Mad River RM 1.1 - 4.3

Conceptual Basis of Design Report

SUBMITTED TO:

Yakama Nation Fisheries

March 3, 2022

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SUBMITTED TO:

Yakama Nation Fisheries
Upper Columbia Habitat Restoration Project
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1. Project Background

The Mad River is a primary tributary within the Entiat River watershed. The watershed is located within the eastern foothills of the Cascade Mountains in central Washington along the western border of the Columbia Plateau (Figure 1). The Mad River flows southeast through the foothills and joins the Entiat River approximately 11 river miles (RM) upstream of where the Entiat River meets the Columbia River near the community of Entiat. The Mad River habitat enhancement and restoration project area extends from RM 1.1 to RM 4.3, near Pine Flats campground. A majority of the project area is within public land managed by the U.S. Forest Service (USFS).

Figure 1. Mad River RM 1.1-4.3 project area.

In its current condition, the Mad River RM 1.1-4.3 project area has diminished ecologic and geomorphic function. A more detailed discussion of site conditions, impacts, and recommended restoration strategies are available in the Lower Mad River Reach Assessment and Restoration Strategy (Inter-Fluve 2018). For the Assessment, RM 0 - 4.3 of the Mad River were divided into four distinct geomorphic reaches. The project area (RM 1.1-4.3) includes Reach 2 (RM 0.86-1.93), Reach 3 (RM 1.93-2.98) and Reach 4 (RM 2.98-4.3).

The goals for the project area include:

1) Increase and improve mainstem habitat conditions for spawning and rearing.
2) Increase and create quality off-channel and side channel habitat for rearing and refugia.
3) Increase frequency of and initiate floodplain connectivity, where possible, to improve geomorphic and ecologic function and complexity.

The limiting factors for the aquatic species of concern in the project area are identified as inadequate aquatic habitat conditions including insufficient quantity and distribution of quality large wood, deficient size and distribution of pools, minimal off-channel habitat, reduced geomorphic/habitat complexity, reduced riparian forest canopy/structure to provide large wood recruitment, limited retention of spawning gravels, and the risk of further diminishing floodplain connectivity. The primary anthropogenic impacts in the project area include road building and the loss of valley floor floodplain by road occupation, historical damming and crossing confinements at Tillicum Fan, and historical logging and large wood clearing from the channel. The project objectives intend to improve conditions in terms of these limiting factors as outlined in Table 1.

Table 1. Limiting factors and project objectives for the Mad River RM 1-1-4.3 project area:

Primary Limiting Factors	Project Objectives
inadequate aquatic habitat and inadequate geomorphic complexity	Increase quality and quantity of large wood in the system by installing Large Wood structures, where hydraulically appropriate.
	Increase availability of quality off-channel aquatic habitat by creating side channels and alcoves, where approproriate.
	Increase frequency and maintenance of pools (>3 ft deep) by installing Large Wood and boulders in appropriate locations
	Capture and store spawning gravels for longer duration with the installation of hydraulic influences (Large Wood Structures, boulders, and side channels)
	Increase floodplain connectivity via side channel construction and Large Wood placement.
	Increase habitat and geomorphic complexity by integrating the installation of large boulders with LW structure. Large boulders expected to support longetivity and maintenance of LW structures.

1.1 NAME AND TITLES OF SPONSOR, FIRMS, AND INDIVIDUALS RESPONSIBLE FOR DESIGN

The concept-level restoration designs developed for this project are sponsored by the Yakama Nation Upper Columbia Habitat Restoration Project (UCHRP). Chris Clemons (Habitat Biologist II) is the project manager for UCHRP. Inter-Fluve was hired as the engineering design firm by UCHRP to develop the restoration conceptual designs for the project area. Dan Miller, PE (Principle Hydraulic Engineer), Pollyanna Lind, PhD (Senior Fluvial Geomorphologist), Mike Brunfelt RG (Principal Geomorphologist), Susan Elliott, EIT (Staff Engineer), and Mackenzie Baxter, CFP (IFI, Fisheries Biologist) are responsible for the conceptual designs related to this basis of design report. Although the restoration designs are expected to benefit a large suite of native aquatic species, there is a particular emphasis on recovery of Endangered Species Act (ESA) listed Upper-Columbia Summer Steelhead (*Oncorhynchus mykiss*), Upper-Columbia Spring Chinook (*Oncorhynchus tshawytscha*), and Columbia River bull trout (*Salvelinus confluentus*)

1.2 LIST OF PROJECT ELEMENTS THAT HAVE BEEN DESIGNED BY A LICENSED PROFESSIONAL ENGINEER

Dan Miller, PE is the licensed engineer of record for this project. Project elements with BPA HIP activity and risk category are included below in Table 2.

Table 2. Activity categories included in the project (HIPIV, vers 5.2 – table 1.4).

Work Element	ID	HIP Category	Risk Level
Improve Secondary Channel and Floodplain Interaction	29	2a	Low
Install Habitat-Forming Instream Structures	30	2d	Medium
Realign, Connect, and/or Create Channel	33	2f	Medium
Riparian Vegetation Planting (by others)	47	2e	Low

1.3 EXPLANATION AND BACKGROUND ON FISHERIES USE (BY LIFE STAGE – PERIOD) AND LIMITING FACTORS ADDRESSED BY PROJECT

The Entiat River sub-basin currently supports anadromous runs of native spring Chinook and steelhead trout, and resident and fluvial bull trout (Arterburn et al. 2017; Andonaegui et al. 2002; U.S. Bureau of Reclamation 2009). According to reported surveys Upper Columbia Salmon Recovery Board (UCSRB, 2018), the Lower Mad River supports spawning and rearing habitat for endangered Upper Columbia spring Chinook salmon and Upper Columbia steelhead. The Mad River is considered a stronghold for resident bull trout, which are listed under the ESA as threatened (see Figure 2 for species distribution map), as well as fluvial bull trout. Coho were once present in the watershed but wild populations have since been extirpated (Nehlsen, Williams, and Lichatowich 1991). Other resident species in the sub-basin include salmonids such as westslope cutthroat trout, redband trout, and rainbow trout, as well as Pacific lamprey, mountain whitefish, and eastern brook trout. Pacific lamprey are present in the Entiat River and therefore may be present in the Mad River. However, there are limited data to confirm the use of the Mad River by adult or juvenile lamprey. In the lower Mad River, the primary focal species for restoration efforts include spring Chinook salmon, steelhead trout, bull trout and Pacific lamprey. A diagram that provides the life stage and usage timing for these species is provided in Figure 3.

The 2017 Revised Biological Strategy for the Upper Columbia Region (Arterburn et al. 2017) describes habitat conditions and primary ecological concerns within the Upper Columbia Basin, including the Mad River. Of primary concern, according to the 2017 revised strategy for the Mad River is channel structure and form (bed and channel form). Habitat complexity in the channel is limited, in part due to the historical logging efforts in the riparian zone, flood control measures that straightened and simplified the channel, and removal of large woody material from the river. Increased amounts of sediment, poor riparian condition or lack of recruitable wood in the riparian zone, limited prey availability, and anthropogenic barriers to habitat are other key ecological concerns for salmonids in the Mad River (Arterburn et al. 2017).

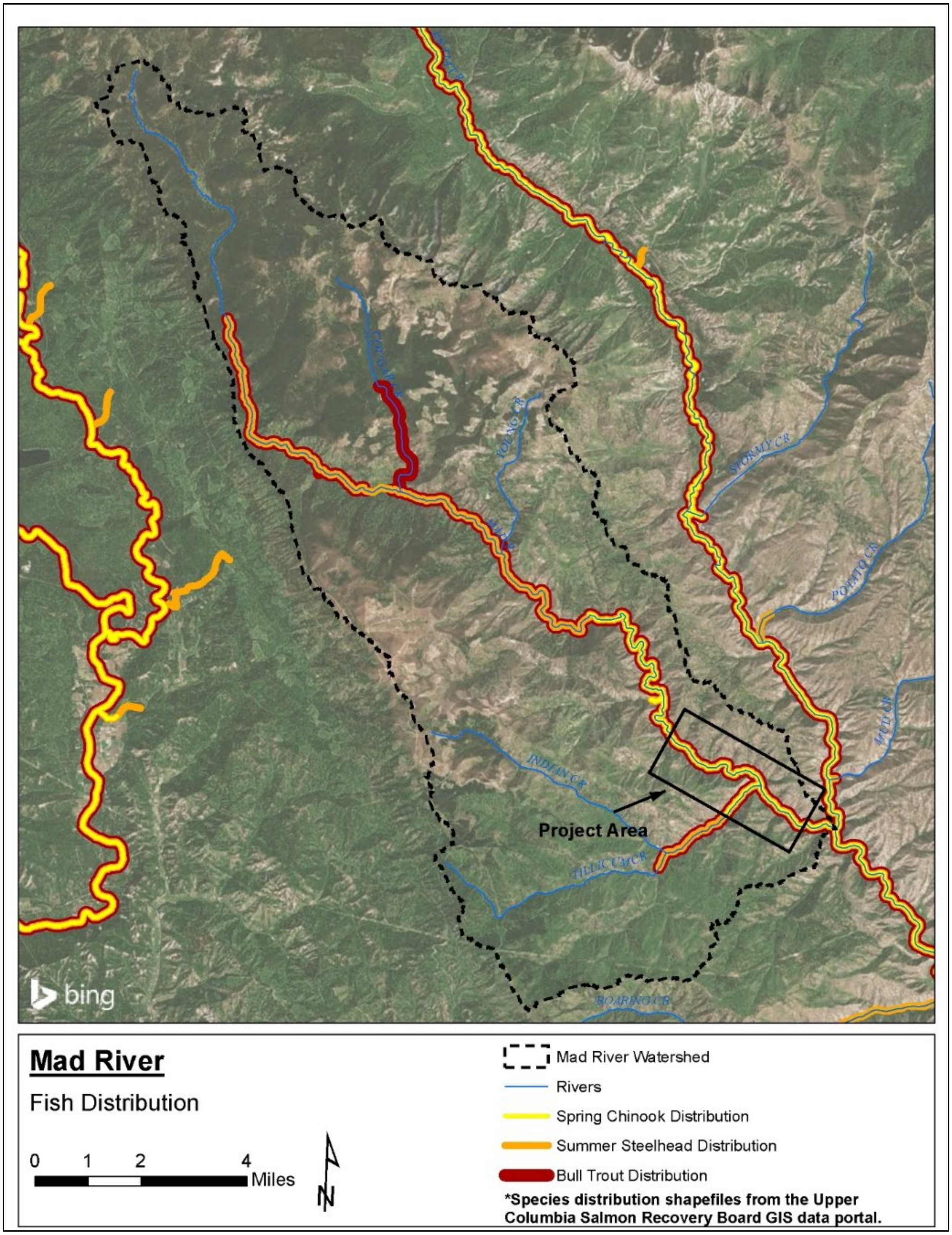

Figure 2. Reported distribution of Spring Chinook, Summer steelhead, and bull trout in the Entiat and Mad River Sub-basins (Upper Columbia Salmon Recovery Board (UCSRB, 2018) – GIS data portal, accessed 9/2018)

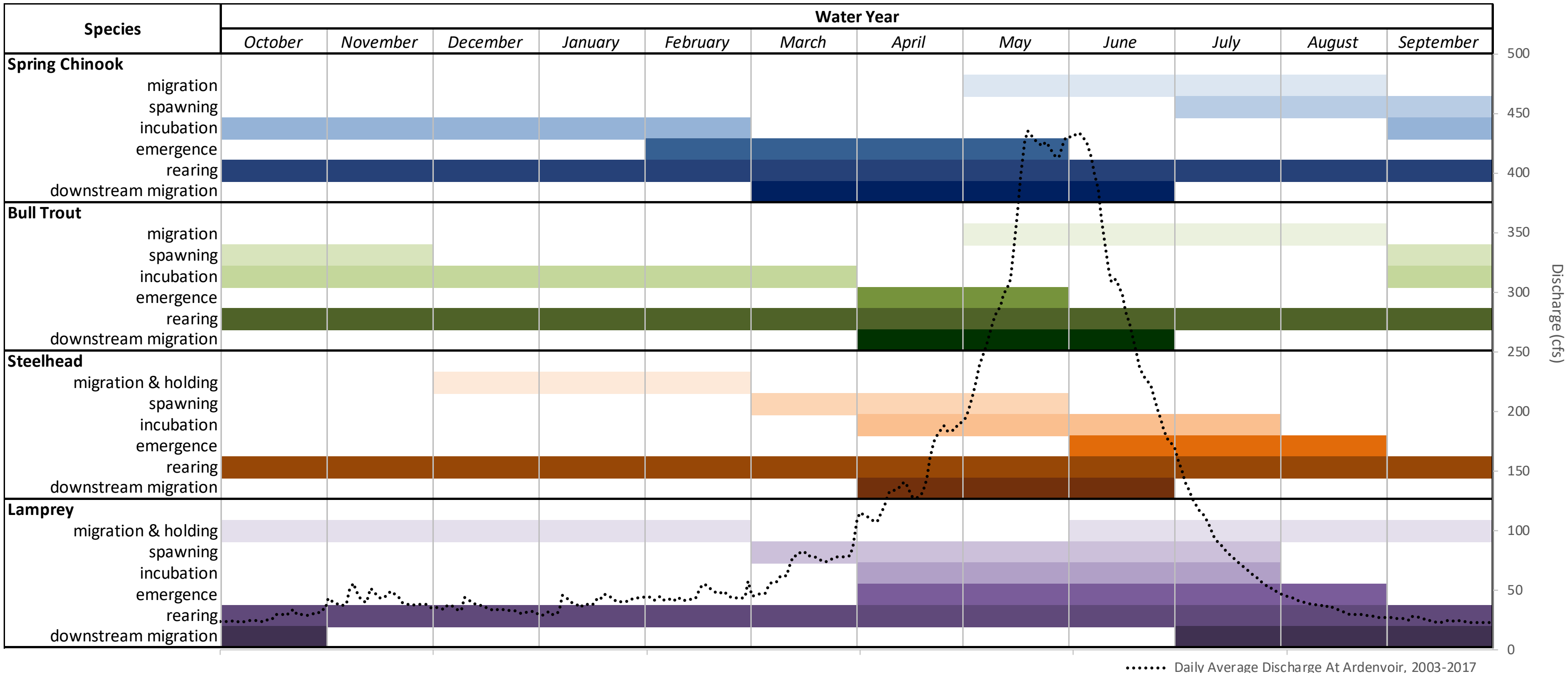

Figure 3. Summary of life history timing of steelhead and bull trout and Chinook Salmon in the Mad and Entiat Rivers, overlaid on an annual hydrograph depicting mean daily discharge from the period 2003 - 2017. (USGS Mad River near Ardenvoir gage (12452890); life history reference cited in species description section 1.41, 1.42, and 1.43.

Steelhead

Steelhead (Oncorhynchus mykiss) enter and ascend the Columbia River in June and July, arriving near their spawning grounds nine to eleven months prior to spawning. Adult steelhead overwinter in the mainstem Columbia, returning to the Entiat in the late winter prior to spawning. Spawning survey data from the Mad River during the 2000–2008 spawning seasons showed that spawning occurred between late March and early May with a peak observed in late April (Phil Archibald 2009). Egg survival is highly sensitive to intra-gravel flow and temperature (Peven et al. 2004) and is particularly sensitive to siltation earlier in the incubation period. Fry emerge from the redds six to ten weeks after spawning (Peven et al. 2004).

Age-0 juveniles spend their first year primarily in shallow riffle habitats, feeding on invertebrates and utilizing overhanging riparian vegetation and undercut banks for cover (Moyle 2002). Age-0 steelhead use slower, shallower water than Chinook Salmon, preferring small boulder and large cobble substrate (Hillman and Miller 1989). Older juveniles prefer faster moving water including deep pools and runs over cobble and boulder substrate. Juveniles out-migrate between ages one and three, though some hold over and display a resident life history form. Smolts begin migrating downstream from natal areas in March (Peven et al. 2004).

Summer steelhead use, including spawning and rearing, has been documented throughout much of the Entiat River and in the lower Mad River (Arterburn et al. 2017; P. Archibald, Johnson, and Baldwin 2008; Washington Department of Fish and Wildlife (WDFW) 2018). Redd surveys conducted in the Mad River by the USFS indicate steelhead spawning occurs from the confluence with the Entiat up to approximately RM 7.

Spring Chinook

Spring Chinook (*O. tshawytscha*) are reported to use the lower Mad River for spawning. Adult spring Chinook enter the Entiat basin in May, holding in deep pools under overhead cover in the Entiat or Mad Rivers. Spawning occurs from very late July through September with a peak in mid to late August. Spawning typically begins when temperatures drop below 16°C (Healy 1991a; Peven et al. 2004). Eggs are very sensitive to changes in oxygen levels and percolation, both of which are affected by sediment deposition and siltation in the redd (Peven et al. 2004). Fry emerge in the spring, which coincides with the rising hydrograph. High water forces juveniles to seek out backwater or margin areas with lower velocities, dense cover, and abundant food (Quinn 2005). Fry are extremely vulnerable in these systems when they emerge, because their swimming ability is poor and flows are high. Near-shore areas with eddies, large woody debris, undercut tree roots, and other cover are very important for post-emergent fry (Hillman and Miller 1989; Healy 1991b). Age-1 parr utilize deeper pools with resting cover in mainstem habitats more than post-emergent individuals. Spring Chinook typically express a stream-type life history where they rear for 1 year in freshwater before out-migrating as yearlings. Out-migration typically begins in March (Peven et al. 2004; Healy 1991b).

Spring Chinook spawning has been documented within the study area of the Mad River (Washington Department of Fish and Wildlife (WDFW) 2018) between RMs 3.1 and 3.6.

Bull Trout

Bull trout (*Salvelinus confluentus*) spawn and rear in the middle and upper Mad River, upstream of the study site. The Mad River supports the largest populations of bull trout in the Entiat Basin. Bull trout from both areas were listed as threatened under the ESA in 1999 (U.S. Fish and Wildlife Service 1999a).

Bull trout may exhibit both resident and migratory life-history strategies (Rieman and Mclntyre 1993). Resident bull trout complete their life cycles in the tributary streams, such as the Mad River, in which they spawn and rear. Compared to other salmonids, bull trout have more specific habitat requirements that appear to influence their distribution and abundance. Critical parameters include water temperature, cover, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (U.S. Fish and Wildlife Service 1999b).

Bull trout normally reach sexual maturity in 4 to 7 years and can live 12 or more years. Bull trout in the Columbia River basin typically spawn from August to November during periods of decreasing water temperatures. Redd surveys in the Entiat and Mad Rivers indicate a majority of bull trout spawning occurs here in September and October (Nelson et al. 2008; U.S. Fish and Wildlife Service 1999b). Preferred spawning habitats are generally low gradient stream reaches, or in areas of loose, clean gravel in higher gradient streams (Fraley and Shepard 1989), and where water temperatures are between 5 to 9° C (41 to 48° F) in late summer to early fall (Goetz 1989). Spawning areas are often associated with cold-water springs, groundwater infiltration, and are typically the coldest systems in a given watershed (U.S. Fish and Wildlife Service 1999b).

Depending on water temperature, egg incubation can last between 100–200 days, and juveniles remain in the substrate after hatching. Fry normally emerge from early April through May, depending upon water temperatures and increasing stream flows (U.S. Fish and Wildlife Service 1999b).

In the Mad River, considered a stronghold for bull trout, spawning occurs primarily upstream of the project area. Within the lower Mad River, juvenile rearing, adult migration, and over wintering have been documented (Washington Department of Fish and Wildlife (WDFW) 2018; Arterburn et al. 2017). Surveys have found bull trout redds in the upper Entiat River and Mad River, though the number of documented redds in the Mad River is very low (UCSRB (Upper Columbia Salmon Recovery Board) 2018).

Pacific Lamprey

Adult upstream migration of Pacific lamprey occurs from the late spring through fall in the Columbia River Basin, with peak passage occurring in the Upper Columbia at Rock Island Dam in late August (McIlraith et al. 2017). In the Entiat basin, spawning generally occurs from March through July at temperatures between 10-15°C (50-59°F) (USBR 2017a). Preferred spawning habitat is in low gradient runs and pool tail-outs. Hatching date varies according to water temperature and is typically around 15 days after spawning. Ammocetes, the larval stage of the lamprey, spend a short period of time (~15 days) in the redd after hatching before drifting downstream to suitable rearing habitats. Rearing habitat typically consists of low gradient areas with low water velocity, soft substrate, and organic material. Ammocetes can rear in freshwater for up to 7 years as they grow, during which time they filter feed on diatoms and suspended organic material. Juvenile downstream migration occurs between July and October and includes metamorphosis into macropthalmia (adult stage), similar to smoltification in salmonids. Macropthalmia then migrate to the ocean during high flows in late winter or early spring (USBR 2017b).

Surveys for adult and juvenile Pacific lamprey in the Mad River indicate there is currently limited suitable habitat available for lamprey rearing or spawning. Despite the appearance of quality lamprey habitat in the lower Mad River (Lampman 2018), juvenile lamprey presence has not been confirmed (R. Lampman, pers. comm., 2022). Randomized surveys in 2015 in the Mad River from Maverick Saddle to the confluence with the Entiat found no evidence of juvenile lamprey (Grote 2018a). Despite a very large lamprey run in the Upper Columbia and Entiat Rivers in 2018, redd and adult surveys in the Mad River did not confirm lamprey were on redds and actively spawning, though there was anecdotal evidence to indicate at least a few lamprey were spawning in the downstream portion of the Mad River (Grote 2018b).

1.4 AQUATIC HABITAT EXISTING CONDITIONS

Aquatic habitat conditions in the lower Mad River were documented during a 2017 field investigation (Inter-Fluve, 2018). Instream habitat conditions in the Lower Mad River include limited deep pools and a large proportion of higher velocity riffles. Based on field observations, spawning areas and refugia are limited as a result of channel simplification. The presence of large wood is minimal, particularly in the lower reaches of the study area. The lower reaches have been especially impacted by historical and ongoing land uses that have either removed large wood from the channel or limited the natural recruitment and retention of instream large wood. The few channel-spanning log jams occurring on the Mad River locally reduce channel gradient, thus facilitating sediment storage and the potential for accumulating better spawning gravel areas. However, these tend to be transitory influences in the higher energy, confined sections of the channel. Micro-pools located behind large boulders in the channel may provide some velocity refuge for salmonids migrating upstream or holding in the system, depending on the flows. Riparian vegetation in the Lower Mad River generally consists of a mid-seral stage coniferous overstory with a frequently dense shrub/sapling understory. Generally, tree age and size and species diversity increase upstream through the project area.

1.5 LIST OF PRIMARY PROJECT FEATURES INCLUDING CONSTRUCTED OR NATURAL ELEMENTS

Primary project features include mainstem engineered large wood structures, side channel creation and enhancement, alcove development and enhancement, and native plant revegetation. A general description of each is provided below.

Mainstem Engineered Large Wood Structure

Engineered Large Wood Structures in the mainstem Mad River (M-ELWS) are conceptually designed in various sizes and configurations to create and maintain localized geomorphic complexity and improve available aquatic habitat. Designs and locations are dependent on field identified characteristics and river processes, preliminary hydraulic modeling, proximity and relationship to existing infrastructure, and the distribution of varied habitat types within the project area. Engineered large wood structures proposed for the Mad River Project area include:

- Bank Buried Large Wood Structures: A large wood structure constructed with 18” dbh 40-ft long logs with rootwads that is ballasted by burying the trunk of the tree into the existing bank, or bracing against existing trees or boulders. Rootwads are positioned over a scour hole. A whole tree with limbs ballasted between and to the structure with vertical log pilings is added in some versions. Where appropriate, the addition of large boulders adds additional ballasting and hydraulic controls. The number of logs and size of the structure is dependent on localized hydraulics and geomorphic conditions. Size ranges from just two large logs with rootwads to up to 21 rootwad logs. Slash is placed under and within the rootwads to provide additional roughness to the structure and increase immediate pool cover function.
- Apex Large Wood Structures: A large wood structure constructed with 18” dbh 40-ft long logs with rootwads and installed at locations to promote and maintain split-flow conditions. The structure is ballasted by burial of the trunks and vertical log pilings. Where appropriate, large boulders are added to the structure for additional ballasting and hydraulics. The rootwads are positioned over a scour hole and horizontal perpendicular logs are added between the layered rootwads. Slash is placed under and within the rootwads to provide additional roughness to the structure and increase immediate pool cover function.
- Deflector Jam Large Wood Structure: Installed on bars or low floodplains to promote deposition and floodplain development, this large wood structure is constructed of vertical logs (12-16” dbh and 12-15’ long) embedded at least 8-ft below the streambed, in a cluster pattern used to rack logs with rootwads (16-18” dbh and about 30’ long) and slash. The structure creates surface roughness.
- Side Channel Habitat Large Wood: Large Wood and salvaged trees/slash material generated from excavating side channel and placed along the side channel bed and banks to provide hydraulic roughness, complexity and varied habitats.

Side Channel Creation and Enhancement:

The side channel creation and enhancement occur by select excavation across existing floodplains, often within an alignment of an historical channel scar that has been abandoned or is currently infrequently activated. Habitat enhancement is added by installing Side Channel Habitat Large Wood (see above) along the channel. Apex Large Wood at the upstream end and a Bank Buried jam at the downstream end maintain connectivity to the mainstem channel.

Alcove Development and Enhancement:

Excavation of an off-channel feature connected at the downstream end to the mainstem channel. Alcoves provide low energy off channel habitats. Bank Buried LW is added to the alcove to enhance habitat quality and feature maintenance.

Native Plant Revegetation:

Native plant revegetation is not currently depicted in the concept-level drawings. However, it is planned for all the areas disturbed during construction. Seeding and plantings of native species will be provided in later phases by UCHRP's planting contractor. Seed and plant species will be submitted for review and approval USFS biologists.

1.6 DESCRIPTION OF PERFORMANCE/SUSTAINABILITY CRITERIA FOR PROJECT ELEMENTS AND ASSESSMENT OF RISK OF FAILURE TO PERFORM, POTENTIAL CONSEQUENCES AND COMPENSATING ANALYSIS TO REDUCE UNCERTAINTY

Constructed large woody material (LWM) structures will be designed to be stable for anticipated flow conditions up to the 100-year event. The intent is for the project features to be resilient and provide continued function in response to potential changes in watershed conditions including potential changes in flow, sediment and wood transport; racking and dynamic retention of wood on structures; and, riparian vegetation conditions. The structures will be built predominantly from naturally occurring materials such that should a structure fail, the LWM will become part of the river LWM dynamic. Risk to public and property will be evaluated using Reclamations' design guidelines risk matrices. As typical with the majority of UCHRP sponsored projects, a monitoring plan will be created and monitoring conducted annually for 3 years following project implementation and in response to high flow events. Snow pack and high flows through each year will be summarized from available SnoTel and USGS gage data. Design staff will visit the site annually for each of the three years to photograph site conditions and annotated observed changes. The monitoring plan will include guidance on what site conditions would trigger remedial actions to correct potential undesired performance.

1.7 DESCRIPTION OF DISTURBANCE INCLUDING TIMING AND AREAL EXTENT AND POTENTIAL IMPACTS ASSOCIATED WITH IMPLEMENTATION OF EACH ELEMENT

Construction will occur during the prescribed in-water work window. Designs and plans will be developed with the intent to minimize impacts, as well as duration, of construction. The UCHRP will work closely with permitting agencies and USFS to coordinate the project features and construction activities.

Potential impacts to sensitive habitats such as wetlands and sensitive plants will be minimized with the proposed designs and discussions with USFS biologists. Access routes will be vetted to minimize impacts to sensitive habitats and wetlands.

Proposed limits of disturbance for access, staging and construction will be indicated in the Plans and will be refined through design. Where possible, access roads will avoid existing wetlands; and follow existing roads, gaps in vegetation, bare gravel bars and remain within constructed feature footprints. Cofferdams, HIP CMs and BMPs will be employed to minimize impacts. Disturbed areas will be graded smooth to match to existing topography, soils will be decompacted if necessary and revegetated with native plant species.

2. Resource Inventory and Evaluation

2.1 DESCRIPTION OF PAST AND PRESENT IMPACTS ON CHANNEL, RIPARIAN AND FLOODPLAIN CONDITIONS

As noted in the Assessment (Inter-Fluve, 2018), there are some historical photos and some written evidence about conditions of the Mad River before the early twentieth century. Field observations, oral accounts, and publicly available information such as logging and fire history as well as underlying geology and known glacial cycles provide additional information on the historical channel process of the Mad River. Overall, the watershed and riparian forests were relatively undisturbed and the valley bottom was vegetated with mature forests composed of very large trees prior to Euro-settlement in the 1800's. These forest conditions would have allowed the river channel to incorporate large wood into the system recruited via floods, fire or blow-down, lateral migration, and hillslope mass-movements (debris flows and/or landslides). As a result, the available aquatic habitat throughout the project area was likely more complex than is expressed today – with more backwater and side channel features, active channel migration, more frequently connected floodplains, and large wood jams capable of sustaining and regenerating for longer periods of time as well as creating scour pools and gravel retention areas.

The Mad River Road now occupies a notable portion of the relatively narrow valley floor that was historically available to the channel. In some places, the road and its prism with riprap armored banks in some locations, occupies half of the available valley floor. Hillslope contributions of sediment and large wood are also inhibited by the road.

2.2 INSTREAM FLOW MANAGEMENT AND CONSTRAINTS IN THE PROJECT REACH

There is no instream flow management or associated constraints in the project area.

2.3 DESCRIPTION OF EXISTING GEOMORPHIC CONDITIONS AND CONSTRAINTS ON PYSICAL PROCESSES

The Mad River watershed is a relatively steep montane system that initiates off the ridges and high meadows of the Entiat Mountains located in the eastern foothills of the Cascades. The channel is primarily single-thread (Figure 4). The width of the modern valley floor in the project area ranges from approximately 280-ft to 25-ft. The floor of the Mad River valley is composed of both alluvial (river deposited) and colluvial (hillslope contributed) materials. Valley width and localized gradient is influenced by the presence of substantial sediment contributions, most extensively at alluvial and debris contribution located at the mouths of tributaries. Except for the upstream-most section of the project area, the Mad River Road occupies a portion of the valley floor, increasing natural confinement conditions and impeding riparian vegetation and hillslope contributions from the river-left (north) side of the valley.

Channel form is straight to sinuous with an average profile slope of 0.0165 (1.65%) through the project area. Substrate is primarily gravel-cobble-boulder alluvium and size distribution varies depending on proximity to active sediment sources, gradient, and geomorphic complexity (Figure 5). Bedrock contacts on adjacent hillslopes next to the channel occur periodically in Reaches 2-4 but no channel-spanning bedrock grade-control was observed in the bed of the channel within the assessment area. Large boulder colluvium in the channel does act as grade control in a few locations as well as add geomorphic complexity where they occur.

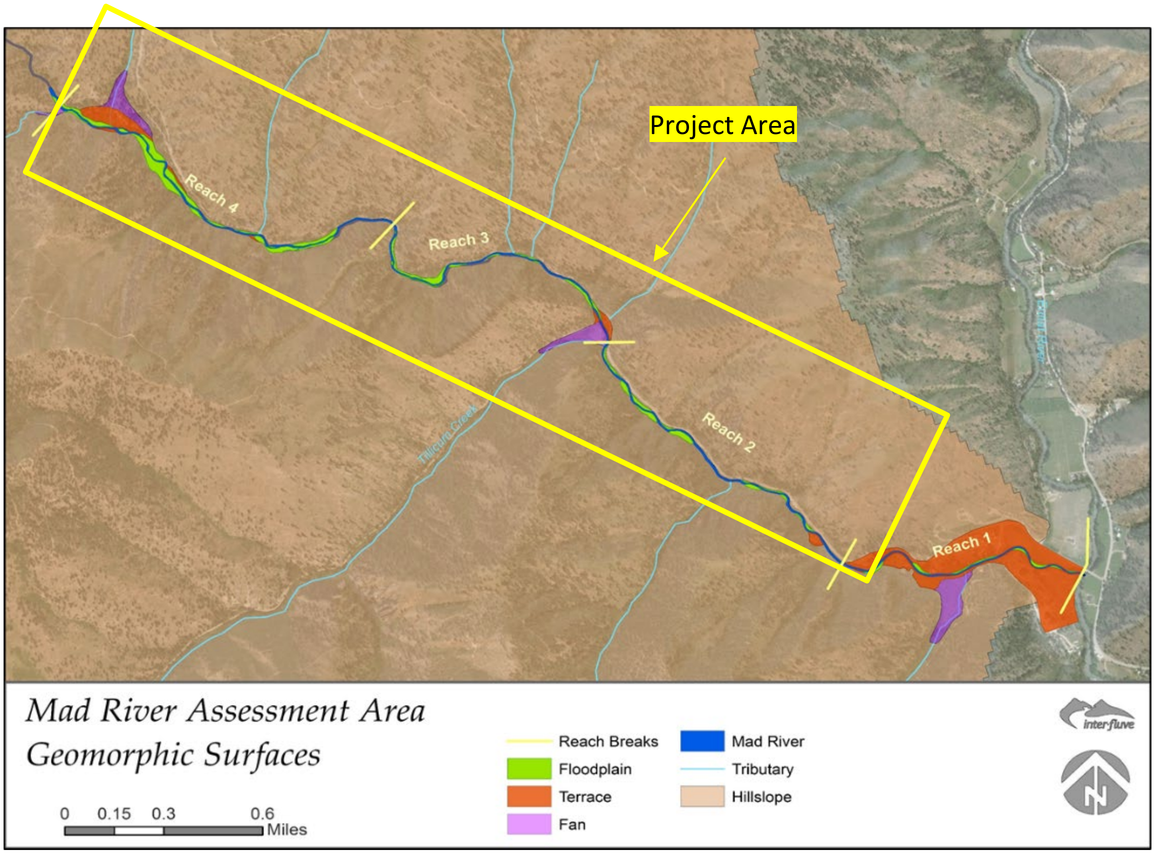

Figure 4. Geomorphic surfaces of the Lower Mad River (RM 1.1-4.3),

	METRIC	Reach 1	Reach 2	Reach 3	Reach 4
Channel and Floodplain	Length (miles)	0.86	1.07	1.05	1.32
	River Mile	0 - 0.86	0.86 - 1.93	1.93 - 2.98	2.98 - 4.3
	Stream Gradient (%)	1.54%	1.79%	2.35%	1.65%
	Sinuosity	1.18	1.07	1.33	1.20
	Dominant Channel Habitat Unit Type	Riffle	Riffle	Riffle	Riffle
	Average Bankful Width (ft)	41.0	51.3	48.0	52.5
	Dominant Substrate	cobble	cobble	cobble	cobble
Channel Habitat Area (%)	Pool	7%	8%	1%	7%
	Riffle	84%	79%	82%	87%
	Glide	9%	13%	17%	5%
	Side Channel	0%	0%	1%	1%

Figure 5. Mad River Reach metrics -- from Lower Mad River Reach Assessment (Inter-Fluve 2018)

The hillslope geology of the Mad River project area is mostly granitic, as well as gneiss and schists. The bedrocks are generally erosion resistant and thus form high, steep hillslopes and walls. The hillslopes and valley of the Mad River were created by the gradual process of downcutting over millennia via fluvial erosion, mass wasting, and subtle faulting. Glaciers did not extend into the assessment area during the last glacial period. As a result, hillslope-valley form is basically “V” shaped and natural hillslope-channel coupling occurs that influences channel form, shape, confinement, and sediment supply. Hillslope and tributary contributions in the form of landslides, rock-fall, debris flows, and bedload have and will continue to influence river morphology through sediment supply and routing. Land use (i.e., logging and road building), as well as wildfires (natural and human caused), are known to alter localized sediment and wood inputs in steep montane systems similar to the Mad River (Beschta et al., 2004; Silins et al., 2009).

The naturally-formed terraces in the upstream section of the assessment area are the result of substantial sediment contributions from tributaries and/or upstream inputs to the valley. The river gradually worked its way through the available sediment and, in its contemporary form, has incised to the point where these historical channel and floodplain surfaces have been abandoned (e.g., up-slope part of Pine Flats Campground). The small terraces near the Tillicum Creek alluvial fan are similar but, past construction of a dam, road, bridge, homesite, and related bank armoring at the fan toe exaggerated entrenchment at this site, making it difficult to discern the difference between natural vs anthropogenic terrace development.

Today, LWM plays only a moderate to minor role in the modern geomorphology and habitat complexity of the channel. A total of 286 pieces of channel-influencing LWM were counted during field surveys completed by Inter-Fluve (Oct 24-26, 2017) between RM 0 - 4.3. At that time only four large wood jams (>10 pieces of LWM) were recorded. Of the four, three of the jams were located in Reach 4 while one was in Reach 2. A site tour in 2021 by Inter-Fluve staff found that the jam in Reach 2 had been washed out – likely because LWM was too small to act as key pieces and sustain its position. Prior to road construction and logging, the floodplain areas of the Mad River would have hosted mature conifers and a dense understory that provided structure to the floodplain, generated channel-influencing large wood that created geomorphic and habitat complexity, and offered shade/cover and nutrient inputs. Lack of mature large wood inputs and periodic “cleaning” of wood from the channel has reduced quantity and natural retention of LWM.

2.4 DESCRIPTION OF EXISTING RIPARIAN CONDITION AND HISTORICAL RIPARIAN IMPACTS

Riparian vegetation in the Lower Mad River generally consists of a mid-seral stage coniferous overstory with a dense shrub/sapling understory. The primary overstory species included Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*) and some large cottonwoods (*Populus trichocarpa*) scattered throughout the riparian zones of the project area. Generally, tree age and size increase upstream through the project area with the largest size class of overstory tree canopy (mature) noted at the upstream end of the project area in areas less impacted by the Mad River Road and repeat historical timber harvest. Understory species increase in diversity and density upstream as well. Which is also a reflection of human land use impacts. In Reach 4, western red cedar (*Thuja plicata*) was recorded both as an overstory and understory species. Understory canopy in Reaches 2, 3, and 4 primarily consisted of small deciduous trees, saplings, and shrubs dominated by willow (*Salix* spp.), alder (*Alnus* spp.), redosier dogwood (*Cornus sericea*), and bigleaf maple (*Acer macrophyllum*).

2.5 DESCRIPTION OF LATERAL CONNECTIVITY TO FLOODPLAIN AND HISTORICAL FLOODPLAIN IMPACTS

The active floodplain surfaces of the Mad River upstream of RM 1.0 are generally discontinuous and occupy the remaining portion of the valley floor not occupied by the channel or the Mad River Road. Almost all of the floodplain surfaces are vegetated. However, the maturity and composition of the vegetation varies depending on land-use history (logging, road building). Vegetation, elevation, observed high-water indicators, and channel form suggest that low floodplain surfaces are partially inundated during high flow events. Density of vegetation on the available floodplains suggests good root access to hyporheic groundwater under all floodplains observed. The floodplains are composed primarily of alluvial deposits, but it is not uncommon for colluvium to be present. Soil pits at Side Channels 1 and 2 and alcove near RM 2.65 indicate fine soils (sands and silts) to depths beyond reach of excavation with hand tools. Two soil pits excavated along Side Channel 3 shows 2-3.5 feet of silty sand over top of alluvial material. The alcove near RM 3.85 showed gravel and cobble to the surface. Gravel and cobble alluvium may be conducive to groundwater interchange with surface water channels.

2.6 TIDAL INFLUENCE IN PROJECT REACH AND INFLUENCE OF STRUCTURAL CONTROLS (DIKES OR GATES)

No tidal influence occurs in the project area.

3. Technical Data

3.1 INCORPORATION OF HIP IV SPECIFIC ACTIVITY CONSERVATION MEASURES FOR ALL INCLUDED PROJECT ELEMENTS

HIP conservation measures will be incorporated into the project elements and included in the future phase plan sets. As the project elements are refined through the design process, additional information will be provided as needed.

3.2 SUMMARY OF SITE INFORMATION AND MEASUREMENTS (SURVEY, BED MATERIAL, ETC.) USED TO SUPPORT ASSESSMENT AND DESIGN

The Lower Mad River Reach Assessment (Inter-Fluve, 2018) involved collecting field data of the area and combining it with already existing available information on the Mad River and the Entiat watershed. Existing available information utilized in the assessment included, but is not limited to, the Entiat Water Resource Inventory Area (WRIA 46) Management Plan Chelan County Conservation District (CCCD, 2005), Biological Overview for the Entiat River Tributary Assessment (Phil Archibald 2009b), Entiat Subbasin Plan (Peven et al. 2004), available digital and paper geologic maps, past habitat assessment results, and Inter-Fluve's Tillicum Creek Habitat Restoration Project Report (2018). New data collection and analysis performed as part of the 2018 assessment included a geomorphic assessment of the mainstem channel, side channels, and floodplain surfaces, as well as an aquatic habitat inventory, characterization of landforms and human impacts, and identification of habitat restoration opportunities. Field surveys and observations were conducted Oct 24-26 and Nov 9-10, 2017 and April 25, 2018. Additional site visits by Inter-Fluve science and engineering staff occurred Sept 29 and Oct 26, 2021.

Seven soil pits were excavated with a soil auger by Wildlands, Inc. crews in areas being evaluated for potential side channel or alcove construction on Oct 26, 2021, with oversight by UCHRP and Inter-Fluve. Perforated pipe piezometers were installed in all pits. Pressure transducer data-loggers were installed in five of the piezometers to collected seasonal groundwater elevations. The data from these loggers will be downloaded in the spring or summer. Water levels will provide guidance on depth of side channels or alcoves to remain in contact with groundwater to aid in remaining wetted during low flow conditions.

Topobathymetric LiDAR was collected (10/30/2021) and processed for the Mad River project area and made available on 12/17/2021 (NV5 2021). The topobathy LiDAR is being used for a number of things including mapping, hydraulic modeling, and side channel grading.

3.3 SUMMARY OF HYDROLOGICAL ANALYSES CONDUCTED, INCLUDING DATA SOURCES AND PERIOD OF RECORD INCLUDING A LIST OF DESIGN DISCHARGE (Q) AND RETURN INTERVAL (RI) FOR EACH DESIGN ELEMENT

A map of the Mad River watershed and its contributing tributaries is available as Figure 6. The largest contributing tributary in the Mad River watershed is Tillicum Creek. This creek meets the Mad River at approximately RM 2.0, in the middle of the assessment area. Otherwise, contributing tributaries within the assessment area have relatively small contributing upstream drainage areas.

The average annual discharge of the Mad River watershed follows a snowmelt runoff pattern typical of east-slope Cascade Mountain streams. A USGS gage located near the mouth of the Mad River, at Ardenvoir, WA (USGS 12452890) provides surface water discharge data. Figure 7 displays the daily average mean discharge at the Ardenvoir gage for data ranging from 2003-2017. The hydrograph depicts elevated spring flows most likely generated by snow melt further influenced by rain events. Base flow is relatively constant from August through October. Autumn and winter rain events usually produce only small peaks from November through February, prior to the snow-pack melting in spring.

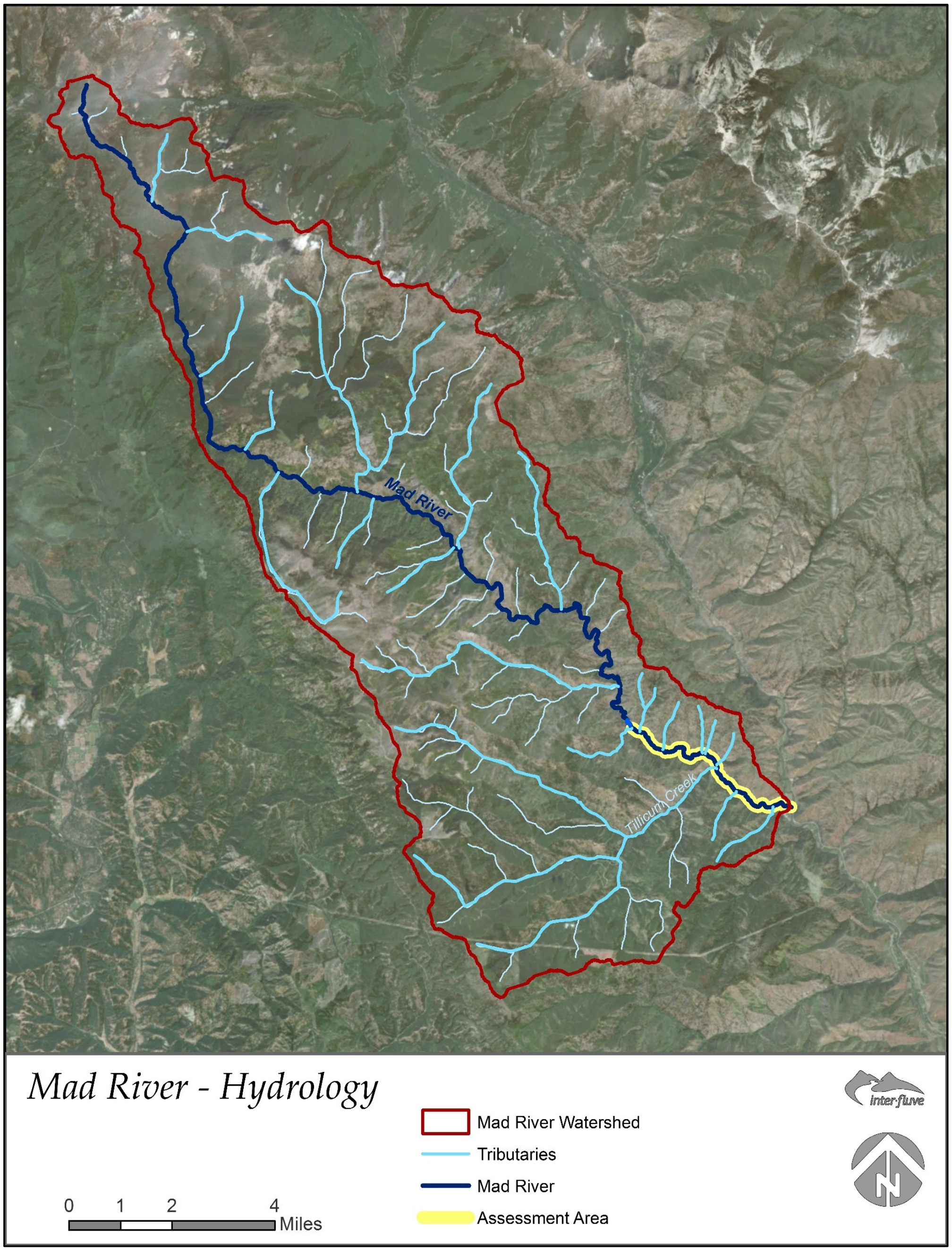

Figure 6. Mad River watershed and tributaries.

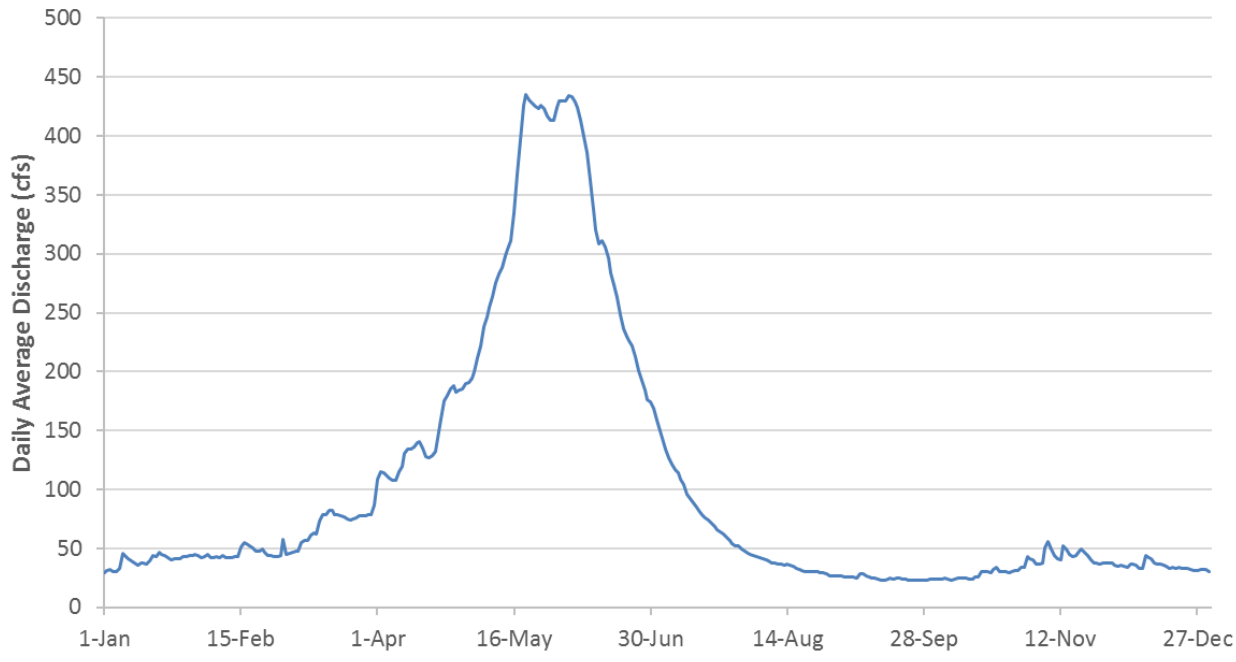

Figure 7. Daily average mean discharge at Ardenvoir 2003-2017 (USGS gage 12452890 Mad River).

Recorded peak flow data on the Mad River at the USGS gage near Ardenvoir was used for 2002–2017. Reported peak flows during that time ranged from 269 cfs in 2015 to 965 cfs in 2006. Although this data set is limited to 16 years of record, a Log-Pearson Type III statistical distribution analysis was performed using annual peak flood events to estimate flood frequency discharges (2, 5, 10, 25, 50, and 100-year flood events). Flood frequency discharges were also estimated in StreamStats (USGS 2017), which uses regional regression equations developed by the USGS (Sumioka, Kresch, and Kasnick 1998). The standard error reported for these estimates range between 96% for the 2-year return period event to 52% for the 100-year return period event. Given the large standard error of the peak flow estimates and the ephemeral nature of contributing streams, these results should be considered with caution. Both estimated peak discharge event results are provided in Table 3. The peak flood events for the same period of record are plotted in Figure 8 with the StreamStats flood estimates.

Table 3. Mad River Estimated discharge for selected recurrence flood events at Ardenvoir.

Flood Return Period	Estimated Peak Discharge (cfs) Log-Pearson Type III	Estimated Peak Discharge (cfs) USGS StreamStats
2- year	650	658
5-year	843	809
10-year	952	896
25- year	1,075	995
50-year	1,151	1,060
100-year	1,226	1,120

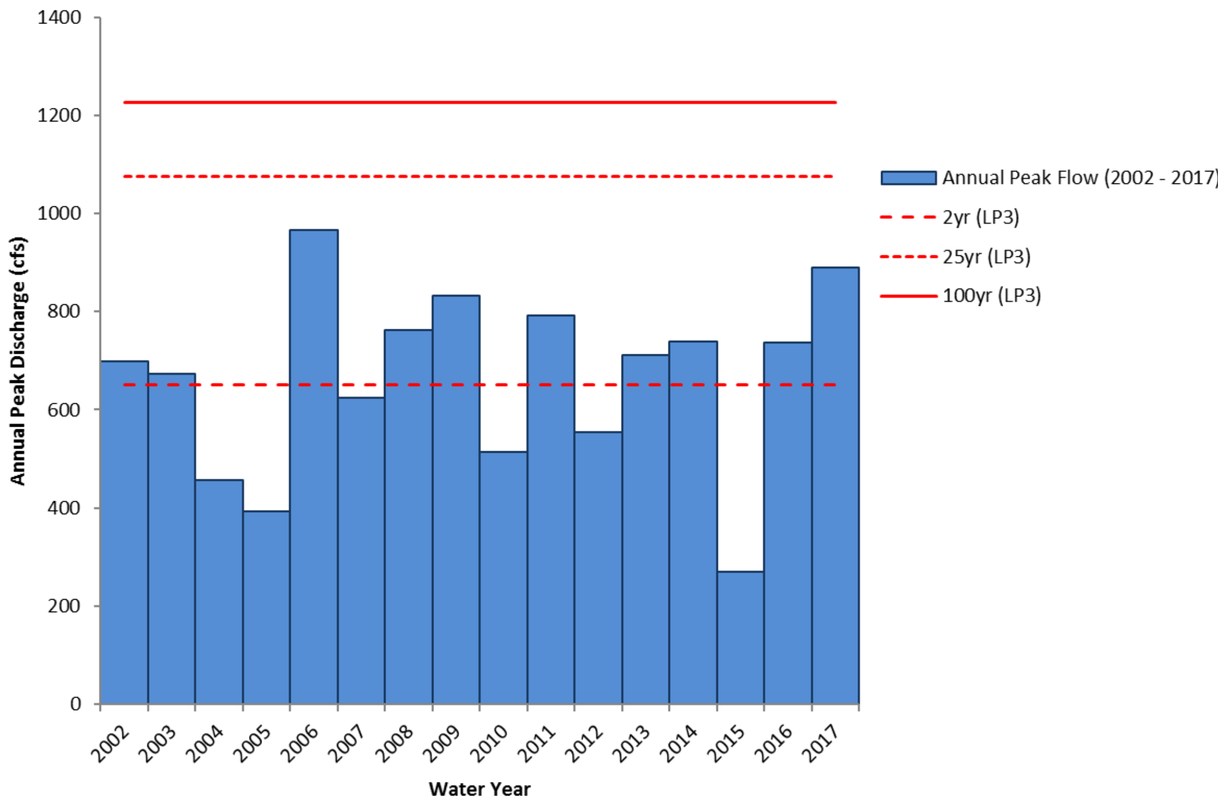

Figure 8: Annual peak flows at Ardenvoir, WA, from 2002–2017 (blue bars) and Log-Pearson Type III estimated flood events (red lines).

3.4 SUMMARY OF SEDIMENT SUPPLY AND TRANSPORT ANALYSES CONDUCTED, INCLUDING DATA SOURCES INCLUDING SEDIMENT SIZE GRADATION USED IN STREAMBED DESIGN

Ocular observations reveal that active channel bed substrate at the time of the assessment (2017) was dominated by cobbles; and, in higher gradient reaches more boulders are present. Gravel counts were completed on exposed bars between Reaches 1 and 4 (two bars per reach) as shown in Figure 9. Gravel bars were relatively rare and small at the time of the survey in Reaches 1-3. The gravel count samples from the bars indicate that active bar material was predominately gravel and cobble. The frequent cobble-dominated ocular observations of the channel bed compared to the active bar grain size surveys indicate that the system does have available spawning gravels but that areas of accumulation are currently limited. The field data also confirm that fine sediment (<2mm), which can be harmful to salmonid survival in high concentrations at spawning grounds, is likely readily transported out of the system and thus pose minimal risk to aquatic habitat quality. A low proportion of boulders were visible on the bar surfaces (between 2 – 4%) but noted as more prevalent in the ocular observations of the channel bed.

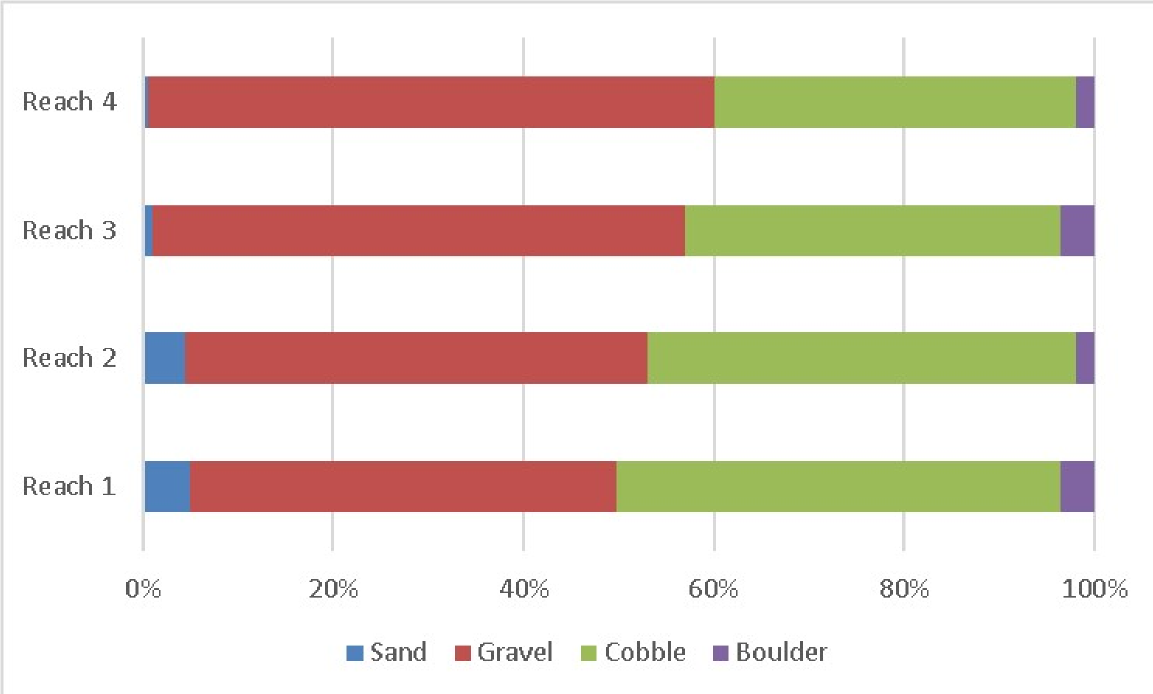

Figure 9. Gravel count classification of active bars by reach for Reaches 1-4. For each reach, two gravel counts were performed and then averaged. Sediment type is classified by the B-axis diameter of the clasts sampled (sand = < 2mm, gravel = 2.1-64 mm, cobble = 64.1-256 mm, boulder = >256.1mm).

Figure 10. Gravel Count 4.1 (in Reach 4) located on an exposed bar. Channel bed substrate dominated by cobbles. Photo by IFI staff on October 26, 2017.

A formal sediment budget has not been completed for the project area. A reach-based stream power and analysis was completed in the Assessment (Inter-Fluve 2018).

Within the study area the floodplains are composed primarily of non-cohesive sands, gravels, and cobbles. Channel form is primarily confined meandering with limited potential for braiding in Reach 4. Point bar and floodplain pocket development of non-cohesive materials occurs only where reduced confinement allows. Sediment is sourced from tributaries, hillslopes, alluvial terraces, and the floodplain. An unstable debris-flow hillslope at the upstream end of the project area on river right is currently the most active and notable sediment source in the project area.

Figure 11. Aerial image (Oct 2021) of river right unstable debris-flow hillslope (RM 4.25) that continues to contribute sediment to the channel.

Preliminary hydraulic modeling results completed with the 2021 LiDAR for the project area (see Section 3.5 below and Appendices B and C for existing and proposed conditions, respectively) provides flow-hydraulics information used to evaluate project installation locations.

3.5 SUMMARY OF HYDRAULIC MODELING OR ANALYSES CONDUCTED AND OUTCOMES – IMPLICATIONS RELATIVE TO PROPOSED DESIGN

METHODOLOGY

A two-dimensional (2D) hydraulic model was developed in the U.S. Army Corps of Engineers HEC-RAS 6.1 software (version 6.1.0, USACE 2021), which can compute hydraulic properties related to the physical processes governing riverine systems. Models were developed for both existing and proposed conditions to assess the current and proposed channel dynamics, as well as assess the overall impacts of a wide range of flows on the existing landscape with and without the proposed design improvements.

MODEL INPUTS

Model Geometry

The model terrain was created using 2021 LiDAR topobathy data (Figure 12). The proposed conditions model terrain was constructed by merging design side channel grading and new roughness polygons for proposed features with the existing model terrain.

The model domain extended from approximately RM 0.5 to RM 4.3. The computational mesh consists of grid cells ranging from 5 to 10 feet, with the smallest grid cells utilized to provide higher resolution results within the channel (Figure 13). Breaklines were added along topographic high points to align cell faces along high ground and to appropriately represent the underlying terrain. Although the average computation mesh size was greater than the terrain resolution, the modeling capabilities of HEC-RAS 6.1 integrate the sub-grid terrain into the computations, thus allowing results to be well visualized at the terrain resolution.

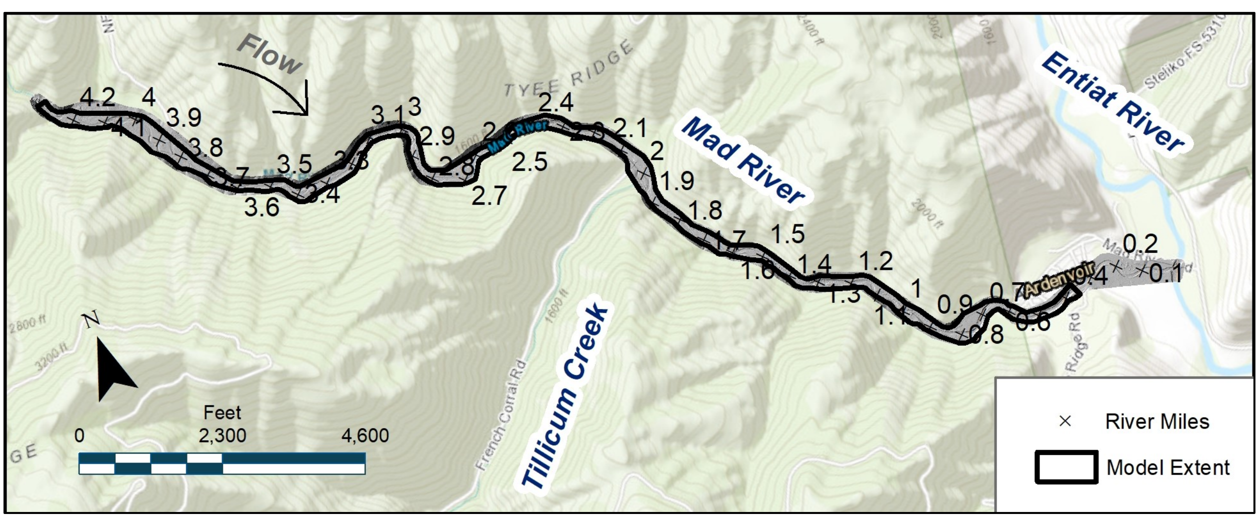

Figure 12. 2D model domain for Mad River RM 1.1 to 4.3.

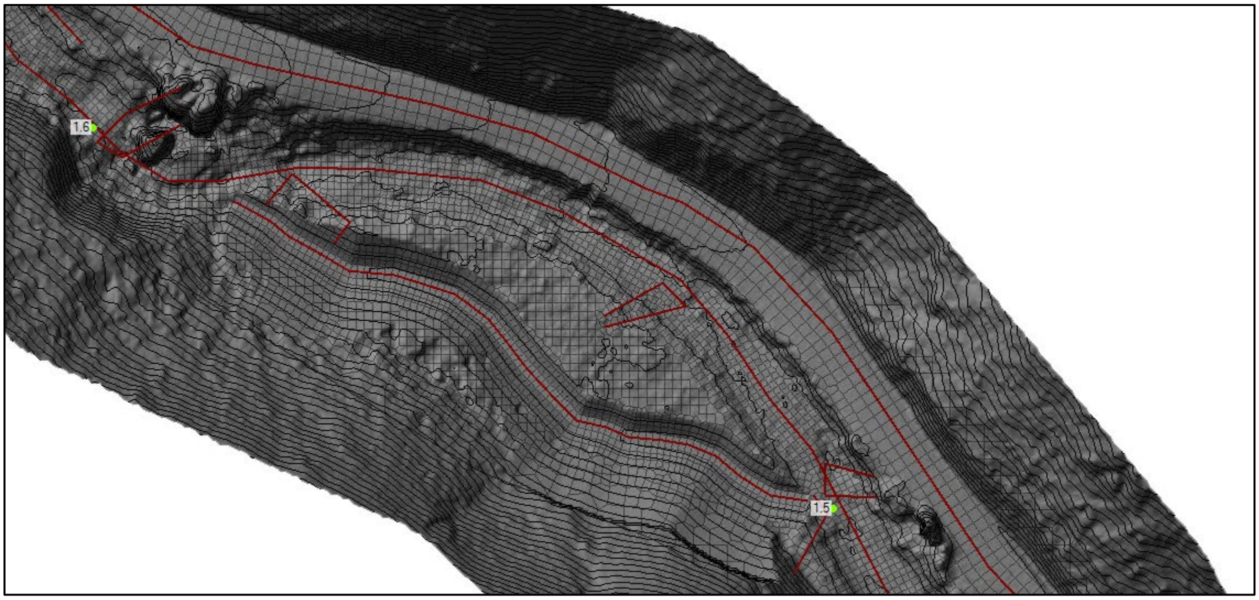

Figure 13. Example cell size within the proposed conditions Mad River hydraulic model. Proposed side channel grading shown. Cells in the channel and along breaklines are 5 ft in width. A wider corridor of 10 ft cells was used around the channel, the road, and the nearby floodplain. Breaklines are shown as red lines.

Model Roughness

A spatially varying hydraulic roughness (Manning's n) layer was developed using ArcGIS tools to represent hydraulic roughness throughout the model domain. The roughness layer was developed by reclassifying a LiDAR derived vegetation height layer with Manning's n coefficients based on varying vegetation heights. These data were supplemented with hand digitized channel polygons where overrides were necessary (e.g., along channel and roads) and where the LiDAR DEM ended (downstream end of model). Additional refinements were made in certain areas, such as forests with light understories, based on field observations. Refinement regions were used over roadways and the channel where vegetation created a canopy. A table of hydraulic roughness coefficients and their associated classifications is provided in Table 4.

Table 4: Roughness coefficients (Manning's n values) utilized in existing and proposed conditions modeling.

Area Description based on Vegetation Height	Roughness Coefficient (Manning's n Value)
Main Channel	0.045
Bare Ground (0 – 0.5 ft)	0.04
Ground Cover (0.5 – 5 ft)	0.1
Shrub (5 – 12 ft)	0.12
Small Tree (12 – 20 ft)	0.08
Large Tree (20+ ft)	0.08
Tillicum Creek Channel	0.045
Existing LWS	0.17
Roadway	0.02
Proposed LWS	0.17
Proposed Side Channel	0.045

Model Discharges

The hydraulic model was used to evaluate existing conditions at flow events ranging from a range of low flow events to the 100-year flow event (Table 5). Low flows were extracted from the daily average mean discharge at Ardenvoir to represent a range of conditions throughout the year from a low flow event to the annual peak event. Peak flows at Ardenvoir were scaled using drainage area to the top of the model domain, approximately 4.3 miles upstream from the gage at Ardenvoir. Tributary flows from Tillicum Creek were found using Streamstats drainage area analysis.

A synthetic "stepped" hydrograph that contains gradual rising limbs between discharges of interest (e.g., 25-year flow) was used as the input hydrograph to simulate steady-state flow conditions (Figure 14). The discharges of interest remain unchanged for durations long enough to allow the model to reach a steady-state, before rising to the next step. It's worth noting that allowing the model to reach a steady-state during large flood events may overestimate flooding results, as floodplain storage throughout the model domain must reach capacity to reach steady-state conditions, which in reality may not occur during actual floods, especially short duration events. The receding limb of a typical flood hydrograph is also not represented when applying this methodology.

HEC-RAS 6.1 2D models require boundary conditions at locations where flow is expected to enter or exit the computational domain. The upstream boundary conditions were set to the stepped flow hydrographs using flow events in Table 5 for the upstream end of Mad River and Tillicum Creek. An energy grade (EG) slope of 0.005-feet/feet was estimated to equal topographic slope from the terrain at the location of the upstream boundary condition for the Mad River and used as an input in the flow hydrograph. A boundary condition was placed at Tillicum Creek with an EG slope of 0.025-feet/feet. The downstream boundary condition was set to normal depth with a friction slope of 0.014-feet/feet.

Table 5: Modeled flow events used in hydraulic modeling.

Flow Event	Mad River Discharge (cfs)	Tillicum Creek Discharge (cfs)
Low Flow	10	10
Low Flow	20	10
Low Flow	50	10
Low Flow	75	10
Low Flow	100	10
Low Flow	200	10
Low Flow	300	10
2 - year	451	145
5 - year	584	270
10 - year	660	378
50 - year	754	539
25 - year	798	685
100 - year	850	841

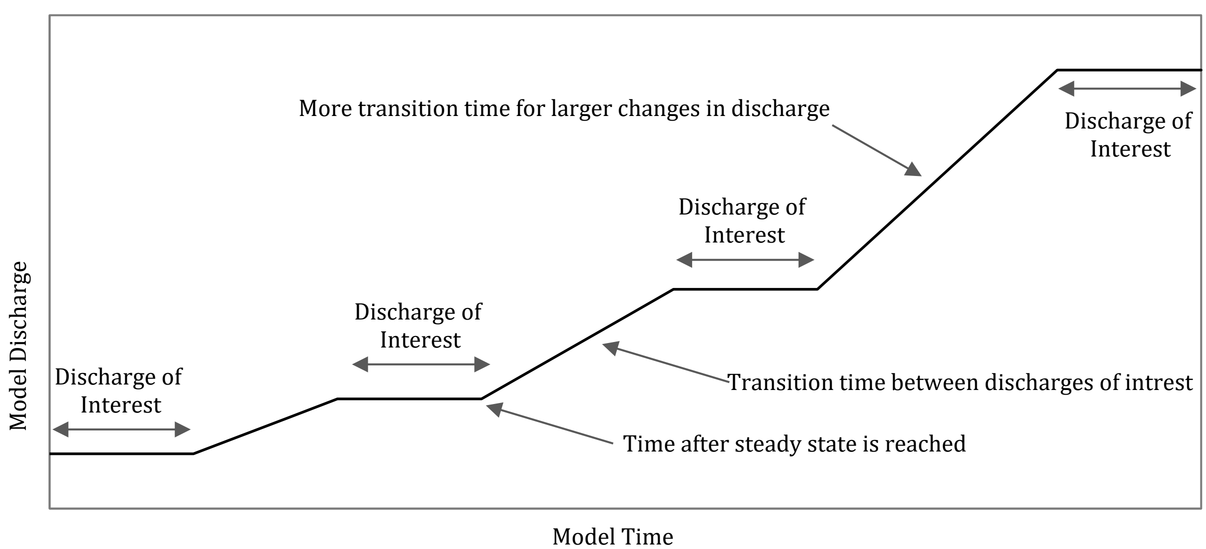

Figure 14: Demonstrative "stepped" flow input hydrograph.

EXISTING CONDITIONS HYDRAULICS

High flow water surface elevations and corresponding flow are not available for calibration of the hydraulic model roughness values.

Existing conditions HEC-RAS model results for depth and velocity are shown in Appendix B for 50 cfs, 100 cfs, 300 cfs, 2-year event, and 100-year event flows. Under existing conditions, minimal floodplain connectivity or side channel habitat exists at lower flow events. There is minimal floodplain connectivity in the upper and middle sections below the 100-year event. In the lower region of the project area, a relatively small portion of the river-right floodplain is activated between the 2 and 5-year event. The 100-year event activates a relic side channel at the base of the river-right upper hillslope. Existing conditions modeling also shows that the river remains contained in the channel on river left until the 100-year event when shallow overbank inundation is expected to occur. In all cases, the model predicts limited hydraulic diversity which is consistent with the plane bed morphology, confined flow conditions, and lack of instream wood material. At lower discharges (20 cfs – 200 cfs), flow velocities mostly remain below approximately 4 ft/s. Velocities in the mainstem during the 100-year event are expected to exceed 10 ft/s over extended segments of the channel. Higher velocities are observed in model results in areas of the channel where floodplain connectivity is not activated.

PROPOSED CONDITIONS HYDRAULICS

Proposed designs were incorporated into the model with terrain grading at side channel locations and modified roughness regions for large wood structure placements. In general, the proposed conditions model results demonstrate that creating side channels and adding large wood structures adds flow hydraulic and habitat complexity at a wide range of flow conditions. The proposed condition model shows the three created side channels have perennial flow. As an illustration of these effects, model results for RM 1.5 to 1.7 for existing and proposed conditions at 50 cfs flow are presented in Figure 15 and Figure 16; and for the 2-year flow in Figure 17and Figure 18. These figures demonstrate the variability achieved with created side channels. Where proposed large wood is located, greater diversity of velocities and reduced flow velocity regions add complexity and aid in retention of gravels.

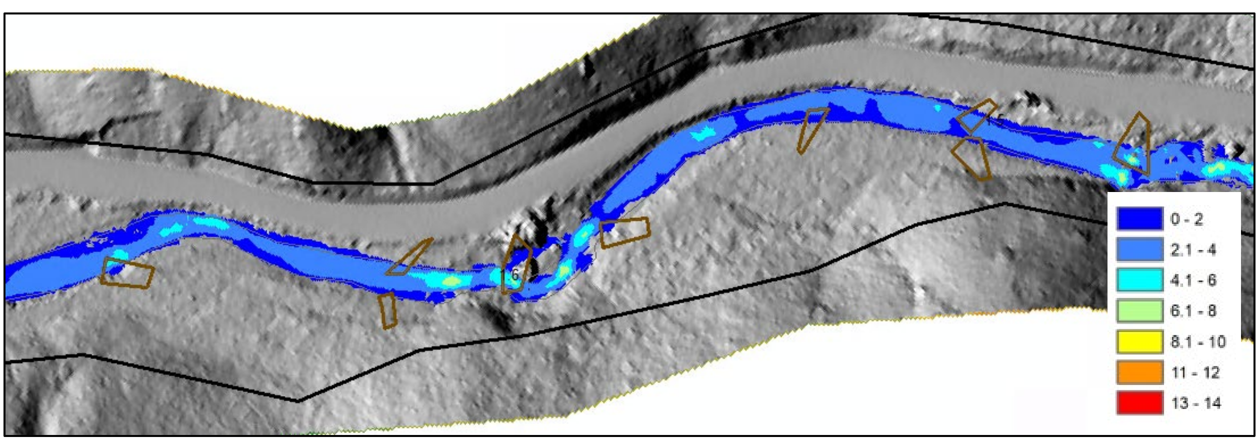

Figure 15. Existing conditions velocity results near river mile 1.6 at the 50 cfs flow event. Proposed LWS outlined in brown.

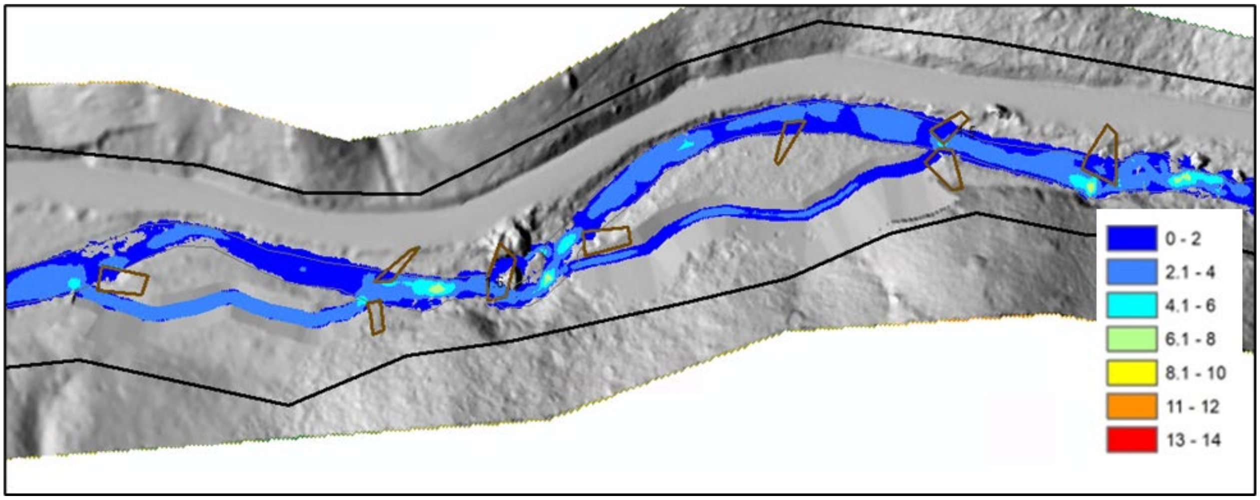

Figure 16. Proposed conditions velocity results near river mile 1.6 at the 50 cfs flow event. Proposed LWS outlined in brown.

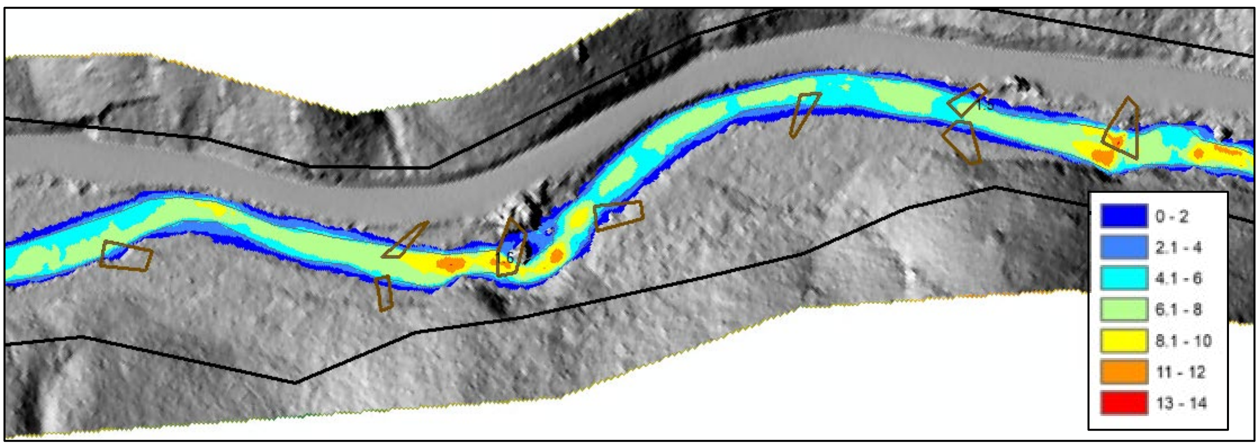

Figure 17. Existing conditions velocity results near river mile 1.6 at the 2-year cfs flow event. Proposed LWS outlined in brown.

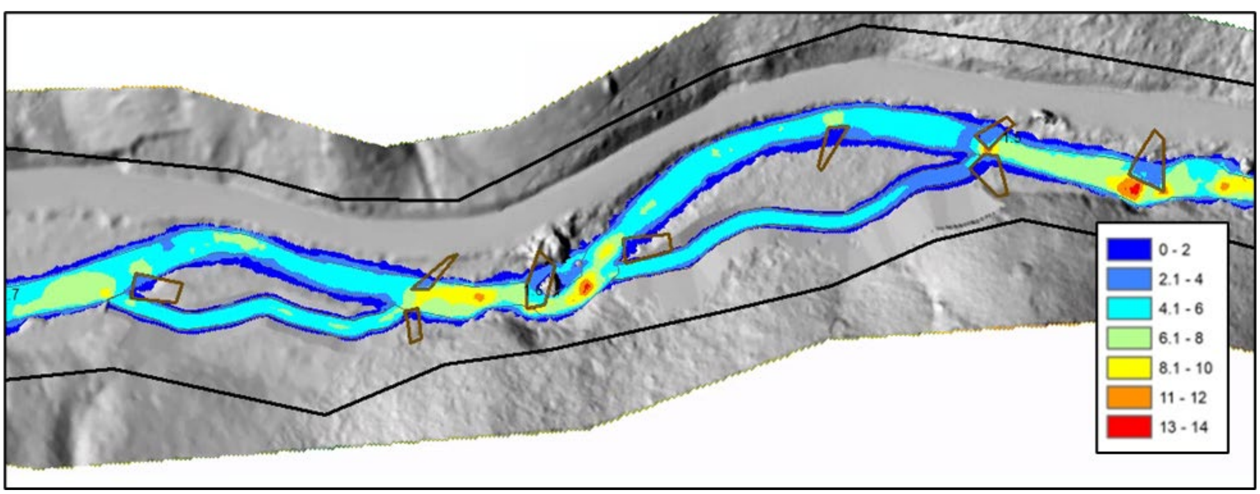

Figure 18. Proposed conditions velocity results near river mile 1.6 at the 2-year flow event. Proposed LWS outlined in brown.

Addition of large wood is a strategy to enhance existing side channels for flow connectivity and habitat complexity - as demonstrated for the existing side channel at RM 3.4, the 2-year event existing and proposed conditions velocities are shown in Figure 19 and Figure 20. This is expected to promote geomorphic and habitat complexity, including gravel accumulations and scour pools. Model results for runs including proposed large wood structures, show improved hydrologic connectivity of the floodplain.

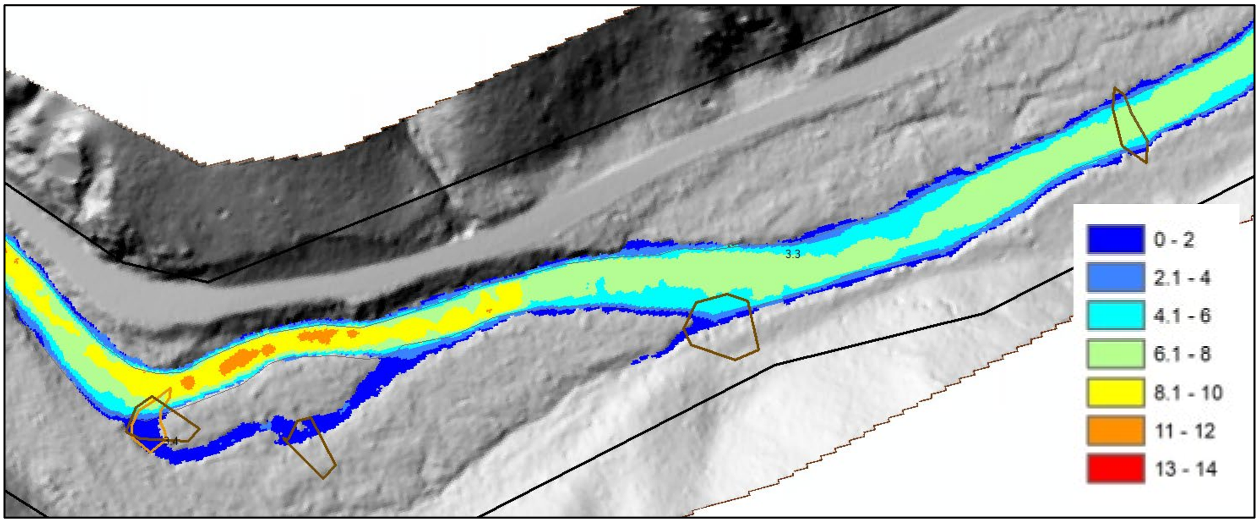

Figure 19. Existing conditions velocity results near river mile 3.3 at the 2-year flow event. Proposed LWS outlined in brown. Existing LWS outlined in orange.

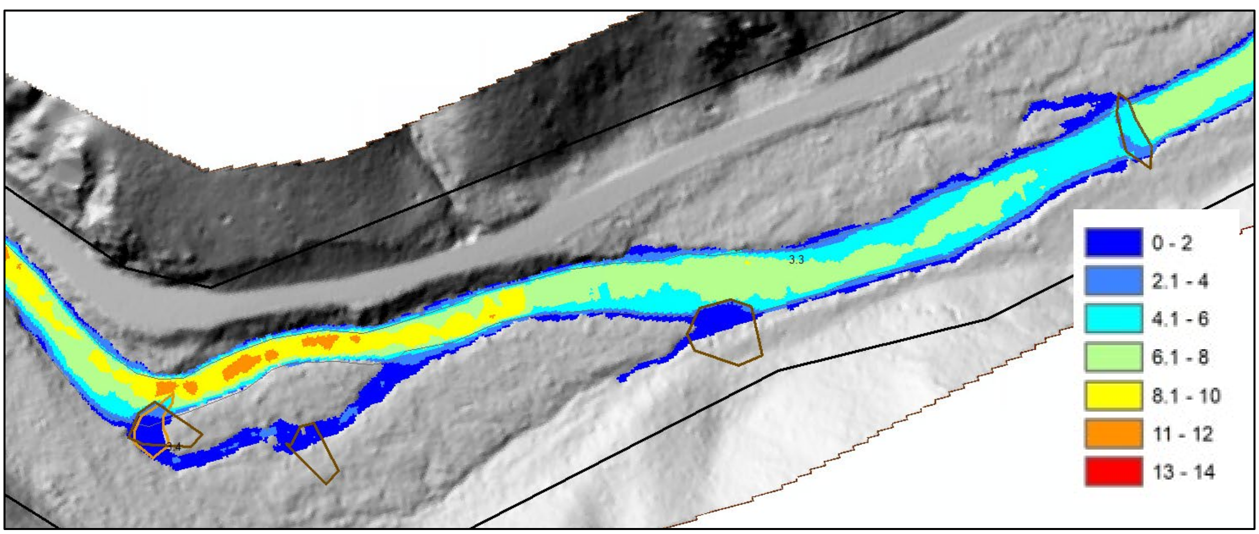

Figure 20. Proposed conditions velocity results near river mile 3.3 at the 2-year flow event. Proposed LWS outlined in brown. Existing LWS outlined in orange.

During future design phases, the proposed conditions hydraulic model results will be refined and used to inform additional engineering analyses such as optimizing channel sizing, channel bed and bank stability calculations, and large wood structure stability calculations.

3.6 STABILITY ANALYSES AND COMPUTATIONS FOR PROJECT ELEMENTS, AND COMPREHENSIVE PROJECT PLAN

Stability analyses and ballasting calculations will be conducted in future design phases of the project.

3.7 DESCRIPTION OF HOW PRECEDING TECHNICAL ANALYSIS HAS BEEN INCORPORATED INTO AND INTEGRATED WITH THE CONSTRUCTION – CONTRACT DOCUMENTATION

Conceptual drawings show the project elements that could provide lift for consideration. Future design phases will refine these concepts at which point future plans and construction documents will be developed.

3.8 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A LONGITUDINAL PROFILE OF THE STREAM CHANNEL THALWEG FOR 20 CHANNEL WIDTHS UPSTREAM AND DOWNSTREAM OF THE STRUCTURE SHALL BE USED TO DETERMINE THE POTENTIAL FOR CHANNEL DEGRADATION

Not applicable.

3.9 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A MINIMUM OF THREE CROSS-SECTIONS – ONE DOWNSTREAM OF THE STRUCTURE, ONE THROUGH THE RESERVOIR AREA UPSTREAM OF THE STRUCTURE, AND ONE UPSTREAM OF THE RESERVOIR AREA OUTSIDE OF THE INFLUENCE OF THE STRUCTURE) TO CHARACTERIZE THE CHANNEL MORPHOLOGY AND QUANTIFY THE STORED SEDIMENT

Not applicable to the project area.

4 Construction – Contract Documentation

4.1 INCORPORATION OF HIP IV GENERAL AND CONSTRUCTION CONSERVATION MEASURES

HIP general and construction conservation measures will be included in future design and construction document development phases. If necessary, UCHRP will request variances at later design phases.

4.2 DESIGN – CONSTRUCTION PLAN SET INCLUDING BUT NOT LIMITED TO PLAN, PROFILE, SECTION AND DETAIL SHEETS THAT IDENTIFY ALL PROJECT ELEMENTS AND CONSTRUCTION ACTIVITIES OF SUFFICIENT DETAIL TO GOVERN COMPETENT EXECUTION OF PROJECT BIDDING AND IMPLEMENTATION.

Conceptual Drawings are included in Appendix A.

4.3 LIST OF ALL PROPOSED PROJECT MATERIALS AND QUANTITIES

Materials and quantities estimates are included in Appendix D.

4.4 DESCRIPTION OF BEST MANAGEMENT PRACTICES THAT WILL BE IMPLEMENTED AND IMPLEMENTATION RESOURCE PLANS INCLUDING:

Project TESC, SPCC best management practices will be prepared in future phases. Details will be prepared in future phases.

Site Access Staging and Sequencing Plan with description

Details will be prepared in future phases.

Work Area Isolation and Dewatering Plan with description

Details will be prepared in future phases.

Erosion and Pollution Control Plan

Details will be prepared in future phases.

Site Reclamation and Restoration Plan

Details will be prepared in future phases.

List Proposed Equipment and Fuels Management Plan

Details will be prepared in future phases.

4.5 CALENDAR SCHEDULE FOR CONSTRUCTION/IMPLEMENTATION PROCEDURES.

Construction will occur during the permitted in water work window. Construction is tentatively planned for July 2023.

4.6 SITE OR PROJECT SPECIFIC MONITORING TO SUPPORT POLLUTION PREVENTION AND/OR ABATEMENT

The Contractor will be required to submit and implement a TESC that meets applicable regulation and permit requirements.

5 Adaptive Management Plans

Section 5 and its subsections will be completed by UCHRP in future phases of the project.

5.1 INTRODUCTION

Details of the monitoring and adaptive management plan will be determined at the discretion of UCHRP. Typically following completion of the project, UCHRP has the designer prepare a monitoring plan and a baseline conditions report for as-built conditions. The monitoring plan typically specifies the designer conduct annual site visits for three years and following floods greater than a specified event (typically, 5-year event). Monitoring typically includes photo documentation of project features, a narrative of observed changes from the prior monitoring event and review of hydrologic conditions during the prior year. At the end of Year 3, the design engineer and UCHRP will discuss if further monitoring is necessary or recommended.

5.2 RESPONSIBLE PARTIES INVOLVED

UCHRP will request and review the monitoring plan and annual monitoring reports. Typically the designer prepares the monitoring plan, prepares the baseline report for as-built conditions, conducts the annual monitoring site work and reports for submittal to UCHRP.

5.3 ASSESSMENT PROTOCOLS

As noted above, assessment protocols include: photo documentation of site conditions, narrative of designers observations and summary of snow pack and river flow hydrologic data during the time period from the prior monitoring activity.

5.4 ADAPTIVE MANAGEMENT TRIGGERS

Management triggers will be developed as one component of the monitoring plan by the designer in consultation with UCHRP staff. The intent of the triggers is to allow desired dynamic conditions; while monitoring for unintended or undesirable performance or trends. Triggers general include minor, moderate and major conditions that require continued monitoring, hand crew remediation or design and equipment remediation, respectively.

5.5 ASSESSMENT FREQUENCY, TIMING, AND DURATION

Annual site visits at Years 1, 2 and 3. Field work typically occurs in September to take advantage of low flow conditions for access and visibility of stream banks, beds and scour conditions.

5.6 DATA STORAGE AND ANALYSIS

Summary design and drawing CADD files will be submitted to the UCHRP.

5.7 QUALITY ASSURANCE PLAN

Monitoring plan, baseline and annual monitoring reports will be submitted to UCHRP for review and comment. Edits will be made as applicable.

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7 Appendices

7.1 APPENDIX A – CONCEPT DESIGN DRAWING PLAN SHEETS

7.2 APPENDIX B – PRELIMINARY HYDRAULIC MODEL RESULTS

7.3 APPENDIX D – CONCEPT LEVEL COST ESTIMATE