Revised Basis of Design Report

Restoration Design
Walla Walla River Bridge to Bridge Reach
Lowden, Washington

for
Tri-State Steelheaders

July 14, 2016

GeoEngineers
Earth Science + Technology

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File No. 11281-005-03

July 14, 2016

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INTRODUCTION

The project reach includes approximately 9,000 feet of the Walla Walla River and associated floodplain, located south and southeast of Lowden, Washington. The project vicinity is located approximately between River Miles 27 and 29 and bounded by McDonald Road at the upstream end and Lowden Road at the downstream end, as shown in Sheet 1.1 of Appendix A, Design Drawings.

This reach of the Walla Walla River is primarily used by salmonids as a migration corridor. Fish species of particular interest include Endangered Species Act (ESA)-listed summer steelhead (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*), as well as reintroduced spring Chinook (*O. tshawytscha*). Local salmon recovery managers have cited the project reach as a priority for enhancement on the Walla Walla River mainstem because of limiting factors such as bank condition; channel confinement; lack of complexity; insufficient instream habitat; a narrow riparian area with few mature trees; and lethal summer water temperatures (Northwest Power and Conservation Council 2004).

GeoEngineers completed a river enhancement alternatives assessment for the Walla Walla River, between McDonald Road and Lowden Road in April 2010. Subsequent to that report, GeoEngineers completed a final design on approximately the upstream one-third of the reach (Phase 1) in May 2012. That design was ultimately constructed during summer 2013. This report and accompanying appendices represent a summary of the methodology and basis of design for the river enhancement design plans for the remaining Bridge to Bridge reach of the Walla Walla River. The premise and intent of this report and design is based on our understanding that the ultimate goal of the project is to enhance instream and off-channel habitat for anadromous fish.

GeoEngineers performed this restoration design based on an alternatives assessment and conceptual design completed in 2010. We implemented this project at the request of Brian Burns of the Tri-State Steelheaders (TSS), in accordance with the signed agreement dated June 7, 2015. The services performed under this contract are described further in this report in the Scope of Services section.

Goals and Objectives

The overarching project goal is to increase, enhance and diversify aquatic, riparian and upland habitat (Appendix A, Sheet 1.3). Our intent is to improve overall ecosystem function by increasing floodplain connectivity and minimizing excessive erosion of the terraces within a reasonable period of time by implementing geomorphically appropriate design techniques within the practical limits of the project constraints.

To achieve the project goal—seven specific objectives described below—have been identified by the Tri-State Steelheaders (TSS) in 2009, in an effort to determine appropriate design elements. GeoEngineers included these objectives in the Walla Walla River Enhancement Alternatives Assessment between McDonald Road and Lowden Road report (GeoEngineers 2010) and used them to evaluate five alternative actions for the project site (Appendix A, Sheet 1.3). These objectives include:

Objective 1—Increase, Enhance and Diversify Aquatic Habitat

Funding for this project was provided by the Washington State Salmon Recovery Funding Board (SRFB). The fundamental purpose of which is improving conditions for resident and anadromous fish. Therefore, the primary objective for this project is to increase, enhance and diversify the aquatic habitat for the benefit of multiple fish species and all freshwater life stages of native fish species. Habitat should improve fish spawning, rearing, holding, and juvenile refugia. In general, these types of improvements include:

- Multiple habitat types in close proximity
- Primary pool habitat
- Substrate diversification
- Habitat structure and cover
- Side-channel and off-channel habitat

Objective 2—Increase, Enhance and Diversify Riparian and Upland Habitat

Healthy riparian habitat provides bed and bank stability, large woody debris (LWD) recruitment, shade and also provides habitat for macroinvertebrates to thrive. Therefore a healthy riparian corridor benefits fish both directly and indirectly. In addition, healthy, diverse riparian and upland habitats, composed of native plant species, benefit the wider bird and wildlife communities that currently and/or historically inhabit or migrate through this river corridor.

Objective 3—Increase Floodplain Connectivity:

Increased connectivity between the river and floodplain, during relatively frequent high-water events provides many benefits including: reduced erosion, bed and bank stability, and increased hyporheic (shallow ground water) exchange. Increased floodplain connectivity also supports healthy riparian habitat, which in turn benefits fish, wildlife and the larger floodplain ecosystem.

Objective 4—Minimize Bank Erosion on Upper Terraces

There are currently numerous high, vertical, unsafe, eroding banks along the project reach. In many locations vertical banks are migrating laterally, which is inhibiting riparian development and limiting cover and complex habitats for native fish populations, resulting in the loss of cropland. In addition, these steep banks are resulting in a loss of productive cropland as they migrate laterally. While we recognize that erosion and lateral migration of the river is a natural and ultimately a self-healing process, it is also understood that such processes must be balanced with safety, stability and land use.

Objective 5—Geomorphic Stability

Geomorphic stability involves creating a condition in which the proposed condition is self-sustaining and self-maintaining; rates of erosion are balanced with the rates of deposition; vegetation loss is equal to regeneration. Natural materials, including LWD structures, vegetation and limited amounts of rock are typically used in lieu of riprap and concrete. In addition to providing bed and bank stability and a platform for long-term vegetation and habitat maturation, geomorphically stable systems are less prone to excessive avulsions and require less long-term maintenance.

Objective 6—Rapid Recovery Time

Recovery time is the time required for the disturbed areas to stabilize and provide highly functioning habitat conditions. This includes the time for new and/or disturbed vegetation to establish enough to provide sufficient erosion resistance. It also includes the time necessary for the bed and banks of the new channels to stabilize in terms of sediment transport, scour hole development, gravel bar development and bar and bank vegetation establishment. Recovery time can vary significantly between the proposed treatments and alternatives. For example; recovery time is relatively minimal for the small overflow/side channels proposed in the floodplains compared to the time necessary for a pilot channel to develop, expand, migrate and then stabilize itself over the course of many years. Longer recovery times generally involve more maintenance and greater risk of uncertainty and failure.

Objective 7—Design Practicality

Rather than specifically focusing on a specific design intent (for example, enhanced fish habitat), design practicality includes a number of items that are commonly considered as project constraints or limitations. In order to be successful, alternatives must address a wide range of design considerations, including:

- Accommodating physical, practical and regulatory concerns, such as:
  - Public safety
  - Zoning, easements, setbacks, flood zones
  - Property boundaries, landowner concerns
  - Neighboring landowner concerns
- Minimizing Project Complexity
  - Minimal disturbance to existing ground, habitat, vegetation and structures
  - Minimal landowner disturbance
  - Minimal construction schedule/seasons, phasing, river diversions
  - Minimal permitting concerns
  - Minimal maintenance

While project cost is directly proportional to some of these considerations, cost is not considered in this objective. Project costs were factored into the 2010 alternatives selection process by considering the benefit-to-cost ratio (GeoEngineers 2010).

REPORT OVERVIEW

The body of this report provides a summary of rationale and analyses supporting the proposed design as represented in the accompanying design drawings (Appendix A). GeoEngineers prepared this report with input from the collaborative planning group that included the project area landowners, TSS, Washington Department of Fish and Wildlife (WDFW) and Confederated Tribes of the Umatilla Indian Reservation (CTUIR). This design report, drawings and supporting technical analyses are intended to present proposed plans to the TSS, regulatory agencies and project area landowners.

SCOPE OF SERVICES

GeoEngineers performed the following services in accordance with the agreement between GeoEngineers and the Tri-State Steelheaders, dated May 8, 2015 and executed June 7, 2015. The services, briefly described below, have been completed through Task 4A. Subsequent to this design, the remaining tasks will be completed.

Task 1—Kick-off Meeting

GeoEngineers conducted an on-site kickoff meeting on August 27, 2015. The TSS, the landowner, and four GeoEngineers representatives attended this meeting to discuss lessons learned from the previous phase. The meeting also provided a forum for the stakeholders to discuss concerns and opportunities they had for this project. The kickoff meeting established communication channels with stakeholders for future collaboration that will occur throughout the design process.

Task 2—Collect Additional Site Data

GeoEngineers performed a reconnaissance of the Walla Walla River site on August 27, 2015. The purpose of the reconnaissance was to study the specific geomorphic and physical characters of the design area. Specifically, this included an assessment of the channel bed, bank and floodplain composition throughout the site as well as a habitat survey to document existing conditions. The additional data allowed us to identify locations, features, infrastructure and enhancement opportunity areas to be included in the topographic/bathymetric survey (Task 3) and ultimately the project design. The geomorphic assessment builds upon the Phase 1 assessment completed in 2012 (GeoEngineers 2012). We refer to the previous geomorphic assessment, where appropriate, and describe the site-specific geomorphic assessment in greater detail in this report.

Task 3—Site Survey

As a subconsultant to GeoEngineers, HDJ Group provided topographic and bathymetric survey data. The survey included approximately 11,000 feet of channel length and approximately 8,500 feet of floodplain length. The survey also included the existing Lowden Road Bridge, located at the downstream extent of the project reach and 21 cross-sections.

GeoEngineers meshed the field topographic data with an existing LiDAR surface from a previous aerial survey completed in 2010. We used this existing conditions surface in the design. The combined surface is presented in one-foot contour intervals and shown in the Design Drawings (Appendix A, Sheets 2.3–2.4).

Task 4—River/Floodplain Design

As a SRFB funded project, we understand the design must be developed in accordance with the guidelines described in Appendix D of the Recreation Conservation Office (RCO) Manual 18. The guidelines in the Manual require conceptual design plans to be developed and reviewed. For the purposes of this project, we assume the concepts developed in GeoEngineers' April 2010 River Enhancement Alternatives Assessment for the Walla Walla River, between McDonald Road and Lowden Road report satisfy the conceptual design element of the Manual 18 guidance. However, we did develop more specific concepts relative to this phase of the project and met with the landowner and TSS on February 8, 2016, then again with TSS, WDFW and CTUIR on March 9, 2016 to discuss prior to developing the preliminary designs. The design steps we completed under this task included the Preliminary Design (Task 4A) and Final Design (Task 4B).

Task 4A—Preliminary Design

The preliminary project design was an intermediate deliverable for review, prior to completing the final design. The preliminary design included a preliminary basis of design report, preliminary enhancement design plans and a preliminary construction cost estimate. We developed the preliminary submittal following guidelines referenced in the RCO Manual 18 requirements (RCO 2014).

Preliminary Construction Cost Estimate

The preliminary construction cost estimate itemized construction quantities, unit costs and total estimated project construction cost.

Preliminary Design Review

The preliminary documents were circulated to stakeholders and the SRFB for review and comment by TSS.

Task 4B—Final Design

GeoEngineers incorporated comments received by TSS and SRFB through the preliminary design review stage of the project and produced the final design deliverables herein. Due to potential funding limitations, the project may be constructed in phases. The final design drawings identify likely phase boundaries should they be necessary for a phased construction approach (see Appendix A, Sheet 3.1 for project phasing):

GeoEngineers received SRFB review comments from the preliminary design submittal and addressed those comments with a comment response letter included in Appendix B, modifications to the basis of design report and modifications to the construction drawings in Appendix A.

Technical specifications and contract bidding documents—To be submitted under separate cover.

Task 5—Project Management

The design process has included several scheduled and impromptu project coordination calls and meetings to facilitate collaboration with the TSS and stakeholders. In addition, project management has included report processing and file management associated with each design deliverable.

EXISTING CONDITIONS

General

The Bridge to Bridge project reach is located on the mainstem Walla Walla River between River Miles (RM) 27 and RM 29, near Lowden, Washington. The project reach of the Walla Walla River is located within the northeast quarter of Section 33 and southeast quarter of section 28 of Township 7 North, Range 34 East, as shown in the Design Drawings (Appendix A, Sheet 1.1). An aerial photo of the site is presented on Sheets 2.1 and 2.2 and includes property boundaries with ownership information.

The upstream limits of the project start downstream of the McDonald Road Bridge. The project reach extends downstream to the Lowden Road Bridge. Within the reach, the channel is a moderately incised, predominantly straight, and wide aggrading reach with recurring mid-channel gravel bars forming throughout. Meander development is occurring in areas where lateral channel migration is eroding unvegetated vertical banks. Mature riparian vegetation is limited in many areas, specifically along eroding banks, however dense patches of alder, willow and cottonwood are present in some areas throughout the reach. A network of side channels exists on both the south and north sides of the mainstem channel, some of which remain active during low flow conditions.

The Walla Walla River valley is underlain by gravel alluvium deposited during the Missoula Floods subsequently overlain by sand and silt derived from windblown glacial loess and reworked floodplain deposits (Beechie et al. 2008). This material has partially cemented over time, resulting in a relatively erosion-resistant conglomerate underlying the floodplain sediment throughout much of the project area. Historically, it is assumed that the Walla Walla River was primarily a single-threaded channel with many smaller side channels and off-channel habitat occupying a broad floodplain densely forested with mature cottonwood trees and willows. Like most streams in this area, it is probable that beaver activity contributed to historic channel development by adding instream structure in the form of woody debris which promoted local sediment deposition, channel migration, and side channel creation.

Over the last century, the mainstem Walla Walla River was channelized and straightened in many areas, including within the project reach. This consolidation of flow and reduction of stabilizing riparian vegetation has resulted in channel incision within the project area up to 12 feet in height. Terraces adjacent to highly incised areas are high enough above the existing floodplain that any stabilization benefit of vegetative root mass has been lost, since most of the root mass is concentrated within the upper four feet of the soil profile. Decades of limited mature riparian vegetation have also severely limited LWD recruitment in the area and little or no mature riparian vegetation remains on the terraces to promote LWD recruitment. Within the project area, the channel is an aggradation reach and the creation of mid-channel gravel bars is directing flow laterally towards the banks. As a result, erosion and bank recession is occurring in several locations where the river now flows directly against the base of the unprotected banks.

Habitat

Historically, the mainstem Walla Walla River was part of an intricate network of side-channels, tributary/distributary channels and wetlands. As a whole, this landscape provided an enormous area of ideal fish habitat. In particular, this network provided secure low-velocity areas maintained by a robust and expansive riparian floodplain community. Over the last century human manipulation and alteration has been reduced to a single thread through much of the floodplain. Physical processes and biological cycling have been isolated from one another and fish and wildlife populations have experienced significant declines including the extirpation of spring run Chinook. A survey of existing habitat type completed August 26, 2015 indicates that during low-flow conditions, the area is predominately glide and pool habitat. Despite the relatively large area of pool habitat, overhead cover is sparse, rendering much of the pool habitat unsuitable for salmonid rearing. The fairly uniform channel provides limited channel complexity and is relatively homogeneous throughout. Habitat types and relative abundance is summarized in Table 1.

TABLE 1. PERCENT HABITAT TYPE AND PERCENT COVER

Habitat Type	Percent Habitat Type (%)	Percent Cover (%)
Glide	37	10
Pool	33	30
Riffle	14	6
Run	17	16

Riverbed Grain Sizes

Riverbed surface grain size distributions were estimated through pebble count sampling of exposed gravel bars at four locations in the project site. At least 100 grains were sampled from each geomorphic units and measured with an aluminum gravelometer template. Characteristic grain sizes for the gravel bar furthest downstream (ID 4) include D_{16}=15 mm, D_{50}=30 mm, and D_{84}=53 mm are shown below in Table 2 and Figure 1, Grain Size Sample Locations. The bar immediately upstream, within the project reach (ID 3), contained moderately smaller material, with D_{16}=14 mm, D_{50}=25 mm, and D_{84}=41 mm (Table 2 and Figure 1). The estimated grain sizes from the next upstream gravel bar (ID 2) were D_{16}=19 mm, D_{50}=35 mm, and D_{84}=58 mm (Table 2 and Figure 1). The characteristic grain sizes from the furthest upstream gravel bar (ID 5) were D_{16}=9 mm, D_{50}=21 mm, and D_{84}=41 mm (Table 2 and Figure 1).

TABLE 2. RIVERBED GRAIN-SIZE (MM) STATISTICS FROM PEBBLE COUNTS

Grain-size Statistic	ID 4	ID 3	ID 2	ID 1
D95	74	53	79	56
D84	53	41	58	41
D75	44	36	51	32
D50	30	25	35	21
D25	21	17	23	13
D16	15	14	19	9
D5	6	10	13	2

Note:

Sampling locations are ordered from downstream (ID 4) to upstream (ID 1)

Channel Geometry and Hydraulics

Upstream and downstream of the project area, the Walla Walla River has been straightened to a greater extent than throughout the project reach. This has resulted in the project reach exhibiting different reach-average characteristics than the upstream and downstream reaches. Reach-average slope is approximately 0.3 percent. Within the project reach the channel gradient is slightly steeper at the upstream extents. At bankfull discharge (assumed to be equal to the 1.5-year recurrence interval) channel top widths average 300 feet and range from 75 to 600 feet. At this discharge hydraulic depths averages 2.8 feet and maximum channel depths are as deep 8 feet in some pools. A network of side channels exists throughout the reach and some remain active at low flo7ws. At bankfull flow many of the side channel are hydraulically connected to the main channel as water surface elevations exceed floodplain elevations. Additional hydraulic details are described under the Existing Conditions Hydraulic Model below.

FEMA Floodplain

FEMA has identified areas of flooding concern for the Walla Walla River in the vicinity of the project site. The boundary of these flood limits are presented on the FEMA Flood Insurance Rate Map (FIRM) Panel 530194 0420B, for Walla Walla County, Washington, effective December 1, 1983, and a reduced size FIRM (Firmette) including the project reach is included as Figure 2, Effective FEMA Flood Insurance Rate Map (Firmette). There are currently no FEMA regulated base flood elevations for the Walla Walla River within the project reach. The project is located within a FEMA Zone A floodplain. Specifically, this Zone A floodplain currently includes the Walla Walla River from the project's upstream boundary, at McDonald Road, downstream past the limits of the project reach. A FEMA Zone A floodplain is defined as areas of the 100-year flood where base flood elevations and flood hazard factors are not determined.

PRELIMINARY DESIGN ALTERNATIVES

GeoEngineers prepared an Enhancement Alternatives Assessment (GeoEngineers 2010) for the Tri-State Steelheaders (TSS) dated April, 9 2010. The assessment was a collaboration with the TSS, the adjoining property owners and the WDFW and included an evaluation of five alternatives and provided a quantitative comparison of each with the intent of selecting an alternative that best meets the project objectives. Reference GeoEngineers Walla Walla River Enhancement Alternatives Assessment between McDonald Road and Lowden Road for a detailed description of the proposed alternatives and selection criteria (GeoEngineers 2010).

Preferred Alternative

GeoEngineers evaluated five different alternatives for the project site in the Enhancement Alternatives Assessment (GeoEngineers 2010). We compared the alternatives relative to each other based on seven objectives, which were weighted and used as selection criteria. Project objectives were numerically weighted by project stakeholders and GeoEngineers on a scale of 0 to 5 to reflect the relative importance value of each objective to project stakeholders. Higher values indicate increased importance. Those weighted objectives were used as selection criteria to evaluate the five project alternatives. A benefit-to-cost ratio was then calculated to factor in the cost of implementing the alternatives. Using this process, the alternative with the highest benefit-to-cost ratio is the most desirable or "Preferred Option." Alternative 4 was considered the Preferred Alternative we have advanced in this Design (GeoEngineers 2010).

DESIGN CONSIDERATIONS AND ANALYSIS

Proposed Enhancements

The project design includes measures to improve main and side channel habitat, provide additional side channel habitat, increase floodplain connectivity and stabilize the main channel. The proposed enhancements are described below and are shown in detail in the Design Drawings (Appendix A).

Main Channel Enhancements

Terraces along Eroding Meanders

A two-level terrace will function to stabilize the bank, decrease inputs of sediment to the stream, provide cover and shade, reestablish riparian vegetation and increase hydraulic diversity. The combination of a scour pool adjacent to the terrace and the associated wood elements of the terrace structure provides a current break where juvenile fish can avoid high-velocity conditions while maintaining an orientation that allows them to feed on drifting invertebrates. The lower step of the terrace is inundated at bankfull flows (equal to the 1.5-year flood recurrence flow) and will be heavily vegetated to improve bank stability. Inundation of the upper terrace is anticipated to occur between the 10–25-year flood recurrence interval flows. Flood fencing installed along the lower terrace will act to recruit LWD during inundation, reduce flow velocities and provide conditions for riparian vegetation establishment. Terraces will be installed in four locations and will range from 400 to 600 feet in length adjacent to the channel.

Installation of Wood Structures

Throughout the main channel wood structures composed of 1–5 imported key members will be installed. The installation of the wood structures will require excavation of the channel bank and backfilling with existing material and ballast for stability. These wood structures increase hydraulic diversity, promote bar formation and recruit LWD. Additionally, these structures provide secure rearing habitat for juvenile steelhead, spring Chinook and bull trout. The complexity of the structure enables juvenile fish to hide and avoid predation as well as providing refugia from high current velocities.

Longitudinal Stone Toe

A longitudinal stone toe will be installed upstream of Lowden road bridge to reduce migration of the channel toward Lowden road. Enhanced gradation material is placed at the toe of the channel on the outside of the meander bend. Behind the stone toe a terrace is built up as sediments are deposited, and over time riparian vegetation is recruited.

Side Channel Enhancements

Entrance Enhancements

Ten side channels were identified for selective entrance grading. The first 50–200 feet of the side channel entrance will be graded to increase flow into the side channel. Three side channels were identified for selective grading at their downstream limits to limit fish stranding and enhance side channel conveyance. The increase of flow into and through side channels reduces erosional pressures and stream power in the main channel. The side channels also act as a high-flow refugia for juvenile rearing fish during the winter and spring.

Installation of Beaver Dam Analogs

Small wood structures composed of 1 to 3 key members will be placed throughout side channels to increase both the quality and quantity of habitat available to juveniles. Beaver Dam Analogs (BDA) will also be installed in areas to enhance floodplain connectivity. Within the side channels, BDAs function to create localized backwater conditions, increasing floodplain inundation and hyporheic exchange.

Riparian and Upland Planting

Throughout the reach, areas lacking mature vegetation and areas impacted by construction activities will be revegetated. With time, established vegetation will provide shade, bank stability and macroinvertebrate habitat.

Fish Species Present and Habitat Needs

The focal species present throughout the project reach include ESA listed steelhead/rainbow trout (*Oncorhynchus mykiss*), reintroduced spring Chinook (*O. tshawytscha*) and ESA listed bull trout (*Salvelinus confluentus*). Adult migrating steelhead can be present throughout the reach from July through May, while adult spring Chinook can be present from approximately May through the month of August. Both adult steelhead and spring Chinook require resting and holding habitat throughout that duration. Adult resting and holding habitat conditions consist of relatively deep pools and overhead cover, which is sparse throughout the project reach. Suitable spawning gravel for steelhead and spring Chinook is also sparse so the addition of sediment sorting structures can increase suitable spawning conditions adjacent to pools and cover. To improve conditions for adult fish, we considered these habitat needs and incorporated a channel alignment and structures to increase both the quality and quantity of suitable habitat.

Juvenile steelhead/redband rainbow trout, juvenile spring Chinook and bull trout occupy this reach of the river throughout the year. For juvenile fish, maintaining a positive bioenergetic balance might be the most critical factor for survival and likely the most significant population bottleneck. In general, the balance consists of the energy it takes to get food and avoid predation (energy output) versus the energy provided by food resources (energy input). Suitable rearing and feeding habitats are characterized by complex hydraulics that have low-velocity areas with cover to avoid susceptibility to predation because those conditions minimize energetic demand. Likewise, feeding areas adjacent to secure rearing areas maximize growth and fish condition. Side channels and off channel areas were historically common throughout this section of the river and generally provide suitable rearing and feeding conditions. However, human modifications to geomorphic function (levees, channelization, riparian vegetation removal, etc.) have eliminated most of these types of habitats, which restrict rearing fish to less suitable channel margins and pocket water.

Often times, in projects similar to this, pool habitat is the most significant limiting habitat attribute but in this case, pool habitat seems to be adequate. However, based on our project area habitat inventory, we determined that overhead cover is the most limiting habitat attribute throughout the reach to the extent that most of the pools do not provide suitable habitat conditions. Through the development of this design we considered these habitat needs and incorporated structures and channel conditions that will maximize the bioenergetic balance such that both the quality and quantity of suitable habitat conditions are enhanced.

Hydrology

As part of this project, GeoEngineers completed a hydrologic evaluation of the Walla Walla River at the downstream end of the project immediately downstream of Lowden Road. The hydrologic evaluation included basin characteristics, peak flow calculations, log Pearson Type III analysis and regional regression statistics. Part of this analysis, including peak flows and basin characteristics was completed in the Phase 1 design (GeoEngineers 2012).

Basin Characteristics

The watershed of the main stem Walla Walla River at the lower limit of the project site is approximately 438 square miles, with a mean basin elevation of 2,640 feet (NAVD 88). The Walla Walla River watershed can be characterized as a combination of forested area and agricultural fields with an annual precipitation of approximately 29.2 inches (USGS 2016).

Design Discharges

The Phase 1 River Enhancement Design, completed by GeoEngineers, Inc. contains an analysis of peak discharges at the project site (GeoEngineers 2012). To generate peak discharge estimates, GeoEngineers statistically analyzed the historic record at USGS stream Gage No. 14018500 on the Walla Walla River near Touchet, Washington using a Log Pearson Type II (LP3) Distribution. Peak discharges at the gage were reduced to our project site by applying a reduction factor based on location within the state and relative watershed areas between the gage and the project site (1,658 square miles and 438 square miles, respectively). GeoEngineers also estimated peak discharge using regression equations adopted by the Flood Frequency Program within the State of Washington (USGS 2001). GeoEngineers corrected the LP3 results using the results from the regression equations. The combination of the statistical analysis and regression analysis are shown in Table 3.

The Washington Department of Fish and Wildlife outline low-flow guidelines for water crossing structures as the 2-year, 7-day low flow discharge for the basin or 95 percent exceedance flow for migration months of the fish species of concern (WAC 220-110-070). We used the historic record at the USGS Stream Gage 14018500 to develop estimates of both 2-year, 7-day low flow discharge and annual 95 percent exceedance values. These values, scaled to the project site using drainage area, were within 0.5 cubic feet per second (cfs) of each other. The value for 95 percent exceedance is presented as the low-flow value in Table 5 as it is slightly more conservative of the two low-flow estimates.

TABLE 3. DISCHARGE SUMMARY TABLE (CFS)

	Peak Discharge by Flood Recurrence Interval (Years)								Low-Flow Discharge
Flow Reach	**1.25**	**1.5**	**2**	**5**	**10**	**25**	**50**	**100**	**95% Exceedance**
Design Discharges	1,515	1,982	2,645	4,760	6,547	9,279	11,686	14,431	2.3

Existing Conditions Hydraulics Modeling

GeoEngineers performed a hydraulic analysis of the project reach using Version 4.1.0 of the USACE's HEC-RAS (USACE 2010) hydraulic computer model. HEC-RAS is a one-dimensional, steady-state, hydraulic model that computes water surface elevations using a step-wise methodology. We analyzed the project site's hydraulic characteristics using a subcritical flow regime. Detailed output and graphics from the hydraulic analysis are shown in Appendix C, Hydrologic and Hydraulic Analysis.

We developed the existing conditions hydraulic model using the 21 cross sections surveyed in 2015 and two cross-sections sampled from a LiDAR-based Digital Elevation Model (DEM) flown in May of 2009 (GeoEngineers 2010). The two LiDAR based cross sections are located downstream of the Lowden Road Bridge.

Proposed Conditions Hydraulics Modeling

We developed the proposed conditions HEC-RAS hydraulic model by modifying the existing condition topographic survey to reflect the channel and floodplain modifications shown on the Design Drawings. We utilized the same 23 cross section locations as those used in the existing conditions models, and we analyzed the project's hydraulic characteristics using a mixed flow regime. We used the results from this hydraulic model to analyze water surface elevations and channel stability along the project reach. Detailed output and graphics from the hydraulic analysis are shown in Appendix C.

Wood Structure Stability Analysis

GeoEngineers performed a risk assessment of proposed wood structures for the project reach. We followed risk assessment criteria published by the US Bureau of Reclamation (BOR) in the Pacific Northwest Region Resource & Technical Services Large Woody Material—Risk Based Design Guidelines (BOR 2014). We qualitatively assessed the potential public safety risk considering the use of the project reach, sight distance, location relative to bends and hydraulic conditions. We also qualitatively assessed the potential property damage risk considering the stream type, potential channel response, adjacent land use and in channel structures. Based on our qualitative analysis, a 25-year design discharge is appropriate for the wood structures proposed in the project reach (BOR 2014). The factors of safety for sliding and buoyancy recommended by the BBOR are included in Table 4. We selected a more conservative 50-year design discharge to analyze the stability of the proposed wood structures due to evidence of relatively severe recent channel modification through the project reach.

TABLE 4. WOOD STRUCTURE DESIGN FACTORS OF SAFETY

Failure Condition	Factor of Safety
Sliding	1.5
Buoyancy	1.75
Rotation / Overturning	1.5

GeoEngineers evaluated the proposed Meander Jam, Deflection Jam, Longitudinal Log and Apex Jam wood habitat structures for buoyancy and resistance to sliding. We used the output from the proposed conditions hydraulic model of the 50-year design discharge for maximum velocity and maximum depth values. We evaluated resistance to buoyancy by following the standard force balance approach (D'Aoust & Millar 2000). We compared the uplift forces using the volume of wood and wood density with the weight of the structure including the weight of the wood, the weight of soil ballast and the weight of boulder ballast. We used wood characteristics for Ponderosa Pine including specific gravity and shear stress for our analysis. We assumed the structures act as a fully connected structure, and uplift forces due to water velocity to be zero. We selected a minimum factor of safety (FOS) of 1.75 for buoyancy considerations. We evaluated resistance to sliding by comparing the horizontal drag forces exerted on the structures to the horizontal resistance provided by soil friction and timber piles (D'Aoust & Millar 2000). We also included an evaluation of the resistance to horizontal motion provided by timber piles. We selected a minimum FOS of 1.5 for sliding resistance. Results of the wood habitat structures stability analyses are included in Appendix C. Details of the proposed habitat structures are presented on Sheets 11.5 through 11.10 in Appendix A.

Longitudinal Rock Toe

GeoEngineers specified a material gradation for the longitudinal rock toe to resist incipient motion during the 50-year design discharge using results of the proposed conditions hydraulic model at the location of the proposed longitudinal rock toe. We calculated a material gradation using criteria identified in the Federal Highway Administration's Hydraulic Engineering Circular Number 23 (HEC-23). We identified Washington Department of Transportation's standard specification for 6'' streambed cobble (Specification 9-03.11[2]) as an appropriate size for the enhanced gradation. Refer to Appendix C for results of the gradation design workbook. A detail of the proposed longitudinal stone toe is presented on Sheet 11.1 in Appendix A.

PERMITTING AND STAKEHOLDER CONSULTATION

Permitting

Based on information known at the time GeoEngineers prepared this design, we assume most permitting documentation can be accomplished through a Standard Joint Aquatic Resources Permit Application (JARPA). The JARPA application should address WDFW Hydraulic Project Approval (HPA) and U.S. Army Corps of Engineers (USACE) Section 404/Ecology Section 401 (Nationwide #27). In addition to the JARPA permitting process, GeoEngineers will prepare the Restoration Programmatic for the State of Washington Specific Information Form (SPIF), Application for Streamline Processing of Fish Habitat Enhancement

Project and the Self-Certification of proposed Habitat Restoration Activity Consistency with the Habitat Restoration Program, 4(d) Rule, Limit 8 form.

Stakeholder Consultation

GeoEngineers prepared an Enhancement Alternatives Assessment (GeoEngineers 2010) for the Tri-State Steelheaders (TSS) dated April, 9 2010. The Assessment was a collaboration with the TSS, the adjoining property owners and the WDFW. The Assessment included an evaluation of five alternatives and provided a quantitative comparison of each with the intent of selecting an alternative that best meets the project objectives. We used the results of the collaborative alternative selection process to satisfy stakeholder consultation at the conceptual level and prepared the Design Drawings with information we gained in the previous process. Following the stakeholder collaborative process completed in the alternative selection, we engaged in a series of site visits, and discussions with TSS, the adjacent land owner and representation from the CTUIR and WDFW. TSS recognized the Washington Department of Natural Resources (DNR) as a project stakeholder and invited DNR representatives to participate in the stakeholder meetings. The DNR visited the project area on June 14, 2016 and determined the project reach was not included in their Aquatic Resources Authorization area. A summary of the topics discussed in the meetings that occurred in 2015 and 2016 are described in greater detail in Appendix B, Meeting Records and Comment Response.

The Tri-State Steelheaders submitted the Preliminary Basis of Design Report for SRFB project #14-1902 to the SRFB for review in May of 2016 and comments were provided on June 20, 2016. GeoEngineers modified this report and the construction plans in Appendix A of this report to address SRFB comments. In addition, we responded to specific comments in a memorandum dated July 15, 2016, which is included in Appendix B.

CONCLUSIONS

GeoEngineers prepared the proposed enhancement design to address project objectives for the project reach. Table 5 includes a summary of the project design relative to project objectives. Percent cover includes riparian vegetation and in-water structures. We increased the percent cover with the inclusion of wood structures in the short term and anticipate further increases in cover with the development of riparian vegetation. We increased effective side channel length by excavating inlets and alcoves of existing side channel and inundated floodplain locations. The enhancements propose to reduce aggradation through the downstream section of the project reach with increased longitudinal slope and a reduction in sinuosity as compared to the existing conditions. As a result, the relative bed stability, the ratio of the applied shear stress to the critical shear stress, is reduced in the proposed condition during the channel forming bankfull discharge event.

TABLE 5. SUMMARY OF PROJECTIVE OBJECTIVES 1, 3 AND 5

Project Objective	Parameter	Existing Condition	Proposed Condition	Discharge Description
1	Percent Cover	18	24	–
1/3	Side Channel Length (ft)	6,580	8,400	1.5-Year (Bankfull)
3	Total Inundation (ac)	116	119	5-Year

Project Objective	Parameter	Existing Condition	Proposed Condition	Discharge Description
5	Relative Bed Stability (shear/shear critical)[1]	1.9	1.6	1.5-Year (Bankfull)

Notes:

[1] Approximately between Stations 62+00 and 130+00

In addition to the project objectives quantified in Table 5, the following summary briefly describes how the project design meets project objectives. Please reference the Design Considerations and Analysis section of this report for a more detailed description of the proposed enhancements;

- **Objective 2**—The project design enhances riparian and upland habitat with a revegetation plan that includes more than 17 acres of revegetated plantings and seeding. We have also included flood fencing to enhance recruitment within the terraced meanders.
- **Objective 4**—The project design minimizes bank erosion at targeted meanders by reducing the excessively steep slopes, reinforcing with wood habitat structures and redirecting the channel planform to historic locations.
- **Objective 6**—The project design limited recovery time by limiting side channel disturbance to inlets and outlets while allowing grading along proposed alignments to be directed in the field. This construction method will also help maintain the existing riparian vegetation within the floodplain.

CONSTRUCTION QUANTITIES AND CONSTRUCTION COST ESTIMATE

GeoEngineers calculated construction quantities and applied unit costs based on recent project experiences, engineering judgment and published documentation (RS Means 2015). We included a summary of the anticipated construction costs for the project reach in Appendix D, Construction Quantities and Cost Estimate.

LIMITATIONS

We have prepared this Basis of Design report for the Tri-State Steelheaders and their authorized agents and for regulatory agency review.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of river restoration design engineering in this area at the time this report was prepared. The conclusions, recommendations and opinions, presented in this report, are based on our professional knowledge, judgment and experience. No warranty or other conditions, expressed or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

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FIGURES

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial Imagery from ESRI 2014 USDA NAIP data

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

N W E S

1,000 0 1,000

Feet

Grain Size Sample Locations

Bridge-to-Bridge Reach
Walla Walla River near Lowden, Washington

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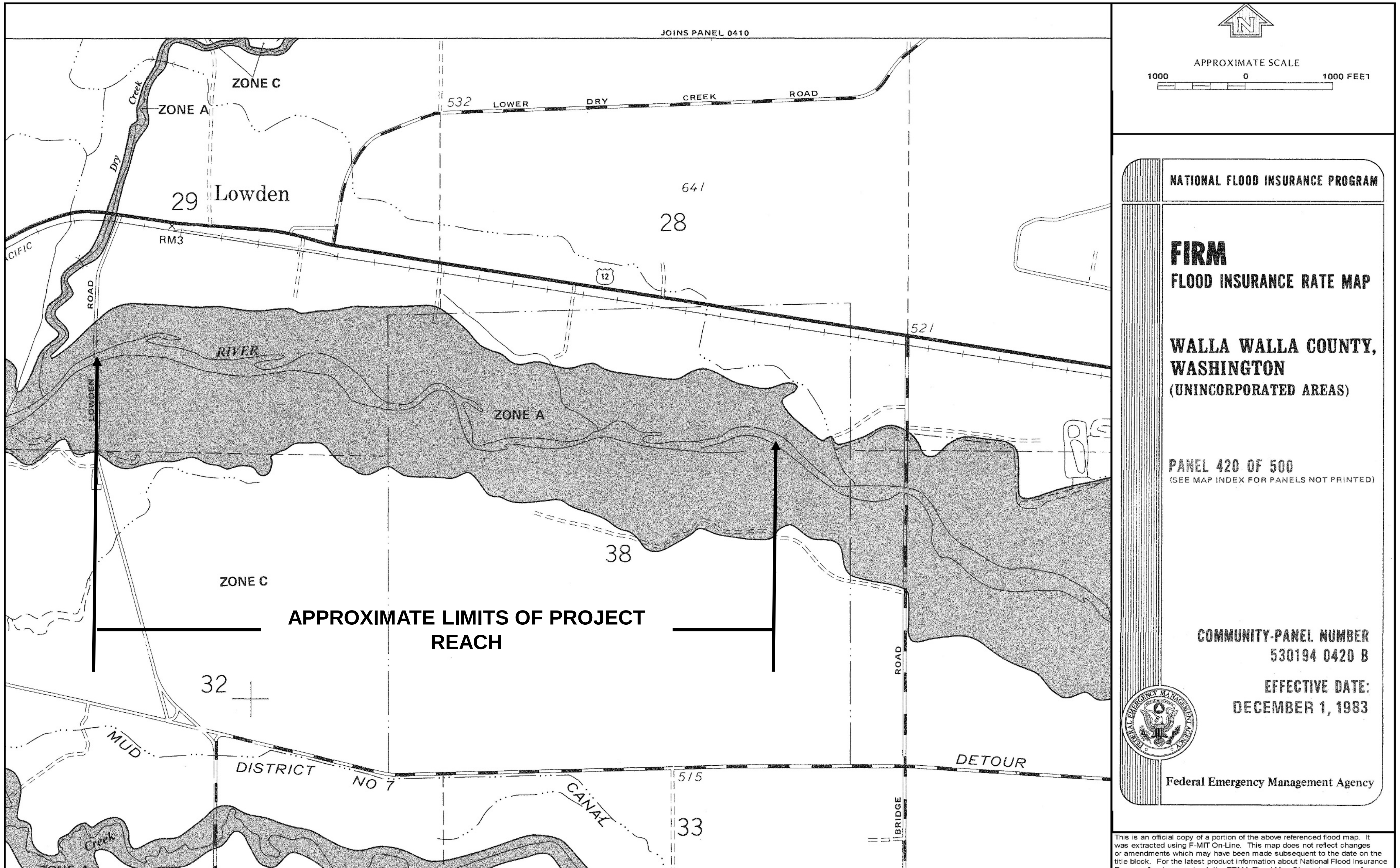
Figure 1



Effective FEMA FIRM

Walla Walla River Bridge to Bridge Reach
Lowden, Washington

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Figure 2

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: FEMA FIRM Panel 530194 0420 B Effective Date: December 1, 1983

11281-005-03 Date Exported: 05/11/16