3.5 Fish Passage Criteria

Fish passage through this structure is an important benefit of the rock ramp design. The existing concrete weir wall is a major fish barrier that disrupts the river's natural ecologic function.

Fish passage goals for this project includes providing at least part-season passage for both non-native sportfish and native non-game fish. Based on input by Mike Ruggles of Montana Fish Wildlife & Parks at the project kick-off meeting on February 26, 2014, important species to be considered as a part of the fish passage design include brown trout (non-native sportfish), dace, and white sucker (native non-game fish). This list could also possibly be expanded to include ling, which though not currently present in the Musselshell River, may be reintroduced to downstream locations in the future.

Table 3-6 Fish Swimming/Jumping Abilities

Species	Burst Swimming Speed cm/s (ft/s)	Jumping Ability cm (ft)	Data Source (See Notes Below Table)	Spawning Time Frame
Brown Trout	250 (8.2)	45	1	Fall
Dace	71-82 (2.3-2.7)	15	2	Spring/Summer
White Sucker	80 (2.6)	15	2	Spring
Ling	80 (2.6)	10	1,2	Winter

1. US Forest Service Aquatic Organism Passage FishXing Sofware (3.0.20)
2. Experience/unpublished data source

Each of these fish species has different abilities relative to swimming speeds and jump heights which must be taken into consideration as a part of the passage design process. These fish species also have differing migration time periods for moving upstream to spawn. As a part of the 90% design, we have collected biological data for each of these species from published sources, unpublished academic sources, and previous project experience. Reliable data related to fish swimming and jumping abilities is severely limited in literature sources, especially with respect to non-game

species. For the purposes of this 90% design effort, we are using the design data shown in Table 3-6 for each of the target species.

Data sets for the swimming and jumping abilities for non-anadromous fish species tend to present a wide range of variability. The values presented are conservative abilities for each of the species based on currently available information. As is demonstrated by Table 3-6, the fish species of interest typically move upstream to spawn at widely different times of the year, and have significantly variable abilities to negotiate a fish passageway.

Based on previous experience, hydraulic calculations, the relative abilities of the various fish species, and the seasonal variation in flows where passage is desirable, we believe that a pool and rock weir fishway will provide the best opportunity for fish passage within practical site constraints and project budget. As currently designed, the low flow channel/fishway average an approximately 8-inch drop between pools. The rock at each pool drop will be grouted in place to create a very short riffle/passage section allowing the smaller fish species with lesser jumping abilities to burst through localized channels between the rocks.

The pool and weir fishway design is not anticipated to provide full year passage for all targeted species at all flows. The intent is to provide appropriate design components in the low flow channel/fishway to allow passage windows for a particular species at the appropriate time of the year.

Results from the RiverFLO-2D modeling effort verify that the fishway design provides significantly lower velocities at all flows between 75 cfs (low flow) and 6,616 cfs (100-year event) than in-stream velocities across the diversion to the left and right of the fishway. Table 3-7 presents an overview of anticipated fishway velocities at various modeled flow rates, timing of the anticipated flow rates compared to each fish species preferred passage window, and the potential for fish passage during the anticipated passage window. This data is derived from the RiverFLO 2-D results provided in Appendix A1.

Table 3-7 Anticipated Fish Passage

Modeled Flow Event	Flow Rate (cfs)	Anticipated Timing of Flow Event	Species of Concern	Fishway Velocity (ft/s)	Fish Passage Potential
Low Flow	75	Fall/Winter	Brown Trout Ling	<2	Yes
	500	Pre-/Post Spring Runoff	Dace White Sucker	<3	Likely (See Discussion)
2 - Year	1,375	Spring	Dace White Sucker	~4	Marginal (See Discussion)
100 - Year	6,616	Spring	Dace White Sucker	~6	Unlikely (See Discussion)

As can be seen from review of the table, fall and winter passage of brown trout is achieved by the proposed design. Although not currently present in the system, it is likely that adult ling could also benefit from the proposed fishway should they be reintroduced.

The passage window for dace and white sucker is anticipated to occur before and after the spring runoff peak. At river flows of up to 500 cfs, the average velocity in the fishway is less than 3 ft/s. The fishway design incorporates gaps between the rocks at the weirs, and in all instances, a minimum of 6 inches of reveal will be maintained between top of grout and top of rock within the fishway. This design will create localized low velocity regions through each weir and along the bottom of the pools to allow for resting and cover areas to facilitate upstream passage of these species.

The RiverFLO 2-D model treats each rock weir as a smooth and level crest, so the velocities calculated by the model are conservative. The model calculations also do not reflect the presence of the interstitial gaps between the rocks. Based on these inherent limitations in the model and prior experience with this type of design, the probability of successful upstream passage of dace and white sucker at flows up to 500 cfs is high.

For flows nearer to bank full (2-year event or 1,375 cfs), velocities in the fishway begin to approach 4 ft/s. At this velocity, it will be more difficult for dace and white sucker to move upstream through the fishway. Some passage is still likely due to the design of the fishway providing for localized low velocity areas as discussed above.

Once flows begin to exceed the bank full event, the potential for successful upstream fish passage through the fishway for the species of concern likely present coincidental to high flows is limited. However, the river begins to access the right bank flood plain at flows exceeding the bank full event. Once river flows extend into the floodplain, any upstream passage will likely take place outside of the river channel and in the floodplain.

3.6 Structural Design

The structural design for the rock ramp diversion ensures that the concrete crest is stable and adequately connected to the existing concrete crest and slab under the anticipated loading conditions. The structural design of the diversion also includes the concrete wall and walkway for the sediment sluiceway. Structural design analysis has been completed per the standards set forth in the 2009 International Building Code, ASCE 7-05 Minimum Design Loads for Buildings and Other Structures, ACI 318-08 Building Code Requirements for Concrete Structures, and American Welding Society D1.1-04 "Structural Welding Code" as appropriate.

4 SAFETY CONSIDERATIONS

The proposed rock ramp design presents a significant safety improvement over the existing condition from both an operational and recreational standpoint. The updated headgates and associated structure will provide improved ease of access, operation, and handrails for operator safety. The sluiceway gate in the diversion structure provides a far safer operational alternative than the existing notch/check boards in the concrete structure. DBWUA personnel will be able to access and operate the sluiceway gate without having to enter the river.

Recreational safety will also be improved as the downstream hydraulics due to the rock ramp diversion will be considerably safer for boaters in the water than the existing

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ENGINEER'S OPINION
OF CONCEPTUAL COST*

Date: 5/28/2014
Project #: 1447.035
Project Name: Deadman's Basin Diversion and Headgate
Engineer: J. Smith

Item No.	Description	Estimated Quantity	Unit	Unit Price	Total Cost
101	Mobilization and Demobilization	1	LS	$50,000	$50,000
102	Diversion and Care of Stream/Dewatering	1	LS	$25,000	$25,000
103	Concrete & Radial Gate Demolition	1	LS	$20,000	$20,000
104	Excavation & Placement of Fill	1	LS	$7,000	$7,000
105	Cast-In-Place Concrete (Diversion)	85	CY	$800	$68,000
106	Cast-In-Place Concrete (Sediment Sluiceway, & Intake Sill)	60	CY	$800	$48,000
107	Cast-In-Place Concrete (Headgates)	90	CY	$800	$72,000
	Riprap (Owner Procured)	1,665	CY	$100	$166,460
108	Grouted Riprap Placement (Rock Ramp)	1,070	CY	$60	$64,200
109	Non-Grouted Riprap Placement (Rock Ramp)	526	CY	$20	$10,520
110	Non-Grouted Riprap Placement (Headgate Outlet)	70	CY	$20	$1,400
	4'x4' Sluice Gate (Owner Procured)	1	LS	$10,000	$10,000
	6'x6' Sluice Gate (Owner Procured)	4	LS	$16,000	$64,000
	Sluice Gate Electric Motor	2	LS	$10,000	$20,000
111	4'x4' Sluice Gate Installation	1	LS	$2,500	$2,500
112	6'x6' Sluice Gate & Controls Installation	4	LS	$2,500	$10,000
113	Misc. Appurtenances (Walkways, Railings)	1	LS	$10,000	$10,000
114	Erosion Control	1	LS	$5,000	$5,000
115	Site Restoration	1	LS	$5,000	$5,000
	CONSTRUCTION SUB-TOTAL				$659,080
	CONTINGENCY		15%		$98,862.00
	CONSTRUCTION TOTAL				**$757,942**
Owner Procured Items:					**$260,460**
Fish Passage Items:					**$64,000**
	Riprap (Only for Fishway)	400	CY	$100	$40,000
	Grouted Riprap Placement (Fishway Chute)	400	CY	$60	$24,000