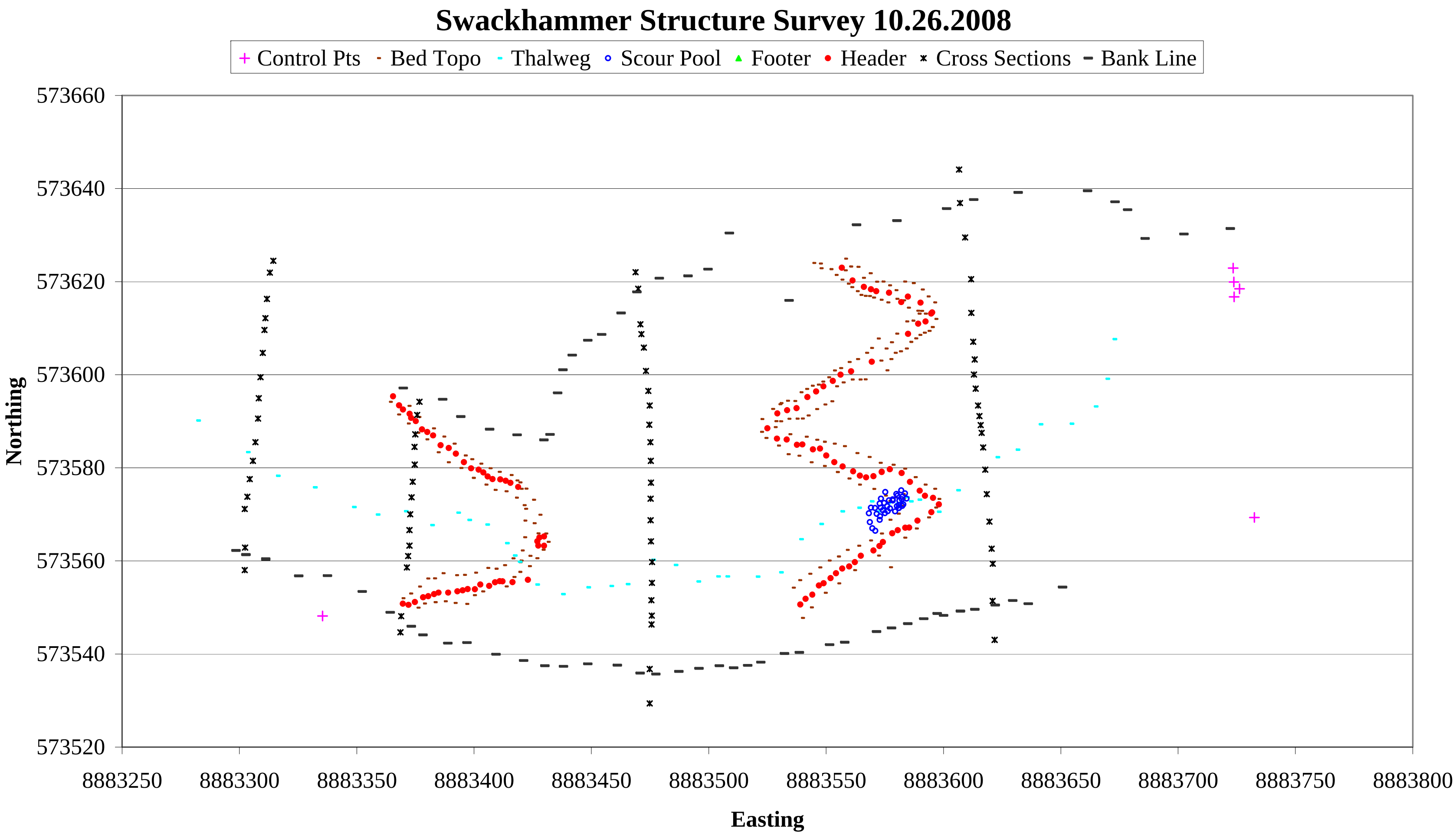

Figure 41. Swackhammer survey data collected on 10/26/2008.

Structure Condition

W-Weir

The area just downstream from the concrete weir appears to have been a depositional area over the past 15 years; at least since the concrete weir was constructed (Figure 42 and Figure 43). The depositional nature may be a result from the wider channel conveyance area downstream from the concrete structure and from a reduction in channel slope. The W-weir is located within this depositional zone and has experienced substantial growth of the gravel bar behind the center and right arm of the weir. Another point bar has begun to establish upstream of the W-weir, splitting flow into two paths that converge near the left throat of the structure. Currently, the W-weir is acting as a U-weir across half of the width of the historical channel, acting to concentrate flow along the left portion of the channel and reduced velocities and shear stresses along the right bank (Figure 44 and Figure 45). Because the W-weir is essentially two U-weirs with only one actually conveying flow, the active structure is referred to throughout this field report as the left U-weir.

Although the concrete weir restricts lateral movement, the right bank downstream of the concrete weir has experienced bank erosion since the installation of the concrete weir. It is unclear if the bank erosion is part of a natural lateral migration process or a process instigated by the presence of the concrete weir. The high sediment load through this section of river and presence of meanders and gravel bars provides some evidence that the channel may have been laterally active prior to installation of the concrete weir.

Figure 42. Prior to installation of the W-weir at Swackhammer, the area downstream from concrete weir was a depositional zone. This picture illustrates the conditions on August 29th, 1997 looking downstream.

Figure 43. This picture is in the same location as that shown in the previous figure. Photo was taken a couple of months prior to the construction of the rock weirs at Swackhammer on May 25, 2005.

Figure 44. Looking upstream across the W-weir at Swackhammer just after its construction in July, 2005. Note the presence of the side channel located in the right arm of the W-weir. Native material was used to backfill the larger rocks of the arms.

Figure 45. Looking upstream in the same location at Swackhammer as the previous figure in October 2008. Note the growth of the gravel bar and the disconnection of the side channel.

The stability of the headers along the left side of the W-weir has been compromised as evidenced by mobilization of headers along the arms (of the left U; Figure 46 and Figure 47) and in the throat (of the left U; Figure 48 and Figure 49). Footer rocks along the arms of the W-weir appear smaller than the header rocks. Header rocks that are intact are tightly spaced with only small gaps between larger angular rocks that do not lock together. Minor seepage between the header and footer rocks was visible along the arms of the left U during the site visit (Figure 50).

Several headers have fallen into scour pool (Figure 51). Material at the bottom of the scour pool consists of very large cobbles and boulders in the deepest parts with fining downstream to gravel of approximately 32 mm in diameter.

Approximately 200 feet separate the W-weir and U-weir with a large bar on river right, several root wads (3) in the right bank, and multiple boulders placed in the channel between the structures to provide additional slow-velocity habitat areas. Although the side channel has become plugged at the upstream end and has filled in with sediment, it may be activated at high flows and could possibly provide some backwater habitat (Figure 52 and Figure 53).

Figure 46. Right arm of left U-weir at Swackhammer. The center section and right arm of the structure are completely buried. October 2008.

Figure 47. Left arm of left U-weir at Swackhammer. Note the slumping of some of the material where the footers have been dislodged and scoured. Some of this material does not appear to be present following initial construction but may have just been covered with backfilled material. October 2008.

Figure 48. Looking downstream across W-weir at Swackhammer. Note the entire center and right arms have completely filled in with sediment and debris. October 2008.

Figure 49. Throat of structure at Swackhammer. Several rocks have slumped into downstream scour pool, creating a series of steps, rather than a steep drop. October 2008.

Figure 50. Rocks along right arm of left U at Swackhammer, illustrating minor seepage underneath and between the header rocks. October 2008.

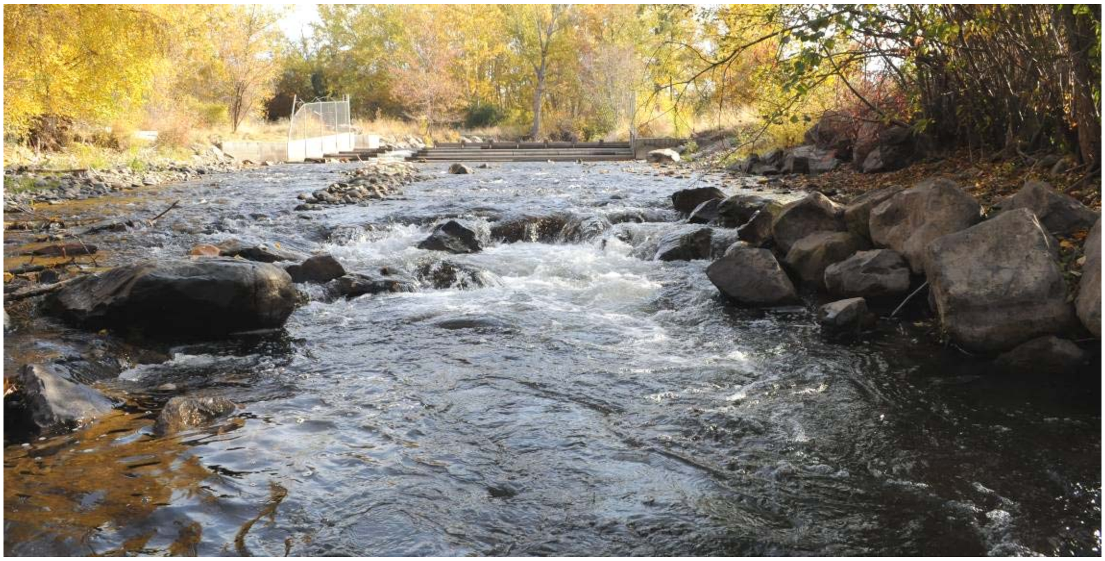

Figure 51. Photo looking upstream across left U-weir at Swackhammer. Several dislodged rocks have fallen into the scour pool. October 2008.

Figure 52. Rootwads installed along right bank between W- and U-weirs at Swackhammer. Photo looking downstream just after construction (July 2005).

Figure 53. Rootwads along right bank looking upstream at Swackhammer (October 2008).

U-Weir

The U-weir is located along the upstream end of a meander bend approximately 200 feet downstream from the W-weir. While the purpose of the U-weir was to provide grade control and protect vegetation along the right bank, a large pool upstream of the U-weir under overhanging vegetation has filled with sediment and the side channel has been partially filled in. The throat of the U-weir was installed at or near grade as evidenced in Figure 54 where no drop in the water surface elevation is present at low flows. The U-weir was not designed with the primary intention to concentrate flow, and therefore the throat of the structure spans nearly 2/3 of the channel width.

Comparison of the U-weir condition just following construction (Figure 54) with the condition during the October 2008 field visit (Figure 55) suggests that structural components of the U-weir have not experienced substantial mobility. The native backfilled material provided a natural appearance post-construction and filled in voids between the larger rocks. However, a large portion of the exposed gravels and small cobbles have been transported out of the structure and voids remain between the larger rocks where the angularity of the rocks prevented interlocking (Figure 56).

Immediately following construction, a pool existed in the location of the U-weir. This area has since filled in with material and appeared shallower during the 2008 site visit with no pool present at the structure throat (Figure 57). However, a smaller, deep pool is now present along the left arm of the structure where plunging flows have scoured a few of the footer rocks and resulted in the slumping of a couple of header rocks into the pool (Figure 58).

Figure 54. Photograph of the U-weir at Swackhammer just after construction in July 2005. The arms of the structure were backfilled and the throat set at grade.

Figure 55. Same location looking downstream across the U-weir at Swackhammer in October 2008. A lot of the backfilled material has been transported downstream.

Figure 56. Right arm of U-weir at Swackhammer. Some voids present between larger rocks and a lot of the native backfilled material has been scoured out of structure. October 2008.

Figure 57. View of the U-weir at Swackhammer looking upstream in October 2008. No pool is present at the structure throat.

Figure 58.Connection of the throat and left arm of the structure at Swackhammer. Several rocks have fallen into the scour pool along the left arm of the structure.

Rock Size

Rock size was measured to obtain a representation of the size of material used to construct each structure. The width and height of the rocks was measured along the structure arms and throat. An attempt was made to measure headers and footers, but all rocks could not be measured due to being partially buried or absent.

In both the W-weir and the U-weir, rocks comprising the structure arms were slightly larger than those in the throats. The average size of rocks in the arms and throats for each structure are depicted in Table 7.

Table 7. Average size of rock measured in each structure at Swackhammer (cm).

Structure	Location in structure	Average Width (cm)	Average Height (cm)
W-weir	Arms	68	40
W-weir	Throat	57	31
U-weir	Arms	68	37
U-weir	Throat	53	27

Bed Material

Representative bed material within the reach was obtained through pebble counts. Two pebble counts were performed using traditional Wolman methodology. The first (SH_01) was collected along a gravel bar, located on the right side (looking downstream) of the low flow channel path. The second (SH_02) was collected downstream from the U-weir on a gravel bar along the right side of the channel. Gradations developed from the pebble counts are shown in Table 8 and Figure 59 and Figure 60.

Table 8. Particle size distribution (mm) obtained from pebble count at Swackhammer located upstream from W-weir and downstream from concrete weir.

Name of Sample	Fines <6 mm	D16	D35	D50	D84	D95	% Bedrock	Note
SH_01	1%	30.5	49.3	64.0	108.9	144.7	0%	Gravel Bar
SH_02	1%	28.9	37.7	43.9	90.6	141.0	0%	Downstream Gravel Bar

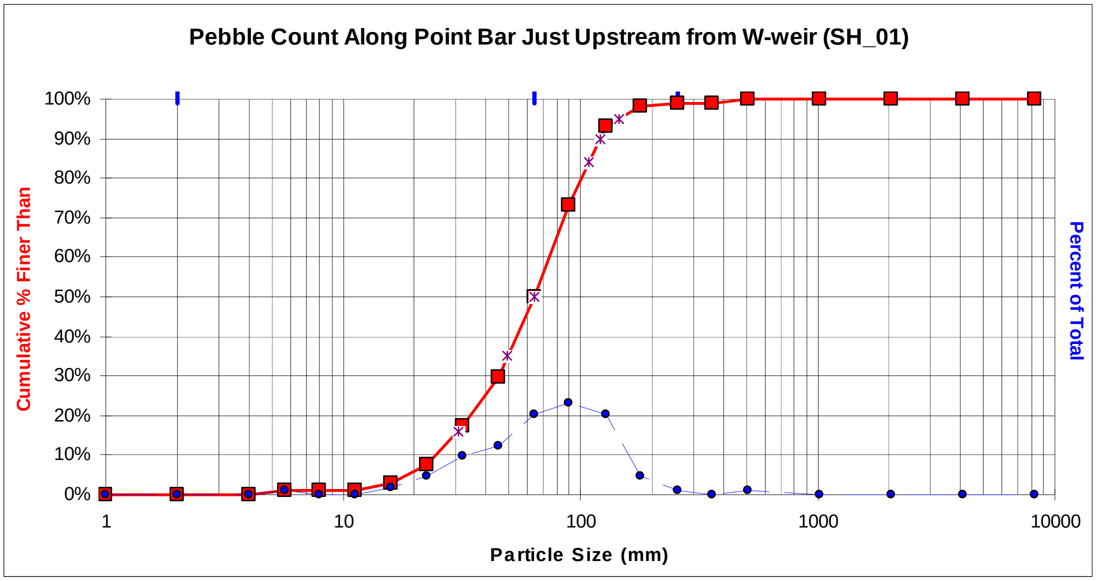

Figure 59. Grain size distribution from pebble count SH_01 at Swackhammer.

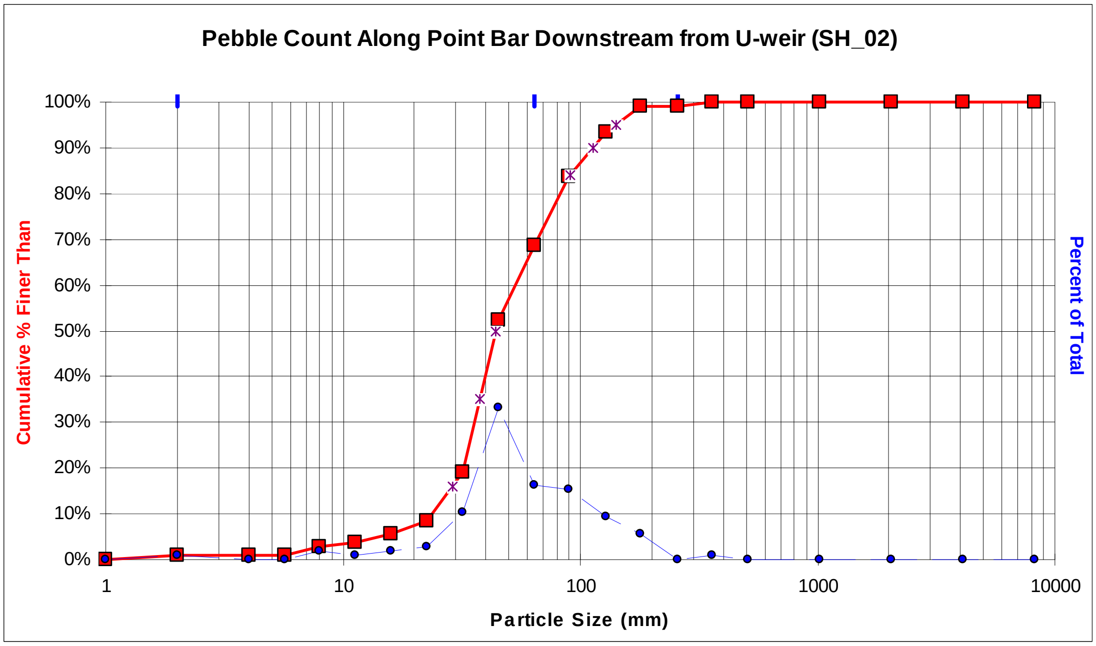

Figure 60. Grain size distribution from pebble count SH_02 at Swackhammer.

Vegetation

Vegetation in the vicinity of the Swackhammer project consisted of brush, cottonwoods, sedges, alder, snow pea, berry bush, and Johnson grass. The presence of young (1-2 year) cottonwoods and willows provide evidence for functioning vegetation recruitment processes. Overall, the riparian corridor is in good condition. However, the left bank near the U-weir is stabilized with a large amount of riprap to protect the dirt road embankment, which impedes woody vegetation establishment. The banks appear to have good root strength and where not comprised of riprap or root wads, consist of a sand and gravel matrix.

Flow Estimate

Flow through the W-weir and U-weir on the date of the survey was estimated by measuring the critical depth through the rectangular fish weir. The following equations were used to estimate flow:

$$q = \sqrt{y_c^3 g}$$

$$Q = qw$$

Where q = unit discharge (ft^2/s)
y_c = critical depth (ft)
g = acceleration due to gravity (ft/s^2)
Q = discharge through rectangular structure (ft^3/s)
w = width of rectangle (ft)

The resulting flow was calculated to be 25.8 ft^3/s.

Conclusions

Channel morphology in this section of river controls the channel geometry. The historical presence of the gravel bar indicates that the area just downstream from the concrete weir has been depositional over the last 15 years. The W-weir appears to be successfully functioning to reduce velocities and shear stresses along the right bank. However, the modification to the hydraulics resulting from the installation of the W-weir has increased the deposition to the extent of plugging the secondary channel and concentrating flow to the left arm of the W-weir. This concentration of flow resulted in an increased scour depth along the structure arms and through the throat that exceeds the structure foundation. The slumping of the footer rocks resulted in mobilization of the header rocks in a few localized areas. Although the side channel is not conveying flow perennially, it may transport some flows under high water conditions. A large enough discharge may result in some mobilization of the material plugging the channel and temporary activation of the side channel. However, the high sediment load and debris present in the system suggest that the depositional nature of the area will persist. The side channel and LWD along the right bank may provide some backwater habitat under high flow conditions.

With the exception of mobilization of a few rocks along the structure arm, the U-weir remains intact. The U-weir has resulted in deposition along the right bank upstream from the structure, thereby protecting vegetation. The need for grade control in this location no longer appears relevant as the previously existing pool has filled in with sediment. The U-weir is currently acting primarily as bank protection and preventing lateral migration of the channel. The design of the U-weir did not substantially alter hydraulics through the channel at this location. Minimal channel constriction (due to the wide throat combined with the lack of a drop over the structure) has resulted in a stable structure.

Catherine Creek – Hempe Hutchinson

Metadata

Conducted by: Elaina Holburn, Chris Holmquist-Johnson, Kendra Russell, and Kent Collins
Structure Types: 3 U-weirs
Location: Located on Catherine Creek downstream from the town of Union, Oregon.

- NAD83 State Plane Oregon North (feet).
- Northing: 574320
- Easting: 8878950
- HUC: 17060104

Description: Three U-weirs are located just downstream from a multi-drop concrete diversion/fish passage structure. Approximate weir spacing is 50 to 60 feet.
Construction Date: Originally constructed between 1997 and 1998, modified between 2000-2001
Initial Site Visit: July, 2005
Data Collection Visit: October, 2008

Background

Background information for Hempe-Hutchinson was provided by Lyle Kukenbecker with Grande Ronde Model Watershed Program and Darell Dyke with Reclamation. This reach of Catherine Creek was historically channelized for flood control. An irrigation diversion had operated in the vicinity previously and prevented upstream fish passage. Therefore, in 1994, NOAA and ODFW designed and constructed a multi-drop concrete weir. Over time, the channel just below the structure down-cut and the jump height for salmonids was exceeded. Therefore, two U-weirs were added for additional grade control three to four years later. Between 2000 and 2001, the two U-weirs were modified, and an additional U-weir was added downstream of the other two structures. Each drop of the concrete weir currently has a resting pool, but it is still not meeting fish passage criteria. Although the structure does not obstruct most adult steelhead, juvenile steelhead and Chinook tend to have passage problems. Therefore, an older fish ladder along the right bank has been reactivated. All structures in this series are located through a straight reach and are spaced sufficiently close to impact the hydraulics of the next upstream structure (Figure 61).

Figure 61. Series of three U-weirs along Catherine Creek, just downstream from the Hempe-Hutchinson Diversion weir and fish passage structure. October 2008.

Data Collection

Data collected during the October 2008 site visit included topographic surveys of the structures and surrounding features (e.g. banks, scour pools, thalweg), bed material samples, structure rock size measurements, and qualitative information related to vegetation, bank condition, and structure performance. Despite attempts to acquire information from local biologists, no information on the habitat value of the structure was provided.

Survey Data

Surveys of the structures were collected to document current conditions of the structure and surrounding topographic features, including the bank lines, channel thalweg, scour pools, and adjacent bed topography. Data collected at the Hempe-Hutchinson site are illustrated in Figure 62.

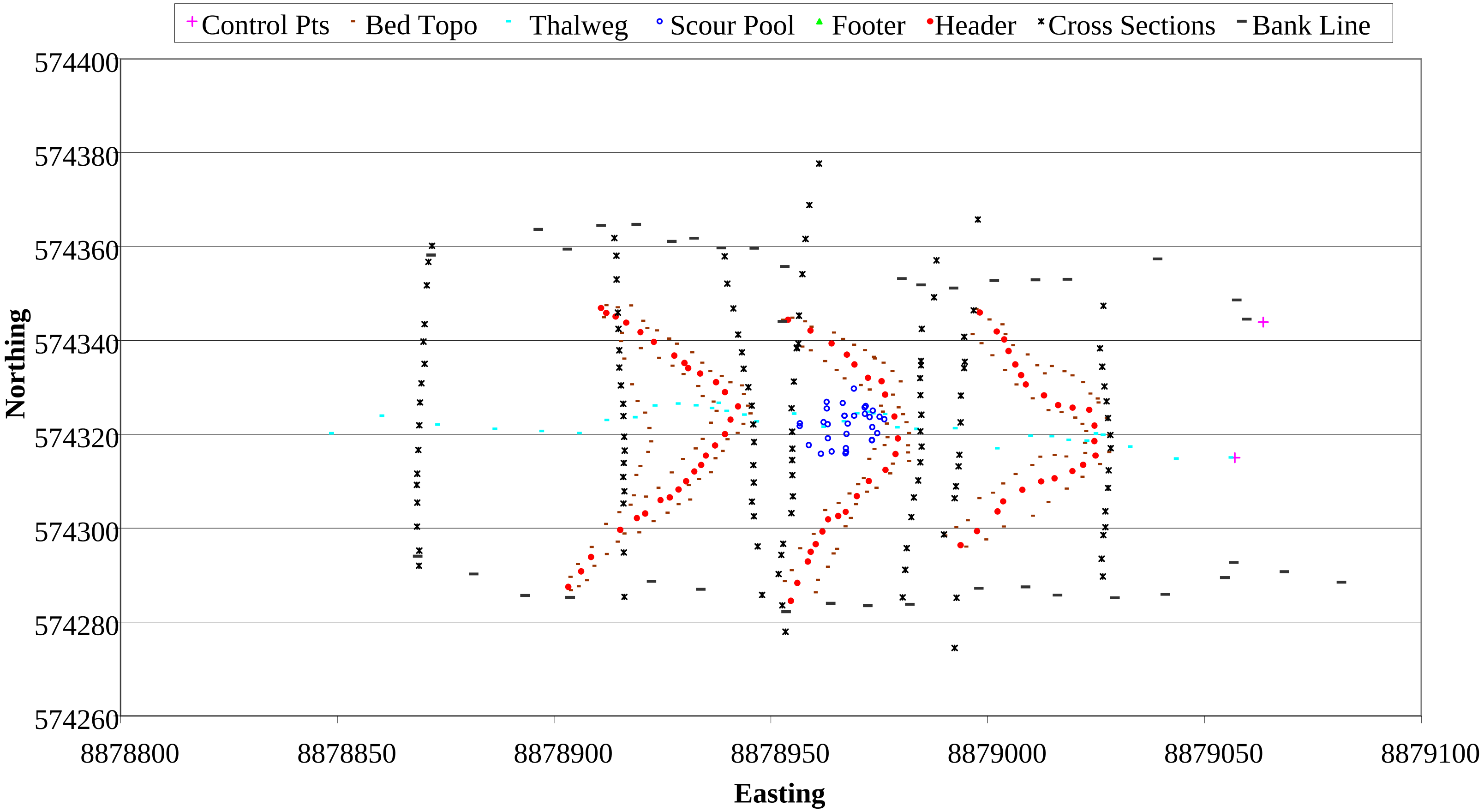

Figure 62. Survey data collected on October 26, 2008 for Hempe-Hutchinson.

Structure Condition

HH1: Downstream-Most U-Weir

The downstream-most structure currently acts more like a roughened channel feature than a stable U-weir. Photo comparison between 2005 and 2008 suggests that some minor shifting of the structure rocks has occurred over the past few years (Figure 63 and Figure 64). Almost all of the header rocks have slumped inward, part of which may have to do with the angular nature of the rocks used in the structure. Some spaces were noted between the rocks where edges of rock were not interlocking. The size of the voids between the rocks ranged from 6 inches to 1 foot. Some flow was noted between the larger voids along the structure arms. A shallow pool is present just downstream of the structure throat with bed material size of approximately 180 mm on average. Because of the roughened nature of the structure, fish passage through the structure is very good. A depositional zone is present downstream from the structure where coarse sands were noted in the bed. This structure is tied-in to the bank and riprap.

Figure 63. HH1 at Hempe Hutchinson in July 2005. Substantial shifting of the structure material occurred since the date of construction.

Figure 64. Structure HH1 at Hempe-Hutchinson in October 2008. Comparison of the 2008 photo with the 2005 photos indicates additional minor shifting of rock along the right arm.

HH2: Middle U-Weir

Structure HH2 is located approximately 50 feet upstream from HH1. The tail water of HH2 is controlled by the head water/header rocks of HH1. The header rocks along the right arm and throat of the structure have shifted (Figure 65). Some of the throat headers have moved into the downstream scour pool due to apparent geotechnical slumping of the footer rocks, which have noticeably tilted forward. Along the intact portions of the arms, the headers are locked together well with smaller material filling the voids between the headers. The scour pool was approximately 3 feet deep and comprised of a few large rocks from the structures with a matrix of sands and gravels. The remaining footers in the structure throat (with no headers) were visibly interlocked (Figure 66). Upstream of the throat, the structure has filled with cobbles and gravels. This structure is tied-in to the bank and riprap.

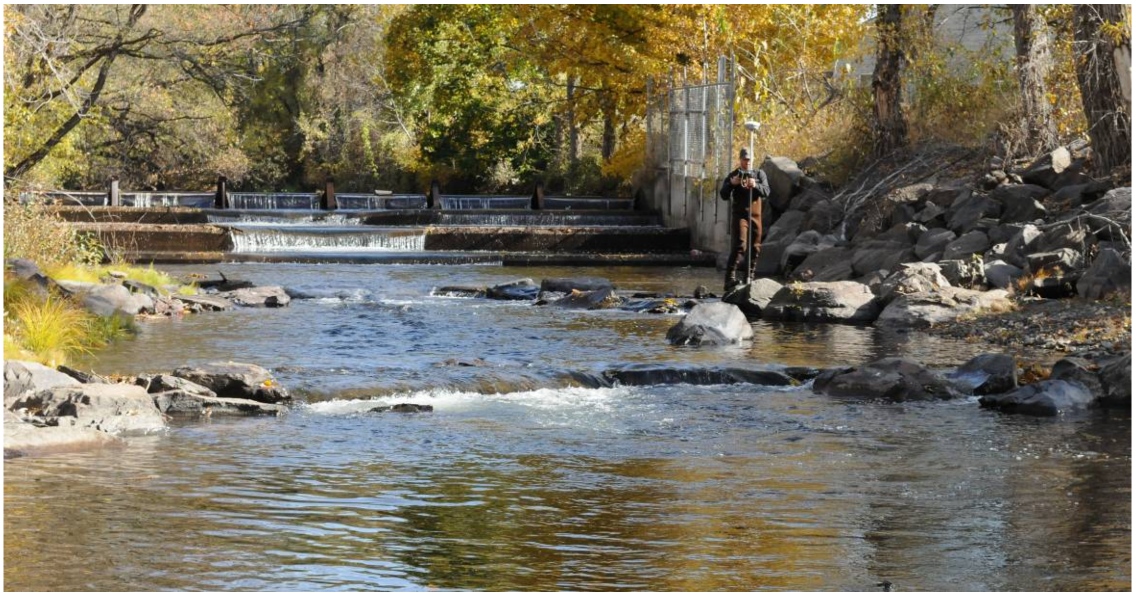

Figure 65. Structure HH2 at Hempe-Hutchinson in October 2008.

Figure 66. Remaining throat of HH2 at Hempe-Hutchinson. Note the titling of the footers and the headers that have slumped into the downstream scour pool.

HH3: Upstream Most U-Weir

HH3 is located approximately 60 feet upstream from the next downstream U-weir, HH2. At the time of the data collection visit, structure HH3 was in good condition relative to the stability of the two downstream structures. The drop over the HH3 was estimated to be 1.5 feet. Some shifting of the header rocks was noted along the left arm and throat of the structure. However, minimal shifting was evidenced between July 2005 and October 2008 (Figure 67 and Figure 68). On the downstream side of the structure, the pool was not well developed. Within the pool, bed material typically ranged between 64 mm to 180 mm in diameter. A header rock appeared to be missing from the throat of the structure, but it was difficult to discern if it was initially present. Some of the crest rocks have shifted forward. Most of the voids present in the header were filled with gravels approximately 32 mm to 45 mm in diameter. This structure is tied-in to the bank and riprap.

Figure 67. Structure HH3 at Hempe-Hutchinson in July 2005.

Figure 68. Structure HH3 at Hempe-Hutchinson in October 2008.

Rock Size

Rock size was measured to obtain a representation of the size of material used to construct each structure. The width (parallel to flow) and height of the rocks were measured along the structure arms and throat. An attempt was made to measure headers and footers, but all rocks could not be measured due to being partially buried or absent. Rocks comprising the structure arms were similar in size to those in the throats, with the exception of structure HH1, where the throat rocks were considerably larger than those along the arms. The average size of rocks in the arms and throats for each structure are depicted in Table 9.

Table 9. Average size of rock measured in each structure at Hempe-Hutchinson (cm).

	Arm Width (cm)	Arm Depth (cm)	Throat Width (cm)	Throat Depth (cm)
HH1 (Downstream)	68	32	120	50
HH2 (Middle)	72	38	71	40
HH3 (Upstream)	79	36	74	25

Bed Material

Representative bed material within the reach was obtained through pebble counts. Two pebble counts were performed using traditional Wolman methodology. The first (HH_01) was collected in the channel approximately 50 feet downstream from structure HH1, near the cattle crossing and fish return pipe. The second (HH_02) was collected just downstream from the concrete diversion/fish passage structure, but upstream from HH3. Gradations developed from the pebble counts are shown in Table 10, Figure 69 and Figure 70.

Table 10. Particle size distribution (mm) obtained from pebble count located upstream and downstream from rock weirs at Hempe-Hutchinson.

Name of Sample	Fines <6 mm	D16	D35	D50	D84	D95	% Bedrock	Note
HH_01	0%	34.7	49.8	60.7	102.8	150.9	0%	Downstream Channel
HH_02	0%	31.3	47.9	61.7	103.6	137.4	0%	Upstream Channel

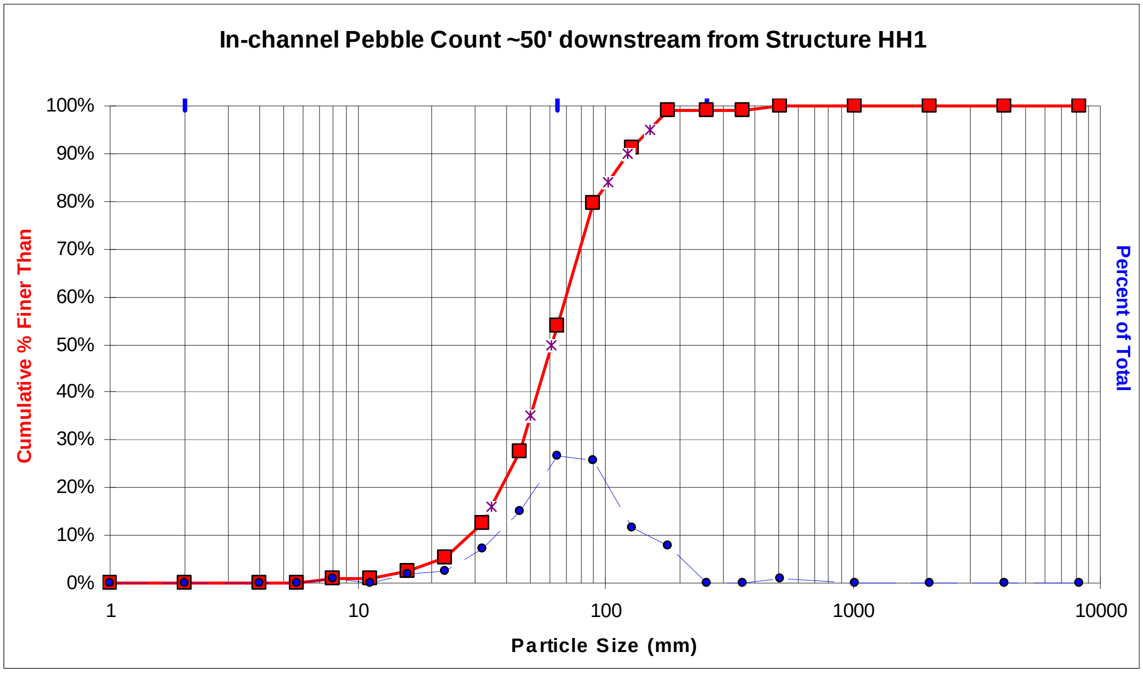

Figure 69. Grain size distribution from pebble count HH_01 at Hempe-Hutchinson.

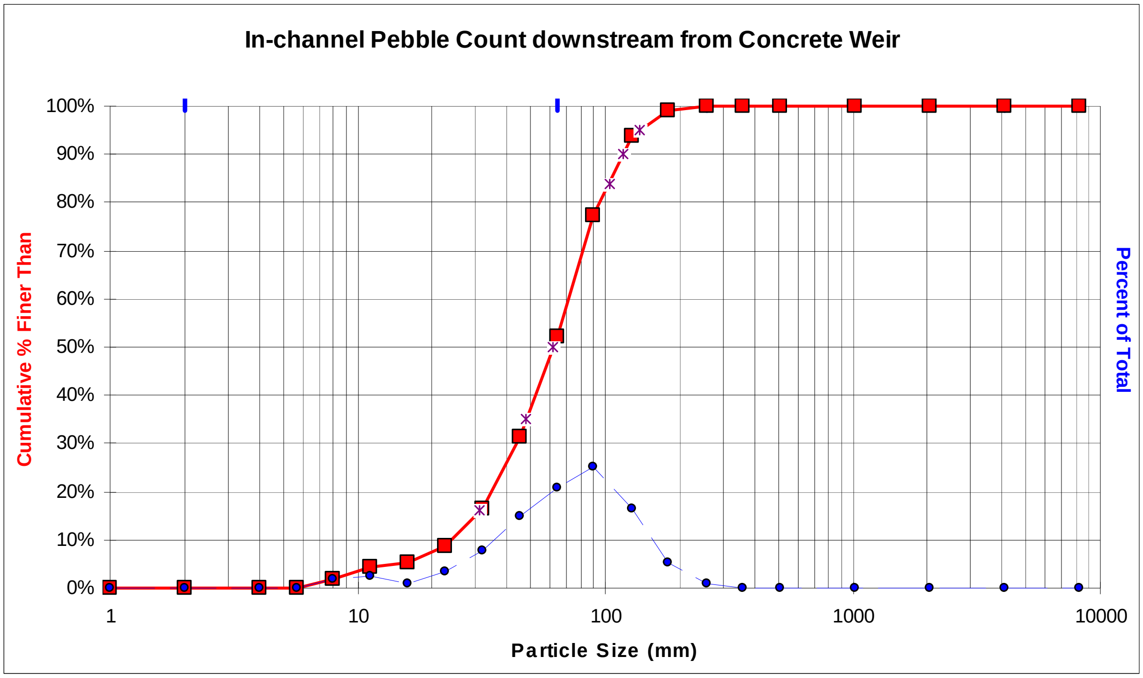

Figure 70. Grain size distribution from pebble count HH_02 at Hempe-Hutchinson.

Vegetation

Vegetation in the vicinity of the Hempe-Hutchinson project consisted of cottonwoods, snow pea bushes, sedges, and high Johnson grasses. Due to historic channelization and clearing of the reach for flood protection, both banks are covered in riprap along the entire lengths of the structures. Riprap is comprised of angular basalts.

Conclusions

All three structures appear to be meeting their original intention of grade control, and it does not appear that fish have difficulty in passing through the rock weirs despite issues with some species passing through the concrete structure. From a stability standpoint, however, all three rock weirs have experienced substantial changes to the position of the headers and footers along the structure throat and arms. The hypothesized mechanism for the mobility of these rocks relates to geotechnical slumping of the footer rocks as a result of undermining through excessive scour. For structure HH1 (downstream-most structure), some of the mobilization may be related to sliding or rolling of the material used to construct the structure, as smaller sized, non-native angular rocks were present in the ramp-like feature, where a scour pool would be expected. Gravels and cobbles have filled in most of the area just behind the structures. Of the three structures, the upstream-most rock weir (HH3) appears to have maintained the greatest stability; the middle structure (HH2) has the most developed scour pool, and the downstream structure (HH1) appears to be the most easily passable for fish species of all life stages.

Entiat River, Structures RM 3.1, RM 3.2, and RM 4.6

Metadata

Conducted by: Elaina Holburn, Chris Holmquist-Johnson, Kendra Russell, and Kent Collins
Structure Type: 2 U-Weirs and 1 A-Weir
Location, NAD83 State Plane Washington North (feet)

- Northing: 244424
- Easting: 1775412
- HUC (17020010 Digit):
    - 13 Pacific Northwest Region
    - Upper Columbia Entiat

Description: Two U-Weirs are located at river miles (RM) 3.1 and 3.2 downstream of the Fire Station Bridge. One A-weir is located at RM 4.6 immediately upstream of the bridge-to-bridge reach near Halhalwy Property.
Construction Date: September, 2001
Initial site visit on September 19-20, 2006
Additional site visit on October 27, 2008
Data collection conducted on September 20, 2006 and October 27, 2008

Background

Background information was provided by Chelan County Conservation District (CCCD) office through Sarah Walker, Joe Lange with the Natural Resources Conservation Service (NRCS), and Phil Archibald with the United States Forest Service (USFS) in 2006. Phil Archibald also led a field visit to examine habitat value of the structures on October 27, 2008. These structures were installed as demonstration structures to provide pools and reduce the width-to-depth ratio. Each structure has a slightly different design to test how the designs function.

The structures were visited in September, 2006 to obtain survey data, qualitative information, and photo documentation (Reclamation 2006a, 2006b, and 2006c). Field reports from the 2006 field investigation were created for each structure. Seven hypotheses for structure failure were also developed. All structures were assumed to be in good condition until a storm in May 2006 (4,500 cfs) occurred. Header and footer rocks along the arms and throat experienced movement in the structure at RM 3.1; the cause was thought to be geotechnical slumping of the footer rocks. In addition the scour pool at RM 3.1 had been filling in the middle but was maintaining some depth along the arms. At the RM 3.2 structure, header rocks in the throat moved; rocks on the arms also experienced movement due to undercutting of footer rocks. The deepest portion of the pool remains on the right side of the structure where the arm was still intact. The structure at RM 4.6 was determined to be intact (no movement from header rocks). However, the structure pool had filled in, likely because of it's location at the downstream end of a riffle. In summary, based on the site visit in 2006 the two U weirs experienced movement of the header and footer rocks and some filling of the pre-excavated scour pool. Pool depths remained deepest along the arms. The A weir did not experience structure movement, but the scour pool did fill some with sediment.

Data Collection

The purpose of the visit in 2008 was to evaluate the current performance of the rock structures, collect additional topographic survey data of the structures and surrounding features (e.g. banks, scour pools, thalweg), structure rock size measurements, and information on the habitat value of the structures. Habitat information was provided by Phil Archibald with USFS.

Survey Data

Surveys of the structures were collected to document current conditions of the structure and surrounding topographic features, including bank lines, channel thalweg, scour pools, and adjacent bed topography. Very limited survey data (partial thalweg and bankline near structure) was collected at RM 4.6 due to time constraints. Data collected at RM 3.1 and RM 3.2 are illustrated in Figure 71 and Figure 72, respectively.

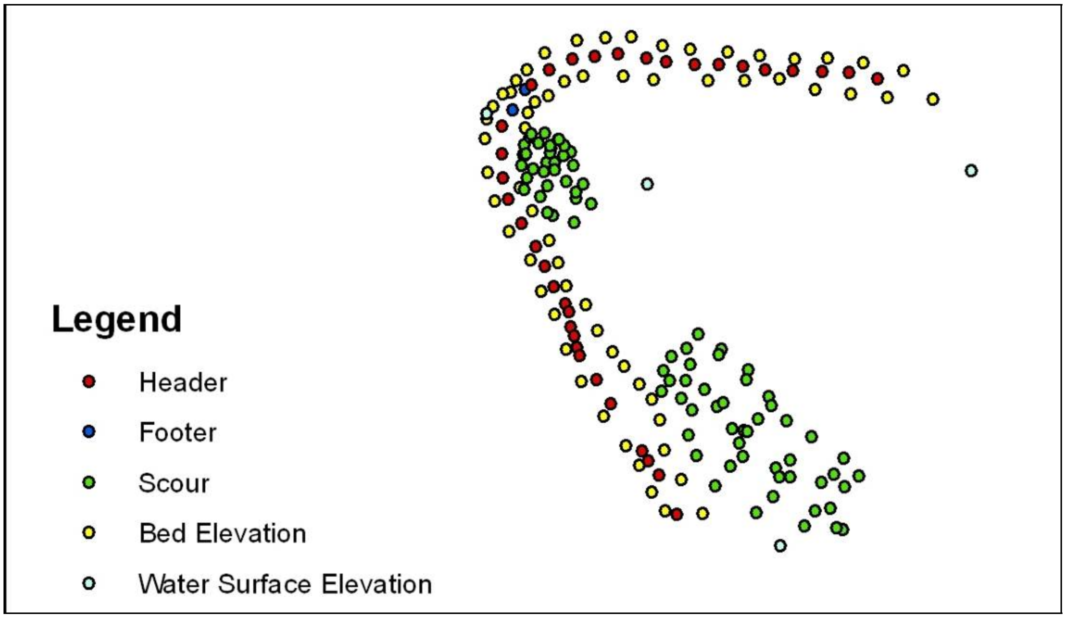

Figure 71. Survey data collected for Entiat River structure at RM 3.1.

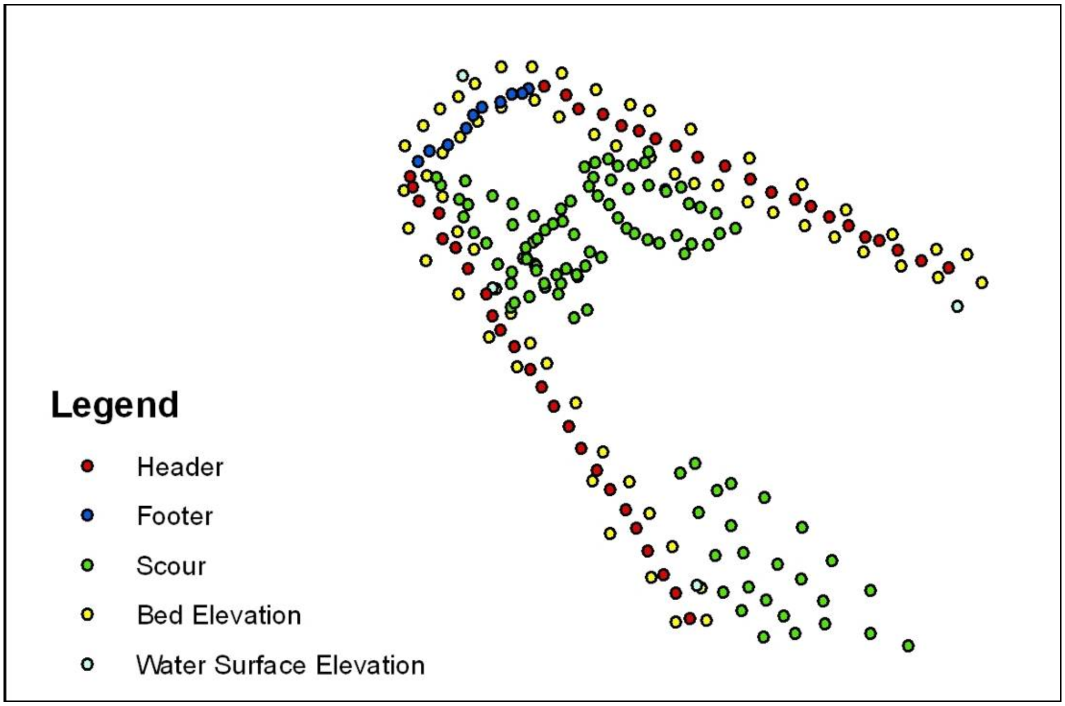

Figure 72. Survey data collected for Entiat River structure at RM 3.2.

Structure Condition

Figure 73 shows a photo of the round nosed U weir structure at RM 3.1 seen in October 2008. The right arm is missing several header rocks and the throat is also missing a header rock (Figure 74 and Figure 75). The left arm is intact with some shifting of the footers. It appears that many of the footer rocks are offset from the headers with material filling in behind structure. Approximately 30% of the flow is going through the right arm where the header rocks dislodged. The scour pool has been partially filled with material consisting of cobbles and boulders with diameters exceeding 500 mm. Because of the filling in the middle of the scour pool, the majority of the scour pool is now located along the right arm upstream and downstream of the gap in header rocks. Based on the 2006 field visit, the movement of the header and footer rocks occurred before 2006. Since that visit it does not appear that there have been major changes in structure form.

The location of the structure at RM 3.1 is between two riffles downstream of a slight meander bend where a pool would likely form naturally. Redds were present along the left arm of the structure.

Figure 73. Entiat River structure at RM 3.1 in October 2008.

Figure 74. Throat of Entiat River structure at RM 3.1 showing movement of several header rocks.

Figure 75. Looking at right arm of Entiat River structure at RM 3.1 with several dislodged header rocks.

Figure 76 shows a photo of the blunt nosed U weir structure located at RM 3.2. The header rocks along the throat (shown in Figure 77) are no longer intact but several footer rocks remain. A very small head drop is present, approximately four to six inches, because of the mobilization of the throat header rocks. There is sediment filling downstream and a pool has been created upstream of the throat. The upstream pool is about 40 feet long and 3 to 4 feet deep during base flow. The right and left arms appear to have had little mobilization of the header rocks except near the throat where some header rocks have been offset from the footer rocks (Figure 78 and Figure 79). Based on the 2006 visit, the movement of the throat rocks and the offset of the header rocks from the footer rocks along the arm occurred prior to 2006. There are gaps in the footer rocks which have been filled with gravel and fines. The upstream sides of both arms have filled with fines and gravel/cobbles. The deposition upstream of the structure arms was present in 2006 and appears to be maintained by the structure hydraulics. A pool has formed along the right arm which was also present in the 2006 visit.

Figure 76. Entiat River structure at RM 3.2 in October 2008.

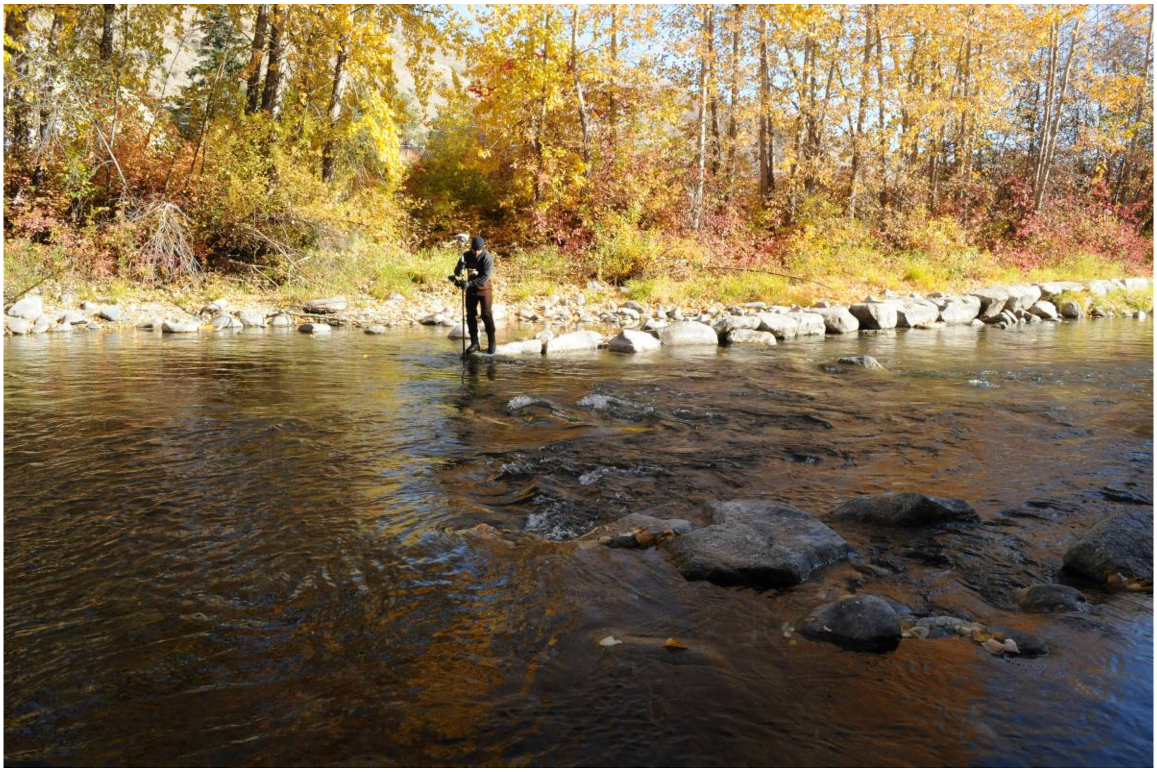

Figure 77. Throat of Entiat River structure at RM 3.2 where the majority of the header rocks have been dislodged.

Figure 78. Right arm of Entiat River structure at RM 3.2 where deposition has occurred upstream.

Figure 79. Left arm of Entiat River structure at RM 3.2.

Figure 80 shows the current configuration of the A weir structure located at RM 4.6. The scour pool has been filling in with bedload and has buried the throat and cross bar producing more of a rock ramp configuration than rock weir. The throat, left arm, and right arm are still intact. Spawning gravel has deposited at the downstream extent of the right arm. Figure 81 and Figure 82 show the structure header rock configuration in 2005 and 2006. Between 2006 and 2008 there does not appear to be dramatic differences in the scour pool and the structure appears to have stabilized at its current configuration. Figure 83 shows the right arm; there appears to be little movement of the header rocks. There are pockets of fine sediment located between the header rocks (see Figure 84). The largest header rock spacing was approximately 4 inches. However, the rocks are still locked together. Several pocket pools have been created along the right arm as well as a pool approximately 3 feet in depth downstream of the cross bar along the right arm.

Figure 80. Entiat River structure configuration at RM 4.6 seen in October, 2008.

Figure 81. Entiat River structure configuration at RM 4.6 on October 06, 2005.

Figure 82. Entiat River structure configuration at RM 4.6 on September 20, 2006.

Figure 83. Header rocks along right arm of Entiat River structure at RM 4.6.

Figure 84. Spacing between header and footer rocks has filled in with sediment at Entiat River structure at RM 4.6.

Rock Size

Rock size was measured to obtain a representation of the size of material used to construct each structure. The width (parallel to flow) and height of the rocks was measured along the structure arms and throat. An attempt was made to measure headers and footers, but all rocks could not be measured due to being partially buried or absent. Only a portion of the right arm rocks were measured at structure RM 4.6.

The average size of the rocks used for the arms and throats for each structure are depicted in Table 11. The throat rocks and arm rocks were similarly sized for structure at RM 3.1 There were no throat rocks measured at the structure at RM 3.2 because they had been dislodged from the structure throat and moved downstream. The rocks used at RM 4.6 were larger than the rocks at RM 3.1 and RM 3.2. A note was recorded in the field that the rock sizes at RM 4.6 were similar to the structures at RM 3.4 and RM 5.1 (installed after 2001). Based on the field notes, the throat rocks at RM 4.6 would be approximately 98 cm by 54 cm (using averages from the structures at RM 3.4 and RM 5.1).

Table 11. Average size of rock measured in each Entiat River structure (cm).

	Arm Width (cm)	Arm Height (cm)	Throat Width (cm)	Throat Height (cm)
RM 3.1	85	50	80	45
RM 3.2	82	48	NA (missing)	NA (missing)
RM 4.6	127	66	98*	54*

*Estimated using average rock size from structures at RM 3.4 and RM 5.1.

Bed Material

Pebble counts were not performed during the site investigation. However, previous pebble counts had been collected in 2005 for the lower six miles by the United State Forest Service (Reclamation 2009). Wolman Pebble Count methodology was used to collect these pebble counts. The nearest pebble counts to the rock weirs are shown in Table 12, Figure 85, and Figure 86.

Table 12. Particle size distribution (mm) obtained from pebble counts collected by USFS on the Entiat River.

Name of Sample	Fines <6 mm	D16	D35	D50	D84	D95	% Bedrock	Note
RM 3.1	18%	1.9	72.9	117.2	300.6	421.9	0%	Channel
RM 4.6	10%	40.9	113.3	153.0	382.1	673.0	0%	Channel

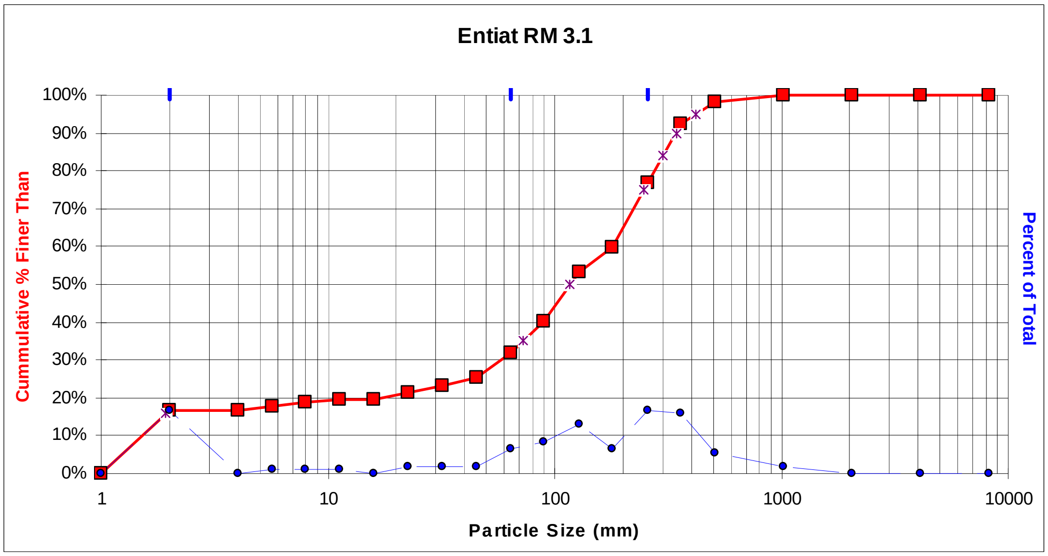

Figure 85. Grain size distribution from pebble count taken at RM 3.1 on the Entiat River.

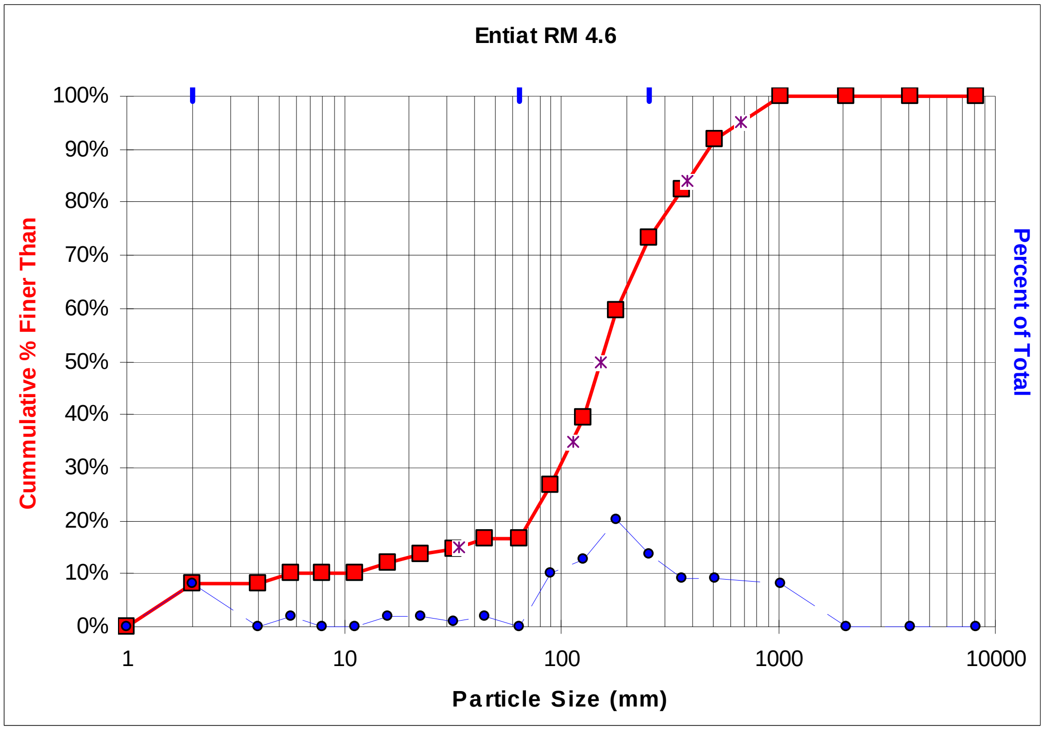

Figure 86. Grain size distribution from pebble count taken at RM 4.6 on the Entiat River.

Vegetation

There is heavy vegetation along both banks at the structures at RM 3.1 and RM 3.2. At RM 3.1 the right bank is dominated by a blueberry bush (unknown species) and the left bank has cottonwoods, willows, and high grasses. At RM 3.2 both banks are dominated by cottonwoods. At RM 4.6, the right bank is heavily vegetated with deciduous trees but the left bank is not as heavily vegetated. Near the downstream end of the structure (near the bridge) there is little vegetation and riprap along both banks.

Habitat

The fish species that use the rock structures on the Entiat River are spring Chinook (both migratory and resident species), Steelhead, and late run Chinook.

The structure at RM 3.1 was installed to help create pools and reduce the width-to-depth ratio in the area. The structure was rated at approximately 75% performance by Phil Archibald because of the shallowness of the pool. However, an added and unanticipated benefit has been spawning gravel depositing along the edges. A gravel lens approximately 50 feet long is located on the downstream left bank. Holding pools, cover, high velocity feeding habitat, rearing and spawning habitat are all being provided by the structure. Archibald further suggested that large woody debris could improve the structure by providing cover for juvenile Chinook. In addition, some maintenance of the header rocks could be completed. It was also mentioned that having a notch in the throat where a header rock fell in has actually been beneficial in providing constant fish passage and has added complexity.

The structure at RM 3.2 was also installed to provide pools and reduce the width-to-depth ratio. Spawning gravel has also deposited downstream of the structure. One unintended benefit is that the structure has been ice free during the winter to date unlike other locations in the area. The pool created by the structure provided better hydraulics than the structure at RM 3.1 because there are velocity seams on each side of the pool. Overall the structure provides holding pools, cover, high velocity feeding habitat, rearing habitat, and spawning habitat. Phil Archibald rated this structure as an 8 on a 1-to-10 scale where 1 was extremely poor and 10 was excellent. It would have been rated higher if there were deeper depths in the pool, and more cover provided for hiding and high velocity areas. LWD was installed with the structure but was quickly buried. Suggested improvements to the structure include adding LWD for cover and doing some maintenance on the structure throat to change the throat area to be round-nosed.

The objectives of the structure at RM 4.6 were the same as the other two structures. Portions of this structure have been filled in completely including the upper plunge pool and below the cross arm. However, gravel deposition has occurred downstream along the left arm and is providing spawning habitat. In addition, a small pool approximately 3 feet deep has established along the left arm. Phil Archibald mentioned the structure has had the most dramatic reduction in width-to-depth ratio, however the best habitat areas (scour pools below the throat and cross bar) have filled in. Therefore the structure received a 50% rating on meeting the intended objectives. Rearing habitat is being provided upstream of the structure along both arms. It was noted that the structure has still been an improvement over the pre-project condition, but is no longer operating with as much habitat as was created initially.

Snorkel surveys have been collected at all three demonstration sites. The structure at RM 3.1 saw the most use of fish in 2003. There have been decreasing numbers of fish since this point which is probably due to the lack of depth in the scour pool. The species seen during the snorkel survey were trout, steelhead, Chinook and whitefish. At RM 3.2 there was no fish use prior to the installation of the weir. Fish use peaked in 2003 and has declined since. The same fish species were seen at the structure at RM 3.2 as at RM 3.1. Prior to the weir installation at RM 4.6, 4 fish were observed. The number of fish peaked in 2002, declined after 2003, and has rebounded slightly since then. Steelhead, bulltrout, and juvenile Chinook have been observed at the structure.

In comparing the three structures, it was noted that the structure at RM 4.6 was the best executed structure in terms of design and construction. However it was the worst in terms of location placement because it was at the downstream end of a riffle and filled in with sediment. The structure at RM 3.2 is providing the best habitat while the structure at RM 4.6 is providing the worst habitat.

Conclusions

The 2001 demonstration structures are performing similarly to their performance in 2006 during the first field investigation. The methods of failure (slumping of the footer rocks at RM 3.1, header rock movement at RM 3.2 and structure pool filling at RM 4.6) still appear to be valid based on the observations in 2008. The location of the deepest pool at the structure at RM 3.2 has shifted from the right arm to along the left arm. Although these structures have partially failed they are still providing habitat. Habitat provided includes holding pools, cover, high velocity feeding habitat, rearing and spawning habitat. Although the structure at RM 4.6 is providing the least amount of habitat it is the one structure where the throat and arms have remained intact. The throat and portions of the arms at structures at RM 3.1 and 3.2 have experienced movement. Improvements were suggested by Phil Archibald including performing some maintenance on re-constructing the header rocks at RM 3.1 and 3.2 and using larger rock. It appears that the round nose U weir was a more stable configuration that the blunt nose U weir since only one throat rock became dislodged at RM 3.1 and the entire throat moved at RM 3.2. Comparison of existing scour pool survey data will provide additional information on whether the pools are continuing to fill in or have stabilized since 2006.

Entiat River, Structures RM 3.4 and RM 5.1

Metadata

Conducted by: Elaina Holburn, Chris Holmquist-Johnson, Kendra Russell, and Kent Collins
Structure Type: U-Weir and A-Weir
Location, NAD83 State Plane Washington North (feet)

- Northing: 244424
- Easting: 1775412
- HUC (17020010 Digit):
    - 13 Pacific Northwest Region
    - Upper Columbia Entiat

Description: The U-Weir is located at river mile (RM) 3.4 approximately 1,000 feet upstream of the Fire Station Bridge. The A-weir is located at RM 5.1 at the Hanna-Detwiler diversion channel
Construction Date: U-weir: September, 2006, A-weir: September, 2007
Initial site visit on October 27, 2008
Data collection conducted on October 27, 2008

Background

Background information for the Entiat structures was provided by Phil Archibald with the United States Forest Service (USFS). Phil Archibald also led a field visit to examine habitat value of the structures on October 27, 2008.

The U-weir structure at RM 3.4 was designed by NRCS in 2006 and installed to provide an irrigation diversion into the Public Utility District (PUD) No. 1 of Chelan County canal. The structure was built in the fall of 2006. The structure was designed to have an 8 foot excavated pool with 48 inch header rocks and 36 inch footer rocks. A geotextile was placed on the upstream side of the header rocks. The design was modified to include a rounded apex and have increased rock size compared to the structures installed on the Entiat River in 2001. Eight rootwads were anchored along the structure arms (4 along right arm and 4 along left arm) to provide habitat. Project design drawings are available for this structure.

The A-weir at RM 5.1 was designed by Reclamation and constructed in September 2007. The structure provides diversion into the Hanna-Detwiler ditch for irrigation purposes. The original design included having footer rocks stacked two deep. This proved too deep for excavation, so the design was modified to include two rows of footer rocks for stability. The header rocks were placed approximately 6 inches higher than the natural bed elevation. The cross-bar of the A-weir was constructed at close to natural grade in order to break up the pool and provide additional complexity. A geotextile was placed on the upstream side of the header rocks. A sluice gate is located along the right arm. Two rootwads were anchored downstream of the arm tie-in for habitat. Both the U-weir and A-weir are channel spanning structures that are located in straight reaches of channel. A pre-project snorkel survey was completed at both sites by USFWS in 2005 and 2006 prior to structure construction.

Data Collection

Data collected during the October 2008 site visit included topographic surveys of the structures and surrounding features (e.g. banks, scour pools, thalweg), structure rock size measurements, and qualitative information related to vegetation, bank condition, and structure performance. Information on the habitat value of the structures was provided by Phil Archibald with USFS.

Survey Data

Surveys of the structures were collected to document current conditions of the structure and surrounding topographic features, including bank lines, channel thalweg, scour pools, and adjacent bed topography. Data collected at RM 3.4 and RM 5.1 are illustrated in Figure 87 and Figure 88, respectively.

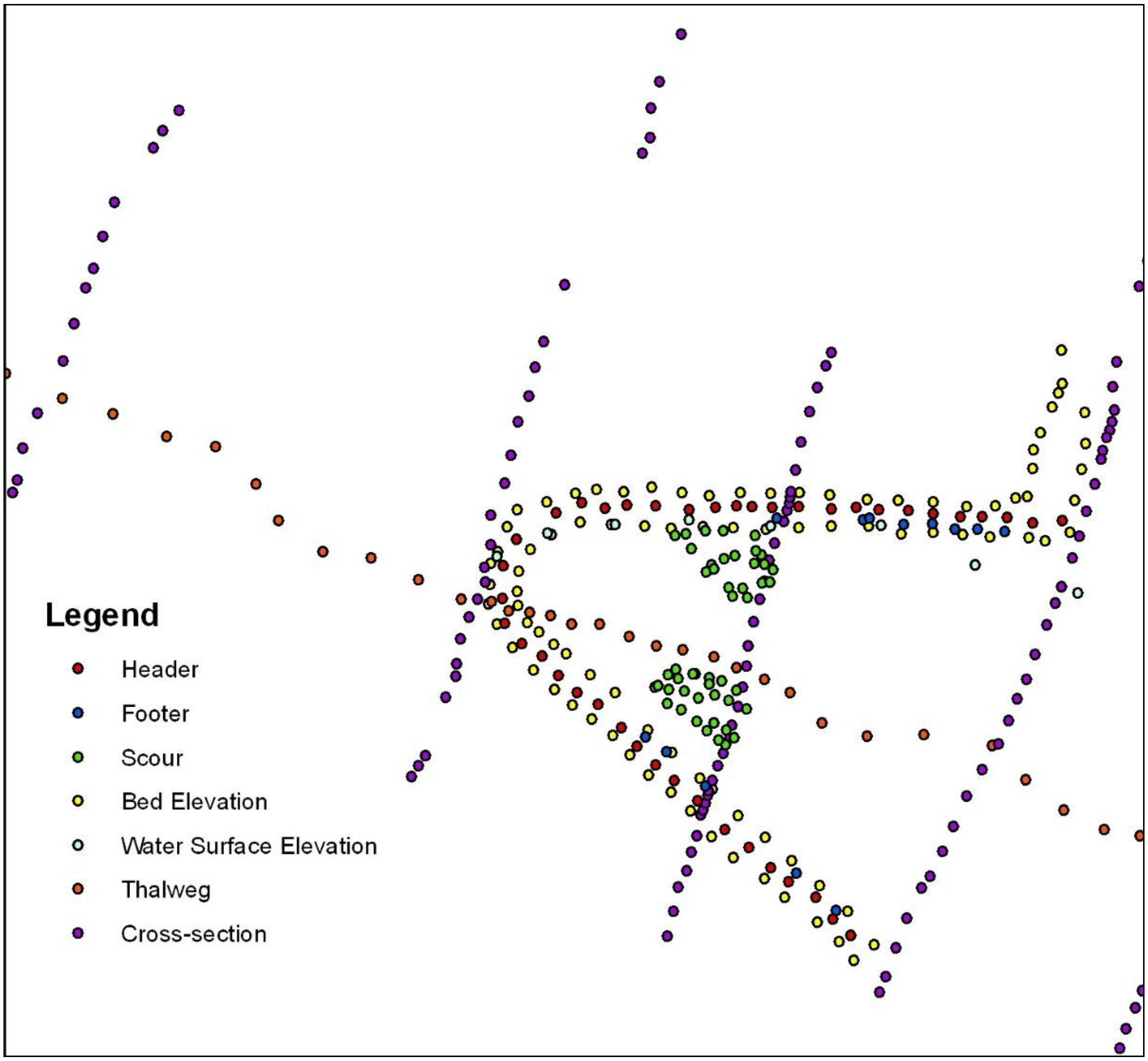

Figure 87. Survey data collected for Entiat River structure at RM 3.4.

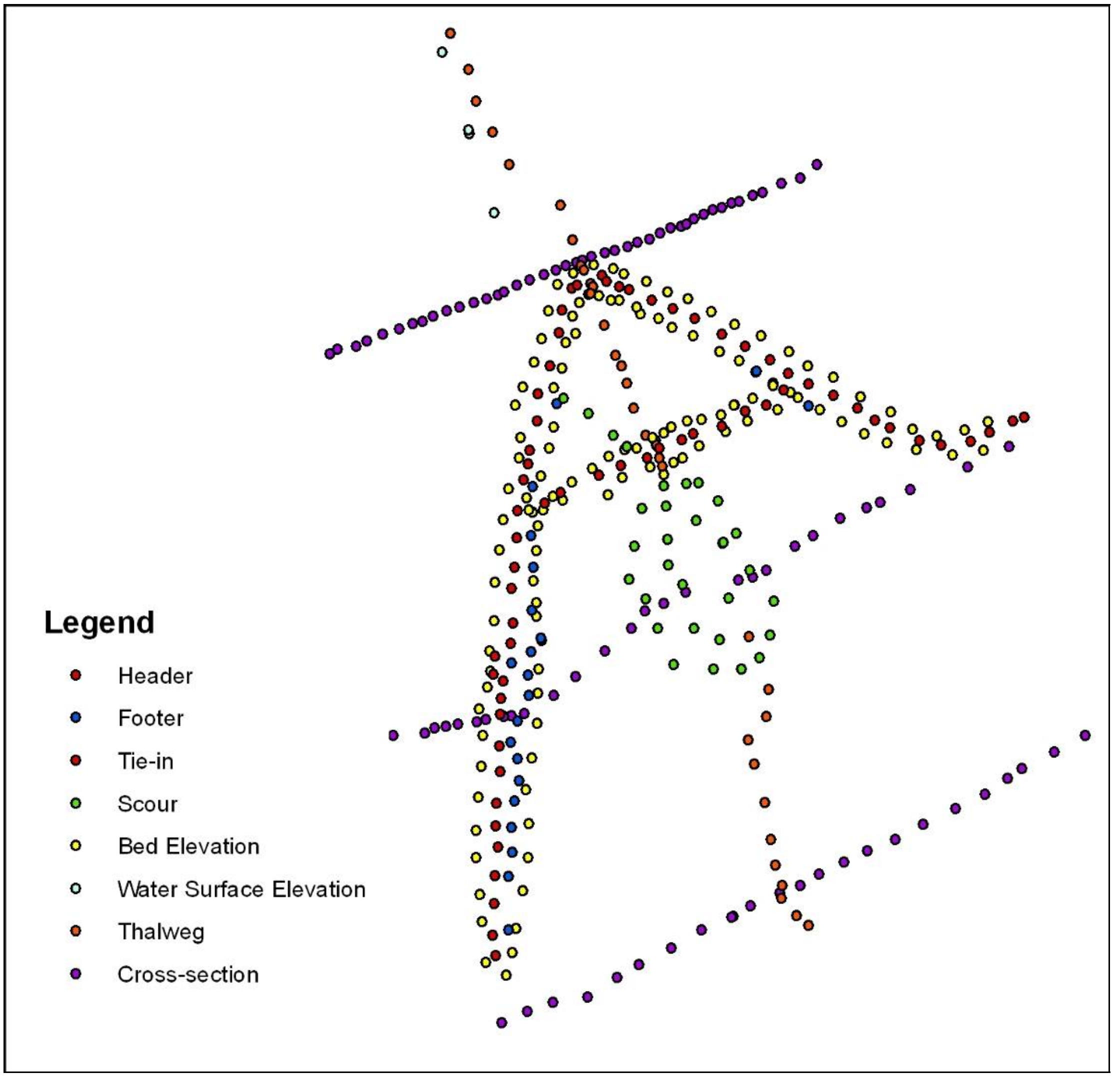

Figure 88. Survey data collected for Entiat River structure at RM 5.1.

Structure Condition

U-Weir

Figure 89 shows a photo of the structure seen in October 2008. The original pool that was excavated during construction has largely, but not completely filled. It is thought that the filling is due to a construction oversight where the spoil pile was placed upstream of the structure during construction and quickly moved downstream into the pool post construction. In October, 2008 a pool approximately 40 feet long and 2.5 feet deep remains. Figure 90 illustrates the depth of the pool as the people can be used for scale. The deepest portions of the pool occur about one-third to one-half of the distance along both of the structure arms. Because of the filling of the pool, the structure is hydraulically acting more like a ramp rather than a drop (Figure 91). The rootwads placed in the pre-excavated pool had very small rootballs. Two of the rootwads were unanchored during storm events and dislodged from the downstream pool. The remaining rootwads have created depositional zones along the crest of the left arm. In addition, gravel has deposited upstream of the arms as shown in Figure 92. Upstream of the structure is a reach with a steep slope and downstream of the structure is a riffle. The structure throat and arm rocks are still intact. The right arm is tied into the bank and the left arm is tied into the diversion berm. There are some small spacings between rocks that allow vortex flow.

Figure 89. Entiat River structure at RM 3.4 in October 2008.

Figure 90. Looking downstream at Entiat River structure at RM 3.4. The pool is approximately 2.5 feet deep.

Figure 91. Throat of Entiat River structure at RM 3.4 is acting hydraulically similar to a ramp rather than a drop.

Figure 92. Gravel deposition upstream of the left arm of the Entiat River structure at RM 3.4

A-Weir

Figure 93 shows a photo of the structure as seen in October 2008. Since construction, several logs have been caught on the structure. One is blocking the sluice gate that was constructed; therefore the gate is no longer working effectively; Figure 94 shows the right arm of the structure with the sluice gate blocked. Another log along the right arm is causing deposition at the downstream end of the arm. Most of the rock spacings have been sealed with gravels and finer sediment. The throat of this structure has an approximate 1.5 foot drop as seen in Figure 95. The downstream end of the pool appears to have fine gravels and sand. The structure does not appear to be filling rapidly which may be due to the riffle at the downstream end acting as a hydraulic control and the reach appears to have a flatter slope than other areas with rock structures. Figure 96 illustrates the depth of the pool as the people can be used for scale.

Figure 93. Entiat River structure at RM 5.1 seen in October 2008.

Figure 94. Right arm of Entiat River structure at RM 5.1 with sluice gate blocked by naturally caught wood.

Figure 95. Throat of Entiat River structure at RM 5.1 which is acting hydraulically like a drop.

Figure 96. Pool of Entiat River structure at RM 5.1. Pool was estimated to be at least 6 feet deep.

Rock Size

Rock size was measured to obtain a representation of the size of material used to construct each structure. The width (parallel to flow) and height of the rocks was measured along the structure arms and throat. An attempt was made to measure headers and footers, but all rocks could not be measured due to being partially buried or absent. The throat rocks on average were smaller than the rocks used along the arms for both of the structures at RM 3.4 and RM 5.1. The rocks used in the structure at RM 5.1 were larger than the rocks used for the structure at RM 3.4. The average size of the rocks used for the arms and throats for each structure are depicted in Table 13.

Table 13. Average size of rock measured in each Entiat River structure (cm).

	Arm Width (cm)	Arm Height (cm)	Throat Width (cm)	Throat Height (cm)
RM 3.4	102	67	96	32
RM 5.1	127	85	100	76

Bed Material

Pebble counts were not performed during the site investigation. However, previous pebble counts had been collected in 2005 for the lower six miles by the United State Forest Service (Reclamation 2009). Wolman Pebble Count metholodogy was used to collect these pebble counts. The nearest pebble counts to the rock weirs are shown in Table 14 and Figure 97.

Table 14. Particle size distribution (mm) obtained from pebble counts collected by USFS on the Entiat River.

Name of Sample	Fines <6 mm	D16	D35	D50	D84	D95	% Bedrock	Note
RM 3.1	18%	1.9	72.9	117.2	300.6	421.9	0%	Channel
RM 5.1	14%	29.2	101.2	162.5	368.8	500.3	0%	Channel

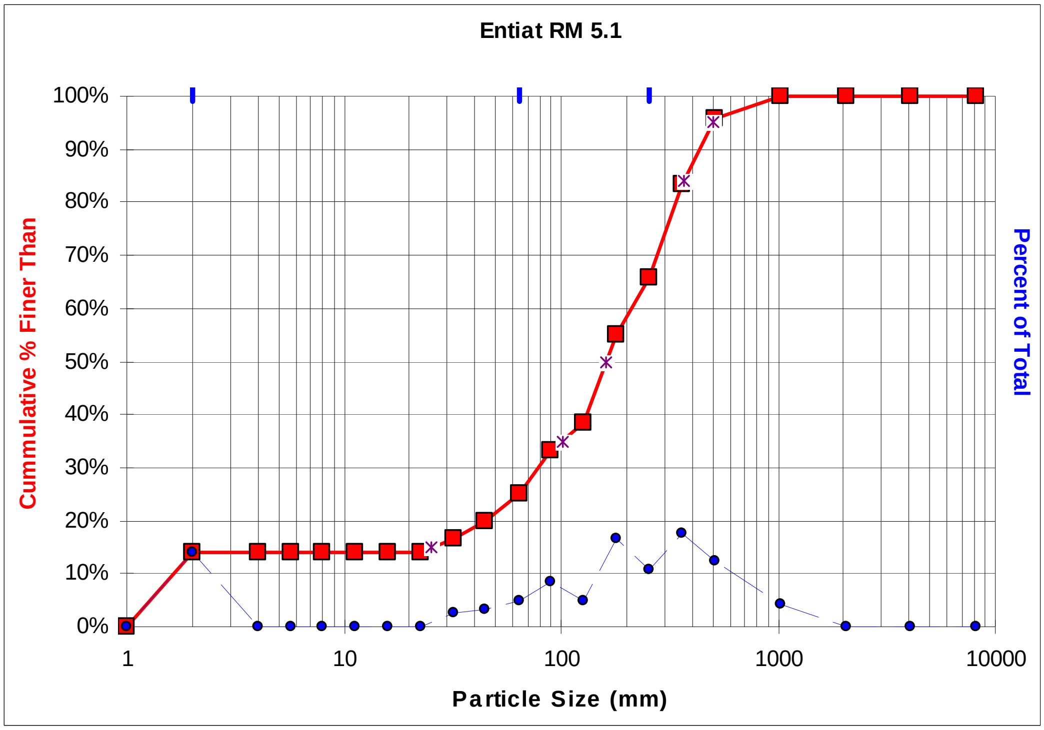

Figure 97. Grain size distribution from pebble count taken at RM 5.1 on the Entiat River.

Vegetation

Vegetation in the vicinity of the structure at RM 3.4 consists of a variety of trees, both coniferous and deciduous. The left bank is thick with these types of trees. The right bank is much less dense due to a residential area which consists of mostly grasses with riprap, a couple of conifers, and shrubs lining the banks.

Vegetation in the vicinity of the structure at RM 5.1 also consists of deciduous and coniferous trees. The left bank is heavily vegetated with woody, leafy vegetation. The right bank has a high steep embankment and is not as heavily vegetated as the left bank.

Habitat

The fish species that use the rock structures are spring Chinook (both migratory and resident species), Steelhead, and late run Chinook.

The structure at RM 3.4 provides spawning habitat where gravel has deposited downstream of the arms and near the entrance to the irrigation channel. Adult holding and juvenile rearing habitat are also provided but to a lesser extent. These habitats are still limiting because there aren’t good pool depths in the scour pool downstream of the structure and not much cover is being provided by the structure. However, this structure has improved the area when compared to the pre-project habitats available. The year after the structure was constructed, Phil Archibald estimated that 300 fish spawned in the disturbed areas around the structure. Archibald rated this structure between a 6 and 7 on a 1-to-10 scale where 1 was extremely poor and 10 was excellent. The rating was due to loss of depth in the pool and the minimal cover provided by the rootwads. It was noted that steelhead do spawn in the upstream end of the irrigation canal and that the structure rocks have been more stable than previous structures installed on the Entiat. A couple of lessons learned from previous structure installations were to stockpile the spoils downstream, to keep a record of the pre-excavation bed elevation during construction, and to place a geotextile upstream which appears to help stabilize the structure.

The structure at RM 5.1 is providing spawning areas, holding pools, cover, high velocity feeding habitat, LWD recruitment, and in-channel and off-channel rearing habitat. Archibald rated this structure a 9 on a 1-to-10 scale where 1 was extremely poor and 10 was excellent. It was rated at a 9 instead of a 10 because the structure is only 1 year old and has not experienced many seasons of high flows or fish to date. Approximately 12 redds were found last year lining the structure. The cross bar placed at the natural bed elevation provides additional complexity to the structure by breaking up the pools. The LWD, header rocks and velocity seams downstream of the structure (dividing high and low velocity areas) provide cover for the fish.

Conclusions

The U weir at RM 3.4 is successfully working to provide diversion for irrigation water into the PUD canal. The footer and header rocks have stayed in place. However, the structure has been providing lesser habitat because the downstream pool has been filled in (from 8 feet depth in design to approximately 2.5 feet in 2008). In addition the rootwads installed in the pool were undersized and do not provide much cover for fish; two of the rootwads were dislodged during storm events. The weir has provided spawning gravels on the upstream and downstream end of the structure arms. Because of the gravel deposition the weir has locally reduced the channel width-to-depth ratio which is seen as a habitat concern.

The A weir at RM 5.1 is currently functioning at a high level. It is providing irrigation diversion as well as numerous habitats for spawners, juveniles, and adults. To date the structure has maintained a deep pool. In addition gravel deposition has occurred downstream of each of the arms. Adequate cover is provided by LWD and velocity seams in the downstream pool area. The sluice gate was blocked by natural LWD recruitment and no longer operates properly. Overall the structure has been functioning well but a determination of its effectiveness cannot occur until the structure has been in place for several years.

References

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Bureau of Reclamation, 2006b. “Entiat RM 3.2 Weir Field Report 2006.09.20”.

Bureau of Reclamation, 2006c. “Entiat RM 4.6 Weir Field Report 2006.09.20”.

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Wolman, M.G., 1954, A method of sampling coarse bed material: American Geophysical Union, Transactions, v. 35, p. 951-956.

Appendix

Habitat Evaluation Forms

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10/25/08

Completed by: Brad Smith, Dist Fish Bio, ODFW brad.smith@state.or.us

Name and title e-mail and/or phone#

Site information/background:

Structure Name: Bear Creek B1

Structure Type (*circle all that apply*): U-weir, [✓ V-weir], A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other:___

Structure Location (general description): Bear Creek Wallowa Co, OR, Upper Diamond Prairie Rd crossing

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): See D-4

Intended objective(s) of structure (*circle all that apply*): [✓ fish passage], grade control, irrigation diversion, bank protection, unknown, other: Pool habitat and improved habitat complexity and cover

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? 1. Yes, 2. Yes, flow July – Sept.

Performance:

Description of how the structure is performing to meet its intended objectives:
Passage good, pool developed good, cover good, channel depth above and below

Description of how the structure is performing to meet additional objectives (list other objectives if applicable):

Has the project improved overall habitat from pre-project conditions? Yes

Types of habitat provided by structure (*circle all that apply*): holding [✓ pools, cover, migration], thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other ________________________

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e., to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):
Nice pool with good cover – assume increased juvenile Chinook use

Please provide anecdotal information of species specific use pre and post project: See D-4

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: 8 .

Please provide justification for why you chose this value: Structure functioning to meet objectives.

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?
Incorporation of woody material for cover.

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)? Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type?_____

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10/25/08
Completed by: Brad Smith, Dist Fish Bio   brad.smith@state.or.us
Name and title   e-mail and/or phone#

Site information/background:
Structure Name: Bear Creek C-1

Structure Type (*circle all that apply*): U-weir, [✓ V-weir], A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other: ____

Structure Location (general description): Bear Creek, Wallow Co OR Malfunction Junction

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): See D-1

Intended objective(s) of structure (*circle all that apply*): [✓ fish passage], grade control, irrigation diversion, bank protection, unknown, other: Pool habitat, increased cover and habitat complexity

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? 1. Yes; 2. Yes, Flow – July-Sept

Performance:

Description of how the structure is performing to meet its intended objectives:
passage at structure good – pool developed intermediate cover low flow good

Description of how the structure is performing to meet additional objectives (list other objectives if applicable): Channel in this reach is narrower than upstream or downstream reaches focused flow not necessary

Has the project improved overall habitat from pre-project conditions? Yes

Types of habitat provided by structure (*circle all that apply*): holding [✓ pools], [✓ cover], [✓ migration], thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other ____

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e., to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):
Naturally recruited wood in pool, provides good pool and cover habitat without compromising passage, assume – increased juvenile chinook user

Please provide anecdotal information of species specific use pre and post project: See D-4

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: 7

Please provide justification for why you chose this value: See above
Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?
Appears to be functioning well, could be enhanced with woody material for increased cover

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type? Not sure

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10/25/08
Completed by: Brad Smith, Dist Fish Bio ODFW brad.smith@state.or.us
Name and title e-mail and/or phone#

Site information/background:
Structure Name: Bear Creek D-4

Structure Type (*circle all that apply*): U-weir, [✓ V-weir], A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other:

Structure Location (general description): Bear Creek, Wallowa Co Oregon . 200 m below Chamberlin Ditch Diversion

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity*): *ESA listed summer steelhead*, spring Chinook* and bull trout*, whitefish, course scale sucker, bridgelip sucker, dace sps, cottid sps, syprinid sps

Intended objective(s) of structure (*circle all that apply*): [✓ fish passage], grade control, irrigation diversion, bank protection, unknown, other: Pool habitat, increased channel complexity structures were intended to focus flow in wide shallow channel areas to provide low flow passage and create pool habitat

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? 1. Yes; 2. Yes, Flow – July-Sept

Performance:

Description of how the structure is performing to meet its intended objectives:
passage in reach good – but flow downstream disposed – pool development marginal

Description of how the structure is performing to meet additional objectives (list other objectives if applicable):

Has the project improved overall habitat from pre-project conditions? It appears so on a reach basis

Types of habitat provided by structure (*circle all that apply*): holding [✓ pools, cover, migration], thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other pool habitat

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e., to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):
Not sure but assumed increase rearing in pools by Spring Chinook

Please provide anecdotal information of species specific use pre and post project: No reports of Spring Chinook adults (target species) trapped on reach by declining summer flows.

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: Existing channel modified and simplified by development relative to historic 4

Please provide justification for why you chose this value: Structure increases complexity nd cover without compromising passage

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?
Inclusion of woody material, improved pool without increasing jump height at structure

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?
Current structure spacing may have resulted in lack of pool formation – increased structure spacing

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site?
If so, what type? Not sure

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10/25/08
Completed by: Brad Smith, Dist Fish Bio (Name and title) brad.smith@state.or.us (e-mail and/or phone#)

Site information/background:
Structure Name: Bear Creek D3

Structure Type (*circle all that apply*): U-weir, [✓ V-weir], A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other:____

Structure Location (general description): See D-4

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): See D-4

Intended objective(s) of structure (*circle all that apply*): [✓ fish passage], grade control, [✓ irrigation diversion], bank protection, unknown, other: Pool habitat and channel complexity and cover

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? 1. Yes; 2. Yes, Flow – July-Sept

Performance:

Description of how the structure is performing to meet its intended objectives:
Drop creates passage issue for smaller fish – pour pool development with limited cover flow focused in channel and providing increased depth relative to upstream

Description of how the structure is performing to meet additional objectives (list other objectives if applicable):

Has the project improved overall habitat from pre-project conditions? Not much for juvenile rearing or passage but improved adult spring Chinook passage

Types of habitat provided by structure (*circle all that apply*): holding [✓ pools], [✓ cover], [✓ migration], thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other ______________________

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e., to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):
Improved Adult Spring Chinook passage, little benefit for rearing fish

Please provide anecdotal information of species specific use pre and post project: See D-4

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: 4

Please provide justification for why you chose this value: improved adult passage conditions
Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?
Reduce drop, increased pool area, increased interaction with cover although cover provided at 3-4 times current flow

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?
Inclusion of woody structure

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type? Not sure

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10/25/08
Completed by: Brad Smith, Dist Fish Bio, ODFW brad.smith@state.or.us
Name and title e-mail and/or phone#

Site information/background:
Structure Name: Bear Creek D2

Structure Type (*circle all that apply*): U-weir, [✓ V-weir], A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other:

Structure Location (general description): See D-4

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): See D-4

Intended objective(s) of structure (*circle all that apply*): [✓ fish passage], grade control, irrigation diversion, bank protection, unknown, [✓ other: Pool habitat and channel complexity]

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? See D-4

Performance:
Description of how the structure is performing to meet its intended objectives:
Drop is challenge for smaller fish, good pool developed and cover, pool extends with depth down

Description of how the structure is performing to meet additional objectives (list other objectives if applicable):

Has the project improved overall habitat from pre-project conditions? Yes

Types of habitat provided by structure (*circle all that apply*): [✓ holding pools], [✓ cover], [✓ migration], thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other ________________________

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e., to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):
Adult spring Chinook passage, impound rearing habitat and assume increased use by rearing juri Chinook

Please provide anecdotal information of species specific use pre and post project: See D-4

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations:_____6____

Please provide justification for why you chose this value:__See above

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?

Increased cover with inclusion of woody material – decreased drop or step to reduce passage issue

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type?___Not sure

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10/25/08

Completed by: Brad Smith, Dist Fish Bio, ODFW brad.smith@state.or.us
Name and title e-mail and/or phone#

Site information/background:

Structure Name: Bear Creek D1

Structure Type (*circle all that apply*): U-weir, [✓ V-weir], A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other:______

Structure Location (general description): See D-4

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): See D-4

Intended objective(s) of structure (*circle all that apply*): [✓ fish passage], grade control, irrigation diversion, bank protection, unknown, other: Pool habitat, increased channel complexity and cover. See D-4.

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? 1. Yes, 2. Yes, flow July-Sept.

Performance:

Description of how the structure is performing to meet its intended objectives:
Main drop is difficult passage challenge for juvenile fish, slots on both sides functioning for passage.

Description of how the structure is performing to meet additional objectives (list other objectives if applicable): Pool development marginal and cover access fair.

Has the project improved overall habitat from pre-project conditions? Yes

Types of habitat provided by structure (*circle all that apply*): holding [✓ pools], [✓ cover], [✓ migration], thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other ________________________

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e., to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):
Improved juvenile rearing habitat, increased habitat complexity – increased juvenile Chinook use.

Please provide anecdotal information of species specific use pre and post project: See D-4

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: 5

Please provide justification for why you chose this value: Fair cover and some pool development passage issue mitigated by partial failure of structures margins.

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?
Decreased center drop – increased pool development.

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?
Inclusion of woody material.

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site?
If so, what type?

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed:__4/20/09__________________
Completed by: __Lyle Kuchenbecker, Project Planner_ ____lyle@grmw.org___________
Name and title e-mail and/or phone#

Site information/background:
Structure Name: Swackhammer

Structure Type (*circle all that apply*): U-weir, V-weir, A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other Comments apply to both W-weir and U-weir

Structure Location (general description): Below Swackhammer Diversion structure

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): ESA-listed Snake River spring Chinook, summer steelhead, bull trout as well as other native species

Intended objective(s) of structure (*circle all that apply*): fish passage, grade control, irrigation diversion, bank protection, unknown, other One must remember the foremost project objective was to improve passage through the concrete structure. Secondary objectives were to maintain bedload transport through the depositional zone, keep the channel from migrating, reduce streambank erosion and maintain the grade.

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? The new structures do provide some habitat diversity, although that was not the objective.

Performance:

Description of how the structure is performing to meet its intended objectives: the W-weir obviously didn't provide the backwater/secondary channel habitat as USFWS had hoped. Our objective of bedload transport through this reach I think will be met in the future now after all the deposition has blocked off the secondary channel. The U-weir seems to be transporting bedload and protecting the streambanks.

Description of how the structure is performing to meet additional objectives (list other objectives if applicable): NA

Has the project improved overall habitat from pre-project conditions? Probably slightly, initially the two channels didn't have much structure.

Types of habitat provided by structure (*circle all that apply*): holding pools, cover, migration, thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other small improvement in pool habitat, maybe some refuge in the lower end of the blocked off channel during very high flow events.

Description of present fish use of the structure’s habitat and of the river segments just upstream and downstream of the structure (i.e. to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure): Not sure, but suspect adults may find a little better holding water adjacent to the large rocks.

Please provide anecdotal information of species specific use pre and post project: unknown

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: the reach probably functions slightly better than prior to the project but as compared with natural habitat it doesn’t function very well. After all we are dealing with very unnatural conditions here, a diversion structure and a channelized stream reach.

Please provide justification for why you chose this value:

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above? The real project objective was never to enhance the habitat, that was something USFWS felt we could do while meeting the initial objectives of keeping the channel from migrating to the north and maintain bedload movement through the reach. Now that we have what we have I would recommend monitoring to make sure the structure continues to remain mostly stable and continues to move bedload.

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?
I’d say nothing, let natural vegetation continue to re-establish.

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type? Not sure. At this site, given we have a very unnatural chunk of concrete in the channel and the location (upper end of the City of Union) we should be emphasizing fish passage, keeping bedload moving and the channel stable, and not worry about habitat for this relatively inconsequential reach.

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10-27-08

Completed by: Phil Archibald USFS
Name and title

e-mail and/or phone#

Site information/background:

Structure Name: 3.1 Spt 2001 demo structure

Structure Type (*circle all that apply*): U-weir, V-weir, A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other rounded nose U-weir

Structure Location (general description): fire station bridge #2

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): * spring chinook, any migratory + resident species
* steelhead, late run chinook

Intended objective(s) of structure (*circle all that apply*): fish passage, grade control, irrigation diversion, bank protection, unknown, other pool creation, reduce width/depth ratios

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? lack of juvenile rearing + adult holding habitat) both need pools

Performance:

Description of how the structure is performing to meet its intended objectives: 80-90% for pool + width/depth
revised to 75% because pool was shallower than last time

Description of how the structure is performing to meet additional objectives (list other objectives if applicable): spawning gravel being provided on edges from deposition

Has the project improved overall habitat from pre-project conditions? clearly, geomorphically + biologically see snorkel + spawning surveys

Types of habitat provided by structure (*circle all that apply*): [✓ holding pools], [✓ cover], ~~migration, thermal~~ refugia, [✓ high velocity feeding habitat], ~~off-channel~~ [✓ rearing habitat], other spawning
depth + turbulence cover

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e. to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure): look at spawning + snorkel surveys - 1x year in day

Please provide anecdotal information of species specific use pre and post project: no list pre

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: 7

Please provide justification for why you chose this value:

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above? do some maintenance reset header bring in some larger clear out fallen headers
Incorporate LWD to provide cover for juv. chinook
whitewater ← influence

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type?
no, good size shape, location etc.

Is #2

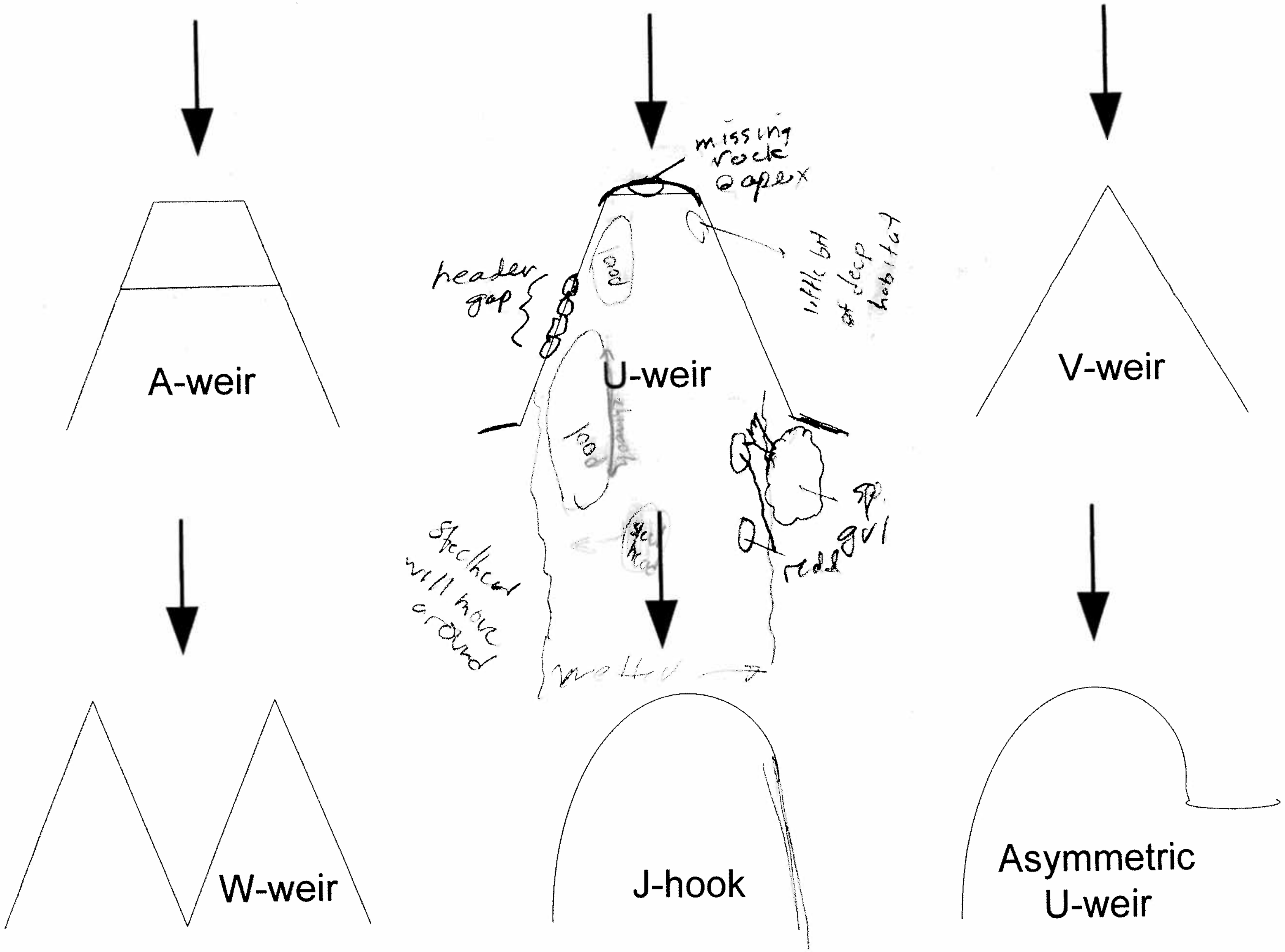


Figure 1. Depiction of Weir Structure Types. Arrows indicate direction of flow.

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10-27-08

Completed by: Phil Archibald USFS
Name and title
e-mail and/or phone#

Site information/background:

Structure Name: 3.2 2001 demo structure

Structure Type (*circle all that apply*) [✓ U-weir], V-weir, A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other

Structure Location (general description): blunt nosed V-weir

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity): Spring chinook steelhead late run chinook all migratory + resident species

Intended objective(s) of structure (*circle all that apply*): fish passage, grade control, irrigation diversion, bank protection, unknown, other Pools + width/depth creation reduction

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance? habitat was limiting factor

Performance:

Description of how the structure is performing to meet its intended objectives: ~~75~~ 80% - because of quality of pool - pool along arm pool is closer to 4 ft in depth

Description of how the structure is performing to meet additional objectives (list other objectives if applicable): Spawning gravel deposition, ice free in winter

Has the project improved overall habitat from pre-project conditions? unanticipated that there was a scour pool upstream of structure

Types of habitat provided by structure (*circle all that apply*): ~~holding pools~~, ~~cover~~, migration, thermal refugia, [✓ high velocity feeding habitat], ~~off-channel~~ [✓ rearing habitat], other Spawning

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e. to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):

Please provide anecdotal information of species specific use pre and post project: basically no fish here previously

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: 8

Please provide justification for why you chose this value: would be a ten if it had better depths (4-5 ft) more cover for hiding, velocity apex falling in

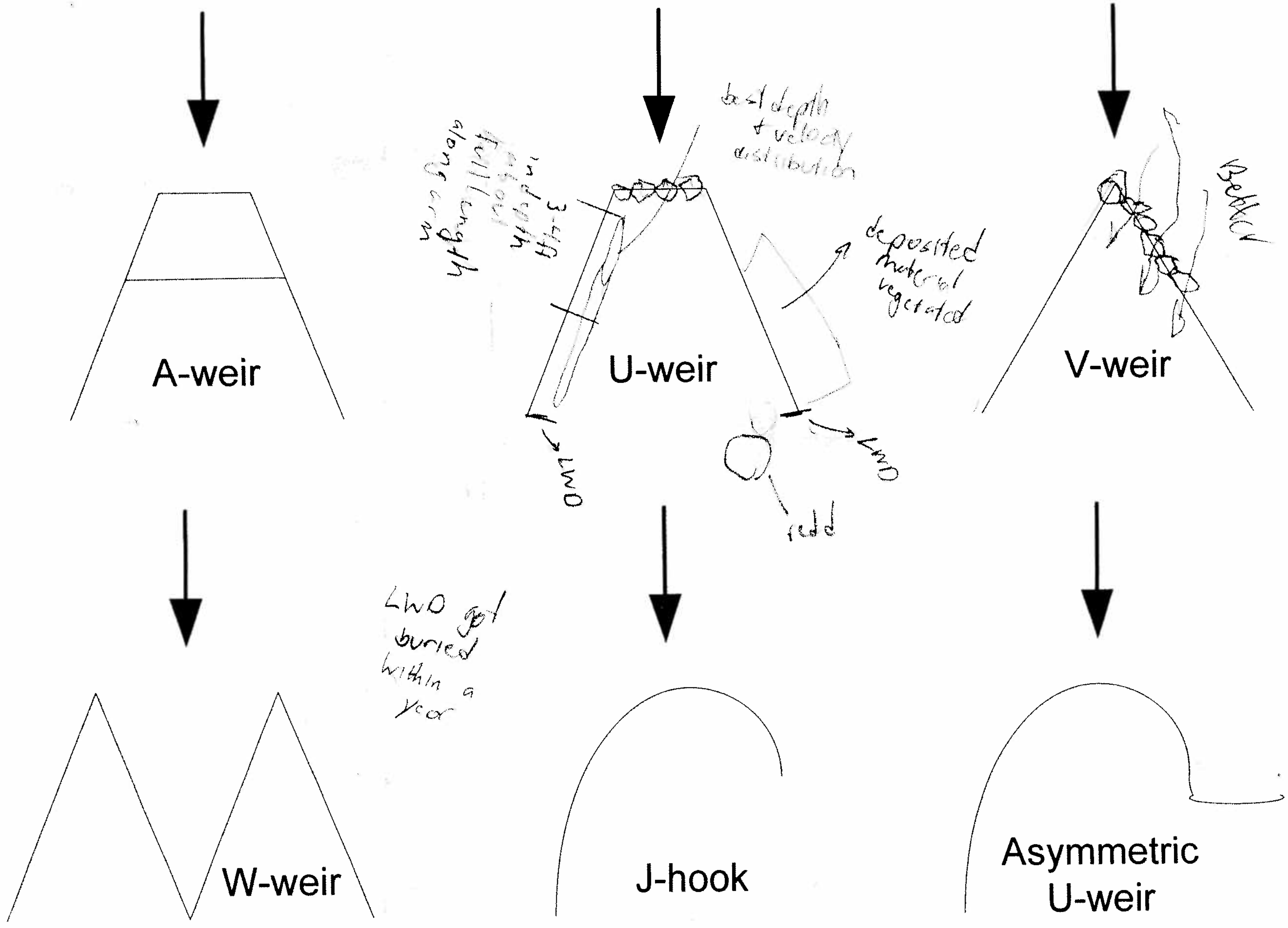
Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above? do some maintenance on structure throat, increase rock size pick out/clean out pool

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)? change to round-nosed LWD for cover

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type? positioned well below bridge change to rounded nose instead

FS #1



best depth + velocity distribution

3-4ft in depth about full length along arm

deposited material vegetated

LWO

LWO

redd

Better

LWO got buried within a year

Figure 1. Depiction of Weir Structure Types. Arrows indicate direction of flow.

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10-27-08

Completed by: Phil Archibald USFS

Name and title

e-mail and/or phone#

Site information/background:

Structure Name:

Structure Type (*circle all that apply*): U-weir, V-weir, A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other

Structure Location (general description):

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity):

Intended objective(s) of structure (*circle all that apply*): fish passage, grade control, irrigation diversion, bank protection, unknown, other

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance?

Performance:

Description of how the structure is performing to meet its intended objectives:

Description of how the structure is performing to meet additional objectives (list other objectives if applicable):

Has the project improved overall habitat from pre-project conditions?

Types of habitat provided by structure (*circle all that apply*): holding pools, cover, migration, thermal refugia, high velocity feeding habitat, off-channel rearing habitat, other Spawning

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e. to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):

Please provide anecdotal information of species specific use pre and post project:

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations:

Please provide justification for why you chose this value:

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type?

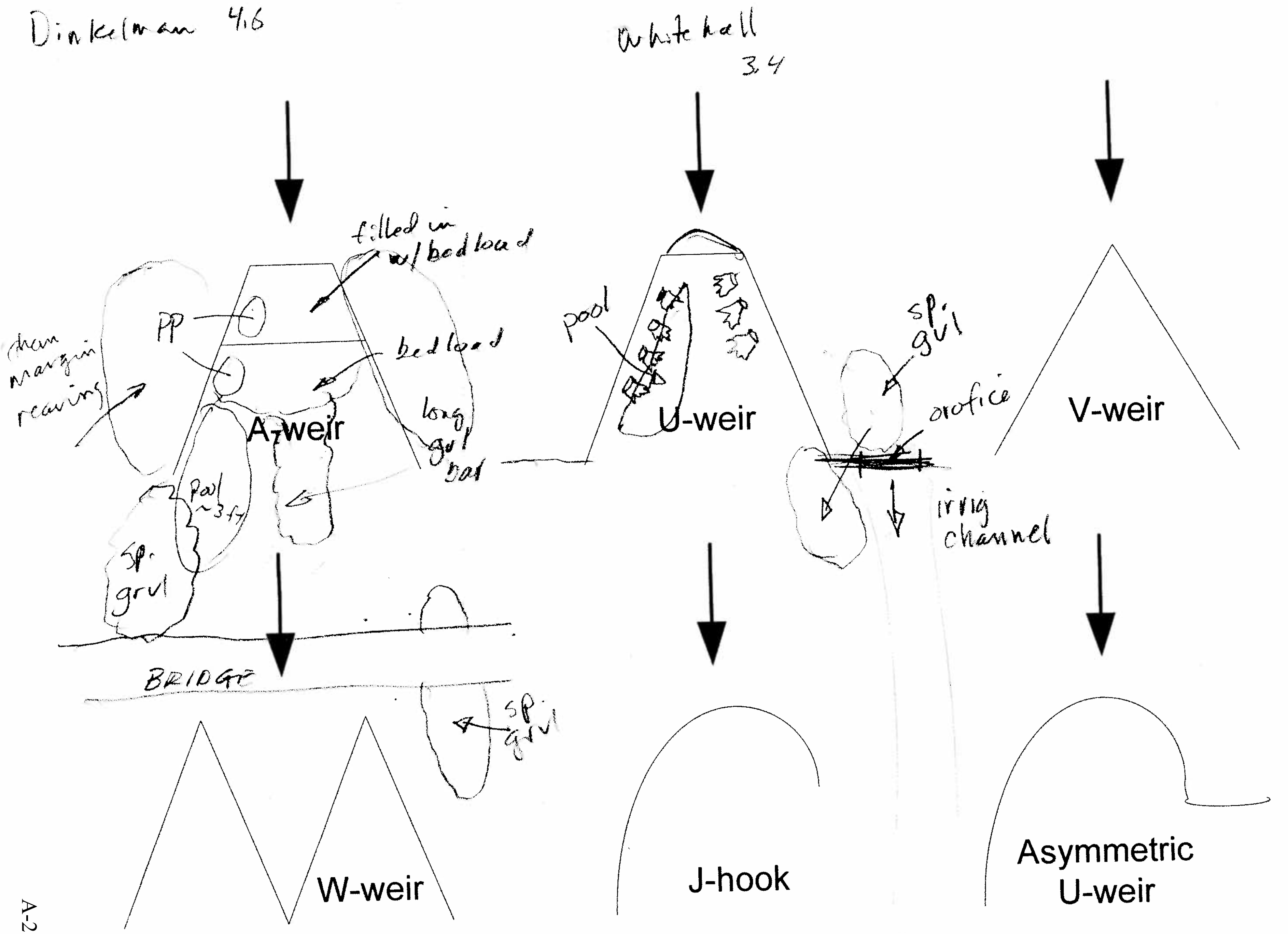


Figure 1. Depiction of Weir Structure Types. Arrows indicate direction of flow.

Habitat Value of River Spanning Rock Structures

Date Evaluation Completed: 10/27/05

Completed by: Phil Archibald USFS
Name and title
e-mail and/or phone#

Site information/background:

Structure Name: Hanna - Detweiler

Structure Type (*circle all that apply*): U-weir, V-weir, A-weir, W-weir, Rock Ramp, LWD, Push-up Dam, other ______________

A weir - round nosed

Structure Location (general description):

Fish species in the basin that might encounter the structure (please note species of particular importance or sensitivity):

Intended objective(s) of structure (*circle all that apply*): fish passage, grade control, irrigation diversion, bank protection, unknown, other ______________ diversion, pools, w/d reduction

Is the habitat provided by the structure a limiting factor in the area? Are there other limiting factors of equal or greater importance?

~~best~~ 0

Performance:

Description of how the structure is performing to meet its intended objectives: best of all, but only 1 year old
90%

Description of how the structure is performing to meet additional objectives (list other objectives if applicable): LWD recruitment
spawning gravel recruitment

10% reduction because only a year old

Has the project improved overall habitat from pre-project conditions?

Types of habitat provided by structure (*circle all that apply*): [✓ holding pools], [✓ cover], migration, thermal refugia, [✓ high velocity feeding habitat], [✓ off-channel rearing habitat], other in channel rearing (more than at others)
spawning

Description of present fish use of the structure's habitat and of the river segments just upstream and downstream of the structure (i.e. to what degree are fish taking advantage of the habitat provided by the structure and how frequent is their presence in areas surrounding the structure):

Please provide anecdotal information of species specific use pre and post project:

On a scale of 1 to 10 (1= extremely poor, 10= excellent,), please rate the value of the habitat provided by the structure compared with natural habitat configurations: 9 +

Please provide justification for why you chose this value: only 1 year old

used by steelhead + chinook

Recommendations for additional mitigation:

How could the structure be improved to enhance the habitat value as rated above?

What other measures could be done to improve the site (additional cover, denser structure spacing, etc.)?

Would a different type of structure be better suited to enhance habitat or meet habitat goals at this site? If so, what type?

sluice did not work out + was an after thought
need good design for this

5.1

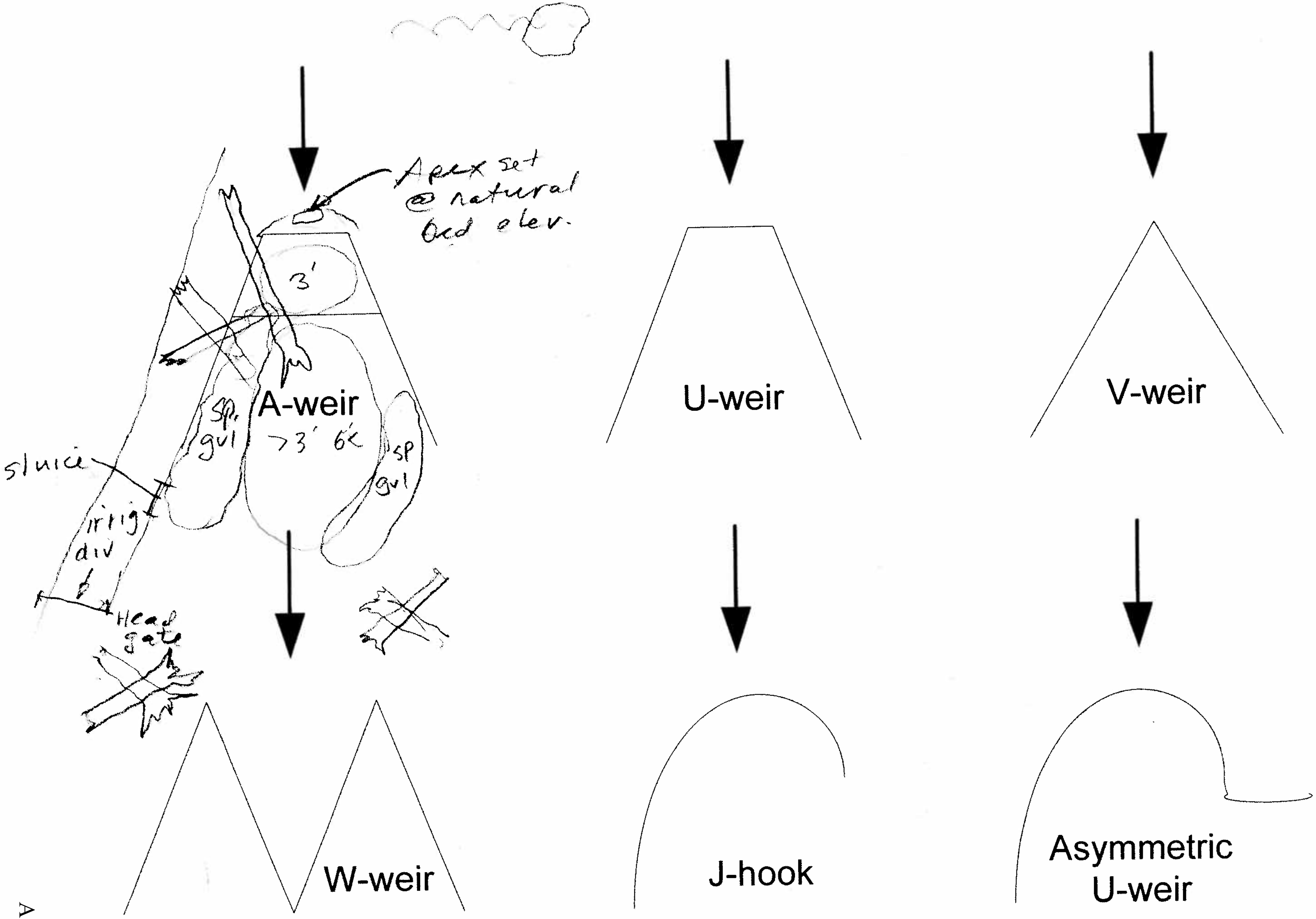


Figure 1. Depiction of Weir Structure Types. Arrows indicate direction of flow.