CONFEDERATED SALISH AND KOOTENAI TRIBES

Jocko River Master Plan: Section 2

A guide to ecological restoration activities in the lower main stem Jocko River corridor

Section 2: Historical, Existing, & Desired Future Conditions

Prepared by the CSKT Fish, Wildlife, Conservation, and Wildland Recreation Program

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Jocko River Master Plan: A Guide to Ecological Restoration Activities in the Lower Mainstem Jocko River Corridor: Section 2

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2.0 Historical, Existing, & Desired Future Conditions

2.1 Introduction

This section describes the setting, natural resources, and developed environment of the lower main-stem Jocko River. It is organized into the following subsections:

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2. Watershed Overview
3. Hydrology and flood-series analysis
4. Channel Geomorphology
5. Vegetation
6. Wetlands and off-channel springs
7. Fish habitat conditions
8. Fisheries and wildlife resources
9. Infrastructure effects on the Jocko River corridor
10. Ecological flows

Because these various ecological components are interrelated, we have included cross-reference links throughout the narrative.

2.1.1 Assessing the Interactions among Components

While it is useful to discuss each of the components of the watershed individually, effective ecological restoration requires an understanding of the linkages between them. For example, major human impacts in the watershed include:

- Irrigation withdrawals from the Jocko River and its tributaries, resulting in an altered river hydrograph;
- Groundwater withdrawals from within the floodplain to supply residential wells and active and abandoned fish rearing facilities;
- Conversion of forested and shrub land to agriculture;
- Leveling of land for agriculture, resulting in simplified surface hydrology and interrupted amphibian movement corridors;
- Construction of levees and berms, transportation corridors, and river channelization, resulting in confinement of flood flows, locally increased sediment transport, and channel erosion;
- Loss of near-bank riparian vegetation, resulting in higher stream temperatures, less woody debris recruitment in the streams, reduced sediment trapping, and elevated rates of bank erosion;
- Reduced sediment trapping, resulting in decreased fish spawning gravels, filled pool habitat and reduced fish prey;
- Bridges constricting the floodplain, causing backwater effects and increased localized scour; and

- Floodplain encroachment by residential and commercial building resulting in riparian vegetation being cleared from the floodplain and altered hydrology.

Each of these impacts can be thought of as a disturbance that changes the way natural processes within the watershed work. Natural processes, defined as anything that causes change independent of human influences, include things like flooding, seed dispersal, fluctuations in groundwater levels, fish movement, river bank erosion and channel migration, wildfire, wind, and precipitation.

These processes, both natural and those that have been influenced by human activities, can be thought of as energy or mass inputs that, in turn, drive key watershed functions, such as:

- Surface-groundwater storage and flow,
- Nutrient cycling,
- Retention of organic and inorganic particles,
- Generation and export of organic carbon,
- Characteristic plant community,
- Characteristic aquatic invertebrate food webs,
- Characteristic vertebrate habitats, and
- Floodplain interspersion and connectivity.

The source, quantity, quality, and timing of water are key factors defining the character of floodplain riparian areas, wetlands, and channels.

It is these functions that form the basis for a major part of our watershed assessment (Hauer et al. 2002).

2.1.2 Ecological Components of the Lower Main-stem Jocko River

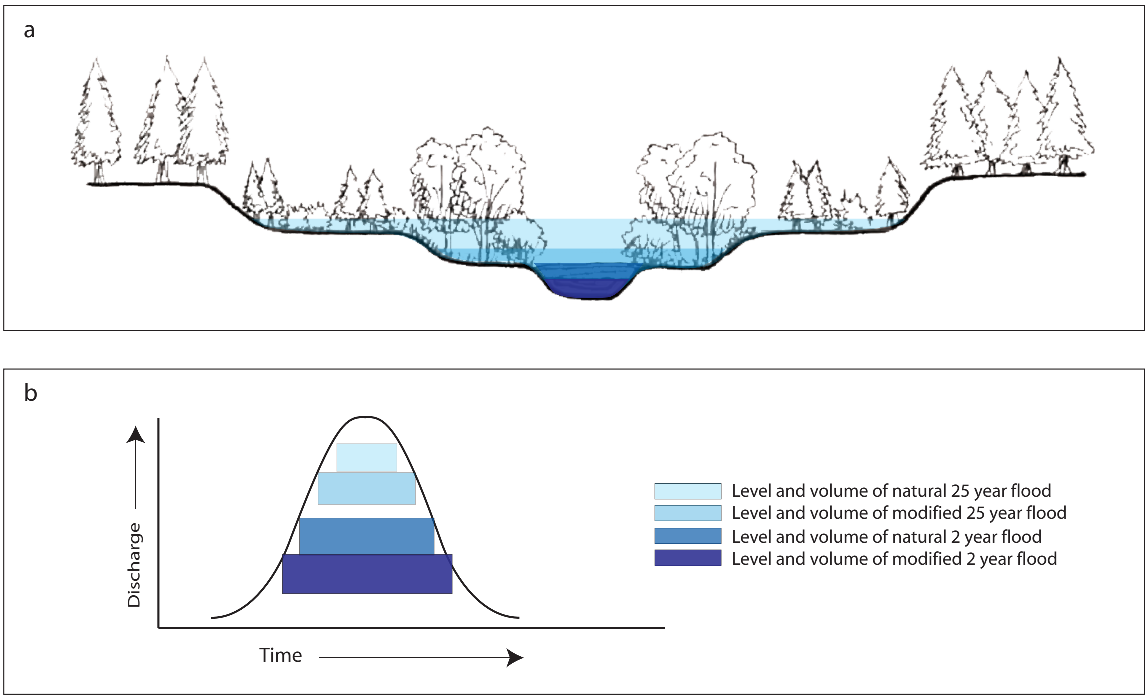
Stream flows

Water is the defining ecological component within any floodplain system. Its source, quantity, quality, and timing are key factors among many that define the character of floodplain riparian areas, wetlands, and channels. In the lower main stem, irrigation diversions have reduced channel maintenance discharge by as much as 50 percent from what it was historically (Subsection 2.3). The reduction is generally higher in dry years and lower during wet years due to demands for irrigation water and natural supply fluctuations. Although the effects of the diversions diminish downstream as tributary and groundwater inputs contribute to stream flows, the river has responded to this overall reduction in peak flows by decreasing its channel conveyance and sediment transport capacity.

The decrease in channel capacity coupled with artificial straightening and bank hardening has increased energy in some reaches of the river, which has resulted in accelerated bank erosion, localized sediment deposition, and the formation of braided channels. These effects have been magnified by agricultural practices that have reduced vegetative cover on the river banks and floodplain surface. The synergistic effects of these impacts have disrupted natural processes in the floodplain.

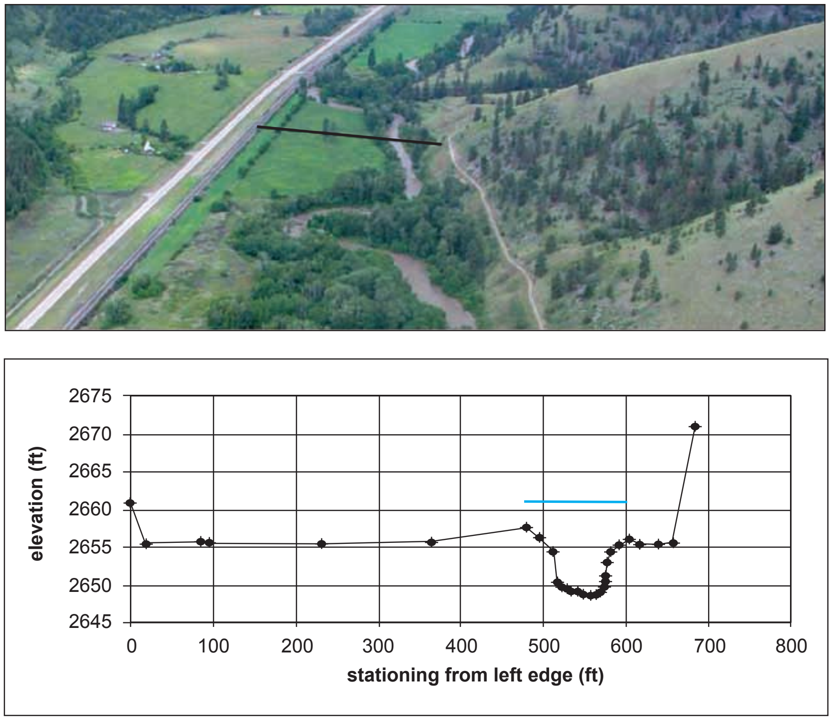
In general, natural processes have been simplified. Many acres of black cottonwood (*Populus trichocarpa*) and ponderosa pine (*Pinus ponderosa*) forest that historically harbored some 50 native vascular plant species (trees, shrubs, forbs, grasses and grasslike plants) have been converted to agricultural land with fewer than five non-native grasses. Floodplain areas once characterized by sloughs, brush piles, downed logs and small areas of high ground have been cleared and graded flat, further reducing habitat diversity. It is also likely that, historically, beavers added to the river's complexity by storing water and changing plant community structure. Reductions in their populations have further simplified habitats.

Figures.2.1.2-1 through 2.1.2-3 show the interactions between water and the floodplain and how those interactions are influenced by land uses and a modified hydrograph. Where the river maintains full access to the floodplain, the seasonal and interannual range in flows sustains a range of ecological processes. But where the human impacts restrict channel and floodplain interactions, those processes can be disrupted and replaced by unnatural processes such as elevated sediment input or elevated water temperatures.



Figures 2.1.2-1 a and b.
These two figures demonstrate the influence that a modified stream hydrograph and modified land uses can have on stream and floodplain ecological processes. Figure 2.1.2-1a (top), indicates that the depth and lateral extent of channel and floodplain inundation is diminished when stream flow is modified by decreasing flow. Figure 2.1.2-1b (bottom) shows how a modified hydrograph affects the duration and volume of flood flows.

2. CONDITIONS



Figures 2.1.2-2 a and b.

A cross section, located on the air photo, contrasts the lateral extent of the floodplain inundation zone for two sections of the Jocko River during the June 4, 2005 flood pulse. The cross section, located in Reach 3, demonstrates the narrow inundation zone for a river reach bounded by artificial levees and bordered by riparian land converted to agricultural purposes.

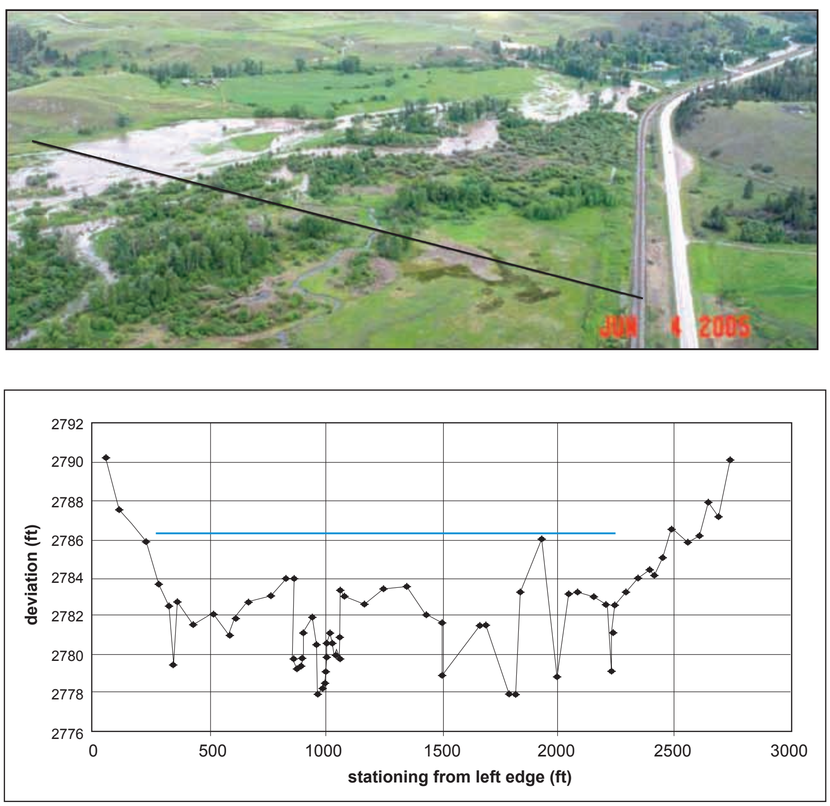


Figure 2.1.2-3 a and b.

A cross section located in Reach 5, does not have bounding levees. In contrast to the channel in Figure 2.1.2-2 a and b, the floodplain is extensively inundated with the extent of soil saturation and floodplain ground water recharge extending beyond the surface inundation zone.

Fish

Currently, there are thirteen fish species in the Jocko River (Subsection 2.8.1), six of which are salmonids. This array of species is the result of habitat alterations and fish introductions. Historically, the only salmonids in the river were mountain whitefish (*Prosopium williamsoni*), bull trout (*Salvelinus confluentus*), and westslope cutthroat trout (*Oncorhynchus clarki lewisi*). Bull trout, a threatened species, now occur primarily in the upper reaches of the river above the confluence with Finley Creek. Westslope cutthroat trout populations are relatively healthy within the watershed. The other salmonids in the river—rainbow trout (*O. mykiss*), brown trout (*S. trutta*), and brook trout (*S. fontinalis)*—have been introduced and are now present as self-sustaining, wild populations. These introduced taxa pose a significant threat to both bull trout and westslope cutthroat trout.

Historically, the only salmonids in the river were mountain whitefish, bull trout, and westslope cutthroat trout.

Bull trout are currently listed as threatened under the Endangered Species Act. The Jocko River drainage was defined as a "core area" for bull trout in the Middle Clark Fork River Drainage Status Review by the Montana Bull Trout Scientific Group (MBTSG 1996). Core areas are strongholds for bull trout because they provide significant spawning and rearing areas (MBTRT 1998). Because it is a core area, the Jocko River is important in the overall recovery of the species within Montana. Westslope cutthroat trout are not protected under the Endangered Species Act; however, they were petitioned for listing pursuant to the Endangered Species Act and are a Tribal Species of Special Consideration and a State of Montana Species of Special Concern.

Five key measures of fish habitat quality suggest the system is functioning well below optimum.

Five key measures of fish habitat quality suggest the system is functioning well below optimum: water temperature is elevated, large woody debris is scarce, pool frequency and quality is generally poor, stream bank condition is poor, and channel width-to-depth ratios are higher than they were historically. More detail is provided about fish habitat conditions in Subsection 2.7.

Wildlife

Riparian habitats, like those found along the lower main stem, support the highest diversity of breeding birds of any habitats in the western U.S. Historically, breeding bird communities along the Jocko River consisted of mostly neotropical migrants inhabiting deciduous habitats. Present day plant communities support many of the same species as well as non-natives such as rock pigeons (*Columbia livia*), European starlings (*Sturnus vulgaris*), and house sparrows (*Passer domesticus*). These non-native birds occupy nesting locations and compete for forage opportunities with native species; some are also nest predators. A few historically occurring native species, for example, least flycatcher *(Empidonax minimus)* and Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), are no longer found along the Jocko River. Subsection 2.8.2 includes more detailed descriptions of bird species along the lower main stem.

Between 1993 and 2000, the Tribes conducted several amphibian and reptile surveys along the Jocko River, documenting four species along the lower main stem: long-toed salamander (*Ambystoma maculatum*), Columbia spotted frog (*Rana luteiventris*), Pacific chorus frog (*Pseudacris regilla*), and painted turtle (*Chrysemys picta*).

Mammal species using the river for food and as a travel corridor include: bobcat (*Felis rufus*), red fox (*Vulpes vulpes*), coyote *(Canis latrans*), raccoon (*Procyon lotor)*, striped skunk (*Mephitis mephitis*), mountain lion (*Puma concolor*), black bears (*Ursus americanus*), and grizzly bears (*Ursus arctos horribilis*). A few species — beaver (*Castor canadensis*), muskrat (*Ondatra zibethica*), and river otter (*Lutra canadensis*) — depend exclusively on the river for survival.

2.1.3 Reach Descriptions

The paragraphs that follow summarize the channel, floodplain, vegetation, and wetland conditions within each reach (Figure 1.5-1) . The channel morphology of each reach is decribed in Subsection 2.4.4 including the flood history and the historical, existing and desired future conditions of the river.

Reach One

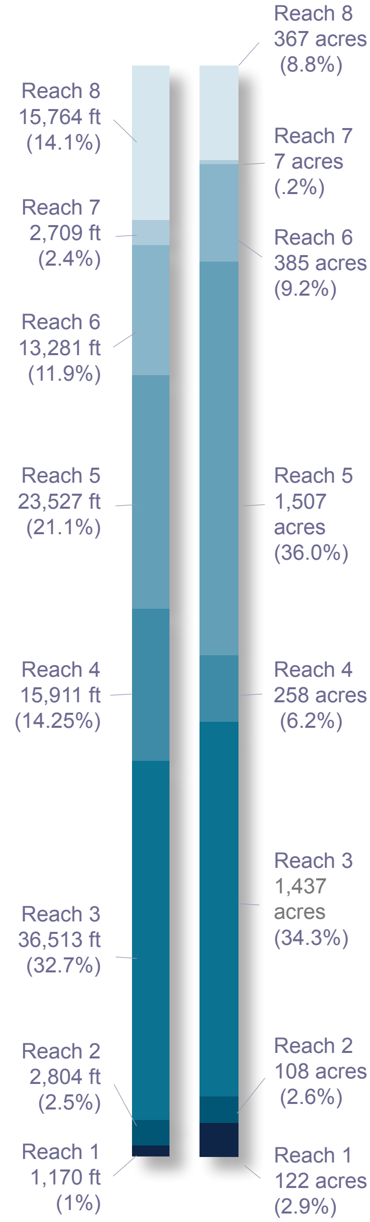
Reach One is the farthest downstream and includes the Jocko River delta upstream of the confluence with the Flathead River. Currently, the river is a single thread channel through this reach. It may have once been braided, although no conclusive evidence of this exists. The ecological floodplain south of the active channel has been converted to agricultural pasture. North of the active channel, the ecological floodplain maintains diverse floodplain topography and vegetation, including swales that carry water during flood events. Bank armoring has reduced floodplain connectivity, but over-bank flooding occurs during most flood years. However, a railroad bridge and rights-of-way fill constrict over-bank flood flows and shallow, alluvial groundwater. Operations at Kerr and Hungry Horse Dams have modified the magnitude and timing of peak flows in the Flathead River, which in turn, may be influencing the extent of backwater conditions in the delta that occur during synchronous peaks of the Jocko and Flathead Rivers. (Kerr Dam, finished in 1939, is located approximately 50 miles upstream of the Jocko-Flathead confluence.)

Our wetland and vegetation assessment combined Reaches One and Two. Approximately 32 percent of the two reaches is forested, 18 percent is dominated by shrubs, 4 percent is emergent wetland (HGM Cover Type 6), 5 percent is either river channel or side channel, 30 percent is agricultural land, and 11 percent is developed.

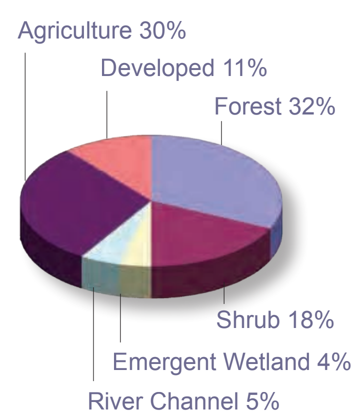
Restoration goals for Reach One include restoring floodplain connectivity across the railroad right-of-way, increasing HGM Cover Types 1, 2, 3, 4 and 5 in the agricultural area west of the existing channel, and potentially restoring the active channel into a former, more sinuous alignment.

Reach Two

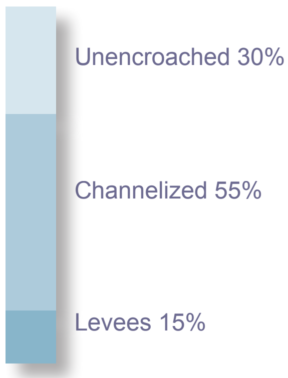
Reach Two is a transitional reach connecting the Flathead and Jocko river valleys. It has been impacted by local channel modifications, floodplain filling, and the transportation infrastructure. The railroad and highway bridge openings at the upstream and downstream ends of the reach partially control the channel alignment. Riparian grazing along the southwest side of the channel has reduced riparian vegetation densities which, in turn, have reduced bank stability, riparian habitat, and stream shading. Over time, the channel length has decreased due to the abandoning of a river meander south of the existing channel.



Lengths (and % of total lower main stem length) of river reaches (left) and areas (and % of total) of ecological floodplain by reach (right).



HGM Cover Types in Reaches One and Two.



Fifteen percent of Reach Two has levees, and 55 percent is channelized.

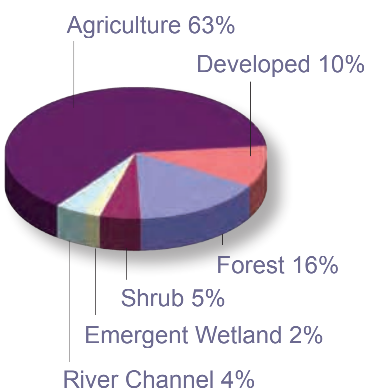
Fifty-five percent of the reach has been channelized, and 15 percent is affected by constructed levees. General classes of vegetation and wetland cover are described above under Reach One.

Restoration goals for this reach include modifying the railroad bridge and rights-of-way fill to allow for some lateral channel migration, modifying the transportation infrastructure to increase downvalley floodplain connectivity, reducing grazing impacts to promote denser forested cover along streambanks, and reducing channelization to allow the floodplain to more effectively connect to the river to promote increased diversity of vegetative cover types, particularly along the river's banks.

Reach Three

Throughout Reach Three much of the floodplain has been converted from black cottonwood (*Populus trichocarpa*) forest to agricultural pasture. Construction of the railroad, and later the highway, separated the active river from the formerly active floodplain. Instream structures and extensive channelization and bank armoring through the reach have further reduced channel sinuosity and simplified instream habitat.

Figure 2.1.3-1 is a historical photo of a portion of the reach that shows the railroad right-of-way approximately 15 years after completion. Abandoned river meanders and remnant riparian vegetation are visible in the foreground of the photo. Most of the riparian vegetation in the foreground has since been converted to agricultural land, and the topography associated with the river meanders has been leveled.



HGM Cover Types in Reach Three

We divided Reach Three into 14 subreaches. Subsection 2.4.4 describes the current and potential channel types of each subreach in detail.

The current channel is against the valley's northern edge. Constructed levees limit the channel's ability to access the historical floodplain. In places, conversion of riparian forested and shrub plant communities to agricultural land has reduced the channel's resistance to lateral scour, decreased channel shading, and reduced the frequency and distribution of large woody debris in the reach.

Within this reach, 5 percent of river bank is rip-rapped, 20 percent of the river's length is channelized, and 30 percent is affected by constructed levees.

Approximately 16 percent of the ecological floodplain is forested, 5 percent is dominated by shrubs, 2 percent is emergent wetland, 4 percent is either river channel or side channel, 63 percent is agricultural, and 10 percent is developed.

Historically, most of the agricultural and developed land was probably covered by a matrix of forest, shrub, and emergent vegetation with some upland inclusions. Aerial photographs from 1937 show that 41 percent of the floodplain was covered by woody vegetation, compared to 20 percent in 2002.

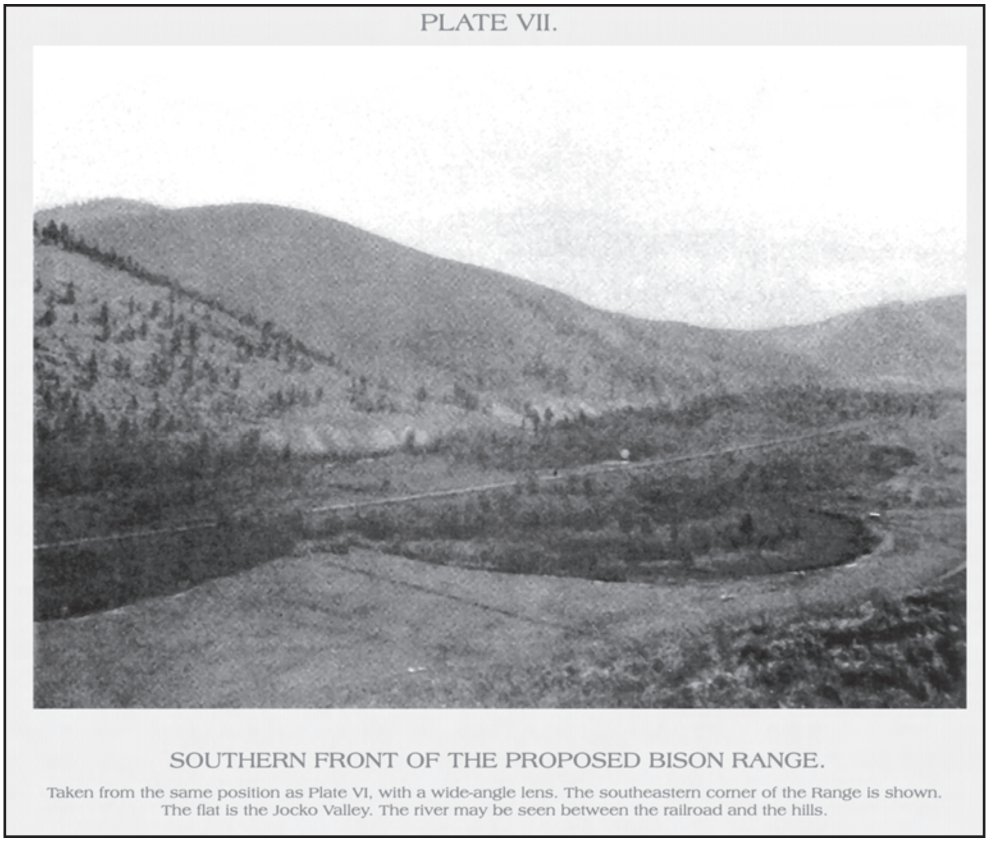
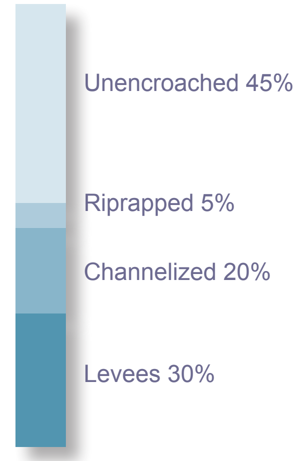
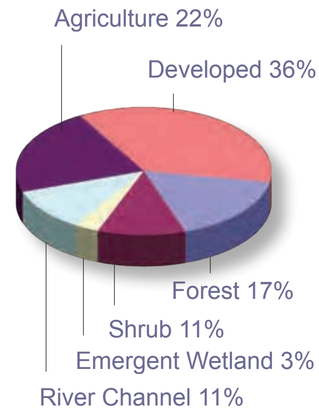


Figure 2.1.3-1.
Historical photo showing a portion of Reach Three.



Thirty percent of Reach Three has constructed levees, 20 percent is channelized, and five percent is riprapped.

There are significant restoration opportunities within Reach Three. Levee removal and channel realignment would restore many of the natural processes that have been incrementally lost over the past 120 years of channelization. In addition, shifting land use out of agricultural production and grazing would allow riparian vegetation to become reestablished and additional woody vegetation to be recruited into the channel.



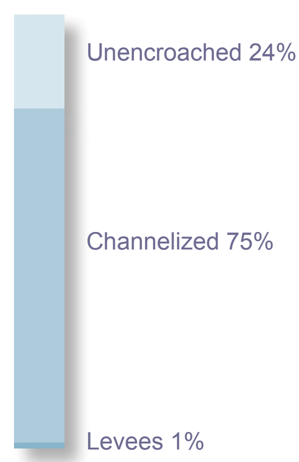
HGM Cover Types in Reach Four

Reach Four

This reach is between the Highway 200 Bridge crossing near the town of Ravalli and the Valley Creek confluence. The valley bottom, confined within a canyon formed in Precambrian bedrock, is wide enough to contain the river and a narrow floodplain. Virtually all of the valley bottom has been narrowed and confined by berms, levees, the railroad, or the highway. Construction of the railroad and US Highway 93 cut off a significant river meander. Of the eight reaches, this one has the highest percentage of developed land. Indeed, portions of the town of Ravalli lie within the ecological floodplain.

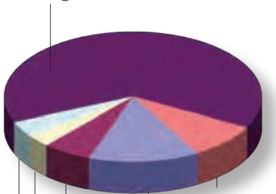
Within this reach, 75 percent of the river's length is channelized, and 1 percent is affected by constructed levees.

Approximately 17 percent of the ecological floodplain area is forested, 11 percent is dominated by shrubs, 3 percent is emergent wetland, 11 percent is either river channel or side channel, 22 percent is agricultural land, and 36 percent is developed.



One percent of Reach Four has constructed levees, 75 percent is channelized.

Aerial photographs from 1937 indicate 33 percent of the floodplain had woody vegetation. That compares to 27 percent in 2002. Opportunities for channel realignment are limited by the railroad and highway, and restoration opportunities may be limited to instream habitat enhancement and a limited amount of revegetation.



HGM Cover Types in Reach Five

Reach Five

Reach Five extends from the Valley Creek confluence to approximately half way to the Finley Creek confluence. It traverses a wide alluvial valley with two prominent glacial outwash terraces, and is bounded on the valley margins by lacustrine deposits from Glacial Lake Missoula. At the lower end, the bedrock that forms Ravalli Canyon constricts the stream corridor, influencing both channel and floodplain morphology. Over time, this constriction has created a backwater effect and caused the deposition of sediment during significant flood events. The result is a broad, low-relief floodplain and meandering channel system. Near-surface bedrock formations also force groundwater to the surface, creating dense, lush wetlands, side channel spring creeks, and a gaining stream reach. Several large spring creeks enter the main river in Reach Five, including Jocko Spring Creek from the east and drainage from the Squeque wetlands complex from the west.

Disturbances in Reach Five include channelization, floodplain encroachment, and riparian vegetative conversion. Ten percent of the banks are rip-rapped, 5 percent of the length is channelized, and 20 percent is affected by constructed levees. Figure 2.1.3-2 is an example of a levee system constructed of vehicles cabled together. Although an individual feature like this may not influence overall channel stability, the cumulative effect of numerous channel confinement features can lead to reach-scale channel instability.

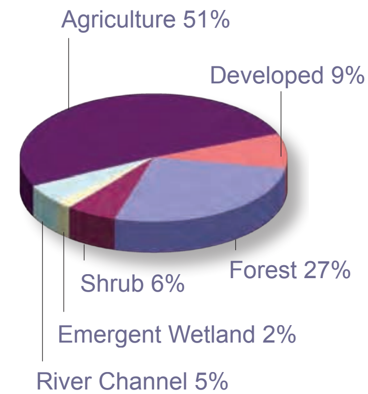
Twenty percent of Reach Five has constructed levees, 5 percent is channelized, and ten percent is riprapped.

Figure 2.1.3-2.
An example of channel confinement features, vehicles cabled together to form a levee system.

The Jocko River in Reach Five is wider, straighter, and steeper than the historical channel due to land uses along the channel margin and floodplain. In-channel sediment storage related to high bank sediment inputs has lead to channel instability, high width-to-depth ratio, and poor aquatic habitat.

Approximately 14 percent of the area is forested, 6 percent is dominated by shrubs, 3 percent is emergent wetland, 4 percent is either river channel or side channel, 64 percent is agricultural land, and 9 percent is developed.

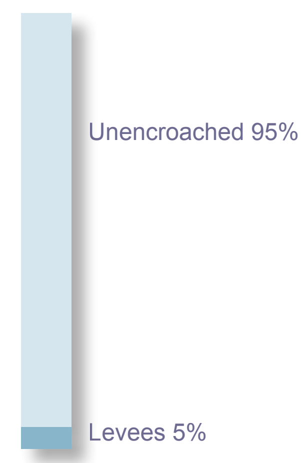
Woody vegetation has been reduced by approximately one-third since 1937. Floodplain hydrology has been altered by channelizing spring channels and reducing the interconnectivity between the channel and the floodplain. Many opportunities exist to restore geomorphic processes. On land parcels where detrimental land uses have been shifted, natural processes such as sediment redistribution and reestablishment of alternating gravel bar sequences have increased aquatic habitat diversity and generated alluvial surfaces now being colonized by riparian vegetation.



HGM Cover Types in Reach Six

Reach Six

This reach is located between the Morin Ditch and Lower S Canal diversions. From upstream to downstream, it transitions from a confined floodplain bounded by high glacial outwash terraces to a less confined reach with diverse floodplain topography. Bedrock exposures on the channel bottom control grade through the reach. Numerous small springs emerge, primarily at abandoned oxbows in proximity to the bedrock outcrops.



Five percent of Reach Six has constructed levees.

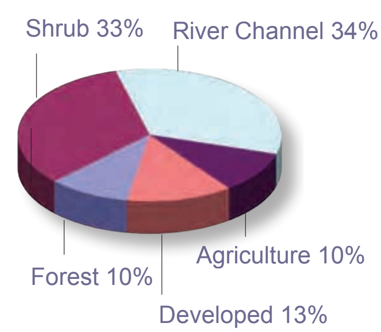
Channelization, hydrologic modifications, and floodplain encroachment have disturbed the stream corridor. Five percent is affected by constructed levees. A small, private diversion diverts surface flows from the river in the lower portion of the reach.

Approximately 27 percent of the ecological floodplain is forested, 6 percent is dominated by shrubs, 2 percent is emergent wetland, 5 percent is either river channel or side channel, 51 percent is agricultural land, and 9 percent is developed.

Aerial photographs from 1937 reveal that 40 percent of the floodplain was covered by woody vegetation. That compares to 31 percent in 2002. Shifting land use away from agriculture and grazing and realigning a limited length of the channel would restore disturbance processes to portions of the floodplain and result in increased recruitment of woody vegetation.

Reach Seven

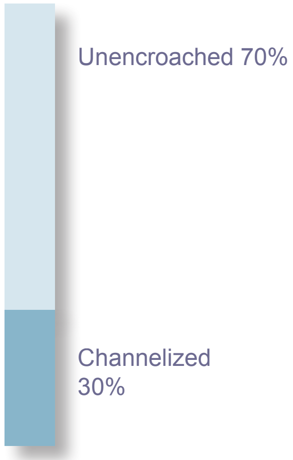
Reach Seven extends from immediately downstream of the Lower S Canal upstream to the Finley Creek confluence. The river is confined within a canyon formed of Precambrian bedrock. With the exception of the Lower S Canal diversion, the river corridor has changed little over time.



HGM Cover Types in Reach Seven

Within this reach, 30 percent of the river length is channelized.

Approximately 10 percent of the area is forested, 33 percent is dominated by shrubs, 34 percent is either river channel or side channel, 10 percent is agricultural



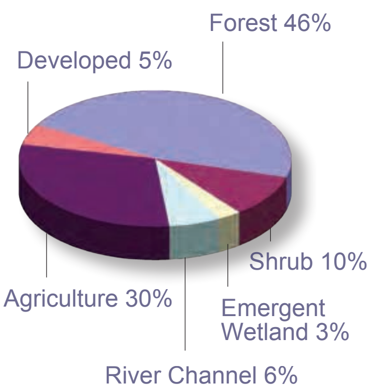
Thirty percent of Reach Seven is channelized.

land, and 13 percent is developed. Between 1937 and 2002, woody vegetation increased from 33 percent to 43 percent.

Restoration opportunities are limited. However, reconstruction of the initial 1,000 feet of the Lower S Canal would increase floodplain width and reduce chronic impacts associated with diversion maintenance.

Reach Eight

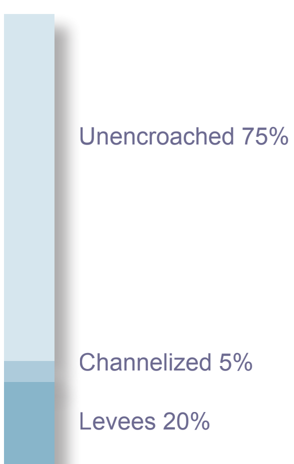
This reach extends from the Finley Creek confluence upstream to the K Canal. Upland areas transition from grasslands to forest cover. The river is incised into a large depositional fan of glacial outwash. In upper portions of the reach, the channel is deeply incised in outwash sediments, and the lateral floodplain width is limited. Downvalley through the reach, incision into outwash sediments decreases and valley width increases. Near the US Highway 93 crossing exposed bedrock has created a backwater effect that historically caused the deposition of sediment during significant flood events. Long-term sediment deposition produced a wide and very diverse floodplain bounded between outwash terraces. Near surface bedrock forces groundwater to the surface, creating dense, lush wetlands, floodplain spring creeks, and a gaining stream reach.



HGM Cover Types in Reach Eight

Human disturbances include channelization, riparian vegetation conversion caused by riparian logging, riparian conversion for agriculture and grazing, and floodplain encroachment. Five percent of the river length is channelized, and 20 percent is affected by constructed levees. Figure 2.1.3-3 is a downvalley view through a channelized portion of Reach 8. Levees on both the left and right margin of the channel were built after a 1948 flood event to protect the Arlee Fish Hatchery. By isolating the channel from the floodplain, these levees have caused the channel to incise up to seven feet. That and recent failure of the levee system has caused elevated coarse sediment loading through this portion of reach eight.

Approximately 46 percent of the floodplain is forested, 10 percent is dominated by shrubs, 3 percent is emergent wetland, 6 percent is either river channel or side channel, 30 percent is agricultural land, and 5 percent is developed. Between 1937 and 2002, woody vegetation decreased from 68 percent to 53 percent, primarily from timber harvesting and agricultural clearing.



Twenty percent of Reach Eight has constructed levees and 5 percent is channelized.

2. CONDITIONS

Figure 2.1.3-3.
Down-valley view through a channelized portion of Reach 8.

A reference reach is a segment of river functioning at or near its potential in terms of stability and productivity. It is not necessarily undisturbed. It simply represents the most productive and stable conditions found within the area.

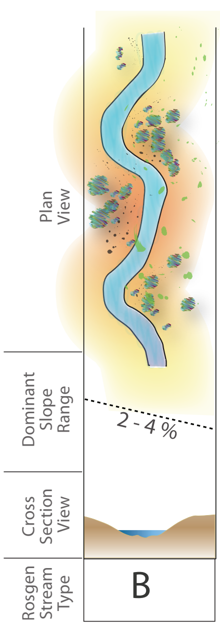
The section of the river adjacent to the State of Montana's Arlee Fish Hatchery is incised and over-widened and has been identified as one of the highest priority areas along the river for active restoration, primarily because in its current condition it is a significant source of sediment to the lower main stem. Additionally, restoration provides an opportunity to raise floodplain water table elevations and expand the extent of floodplain wetlands.

Spring Creeks

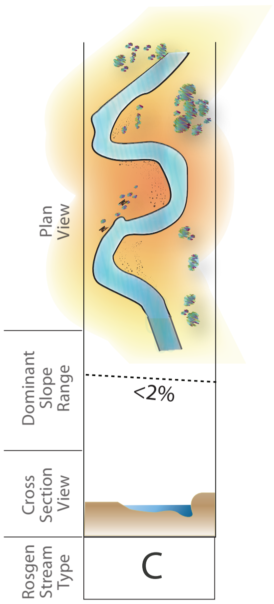
Several spring creeks occur along the lower main stem, either in areas where groundwater is forced to the surface by shallow bedrock or where groundwater flow paths have a strong upward, hydraulic gradient. Plant communities along the spring creeks are flooded less often and have developed deeper organic soils, which has resulted in more bog-like conditions. In places, some of the spring creeks have been modified to include artificial ponds for fish rearing. Productive lands adjacent to the spring creeks have spurred heavy agricultural use that has caused severe impacts along some reaches.

2.1.4 Reference Conditions

We use reference reaches to identify target channel characteristics for restoration design work. The reference reach near station 80+00 (east of Dixon, Montana in Reach Two) is a Rosgen B4 stream type that will serve as the model for restoration of B stream types within Reaches Two and Three. The reference reach near station 380+00 (located near the Lower J Canal in Reach Three) is a Rosgen C4 stream type that that will serve as the model for restoration of C4 stream types within Reaches Three and Four. The reference reach near station 880+00 (located near the middle of Reach Six), is a Rosgen C4 stream type that will serve as the model for restoration in Reaches Five through Seven. The reference reach near station 1180+00 (located upstream from Reach Eight) is a Rosgen B3 stream type that will serve as the model for restoration in within Reach Eight.



B4 and B3 stream types are moderately entrenched on slopes of 2 - 4%. They develop in narrow, moderately steep colluvial valleys. Channel beds of B4 streams are mostly gravel, while those of B3 streams are mostly cobble (after Rosgen 1996).



C4 stream types are only slightly entrenched on gentle slopes (<2%). They develop in broad, gentle-gradient, alluvial valleys and river deltas. Channel beds are mostly gravel (after Rosgen 1996).

The black cottonwood/red-osier dogwood community type, one of the reference plant communities, typically occupies much of the floodplain, alluvial terraces, and point bars. Many of these sites are flooded in the spring but may dry deeply by summer's end.

Reference plant communities, derived by combining information from the Jocko River with other published information about plant community structure and composition, will guide restoration of upland, riparian, and wetland vegetation within the ecological floodplain. The black cottonwood community type (Hansen et al. 1995) is a reference plant community that represents the desired future condition for significant portions of the lower main-stem Jocko River floodplain.

2.1.5 Desired Future Condition

The desired future condition for the lower main stem is a riverine floodplain system where natural processes are reasonably uninhibited by land use impacts; where the floodplain is characterized by particular plant community types and distributions of land cover types; where there is a balanced channel dimension, pattern, and profile; and where there are unimpeded downvalley or longitudinal and cross-valley or lateral linkages for the movement of animals and energy and mass processes like floodplain sediment storage or floodplain nutrient storage. Various metrics are available to objectively measure how well such a system and its components are functioning.

The desired future conditions for stream flow are to achieve the components of an ecological hydrograph (Subsection 2.10) frequently enough to both initiate and sustain floodplain ecological processes, although it is recognized that there are existing water uses for irrigation. Specifically, our goal is to always maintain instream flows or flow levels that maintain critical habitat units; to achieve a channel maintenance flow — the flow that maintains channel dimension and completes instream sediment transport; and to achieve these flows every year that the natural water supply will support a channel maintenance flow, typically two of every three years. Some portion of a channel maintenance flow may be diverted for irrigation supply, but the desired future condition has a flow of a magnitude and duration that will achieve channel maintenance functions. The higher-magnitude ecological flows — riparian maintenance and valley maintenance flows — tend to occur when natural water supply is available. Because of their importance in reshaping floodplain topography and the distribution of floodplain sediments, our goal is to maintain these flows in all years when natural supply is available. This precludes future uses that would diminish this flow and the development of infrastructure in the flood-passage area.

We used Hauer et al. (2002) to develop the following floodplain vegetation goals (these goals assume that HGM scores are based on reference floodplain systems that represent high levels of floodplain function):

- Forested riparian plant communities should occupy between 30 and 80 percent of the ecological floodplain. The remainder of the floodplain should consist of a balanced distribution of recently colonized alluvial bars, pole-sized trees, shrub dominated plant communities and herbaceous emergent wetlands.
- Conifers, cottonwoods and willows should occupy between 50 and 80 percent of the ecological floodplain with well developed connections between patches.

2. CONDITIONS

- Plant communities should be managed primarily for native vegetation cover and diversity.
- Forested areas should have approximately 240 to 480 trees per acre.
- In conifer dominated areas, 50 to 80 percent canopy cover should be shrubs.
- In cottonwood dominated areas, 60 to 100 percent canopy cover should be shrubs.
- Minimum native plant composition should be 80 percent herbaceous and 100 percent shrub and tree.
- Maximum noxious weed and invasive plant species canopy cover should be less than 5 percent.

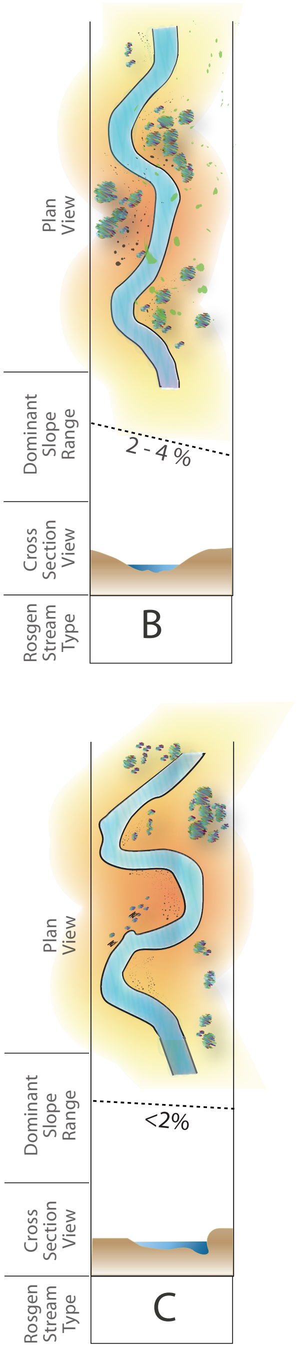
A good illustration of desired future condition for floodplain vegetation communities can be found in descriptions of key plant communities (Subsection 2.5). These communities are the black cottonwood/red-osier dogwood (*Populus trichocarpa/Cornus stolonifera*) community type and ponderosa pine/red-osier dogwood (*Pinus ponderosa/Cornus stolonifera*) habitat type that historically occupied large portions of the lower main-stem floodplain. They represented the dominant vegetation cover in a matrix of forested, scrub-shrub, emergent and upland plant communities. Complex in terms of physical structure and plant species richness, forested riparian areas provide shade, contribute large wood to the stream channel, and provide habitat for mammals, birds, amphibians, and fish. They develop over time as a direct result of fluvial disturbance and are closely linked to and dependent on channel morphology and associated river processes.

Historically, the black cottonwood/red-osier dogwood community type (top) and ponderosa pine/red-osier dogwood habitat type (bottom) occupied much of the floodplain.

Similarly, we used the scoring criteria in Hauer et al. (2002) to develop the following desired future condition goals for river channel morphology and floodplain connectivity:

- Side channels, oxbow features, scour pools, and ponded areas should be well connected to the main channel on an annual cycle. Ponded areas should be isolated during base flow conditions to create habitats favorable to rare species whose life cycles require periods of isolation from fluvial processes.
- Existing geomorphic modifications should be eliminated to allow fluvial disturbance processes that drive plant community succession to function unimpaired.

The desired future condition for channel dimension, pattern, and profile can be found in descriptions of reference reaches (Subsection 2.4.5). In the context of stream systems a reference reach is a segment of river functioning at or near its potential in terms of stability, aquatic habitat, and productivity. A stable stream may appear very dynamic over a short time period, but over a multi -year, or multi-flood cycle, it transports the flows and sediment produced by its watershed so that its channel characteristics are maintained without aggrading or degrading (Lane 1955). On the lower main stem, a stable condition means the floodplain is frequently inundated and the river is able to migrate laterally across it while maintaining a consistent channel pattern.



On the lower main stem, reference channel types are either C or B Rosgen channel types, depending, respectively, upon whether the valley bottom is wide or confined within a canyon.

On the lower main stem, reference channel types are either C or B Rosgen channel types, depending, respectively, upon whether the valley bottom is wide or confined within a canyon. Neither channel type is incised below the floodplain. C stream types are meandering channels characterized by patterns of lateral erosion on the outside of meander bends and sediment deposition on the inside of meander bends. Depositional areas provide substrates where willow and cottonwood communities can become established. Infrequently, large floods may cause the channel to avulse and move to an entirely new location, leaving behind an abandoned channel that develops into a wetland complex. B stream types, generally confined within steeper valley systems, are more laterally stable than C stream types. However, B stream types transport and deposit sediment within a relatively narrow, active floodplain. Channel migration, or avulsion, in these stream systems often occurs where woody debris jams initiate backwater conditions and over-bank flow. Scour or depositional events provide substrate where early successional woody plant species can become established.

Desired future conditions for fish habitat in the lower Jocko River depend on the potential for floodplain connectivity. Where floodplain connectivity exists or has the potential to exist, the desired future condition for much of the lower river would be to have macro habitats in proportions similar to those found in the C stream type reference reaches (i.e., there would be greater amounts of pool habitat). There would be a much greater abundance of instream woody debris, and riparian areas would be more extensive with many more trees and shrubs. Trees and shrubs would provide bank stability and overhead cover. More woody riparian vegetation would moderate temperatures, increase bank stability, and yield more allocthonous or out-of-stream inputs thereby enhancing stream productivity. Overall, the lower main stem would meet USFWS habitat matrix requirements for bull trout (e.g. stream temperatures would not exceed 15º C, pool frequency would approximate 20 per stream mile, large woody debris abundance would approximate 20 pieces per mile, and bank stability would be greatly increased).

The legacy of past, current, and future land use will affect the success of restoration actions. As a consequence, the desired future condition must include perpetual management actions designed to compensate for factors beyond our control. Examples of perpetual management actions include:

- Weed management to limit spread of existing invasive species, currently listed noxious weeds, and future infestations of weeds from other regions;
- Controlled burning to maintain or restore cultural landscapes; and
- Periodic vegetation clearing to ensure a diverse matrix of natural vegetation types that will benefit wildlife.

In summary, the desired future conditions for the Jocko River and its associated floodplains address the development and maintenance of dynamic geomorphic and ecological processes and the habitats that derive from them. A brief description of these guiding principles and healthy river structure can be found in the executive summary.

2.2 Watershed Overview

2.2.1 Cultural Resources

The Jocko River Watershed is an important cultural resource to members of the Confederated Salish and Kootenai Tribes. It serves as a place to hunt, fish, harvest food and medicinal plants, and conduct many other traditional practices. In 1974, the South Fork of the Jocko Primitive Area was set aside by the Tribal Council as a recreational and cultural use area. In 1979 use of the area was restricted to Tribal members and their families. In 1990, South Fork of the Jocko Primitive Area was expanded to include several drainages to the northwest. Logging is no longer permitted in the area. The Jocko Range, which includes a portion of the South Fork of the Jocko Primitive Area and which borders the federally designated Rattlesnake Wilderness, contains one of the largest roadless tracts on the Reservation. The mountains are crossed by a series of backcountry trails that lead to high mountain lakes. The entire area is valued for its pristine environment and opportunities for solitude. Recent natural resource mitigation awards from the relicensing of the Kerr Hydroelectric Facility and ARCO afford the opportunity to protect and enhance this critical watershed for native species so that future generations of Tribal members may enjoy it as well. The Arlee Celebration Grounds, located just outside of Arlee, is the site of the annual Fourth of July Powwow Celebration, one of the largest cultural events on the Reservation.

2.2.2 Land Uses and River Response in the Floodplain

Overview

Land uses within the Jocko River Drainage are similar to land uses in other western Montana valleys. Economies and lifestyles long dependent on agriculture and forest products are giving way to suburban development and an increasing dependence on larger communities, in this case Missoula, for economic viability. The trend is apparent in the 1990 and 2000 census data. The Lake County growth plan reports an overall growth rate of 22 percent for the 1990s in Lake County. Growth rates exceeded this value in the Arlee area. The 1990 census reports 2,415 individuals living in the Jocko River watershed; the 2000 census reports 3,896 individuals. Despite these trends, agriculture and forest products remain major land uses, and impacts to aquatic resources continue. Transportation rights-of-way for the former Burlington Northern Santa Fe (BNSF) Railroad and US Highway 93 have also played a role in altering the floodplain environment. Impacts from rights-of-way have been especially significant because of the narrow, elongate geometry of the valley floor. Table 2.2.2-1 summarizes the basic pattern of land use and ownership. Figure 2.2.2-1 shows recent major natural and human induced events that have modified the watershed.

Table 2.2.2-1.
Summary of the basic pattern of land use and ownership in the Jocko Drainage as of 2002.

Land type or use	Acres	Percent of watershed	Notes
Land classified with a forested cover type	180,100 acres	73 % of watershed	
Forested land in available Tribal timber base	79,190 acres	32 % of watershed	
Land irrigated under the federal irrigation project	10,720 acres	5 % of watershed	Estimated additional 1,000 acres of private irrigation
Designated Tribal Range Units	86,000 acres	35 % of watershed	Five range units with permit for 6,180 AUM's

Alex Matt stands next to a canal built by him about 1890, in the Evaro area.

In 1883, the Northern Pacific Railroad was built. Here the railroad passes through Ravalli, circa 1890.

1860

1863: Montana Territory established

1864: Montana gold rush, far- reaching impacts

1850's –1890's: small-scale timber harvest in Jocko Drainage

1870

1860's and 1870's: first Indian irrigation ditches constructed

1873: First few families of Bitterroot Salish removed to Flathead Reservation, settled in Jocko Valley

1880

1883: Northern Pacific Railroad constructed through Jocko Valley, timber harvest for RR tracks. Ravalli, Arlee, Evaro depots established

1885: More Salish removed from Bitterroot Valley to Jocko Valley

1890

1890: State of Montana established

1891: Forced removal of Charlo and remaining Salish from Bitterroot Valley to Jocko Valley

1894: high water year, Lower Flathead River estimated at 110,000 cfs

1894, 1898: Around these years large wildland fires, extensive fires in South Fork Jocko

1900

1904: Flathead Allotment Act

1906: Federal bill authorizing FIIP, work starts in 1908; March windstorm, 18 mbft blowdown, logging in Evaro area

1906-1918: Early USGS stream gaging in Jocko Drainage

1908: State starts road construction on current US 93 alignment

1910

1908-1910: K canal headworks and canal constructed along alignment of existing 6 mile Indian Service Canal

Figure 2.2.2-1.

Recent major natural and human induced events that have modified the watershed.

1910

1910: Opening of Flathead Reservation to non-Indian settlement; Large fires in North Fork Jocko, Pistol Creek, Charity Peaks area; Project Engineer reports natural Jocko Lakes discharge only below ground. " These lakes are swarming with trout."

1911: East Finley Creek headgate and canal installed

1913: 2,809 acres irrigated in Jocko Valley

1916: High water year regionally; Upper S canal complete to Big Knife Creek, Wood siphon over Jocko constructed

1917: Establishment of townsite of Arlee; 47 mbft sold in Evaro/Arlee unit the Jocko Valley

1920

1920: Jocko logging unit sold

1921: Frog Creek logging unit sold 46 mbft; 4,214 acres irrigated in the Jocko Valley

1922-1925: Tabor Feeder Canal completed, North Fork Jocko Dam completed in 1924

1923: Valley Creek logging unit sold 146 mbft

1923 to 1954: 1923 grazing organized under Division of Forestry to 1954

1924: Lower J Canal and headworks completed

1925: Revais R Canal and headwork's completed

1927, 1928: Regional high water years

1927, 1929: Active fire years with fire in several Jocko Drainages

1929 through 1945: Long-term drought, 1941 and 1944 most severe years

1930

1930's: New Deal Era, CCC camps, trails, roads through Jocko; By early **1930's**: non-native rainbow, brown, and brook trout introduced into Jocko Drainage

1931, 1935, 1939: active fire years with large numbers of smaller fires

1933: Regionally high water year, peak flows similar to 1948

1935: Governance of Flathead Indian Reservation reorganized under terms of Indian Reorganization Act

1937: Lower Jocko Lake tunnel and dam works completed

1940

1940: By 1940 most major irrigation structures in Jocko Valley complete

1940's: Fairly inactive fire period with exception of 1941

1948: High water year, Jocko River peaks at 3,699 cfs, flood damage to State Hatchery

1950

1956: Natural earth barrier forming Black Lake fails

1957, 1958: Active fire years, fire start on Jocko River burns 5-6,000 acres into Pistol Creek

1960

Figure 2.2.2-1 (cont.).

Recent major natural and human induced events that have modified the watershed.

In the Jocko drainage, large-scale timber harvest started about 1917.

Early waterwheel. By 1940 most major irrigation structures in the Jocko Valley had bene completed.

From the 1970s to the present, fire suppression efforts have kept fires in Jocko Drainage small.

In 1982, the Tribes established the Mission Mountains Tribal Wilderness, the southern end of which lies within the Jocko Watershed.

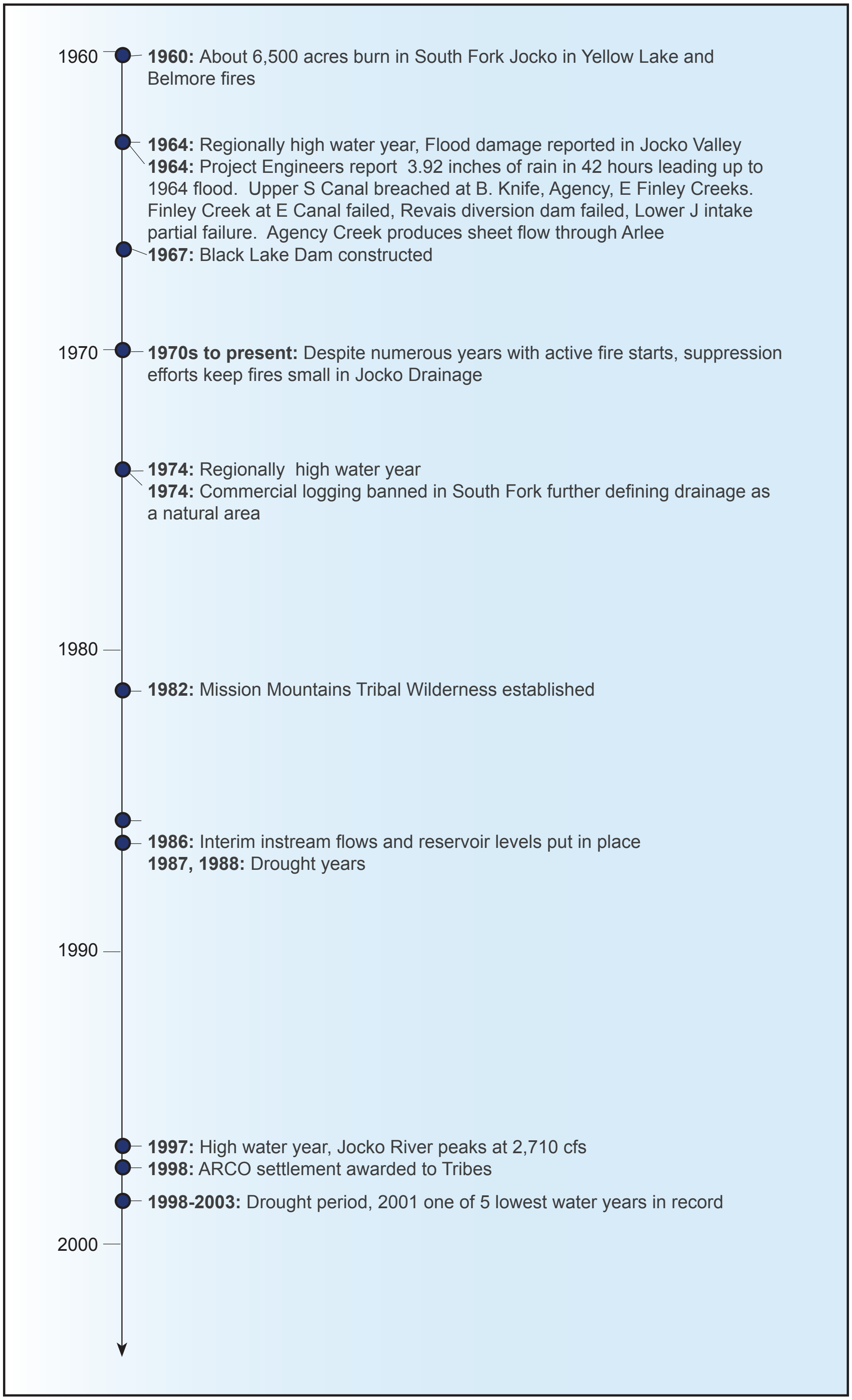


Figure 2.2.2-1 (cont.).
Recent major natural and human induced events that have modified the watershed.

Table 2.2.2-1 (cont.).
Summary of the basic pattern of land use and ownership in the Jocko Drainage as of 2002.

Land ownership categories	Acres	Percent of watershed	Notes
Tribal land	182,425 acres	74 % of watershed	
Allotted land	8,195 acres	3 % of watershed	Allotted lands are lands owned by individuals and held in trust
Fee land	39,520 acres	16 % of watershed	
Federal land	6,400 acres	3 % of watershed	
State land	8,645 acres	4 % of watershed	
Restricted Trust lands	80,260 acres	33 % of watershed	59,047 acres in the Jocko Primitive Area and 21,212 acres in Mission Wilderness

Forest Practices

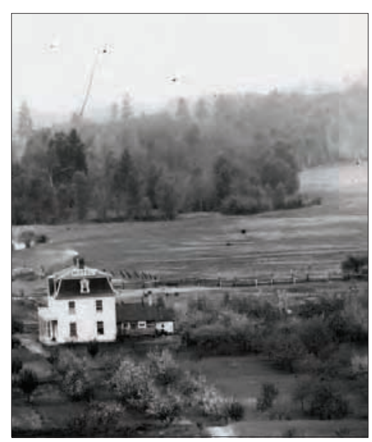
Between the 1850s and the 1890s, only a minor amount of timber harvesting occurred in the Jocko River Drainage. Probably the most significant activity was associated with the production of ties and timbers for the BNSF Railroad. During 1910, 60,000 acres burned on the Flathead Reservation, including areas near Evaro. In the Jocko drainage, large-scale timber harvest started about 1917. Four large sales were completed before 1925; the largest in Valley Creek included the harvest of approximately 146 million board feet (HRA 1977). These early sales relied on railroad logging practices, and there are several locations where tracks and log deck bridges can still be seen in stream channels or adjacent floodplains.

"Looking north across the Jocko District" This photo, taken in 1937 carried the caption: "An excellent Ponderosa pine forest once grew here."

Large-scale forest operations have continued throughout the drainage. Recent sales include the Frog Complex in the Finley Creek Drainage, the Valley Creek complex of sales throughout the Valley Creek Drainage, the Pistol Creek sale, and the Kelly's Ridge sale, parts of which are in the North Fork of the Jocko watershed. A sale is also planned for the Finley area in the headwater tributaries to Finley Creek. In the available commercial forest base, road densities generally exceed four miles of road per square mile, and there are numerous locations where historical road impacts have caused elevated sediment inputs to stream channels, bankside disturbances, and the impairment of aquatic habitats.

Agricultural Land Uses and Irrigation Infrastructure

Starting in the 1860s, agricultural producers constructed a series of small canals or "Indian ditches" on tributaries to Finley Creek, Big Knife Creek, and Agency Creek. Many continue to be used to this day. In 1906, Congress passed and the President signed a bill establishing the Flathead Indian Irrigation Project, and in 1908 construction work on the project started. Then in 1910, the Federal government opened the Reservation to non-Indian settlement, which increased demand for irrigation. By 1940 the Department of Interior had completed most of the major canals and structures related to the Flathead Project.



This photo, taken in 1907 at Ravalli, shows riparian areas cleared for grass and hay production and fruit trees.

There are two, on-channel storage systems in the headwaters of the Middle Fork Jocko River: Lower Jocko Lake and Black Lake. Both are natural lakes that formed behind landslide deposits. The tunnel and reservoir structures for the Lower Jocko Lake were completed in 1937, and the reservoir has operated as a seasonal detention reservoir since then. The natural fill forming Black Lake failed in 1956. The current earthen dam and reservoir structure were constructed in 1967.

Numerous large irrigation structures and approximately 100 miles of canal are located within the Jocko River Drainage. These are used to divert water from the Clearwater Drainage into Black Lake, to move water from the Jocko River drainage into the Mission Valley, and to distribute run-of-the-river flows and stored water throughout the irrigated land base. Canal diversion records indicate that over 4.5 acre-feet per acre are diverted to irrigated lands during the irrigation season. Crops are restricted to grass and alfalfa hay, irrigated pasture, and a small amount of grain.

Because of human-caused changes, even moderate to low recurrence interval floods, like the 1997 flood, have led to significant bank erosion, channel incision, and continued stream channel instability.

Early grazing management was brought under the Bureau of Indian Affairs (BIA), Division of Forestry in 1923 and was transferred to the BIA Range Management Program in 1954. Currently, there are five designated range units in the Jocko River watershed (Table 2.2.2-2).

Table 2.2.2-2.
Summary of Range Units based on 2002 data.

Range unit	Acres	AUM's
RU 18 – Valley Creek	31,600 acres	3,300 AUM
RU 19 – Lower Finley Creek	8,600 acres	380 AUM
RU 20 - Frog Creek	2,500 acres	250 AUM
RU 21 – Upper Finley Creek	11,000 acres	450 AUM
RU 22 – Jocko	32,300 acres	1,800 AUM

In addition to open grazing on range units, individual parcels of Tribal Trust, allotted land, and fee lands are managed for grazing or agricultural production.

Figures 2.2.2-2 a and b illustrate how agricultural activities have influenced the floodplain of the lower main stem. The view down the Morin Ditch (a), a private irrigation diversion located in Reach Six shows the gravel berm forming the intake to the ditch. Over the years, the producer has extended the berm upstream. It is now approximately 1,000 feet long and restricts the river channel's access to the floodplain. As a consequence, the river has become incised. The aerial view of a segment of Reach Five (b) shows the floodplain during the waning stages of the 1997 flood. The land on the left side of the photo was cleared to improve grazing forage. The photo documents elevated bank and channel instability where the land has been cleared. The result has been elevated bank sediment inputs and increased in-channel sediment storage.

Figure 2.2.2-2 a.
Example of agricultural infrastructure that has initiated stream responses in the lower Jocko River.

Figure 2.2.2-2 b.
Example of land use that has initiated stream responses in the lower Jocko River.

Floodplain Disturbances

The lower main stem is a dynamic alluvial river system. Understanding the current condition and achieving the desired future condition requires knowledge of the type and extent of human activities that have altered it. Throughout the lower main stem, floodplain levees and bank-hardening features have been constructed, the channel has been straightened, and floodplain encroached upon by transportation rights-of-way. Woody riparian vegetation has been converted to cultivated land and more open vegetation types. These changes have reduced the accessible area of floodplain inundation during flood events, reduced floodplain roughness and flood storage capacity, and focused the distribution of stream power to the active channel during flood events. Consequently, moderate to low recurrence interval floods, like the 1997 flood, have led to significant bank erosion, channel incision, and continued stream channel instability.

Isolating the floodplain from the active river or severely modifying it has interrupted ecological processes, including the scouring and creation of floodplain surfaces that are subsequently colonized by early successional vegetation, the inundation of floodplain wetlands and slow release of soil moisture back to the river, the seasonal increase of the water table during flood events, and the retention and cycling of fine sediment and nutrients (Figure 2.2.2-1).

Figure 2.2.2-3 a shows the Jocko River adjacent to the State of Montana's Arlee Fish Hatchery (fish hatchery) raceways (Reach Eight). The photo was taken shortly after the recession of the 1997 spring flood. Large earthen berms located on the left and right margins of the channel were constructed in the early 1950s in response to flood damage at the fish hatchery that occurred in 1948. The berms have restricted over-bank flooding, and because of the concentration of stream power on the levee banks, they actively contribute coarse sediment to the active channel. Figure 2.2.2-2 b is a schematic of a valley-wide cross section located at the upstream end of the view in the photo. It shows the berms, the incision of the active channel, and inferentially, the isolation of the active channel from the floodplain. This channel modification, completed over 50 years ago, continues to destabilize the Jocko River throughout much of Reach Eight.

Figure 2.2.2-3 a.
Example of the response of the Jocko River to floodplain encroachment.

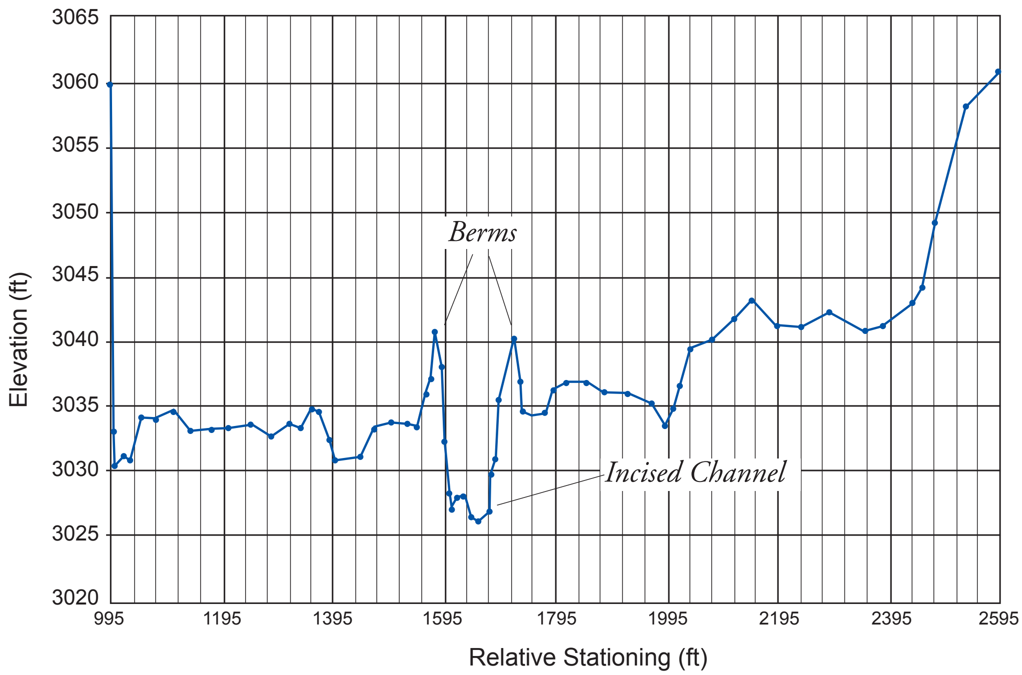


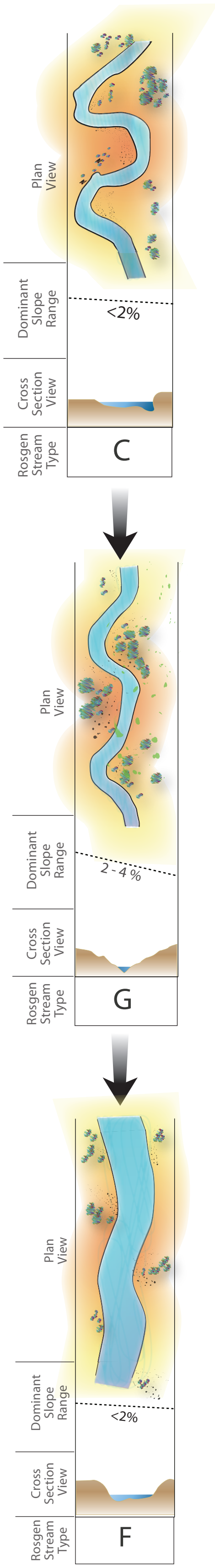
Figure 2.2.2-3 b.
Example of the response of the Jocko River to floodplain encroachment.

Channelization affects channel reaches both upstream and downstream from the actual channelized reach.

Table 2.2.2-3 summarizes the floodplain encroachment features by reach. The location of these features is also shown on the aerial photos in Appendix D-1. The table groups floodplain encroachment features into three categories.

1. **Channelization** occurs where the river has been straightened for transportation infrastructure or other purposes. Where channelization is reported, it refers to both river banks, and the total amount of channelization per reach can only equal the length of the reach.
2. **Constructed levees** are features constructed on one or more margins of the channel to isolate the floodplain during high flow events. They are mapped on one or both sides of the channel. The total amount of constructed levees per reach may equal two times the reach length.
3. **Bank hardening features** are structural treatments designed to stabilize channel banks. They may be located on one or both sides of the channel margin. Like levees, the total amount of bank hardening features per reach may equal two times the reach length.

We located and measured floodplain encroachment features in the field using a procedure identified in Makepeace (2001).



Some C-type segments have incised to become G stream types, which over time, can convert to F stream types. (after Rosgen 1996).

Table 2.2.2-3.

Floodplain Encroachment Features – total channel length for Reaches One through Eight = 111,715 ft (total bank length ~ 223,430 ft)

Reach	Encroachment feature	Length	Percent of channel length in reach
2	Channelization	1,605 feet	57 %
2	Constructed levee	480 feet	17 %
3	Bank hardening - rip-rap	1,820 feet	5 %
3	Channelization	7,520 feet	20 %
3	Constructed levee	11,685 feet	30 %
4	Channelization	12,185 feet	75 %
4	Constructed levee	65 feet	1 %
5	Bank hardening – rip-rap/ cars	2,110 feet	10 %
5	Channelization	1,215 feet	5 %
5	Constructed levee	4,695 feet	20 %
6	Constructed levee	535 feet	5 %
7	Channelization	815 feet	30 %
8	Channelization	400 feet	5 %
8	Constructed levee	3,270 feet	20 %
Summary for 1 through 8	Channelization	23,740 feet	20 %
Summary for 1 through 8	Constructed levee	20, 730 feet	20 %
Summary for 1 through 8	Bank hardening	3,930 feet	4 %
Cumulative floodplain encroachment as a percent of total bank length		96,800 feet	43 % of the lower 22 miles of river

Channelization

Channelization can be caused by direct manipulation of the river channel or the placement of floodplain fill. Both seek to limit the river's access to the floodplain, increase the amount of (and access to) arable land, and/or to facilitate other land uses such as agriculture, residential development, or transportation corridors. Channelization of the Jocko River has been locally extensive and has disrupted several of the previously identified riverine functions in the lower main stem. It has included direct straightening of the river, construction of road and railroad rights-of-way adjacent to the river, construction of irrigation rights-of-way, and construction and maintenance of bridge-approach sections.

Direct channel modifications typically result in a series of channel adjustments. A common result of channelization and floodplain encroachment is a reduction in channel length and a corresponding increase in channel gradient. Initially the energy gradient and distribution of stream power increases causing channel downcutting, or degradation, which leads to channel incision and further isolation from the floodplain. In portions of the Jocko River, particularly adjacent to the fish hatchery and the National Bison Range, C stream types have incised to become G-type segments. With the change in stream type from a stable C to a highly erodable G stream, the base elevation of the river lowered. Once the channel bed lowered, the streambanks became more susceptible to erosion because the channel bed was below the roots of the bank vegetation. The reduced resistance to lateral scour enabled the higher-energy stream to erode its banks, and the channel widened. Over time, these processes widened the channel bottom, forming an F stream type disconnected from the adjacent floodplain except during large floods. These F stream type reaches are characterized by a straight channel planform, homogenous riffle habitat, and poor aquatic habitat diversity.

Figures 2.2.2-4 a, b, and c illustrate this sequence of channel responses. The initial photo shows a section of the Jocko River in a C stream type located in the Lower J canal reference reach. Here, the river has formed alternating bar sequences, and it has access to a wide floodplain.

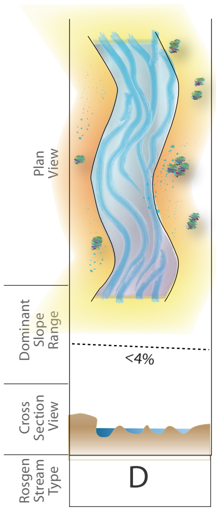
Figure 2.2.2-4 a.
C stream type

Figure 2.2.2-4b shows a section of the river that has been channelized and forced against the hillslopes along the National Bison Range. This G stream type section does not have access to its floodplain and has formed a very simplified channel.

Figure 2.2.2-4 b.
G stream type

The final photo (Figure 2.2.2-4 c) shows a section of the river where initial river incision following disturbance has stabilized, and the river is forming a new floodplain at a lower level.

Surfaces that border the river and that were floodplain features prior to channel incision have converted to drier terrace surfaces with lower frequency of inundation and dry site vegetation.



D-type segments have multiple channels separated by mid-channel bars (after Rosgen 1996).

Figure 2.2.2-4 c.
Historical and modern floodplain elevations.

Channelization also affects channel reaches upstream and downstream from the actual channelized reach. The higher-energy gradient of the channelized segment increases sediment transport efficiency. Where the channelized reach ends, a depositional area often forms, creating lateral and mid-channel bed deposits. They cause divergent stream flows and local increases in bank instability. This pattern is apparent on the Jocko River downstream from the fish hatchery. Reaches characterized by abundant bed load deposits are classified as D stream types. Figure 2.2.2-5 shows a D stream type in Reach 8 where sediment is stored as mid-channel bars.

Figure 2.2.2-5.
D stream type exhibiting sediment storage at mid-channel bars.

2. CONDITIONS

The upstream effects of channelization can manifest themselves as migrating headcuts as the higher energy gradient is capable of increased bed scour. With elevated shear stress produced by the increased water velocities, large particle size substrate can be set into motion during flood events. Ultimately the channel bed can continue to incise for a distance upstream of the channelization until an equilibrium point (e.g. bedrock) is encountered. Field surveys completed on the Jocko River suggest that the reach upstream from the straightened reach adjacent to the fish hatchery has incised into the historical floodplain and started to stabilize three to four feet below the historical floodplain (Figure 2.2.2-3a).

Reaches with woody debris accumulations are generally characterized by more diverse aquatic habitat, increased water depth, and greater overall channel complexity.

Floodplain Encroachment

The term floodplain encroachment encompasses any activity that limits the dispersal of floodwaters onto the floodplain, restricts lateral channel migration, and isolates floodplain waterbodies and abandoned channel remnants from the active channel during flood events. Examples include berms, levees, and other forms of fill designed to separate an area from the river. The placement of infrastructure such as roads and residential development also limits the lateral spread of floodwater.

Confinement of flood flows to the active channel has predictable repercussions for channel stability and aquatic habitat. The increased energy resulting from excess water in the channel increases the scour potential of the river during floods. Increased water velocities and shear stress increase the river's capacity to transport sediment, which causes excessive bank scour.

Confinement of the floodplain also reduces the frequency of water-table recharge. Besides inundating off-channel wetlands and other riparian habitats, the floodplain environment acts like a sponge, providing a surface to absorb floodwater and filter fine sediment transported by the river. Floodwaters retained in the floodplain are then released back to the active channel over time as the surface water elevation recedes over the course of the year. Shallow groundwater discharge to the active channel late in the year maintains the base flows essential for robust aquatic communities. Isolation of the Jocko River from its floodplain weakens this complex web of interdependent systems.

Large Woody Debris (often abreviated LWD) is defined as pieces of wood larger than 10 feet long and 6 inches in diameter that are within a stream channel.

Riparian Vegetation Conversion

The black cottonwood (*Populus trichocarpa*) gallery forest that once covered the Jocko River Valley bottomlands has been reduced by riparian logging, vegetation conversion for agriculture and grazing, residential development, and transportation corridors. As the forest is converted to other vegetation types, the stream responds physically and biologically. For example, removal of the mature trees alters the canopy overstory, exposing the stream to solar radiation, which increases water temperatures. Removal of mature trees also reduces the potential for large woody debris recruitment to the river. Large woody debris plays a pivotal role in channel function and habitat creation in the rivers of western Montana. Reaches with woody debris accumulations are generally characterized by more diverse aquatic habitat, increased water depth, and greater overall channel complexity. Floodplain encroachment and riparian conversion diminish the quantity of large woody debris available to the river. Channelization, by increasing the energy gradient, reduces the residence time of large woody debris in the system. Straightened, armored banks with minimal mature riparian vegetation provide a poor source of large woody debris and are ineffective at capturing transported woody material.

When streambank vegetation is removed and stream banks lose their ability to resist the erosive forces produced in the channel during high runoff periods, stream channel widening can occur. In a geomorphic setting similar to the Jocko River, the stream initially begins to migrate laterally at an accelerated rate, transitioning from a moderate width-to-depth ratio, stable C stream type to an over-widened, high width-to-depth ratio C/D stream type. An F stream type can also result if the channel becomes entrenched or if floodplain berms confine the active channel. Because of accelerated downstream meander migration and bank erosion, the stream erodes through the outside bend of one or several meanders over time. Point bar chute cutoffs form, shortening the channel length. Both processes result in a shorter channel characterized by an over-steepened bed profile (or energy-grade line) increased slope, hydraulic radius, and channel depth, which collectively increase the conveyance and shear stress on the channel perimeter.

Bank Erosion

Makepeace (2001) field measured the length of channel with eroding banks. The data cannot be broken out by the eight reach breaks, but for the lower 22 miles of the main stem, 41,160 feet of bank (41 percent of the lower main stem's length) exhibited unstable, eroding banks. Lateral channel migration and bank erosion are natural processes in alluvial river systems, but the combination of channelization, floodplain encroachment, and riparian plant community conversion has greatly accelerated bank erosion.

Bank erosion and bank retreat can lead to high width-to-depth ratio channel cross section geometry and simplified and unstable channel margin habitat. Elevated coarse sediment inputs can lead to pool infilling, formation of braided channel networks, and a reduction in interstitial substrate habitat.

Conclusion

Irrigation withdrawals have reduced the annual occurrence of bankfull forming flows, most notably during average to below average years (Subsection 2.2.4). However, since there are conveyance limitations on the irrigation infrastructure, irrigation withdrawals have had only a limited influence on higher magnitude flood events (Subsection 2.2). One predictable channel response when bankfull flows are reduced is a reduction in the cross sectional area of the channel as additional sediment is stored in the channel, and vegetation advances onto sediment surfaces.

Floodplain encroachment, channelization, and the removal of riparian vegetation all tend to increase stream power and the rate of bank erosion over a wide range of flows. This relationship is supported by the high percentage of eroding channel bank that has been measured in the lower main stem. Elevated rates of bank erosion tend to create channels that are wide and shallow and less able to transport sediment.

These two critical processes—hydrologic modification and floodplain modification—tend to move channel morphology in opposite directions. The net result, however, is a channel environment that is no longer in dynamic equilibrium that has habitat characteristics well below potential. Further, the response of the Jocko River to the 1997 flood (a ten-year flood event), suggests that the river corridor may be at a threshold; a high magnitude flood could lead to significant and widespread floodplain scour and channel instability.

2.2.3 Geology and Soils

Geology

Geologic controls influence the overall alignment of the Jocko Valley, and consequently the alignment of the Jocko River. For example, the St. Mary's fault controls the alignment of the Jocko River from Ravalli to its confluence with the Flathead River. Glacial and glacially reworked sediment deposits are responsible for much of the character of the current Jocko River environment. River bed sediments reflect their glacial origin. Surface and groundwater interactions that support baseflows and that are responsible for diverse floodplain topography are largely related to formation of extensive alluvial aquifer systems in sediments deposited in a proglacial environment.

The Jocko Basin is a northwest trending intermountain valley. Regional extensional faulting occurred in late-Miocene time and may be responsible for the development of the present configuration of the valley, which is bounded to the east by a sharp range-front fault, to the south and southeast by the Jocko Fault (Ostenna et al. 1990), and to the west by foothill and mountainous terrain. The St. Mary's fault zone controls the alignment of the lower Jocko River, as well as the lower Flathead River (Harrison, J.E. et al. 1986).

The Precambrian Belt Supergroup underlies the entire basin at depth and is exposed in headwater areas and on valley margins. The Belt Series is a massively thick sequence of metasedimentary rocks. The Jocko drainage generally includes the Mt. Shields, Snowslip, and Helena Formations. These units are part of the middle and upper Belt sequence Middle Belt Carbonate and Missoula Groups and are comprised of quartzite, argillite, and carbonate metasediments (Winston 1989).

Materials that are inferred to be Tertiary-age (Oligocene and Miocene) sediments are reported in well logs (Slagle 1988), and are believed to occur stratigraphically between Belt rocks and overlying valley fill. Tertiary sediments reported in well logs include clay beds, sandstones, and siltstones.

The predominant valley fill materials in the Jocko River valley include unconsolidated Pleistocene and Holocene glacial sediments, glacial lacustrine sediments, and alluvial sediments. The materials occur as interbedded clays, silts, sands, gravels, cobbles, and boulders. Well logs indicate that Pleistocene through Holocene sediments are highly heterogeneic and individual sediment beds have limited lateral extent. Along the foothills of the Rattlesnake Mountains, Pleistocene alpine glacial moraines formed from glacial tills are visible, and tills are reported in well logs. Along the axis of the Jocko River, in the Jocko Canyon downstream to the confluence with Valley Creek, there is a large distinct glacial outwash fan derived from Pleistocene alpine glaciers that sourced in the headwaters of the Jocko River valley. Glacial lacustrine sediments deposited during high stands of Glacial Lake Missoula are exposed in the northern portion of the valley and form the high terrace surface on the valley margin. Glacial lacustrine sediments are not as widespread as they are in other valleys in the region. Fluvially reworked Holocene sediments occur along the Jocko River as terrace features, in recent floodplain sediments, and along most major stream systems in the Jocko River Valley.

Soils

The distribution and genesis of soil materials is critical to understanding the environmental history of the basin and planning floodplain restoration activities. In particular soils are a strong determinant for floodplain revegetation and renaturalization efforts. Aerial photos in Appendix D-2 show the ecological floodplain and hydric and floodplain soils along the river. The ecological floodplain is defined as that portion of the floodplain that has potential for restoration based on soil type, vegetative communities, and landform position.

Valley floor soils in the Jocko River drainage reflect the parent material underlying the soil. This occurs because of the recent history of glaciation in the basin, recent surface reworking through fluvial processes, and low precipitation on the valley floor. Many soils exhibit A and B horizon organic matter accumulation with modest soil structure development, B horizon clay accumulation, and rapid transition to primary parent material characteristics in the C horizon.

Within the mapped ecological floodplain of the river (Appendix D-2), soils are identified in two categories: hydric soils (using the Natural Resources Conservation Service definition (NRCS 2002a) and floodplain soils. Floodplain soils formed within the active channel floodway, on low alluvial terraces, and in some instances on surfaces underlain by glacial lacustrine sediments at elevations low enough to be part of the riverine environment. Several of the floodplain soil series are reported to have hydric inclusions, but they are generally a minor component of the map unit. The predominant hydric soil within the ecological floodplain is the Lamoose Series. The primary floodplain soil series include the Jocko Series, the Grantsdale Series, the Hewolf Series, and Xerofluvents. Several additional soils occur as inclusions on the valley floor and within the floodplain of the Jocko River.

The most widely distributed soils, including hydric soils, are summarized by series in the following paragraphs and tables. Information is based on the Lake County Soil Survey (NRCS 1998) and the Sanders County Soil Survey (NRCS 2004). Table 2.2.3-1 provides a compilation of soils by reach within the ecological floodplain.

Table 2.2.3-1.
Summary of soil types within the ecological floodplain.

Reach number	Reach name	Acres of ecological floodplain in reach	Acres of hydric soils by reach	Acres of floodplain soils by reach
1	Lower Delta	122	0	122
2	Upper Delta	108	0	108
3	Bison Range	1,437	532	892
4	Ravalli Canyon	258	1	235
5	Squeque	1,507	635	865
6	Schall Flats	385	45	340
7	Jocko Hollow Canyon	7	0	6
8	Demonstration	367	245	130
Cumulative		4,190	1459	2,699

Jocko Soil Series – The Jocko soil series ranges from a gravelly loam to a very stony loam (Figure 2.2.3-1). Typical Jocko soils form on glacial outwash material on the upper alluvial surface in the Jocko Valley. In the Schall Flats area in Reaches Five and Six, the series is mapped on active floodplain surfaces and low fluvial terrace surfaces that have similar sedimentologic characteristics as the Jocko glacial outwash.

Figure 2.2.3-1.
Photo showing soil profile through the Jocko gravelly loam.

Lamoose Soil Series – The Lamoose soil series is an organic-rich loam near the surface that transitions rapidly to extremely gravelly sand at depth (Figure 2.2.3-2). Lamoose soils form on floodplain surfaces on alluvial substrates and are the predominant hydric soil series in the lower Jocko Valley. The series contains actively modified floodplain areas. It is a hydric soil with near-surface water table elevations and redoxomorphic conditions in the B horizon. Lamoose soils are found primarily over groundwater upwelling areas and in areas with emergent wetland types. High surficial organic matter content is related to high vegetation productivity rates. Organic matter content and organized soil structural properties (weakly prismatic structure) drop off rapidly below 20 inches of depth.

Figure 2.2.3-2.
Photo showing soil profile through the Lamoose soil series.

Xerofluvents – Xerofluvents occur throughout the floodplain environment of the Lower Jocko Valley. The Revais silt loam with a gravelly substratum underlies the entire Jocko River delta and is also classified as a xerofluvent. Xerofluvents are described somewhat differently in Lake and Sanders Counties. Generally, this series contains a shallow surficial loam layer that trends to a very to extremely gravelly sandy loam at depth. Subsoil materials tend to be very gravelly. Xerofluvents are mapped within the active floodplain, and consist of very recently developed soils formed on alluvial surfaces. As the name indicates, xerofluvents tend to have a dry or aridic soil moisture regime.

Hewolf Gravelly Loam – The Hewolf gravelly loam is a gravelly loam in the surface and a very to extremely gravelly loam and loam sand at depth. Sand textures reported in the series are similar to sand intervals reported in floodplain well logs below Ravalli Canyon. The series is generally mapped on Holocene terrace surfaces adjacent to or in the vicinity of the Jocko River. It is mapped in Sanders County, not Lake County and is found in a similar landform position as parts of the Jocko soil series. Subsoil materials tend to be sandy.

Grantsdale Silt Loam – The Grantsdale series is a finer textured series that has developed on abandoned terrace surfaces formed of alluvial material and sandy glacial lacustrine materials outside of the active floodplain. Surface textures are silty loams, and basal soil textures are very gravelly loams.

Soils in the Vicinity of Jocko Spring Creek - A mosaic of three soil series overlie the valley floor adjacent to Jocko Spring Creek: Borohemists, Ninepipe silt loam, and Colake silt loam. The Colake silt loam has large areas classified as drained. These soils may present opportunities for wetlands restoration, creation, or enhancement. Borohemists are peat soils overlying alluvium, and they occur in the spring source for Jocko Spring Creek. The other two series are fine textured, well developed silt loams. All three soils are hydric soils, or have hydric inclusions and overlie fine textured parent materials inferred to be glacial lacustrine silts and fine grained over-bank deposits.

2.2.4 Surface and Groundwater Resources

Surface Water Resources

The Jocko River drains approximately 380-square-miles. Elevations range from over 7,000 feet at the headwaters to 2,500 feet at the confluence. Mean annual precipitation ranges from over 70 inches at the watershed divide to 16 inches in the lower Jocko (Western Regional Climate Center). Headwater streams originate in the glaciated Mission Mountains Range with the primary tributaries emerging from forested mountain slopes. Low gradient spring creeks arising on the valley floor also contribute significant flows to the Jocko River in the lower part of the watershed.

The annual hydrograph of the Jocko River generally exhibits one peak flow period that occurs sometime during May or June in response to snowmelt runoff. Snow pack characteristics, air temperature, and spring rain events influence the timing and persistence of spring runoff. Stream flow in the lower basin is augmented by groundwater recharge attributed in part to irrigation return flows.

Irrigation withdrawals have a strong influence on flow patterns in the river. In 1987 the Tribes established interim instream flows at nine locations to maintain minimum flows for fisheries protection (Table 2.2.4-1). The current instream flows are flat-line flows maintained year -round unless natural inflow drops below the instream flow value.

Table 2.2.4-1.
Interim instream flows located in the Jocko Drainage

Location	Instantaneous stream flow (cfs)
Middle Fork Jocko River below Tabor Feeder Canal	20.0
North Fork Jocko River below Tabor Feeder Canal	18.0
Jocko River below K Canal	36.0
Jocko River below Lower J Canal	76.0
Jocko River at Mouth	96.0
Big Knife Creek below Jocko S Canal	2.0
Agency Creek below Upper J Canal	8.0
Finley Creek below E Canal	7.5
Finley Creek at Mouth	8.5

The effects of the Flathead Agency Irrigation District Project on the flow regime of the Jocko River were analyzed by the Confederated Salish & Kootenai Tribes in Jocko Basin Hydrology Report (hereafter Hydrology Report) (CSKT 2003). The report naturalized stream flows (removed the influence of irrigation diversions) and compared those flows with the existing flow regime for the period from 1992 to 2001. It presents hydrographs and flow duration curves for three locations – the North Fork of the Jocko River, the Middle Fork of the Jocko River, and the Jocko River below Ravalli Canyon at the lower J canal. The hydrographs show the existing and naturalized flow pattern for a wet (1997), dry (1992), and near average (1999) water year for the period. The flow duration curves illustrate modification to specific flow magnitudes for the existing and naturalized hydrology for each mean daily flow for the analysis period. The South Fork of the Jocko River is the only larger tributary that does not have any diversion. The flow pattern for the South Fork can be reviewed at http://waterdata.usgs.gov/mt/nwis/uv?12381400

North Fork Jocko River

The North Fork Jocko is a headwater tributary that serves as the primary source of water for a transbasin diversion into Tabor Reservoir. Much of it is diverted into the Tabor Feeder Canal.

In dry years, and to a lesser extent in average years, peak flows critical to the maintenance of channel dimensions and the inundation of floodplain surfaces are diverted into the Tabor Feeder Canal. Bankfull discharge for the North Fork above the diversion is estimated at 290 cfs. Above the diversion this flow is estimated to occur approximately 16 days per year. Below the diversion it is estimated to occur approximately 3 days per year. The duration curve shows that flows above the minimum instream flow of 18 cubic feet per second (cfs) have been reduced.

Middle Fork Jocko River

The Middle Fork Jocko River has two on-stream reservoirs upstream of the measurement site. The reservoirs supply irrigation demands in the Jocko River Drainage after water from the unregulated South Fork of the Jocko River cannot meet demand at the K Canal diversion point. Some early season flow is also diverted into the Tabor Feeder Canal to supply Tabor Reservoir.

The Middle Fork of the Jocko River is operated in a markedly different fashion than the North Fork. In all but the wettest years, the peak flow is shifted from a spring, early summer pattern to a mid to late summer release pattern. The duration curve indicates that mid to late summer flows may mimic the magnitude and frequency of natural channel forming flows. The duration curve also shows that intermediate to low flows occur with much greater frequency than the naturalized pattern, due in part to reservoir seepage and lagged return of seepage into the active channel.

Jocko River below Big Knife Creek

The Jocko River below Big Knife Creek is downstream of the largest diversion in the drainage, the K Canal intake. Hydrologic patterns observed at this site are generally the same as those observed in Reach Eight of the lower main stem.

Flow patterns at this location are similar to upstream sites in that peak flows are severely truncated in all but high water availability years. Bankfull discharge at this site is 600 cfs ± 50 cfs. The duration curve shows that the occurrence of bankfull discharges have dropped from approximately 33 days per year to 10 days per year, a roughly 70 percent reduction.

Jocko River below Lower J Canal

Stream flow patterns at the Jocko River below Lower J Canal characterize the hydrology of Reach Four, and the pattern is similar at the mouth of the drainage. All surface tributaries have joined with the river, and there are no known significant ground water gaining areas between this site and the mouth.

Table 2.2.4-2.

Summary of flow duration characteristics for specific measurement sites.

Flow class	1500 cfs		1000 cfs		500 cfs		250 cfs		100 cfs		50 cfs		10 cfs	
	% of time exceeded	Days per year	% of time exceeded	Days per year	% of time exceeded	Days per year	% of time exceeded	Days per year	% of time exceeded	Days per year	% of time exceeded	Days per year	% of time exceeded	Days per year
S Fork					0.5%	2	3.5%	13	16.7%	61	28.0%	102	86.4%	315
N Fork existing flow					0%	0	1.0%	4	4.3%	16	7.6%	28	53.8%	196
N Fork naturalized flow					0.38%	14	6.0%	22	15.8%	58	21.6%	79	53.8%	196
M Fork existing flow					0%	0	0.2%	7	2.8%	10	17.2%	63	72.2%	263
M Fork naturalized flow					0%	0	0.3%	11	4.8%	18	15.8%	58	48.8%	178
Jocko below Big Knife existing flow	0.2%	1	1.1%	4	2.7%	10	7.9%	29	23.0%	84	63.7%	233	100%	365
Jocko below Big Knife naturalized flow	0.3%	1	2.1%	8	9.0%	33	18.6%	68	32.3%	118	63.9%	233	100%	365
Jocko River below Lower J Canal existing flow	0.8%	3	1.6%	6	5.9%	22	18.4%	67	98.4%	359	100%	365	100%	365
Jocko River below Lower J Canal naturalized flow	1.3%	5 days	4.2%	15	16.3%	59	34.2%	125	94.7%	346 days	100%	365	100%	365

The same types of relationships between existing and naturalized flow exist at this site as upstream sites except that the influence of irrigation withdrawals is muted because of the contributions of tributary inflows and significant groundwater gain upstream of the site. Bankfull discharge in this reach equals 1,050 cfs ± 75 cfs (Subsection 2.3). The duration curve shows that the occurrence of bankfull discharge has dropped from approximately 15 days per year to 6 days per year, a reduction of 60 percent.

Table 2.2.4-2 summarizes the information reported in the duration curves. For identified sites, the table reports the percent of time discharge was equaled or exceeded and the approximate number of days per year the specific flow class occurs.

A flood-frequency analysis comparing existing and naturalized flood flows is also included in the Hydrology Report. It shows that under the existing flow regime, higher recurrence interval floods occur much less frequently than they would have naturally. However, larger magnitude, low recurrence interval floods are not heavily influenced by irrigation withdrawals. This is because there are hydraulic limitations on the storage and diversion capacity of the irrigation infrastructure. Subsection 2.3 provides an in-depth review of flood characteristics in the lower main stem.

Groundwater Resources

Groundwater in the valley floor area of the Jocko River Drainage occurs in unconsolidated glacial outwash and alluvial aquifer systems. The most extensive lateral aquifer is the unconsolidated glacial outwash aquifer, located along the axis of the Jocko River from upstream of the confluence with the North Fork to about Valley Creek. Lower portions of this aquifer, from Arlee to Valley Creek, interfinger with river-reworked alluvial sediments. Along Jocko Spring Creek, the aquifer transitions to a confined system overlain by fine textured alluvial and glacial lacustrine sediments.

Through Ravalli Canyon downstream to the confluence with the Flathead River, the Jocko River flows over an alluvial aquifer system comprised of sandy gravels interbedded with laterally continuous brown sand layers. Water occurs in more gravelly layers, generally at depths greater than 20 feet.

Figure 2.2.4.1 is a potentiometric surface map for the maximum seasonal water table elevation period, July and August. Groundwater flows along streamlines in a direction perpendicular to the water table contours. The map shows areas where groundwater flow is directed toward the Jocko River. These areas correspond to recognized zones of groundwater upwelling.

The Jocko River interacts dynamically with underlying unconfined aquifer materials throughout its length. There are gaining and losing reaches in headwater tributaries related to valley floor geology, slope and tributary inputs, and irrigation dam seepage. Upstream of the confluence with Big Knife Creek on the main-stem Jocko River there is a groundwater gaining reach where the cross sectional area of alluvial valley fill is reduced by bedrock confinement. Downstream of Reach Seven, where the alluvial valley becomes unconstrained, gaining and losing reaches migrate based on seasonal changes in water table elevations.

Groundwater discharge is a significant component of the river base flow. It forms substantial floodplain wetlands and spring channels, and the surface and groundwater interactions along the ecological floodplain provide a critical platform for restoration activities.

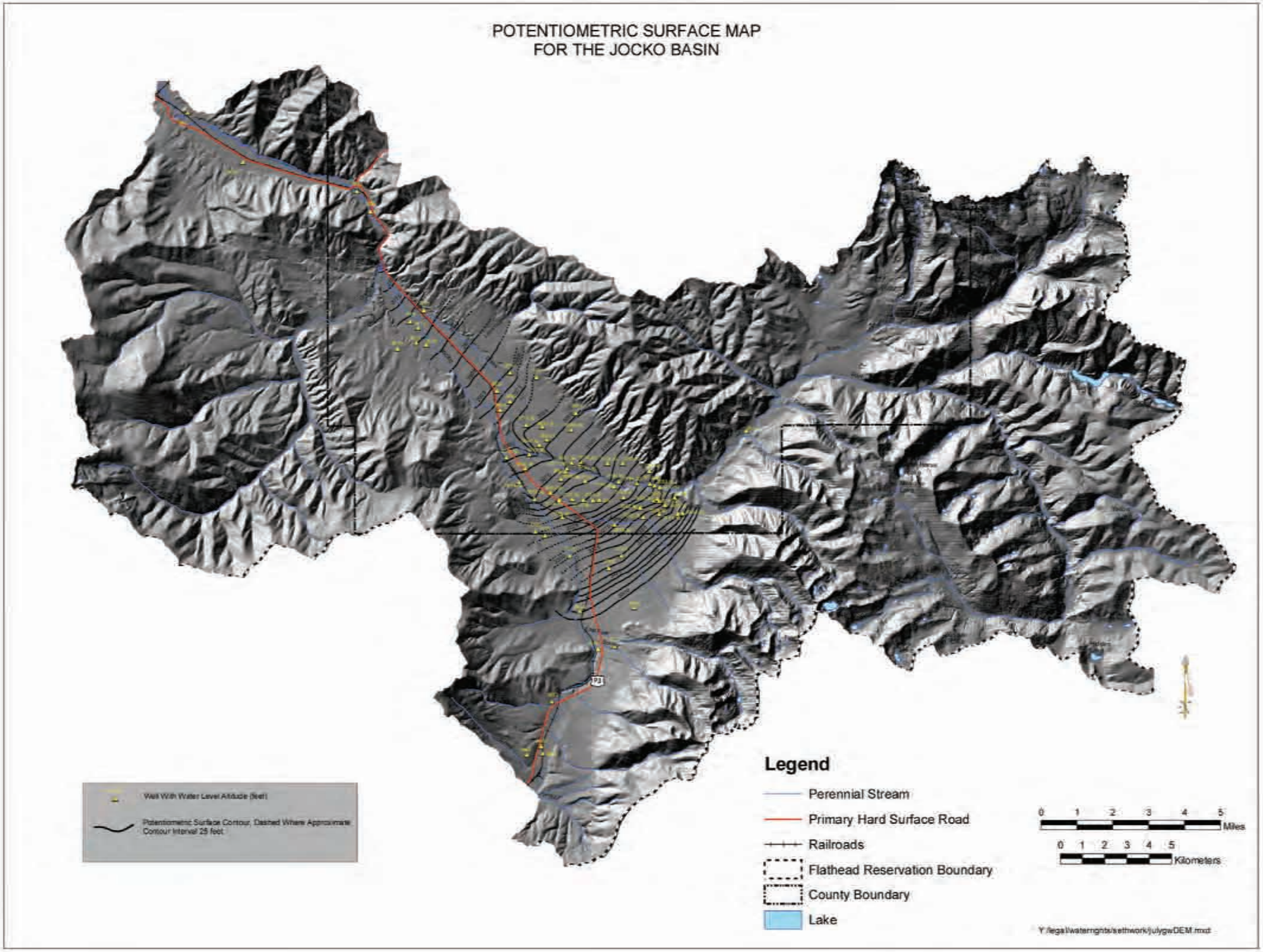


Figure 2.2.4.1.
A potentiometric surface map for the maximum seasonal water table elevation period, July and August.

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2.3 Hydrology and Flood-series Analysis

2.3.1 Introduction

This subsection describes the methodology used to determine the bankfull discharge and flood series, both of which are important to characterize river flow and provide input for river restoration designs. The analysis divides the river into three segments:

- The lower main stem from the mouth to the confluence with Valley Creek (Reaches One, Two, Three, and Four);
- The Jocko River from Valley Creek to the confluence with Finley Creek (Reaches Five, Six, and Seven); and
- The upper Jocko River from the Finley Creek confluence upstream (Reach Eight).

2.3.2 Bankfull Discharge Analysis Techniques

The bankfull discharge is the dominant, or channel-forming discharge that shapes and maintains the channel system over time. It affects channel attributes like channel dimension, pattern, and profile, as well as floodplain width, which is also influenced by the valley type, gradient, and geologic controls (Leopold et al. 1964).

Bankfull discharge occurs most years for a short period of time and is roughly equated to the mean annual peak discharge. Commonly, the bankfull discharge has a 1.5-year ($Q_{1.5}$) to 1.8-year ($Q_{1.8}$) recurrence interval. This recurrence interval has been recently corroborated for western Montana streams (Lawler 2004).

We used three methods to estimate the bankfull discharge for the lower main stem: hydraulic geometry and hydraulic modeling; high-flow bankfull field calibration; and Jocko River stream-gauge evaluation. The first two methods are similar; the second uses the first to predict stream discharge. The U.S. Geological Survey (USGS) developed regional equations for flood-frequency analysis based on drainage area and precipitation (Omang 1992; Parrett and Johnson 2004). This method is usually employed as another way to estimate bankfull discharge. However, because hydrology in the Jocko drainage has been heavily altered, the existing stream gage and reference reach information provides a better estimation than the USGS method, although we do use the Omang equations in our flood-frequency analysis.

Hydraulic Geometry and Hydraulic Modeling

We identified and surveyed five reference reaches for bankfull field calibration prior to the 2002 spring runoff. We will use field data and the hydraulic modeling results for the five reference reaches to develop design channel dimensions for stream restoration projects. The station, stream type according to Rosgen (1996), and approximate location of each reference reach is listed below (and shown in Appendix D-3):

- Station 80+00, B3c type stream, located east of Dixon, Montana in Reach Two.
- Station 380+00, C4 type stream, located in the upstream portion of Reach Three.
- Station 880+00, C4 type stream, located in the middle of Reach Six.
- Station 1180+00, B3c type stream, located upstream of Reach Eight.
- Station 1280+00, C4 and B3c type stream, located upstream of Reach Eight.

We were able to identify bankfull indicators in the reference reaches, which improved our confidence in the hydraulic modeling results. Bankfull features are generally those indicators that are consistent with the $Q_{1.5}$ discharge and include the point of incipient flooding at the inside of bends, terrestrial vegetation line, scour line, top of point bar formation, and topographic breaks in the streambank profile. We completed channel cross sections, longitudinal profiles, and bed material sampling in the field to develop the hydraulic geometry of each reference reach. We then used these data to calibrate the discharge models used to estimate the discharge at any stage from base flows to the bankfull discharge. We used channel elevation data to estimate bankfull discharge. We then validated the model with a low-flow discharge measurement completed prior to the 2002 spring runoff.

High-Flow Bankfull Field Calibration and Hydraulic Modeling

The high-flow calibration method is based on recording the surface-water elevation and slope during flows approaching the bankfull discharge. This information is used along with the hydraulic geometry developed during low flows. The surface water elevation and slope are modeled to yield a high-flow discharge estimate. We recorded water-surface elevations between May 22 and June 2, 2002, at stations 380+00, 880+00, 1180+00, and 1280+00. We also measured water-surface elevations on June 6, 2003 and made field observations on the reach 1280+00 on May 30, 2003, one day prior to the peak discharge for the year. We used WinXSPro, a channel cross section hydraulic calculation model (USDA 1998) to estimate bankfull discharge.

We used Tribal stream flow data at each stream gage to validate the modeling results of the first two methods (CSKT 2003). We used the actual stream flow values from the gauges to calibrate the hydraulic model at the measured water-surface elevation to accurately calculate the roughness coefficient and velocity. The calibration of the model during high flows provides an accurate estimate of the bankfull discharge.

We field surveyed most reaches during the high-flow period of 2002 and 2003. Differences between the water surface and the bankfull discharge were estimated. We then used the stream gages to determine actual discharge at the time of field review. This may be the best overall method of determining bankfull discharge over longer reaches because subtle hydraulic effects and changes between reaches can affect how an individual reach responds to the influences. In other words, at bankfull discharge, the water-surface elevation in some short channel reaches will be slightly below the bankfull stage (based on local bankfull indicators), some will be over the bankfull stage, and others right at the bankfull stage. While this seems somewhat unpredictable, variations in cross sections and hydraulics are constantly changing, and an overall assessment of a longer reach is usually necessary to make an accurate determination of bankfull discharge.

Jocko River Stream gage Evaluation

We plotted flood flow frequencies documented in the Hydrology Report on log-log scale to determine the Q1.5 -to-Q1.8-return-interval flood (approximately the bankfull discharge recurrence interval). Since the flood-frequency data were mean daily discharge values rather than instantaneous peak values, we made an adjustment to increase the mean daily value by values ranging from 12 percent down to 5 percent. These values are derived by comparing mean daily to instantaneous peak discharge for measured data at three gauges. We conducted one analysis to compare the mean daily value, the adjusted mean daily value, and the USGS instantaneous value for the one site where all three data sets were available (South Fork Jocko River).

We also identified the mean daily peak flow for water year 1999 (an average runoff year) at the stream gages within the project area and adjusted it upward by the appropriate percent to approximate the instantaneous peak discharge for an average year. We then compared all three methods to determine the best estimate of bankfull discharge. The results are included in the next subsection.

2.3.3 Bankfull Discharge Analysis Results

We present bankfull discharge estimates for three general reaches of the Jocko River based on the major hydrologic breaks described above and CSKT stream gage data. While there is some variation within the reaches due to groundwater inputs and ditch outflows, the variation is not significant enough to warrant refinement of the hydrology to a finer scale (i.e., smaller reaches). Tables 2.3.3-1 and 2.3.3-2 provide summary hydrology data for the Jocko River.

Table 2.3.3-1.
The surveyed reference reaches and estimated bankfull discharge results.

Reference Station	Location	Low Flow Hydraulic Model Results (cfs)	High Flow Hydraulic Model Results (cfs)	Gauge Station flows during field surveys (cfs) Water-surface elevation relative to bankfull indicators. Date
80+00	West of Dixon (Drainage Area: 388 mi^2)	1,080 - 1,144 (Riffle)	N/A	N/A
	CSM	2.8 to 2.9	N/A	
380+00	Reach Three (Drainage Area: 357 mi^2)	970 (run) 1,120 (riffle)	915 (riffle) 970 (run)	718 at Lower J Canal Gauge Station. 0.2-0.3 feet below indicators (5/22/02)
	CSM	2.7 to 3.1	2.6 to 2.7	2.0
880+00	Reach Six (Drainage Area: 245 mi^2)	882 - 939 (riffle) 886 - 940 (run)	952 - 1,011 (run)	Appears to be an error in measurement
	CSM	3.6 to 3.8	3.9 to 4.1	
1180+00	Above Reach Eight (Drainage Area: 151 mi^2)	500 - 570 (riffle)	581 - 626 (riffle)	470 at K Canal Gauge Station. 0.2 feet below indicators (6/7/02)
	CSM	2.6	3.8 to 4.1	3.1
1280+00	Above Reach Eight (Drainage Area: 151 mi^2)	550 - 580 (riffle) 483 - 507 (run) 545 - 583 (riffle)	600 ± (riffle)	470 cfs at K Canal 0.2 feet below indicators (6/7/02)
	CSM*	3.0 to 3.9	2.0	3.1

*CSM * = (CFS/Drainage Area), Gauge values are for less than the bankfull discharge but can be used as a relative value for comparing the modeling results.*

Table 2.3.3-2.
The surveyed reference reaches and estimated bankfull discharge based on hydraulic modeling results.

Reference Station	Reference Reach	Estimated Bankfull Discharge (cfs) To Be Used for Design Purposes	Unit Discharge per Square Mile (CMS)
80+00	West of Dixon (Drainage Area: 388 mi^2)	1,050 ± 75	2.9
380+00	Reach Three (Drainage Area: 357 mi^2)	1,050 ± 75	2.9
880+00	Reach Six (Drainage Area: 245 mi^2)	825 ± 75	3.4
1180+00	Above Reach Eight (Drainage Area: 151 mi^2)	600 ± 50	4.0
1280+00	Above Reach Eight (Drainage Area: 151 mi^2)	600 ± 50	4.0

Lower Main-stem Jocko River downstream from Valley Creek (Reaches One, Two, Three, and Four)

The hydraulic modeling method generated a bankfull discharge estimate of between 970 cfs and 1,120 cfs at the stream gage downstream from the Lower J Canal and between 1,080 cfs and 1,144 cfs near Dixon. The high-flow method yielded an estimated bankfull discharge of between 915 cfs and 970 cfs in 2002 and about 1,010 cfs in 2003 in Reach Three near the Lower J Canal stream gage. During the 2002 field survey, the water surface was about 0.3 feet less than bankfull stage with a gauged discharge of approximately 720 cfs. During the 2003 field survey, the gauged discharge was approximately 1,010 cfs, and the water surface was very near the bankfull condition for most of Reach Three. The hydraulic calculations appear to be accurate in estimating bankfull discharge at about 1,000 cfs.

During the May 2003 field survey, the discharge was about 1,010 cfs at the Lower J Canal stream gage. A field review of the stream indicated that the discharge was very close to bankfull stage based on local indicators. The peak discharge was about 1,062 cfs on May 31, 2003. During the 1999 water year, the peak mean daily discharge was 880 cfs, which would equate to about 925 cfs instantaneous discharge on an approximately average year. The Hydrology Report indicates that the existing discharge for the Q1.5 -to-Q1.8-return-interval flood for the Lower J Canal stream gage would be between 660 cfs and 770 cfs (adjusted upward by 5 percent to convert mean daily discharge to instantaneous) (CSKT 2003). The USGS stream gage near Dixon provides another source of information for calibrating the bankfull discharge. Based on a flood-series analysis by Makepeace (Figure 5 in CSKT 2001), the $Q_{1.5}$ to $Q_{1.8}$ return interval flood for the USGS Dixon stream gage would be between 750 cfs and 900 cfs.

Based upon these data, we determined the bankfull discharge should be approximately 1,050 cfs with a range of between 975 cfs and 1,100 cfs for Reaches One, Two, and Three. Reach Four, from Valley Creek to the Highway 200 Bridge, would have a slightly higher discharge at bankfull conditions than Reaches One through Three. Based on the Hydrology Report, there are no major groundwater sources downstream from Valley Creek. However, the Lower J Canal takes an estimated 50 to 60 cfs out of the river in Reach Three during high-flow conditions. Hence, bankfull discharge for Reach Four should be about 1,100 cfs with a range of between 1,025 and 1,175 cfs.

To further validate these determinations, we compared data from stream gages for an average water year. In 1999, the mean daily peak discharge was 760 cfs at the stream gage below Finley Creek (CSKT 2003). Valley Creek contributed approximately 160 cfs and Jocko Spring Creek delivered approximately 20 cfs on about the same date. Additional groundwater sources added approximately 30 cfs in late May for a cumulative total of approximately 970 cfs. On about the same date in 1999, the stream gage downstream from the Lower J Canal recorded a mean daily discharge of approximately 880 cfs, which does not account for the diversions from the Lower J Canal during this time period. Assuming the Lower J Canal is diverting approximately 60 cfs, the gauged discharge would be approximately 940 cfs. By converting the mean daily discharge to instantaneous discharge, the result would be a peak discharge ranging between 990 cfs (105 percent of 940 cfs) and 1,020 cfs, which is well within the range of the selected bankfull estimate for Reach Four.

The Hydrology Report indicates that the existing peak flow discharge during an average year is approximately one half (51 percent) of the historical or "naturalized" discharge prior to diversion. The effects are more pronounced during dry years (existing flow diminished by more than 60 percent) and much less pronounced during above average years (existing peak flow diminished by less than 20 percent) (CSKT 2003). The physical and geomorphic effects of this reduction are discussed by reach in Section 3.0.

Middle Jocko River between Finley Creek and Valley Creek (Reaches Five, Six, and Seven)

The hydraulic modeling method generated a bankfull discharge estimate ranging between 850 cfs and 890 cfs. The high-flow method yielded an estimated bankfull discharge of between 580 cfs and 630 cfs. Stream flow measurements at the stream gage downstream from Finley Creek (below the S Canal) were adjusted during the 2002 water year due to a peak flow rating shift and were not used in this determination. The calculated discharge (derived by adding data from the stream gage below Big Knife Creek to the stream gage below Finley Creek) was approximately 665 cfs. During the field survey, the water surface was about 0.2 feet less than bankfull stage. The hydraulic calculations appear to be accurate in estimating bankfull discharge at approximately 850 cfs.

During the May 2003 field survey, the discharge was approximately 828 cfs. A field review of the stream indicated that the discharge was very close to bankfull stage based on local indicators. The peak discharge was approximately 988 cfs on May 31, 2003. During the 1999 water year, the peak mean daily discharge was 760 cfs, which would equate to approximately 815 cfs instantaneous discharge on an average year. The Hydrology Report indicates that the existing discharge for the Q1.5 -to-Q1.8-return-interval flood for the stream gage downstream from Finley Creek would range from 465 to 570 cfs (adjusted upward by 7%) (CSKT 2003).

Based upon these data, the selected bankfull discharge should be approximately 825 cfs with a range of between 750 cfs to 900 cfs. The downstream end of the reach, starting at about Station 637+00 (the Squeque drain input), would have slightly higher discharges at bankfull conditions due to groundwater and spring inputs. Based on the Hydrology Report, during early June there is an average of 50 to 60 cfs discharging into the river from groundwater sources during peak flow conditions (CSKT 2003). The bankfull discharge estimates should be increased to account for these additional sources to approximately 875 cfs with a range of between 800 cfs and 950 cfs.

To further validate the bankfull discharge determination, we compared stream gage data for an average water year (using the 1999 discharge data). In 1999, the mean daily peak discharge was 640 cfs at the stream gage below Big Knife Creek (CSKT 2003). An additional 130 cfs was delivered by Finley Creek, and another 20 cfs was contributed by groundwater sources near the State of Montana's Arlee

Fish Hatchery in late May (CSKT 2003). The summation is a mean daily discharge of approximately 790 cfs cumulative discharge downstream from Finley Creek. On about the same date in 1999, the stream gage downstream from Finley Creek recorded a mean daily discharge of approximately 760 cfs, which does not account for the diversions from the Lower S Canal during this time period (CSKT 2003). Converting the mean daily discharge to instantaneous discharge results in a peak discharge of approximately 815 cfs (760 cfs times 105 percent), which is within the range of the selected bankfull estimate.

The Hydrology Report indicates that the existing discharge during an average year is approximately one half (45 percent) of the historical or "naturalized" discharge prior to diversion. The effects are more pronounced during dry years (existing flow diminished by more than 70 percent) and much less pronounced during above average years (existing peak flow diminished by less than 13 percent) (CSKT 2003). The physical and geomorphic effect of this change from historical conditions is discussed by reach in Section 3.0.

Upper Jocko River upstream from Finley Creek (Reach Eight)

The hydraulic modeling method generated a bankfull discharge estimate ranging between 460 cfs and 580 cfs. The high-flow method yielded an estimated bankfull discharge of between 580 cfs and 630 cfs. Stream flow measured at the K Canal stream gage was 470 cfs on the day of the high-flow survey in 2002 and was approximately 0.2 feet less than the bankfull stage. The hydraulic calculations appear to be accurate in estimating bankfull discharge.

During the May 2003 field survey, the discharge was approximately 690 cfs. A field review of the stream indicated that the discharge was very close to bankfull stage based on local indicators. The peak discharge was approximately 810 cfs on May 30, 2003, which left high water marks that were 0.4 to 0.5 feet above bankfull stage. During the 1999 water year, the peak mean daily discharge was 640 cfs, which would equate to approximately 720 cfs instantaneous discharge on an average year. The Hydrology Report indicates that the existing discharge for the $Q_{1.5}$-to-$Q_{1.8}$-return-interval flood for the stream gage downstream from Big Knife Creek would be between 450 cfs and 550 cfs (adjusted upward by 12 percent) (CSKT 2003).

Based on these data, the selected bankfull discharge should be approximately 600 cfs with a range of between 550 cfs and 650 cfs. The downstream end of the reach, starting at about the Arlee Fish Hatchery, would have slightly higher discharges at bankfull due to groundwater and spring inputs. Based on the Hydrology Report, during early June there is an average of 20 cfs discharging into the river from groundwater sources during peak flow conditions (CSKT 2003). The bankfull discharge estimates should be increased to account for these additional sources.

The Hydrology Report also indicates the existing discharge during an average year is approximately one half of the historical or "naturalized" discharge prior to diversion. The effects are more pronounced during dry years (existing flow diminished by more than 70 percent) and much less pronounced during above average years (existing peak flow diminished by less than 20 percent) (CSKT 2003). The physical and geomorphic effect of this change from historical conditions is discussed by Reach in Section 3.0.

2.3.4 Bankfull Discharge Analysis Summary

We used three methods to estimate the bankfull discharge in five project reaches. The results indicated a continuous downstream increase in discharge. The bankfull discharge per unit area decreased slightly with increasing watershed area. This trend exists because there is a higher proportion of lower-elevation areas that receive less precipitation than higher-elevation headwater areas. There is also an increasing number of downstream diversions during the peak flow period. Table 2.3.4-1 summarizes bankfull discharge estimates by reach.

Table 2.3.4-1.
Estimated bankfull discharge for the main-stem Jocko River by reach.

Jocko River Reach	Reach Description and Drainage Area	Estimated Bankfull Discharge (cfs)	Unit Discharge per Square Mile (CSM)
Reach One Reach Two Reach Three	Mouth of the Jocko River to Ravalli (Drainage Area: 380 mi^2)	1,050 ± 75	2.8
Reach Four	Ravalli to Valley Creek Confluence (Drainage Area: 352 mi^2)	1,100 ± 75	3.1
Reach Five	Upstream from Valley Creek to the Squeque Ditch (Drainage Area: 278 mi^2)	875 ± 75	3.2
Reach Six, Reach Seven	Squeque Ditch to Finley Creek Confluence (Drainage Area: 238 mi^2)	825 ± 75	3.5
Reach Eight	Upstream from Finley Creek Confluence (Drainage Area: 165 mi^2)	600 ± 50	4.0

2.3.5 Flood-Series Analysis

In 2006, the USGS completed a floodplain study and floodplain and floodway delineation of the lower main stem (Chase and Parrett 2006). The study defines the limits of the 100-year floodplain and floodway and the 500-year floodplain. In addition, the study reports the results of a flood-frequency analysis for the 100-year and 500-year flood events. We used all available data to develop the flood-frequency analysis, including the Hydrology Report (CSKT 2003), USGS stream gage data, and USGS regional flood-frequency equations (Omang 1992). Table 2.3.5.1 summarizes the results.

The analysis indicates that regional equations developed by Omang are generally close to the CSKT naturalized flow adjusted to instantaneous values. Existing flood flows are by and large considerably lower than the naturalized flows and Omang values after converting to instantaneous values, although the difference diminishes as the recurrence interval of the flood increases. This is consistent with the operation of the large irrigation diversions on the system. Generally, the diversions do not have the capacity to substantially affect large flood flows, but they are adequate to divert a large portion of small floods. Thus, the trend lines converge as the recurrence interval increases (as indicated by Figures 2.3.5-1 through 2.3.5-4). The result is that, relative to historical conditions, the ratio between a 100-year-recurrence-interval flood and the bankfull discharge is much greater with the existing hydrologic condition.

Table 2.3.5.1.
Summary of flood frequency estimates.

Recurrence Intervals	USGS Data	Omang Estimate (cfs)	CSKT Naturalized Flow adjusted (cfs)	CSKT Existing Mean Daily Estimate (cfs)	CSKT Existing Data adjusted (cfs)
Jocko River below Big Knife Creek – instantaneous peaks 12% greater than mean peaks					
2		1245	1165	486	545
5		1741	1610	892	1000
10		2226	1933	1234	1380
20		2597	2265	1619	1815
50		3000	2730	2206	2470
100		3283	3110	2718	3045
Jocko River below Finley Creek– instantaneous peaks 7% greater than mean peak					
2		1380	1290	545	585
5		1960	1790	1007	1080
10		2515	2150	1398	1495
20		2940	2500	1840	1970
50		3400	2985	2516	2690
100		3720	3365	3106	3325
Jocko River below Lower J Canal– instantaneous peaks 5% greater than mean peak					
2		1636	1385	674	710
5		2354	1875	1127	1185
10		3046	2215	1493	1570
20		3569	2560	1893	1990
50		4116	3025	2490	2615
100		4498	3395	3000	3150
South Fork Jocko River (Equals Naturalized Flow)					
2	399	484	380	317	380
5	612	701	610	508	610
10	773	904	796	663	796
20			1002	835	1002
25	999	1075			
50	1180	1254	1315	1096	1315
100	1380	1385	1589	1324	1589
Big Knife Creek USGS					
2	38	68			
5	55	107			
10	67	141			
25	82	175			
50	94	209			
100	106	236			

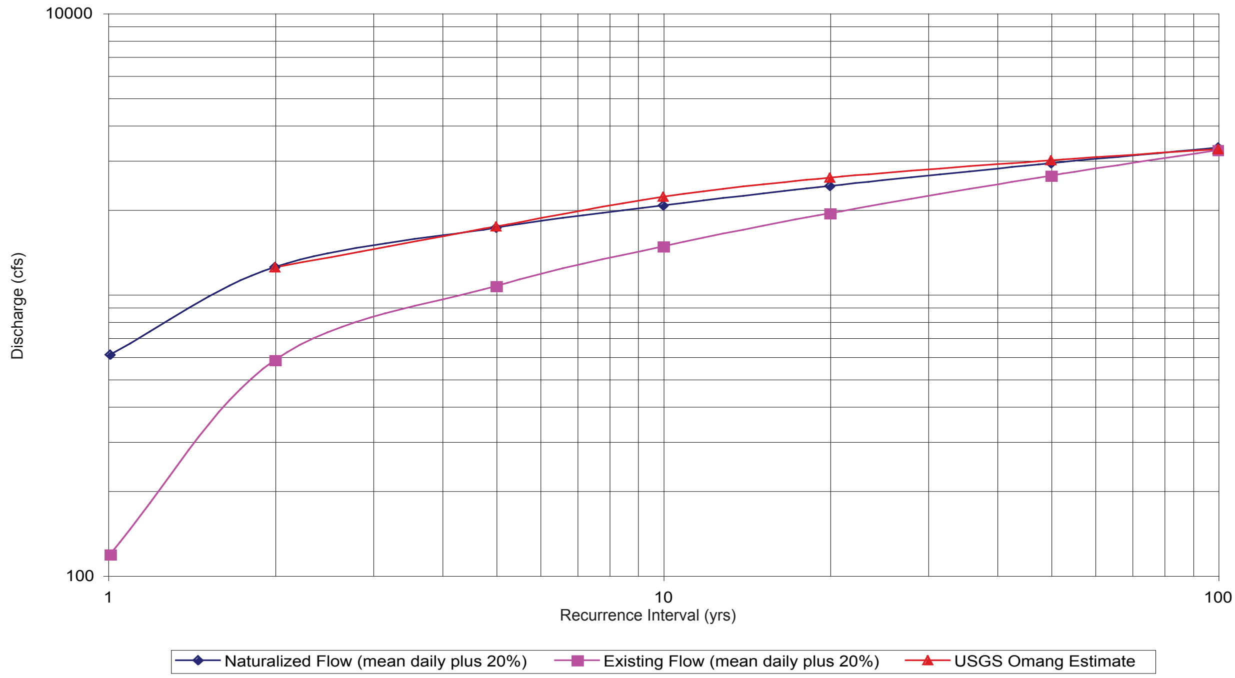

Figure 2.3.5-1.
Flood frequency curve for the Jocko River downstream of Big Knife Creek.

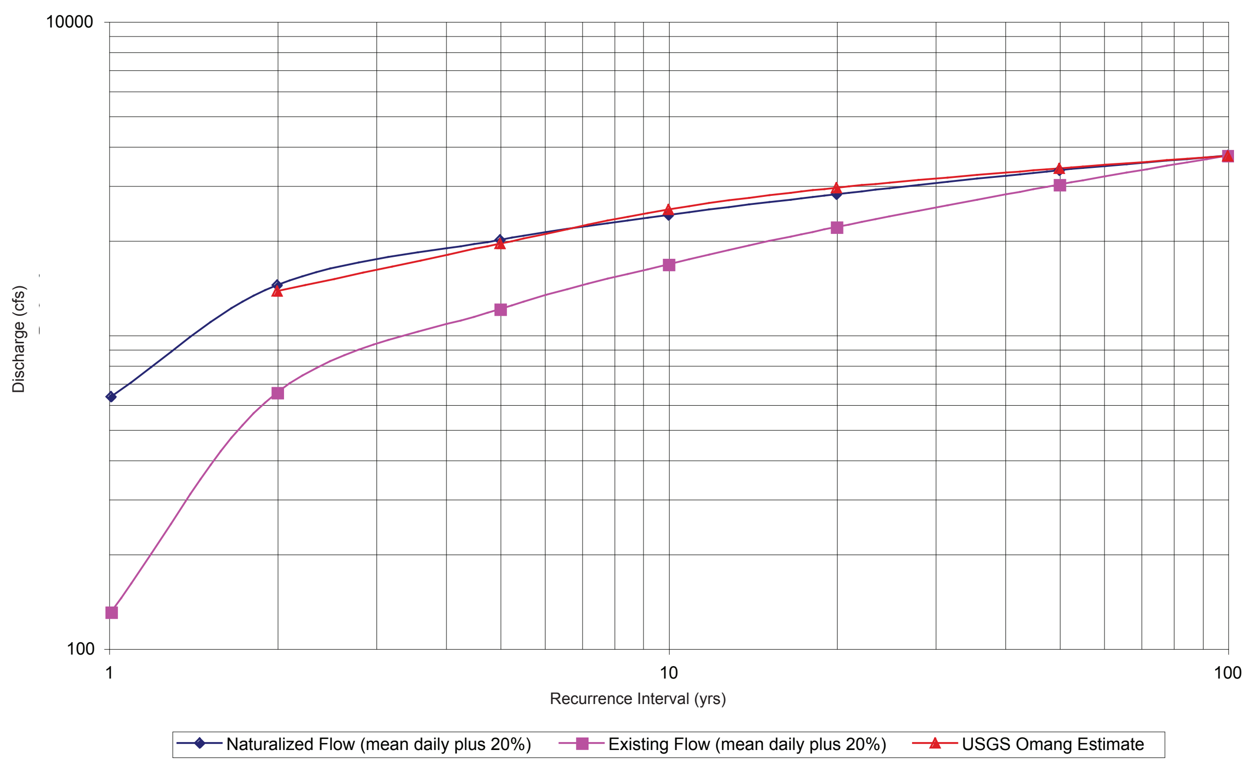

Figure 2.3.5-2.
Flood frequency curve for the Jocko River downstream of Finley Creek.

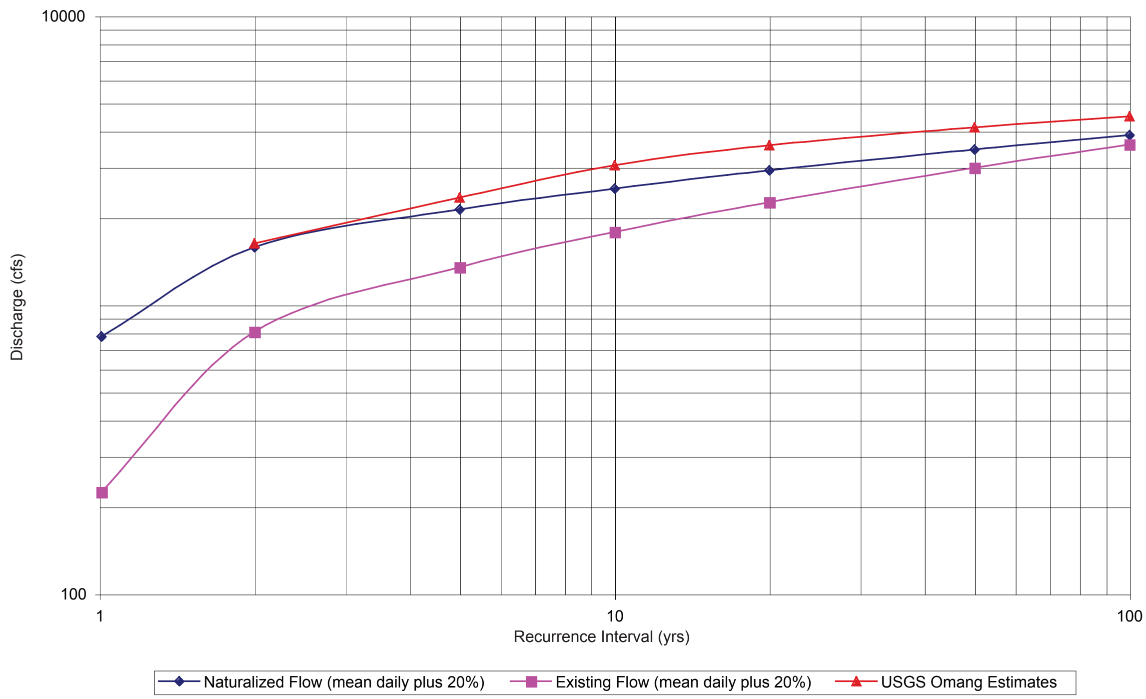

Figure 2.3.5-3.
Flood frequency curve for the Jocko River downstream of the Lower J Canal.

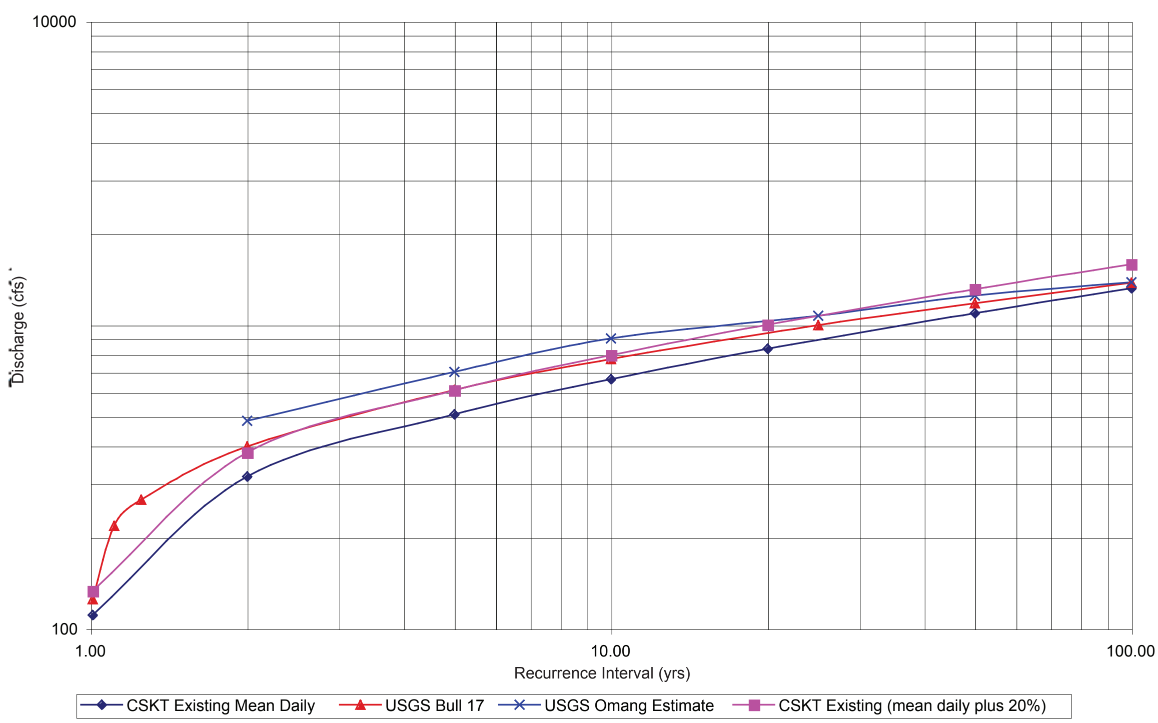

Figure 2.3.5-4.
CSKT and USGS flood frequency comparison for the South Fork Jocko River.

One way of measuring the change between historical and existing conditions with respect to the flood series is to examine the ratio of the large, infrequent floods to the smaller frequent floods. For the Jocko River downstream from Big Knife Creek, the ratio of the 100-year-return-interval to the 2-year-return-interval flood (Q_{100}:Q_2) for historical (naturalized) conditions is about 2.6 (3,110 cfs/1,165 cfs) as compared to 5.6 (3,045 cfs/545 cfs) for existing conditions. This indicates that the magnitude of the large floods relative to the annual high flows is much greater today than it was under historical conditions.

From the standpoint of stream restoration design, the altered hydrology of the basin presents additional challenges. The active channel must be sized for the current bankfull discharge, while the floodplain must be able to accommodate the historical flood conditions (see Section 3.0 for a discussion of channel adjustments following flow diversion). Without an adequate floodplain to disperse flood flows, the energy of a large flood would be concentrated in a channel with reduced cross-sectional area.

2.3.6 Summary

We subdivided the main stem of the Jocko River into three reaches based on tributary inputs to the main stem and then used three methods to estimate the bankfull discharge: hydraulic geometry and hydraulic modeling; high-flow bankfull field calibration; and Jocko River stream gage evaluation. Using these three methods, we predicted the channel-forming discharge in the three general reaches. Surface water diversion throughout the Jocko watershed and especially in the headwaters has significantly reduced the channel-forming or bankfull discharge, however, the infrequent, large-magnitude floods have not been diminished. Apparently, the diversions are either not capable of diminishing high-magnitude floods or are not fully diverting because less irrigation water is needed.

The reference reach data and bankfull flow modeling and calibration indicates that the reduction in bankfull flow due to diversion has reduced the channel cross-sectional area. While the channel has atrophied in response to the diminished average annual or channel-forming discharge, periodic high-magnitude floods continue to occur and they are not diminished proportional to the channel size. When this happens, the river experiences substantial bank erosion and lateral migration, especially where floodplain berms constrict flood flows to the active channel. Groundwater upwelling, floodplain spring creeks, and other tributaries contribute substantially to late summer and fall flows in the main stem. For more detailed information on the effects of altered stream flow on channel conditions, fish habitat, and floodplain vegetation refer to Sections 2.1, 2.2, 2.5, 2.7 and 2.10.

2.4 Channel Morphology and Geomorphic Assessment

2.4.1 Introduction

The following subsections discuss the historical, existing, and potential channel morphology, highlighting the processes that have created the impaired channel conditions. They also describe reference reaches—those portions of the river corridor that still function as they did under historical conditions (Subsection 2.4.5).

2.4.2 Watershed Disturbances and Stream Response

During pre-settlement times, it is likely that most of the Jocko River alternated between two stream types. The first, classified as a Rosgen C stream type (Rosgen 1996) or riffle-pool system (Montgomery and Buffington 1997) has a moderate gradient, meandering riffle-pool channel with a well-developed floodplain. This type of stream regularly accesses the floodplain during flood events that exceed the approximate mean annual or bankfull discharge. Floodplain access allows for the stream's energy to be dissipated and for fine sediments to be deposited. Greater amounts of large woody debris, vital for creating and maintaining aquatic habitat, controlling bed features, and storing sediment, characterize this type of stream. Because they deflect flows and influence bank erosion, debris jams can accelerate or dampen lateral channel migration. Streamside riparian vegetation maintains lateral bank stability, shades the stream, and influences aquatic and terrestrial habitat. Woody material and leaf matter contributed by riparian vegetation are integral to the aquatic food web. This stream type also provides temporary sediment storage in the form of point bars and floodplains. Over time, sediment is deposited and transported during high water periods when the bed material is mobilized. The stream's lateral and vertical stability is sensitive to anything that disturbs bank stability, sediment delivery, or water yield. Rapid changes in one or more of these factors typically results in an adjustment of the channel.

The second stream type, classified as a Rosgen B (Rosgen 1996) or step-pool or plane-bed stream (Montgomery and Buffington 1997) has a moderately entrenched channel with a low sinuosity and moderately steep channel gradient. It has minimal lateral floodplain development and a narrow valley width. Riffle/step-pool habitats maintained by structural bed controls and woody debris dominate. The higher gradient and confined channel condition reduces the sediment storage capacity. B stream types are transitional reaches in the stream type-sediment transport continuum, linking higher gradient stream reaches (e.g. headwater tributaries) with down-valley, low-gradient stream types (e.g. valley bottom streams). Bed and bank materials are relatively stable and depositional areas (e.g. point bars) are uncommon. Most of the valley gradients in the study area are less than 0.02 feet/foot. Because of the relatively low gradients, the moderately entrenched channels within the study area are designated as Bc streams.

Riparian vegetation clearing, land cover disturbances and over use, water diversions, and physical stream modifications (Subsection 2.2) have changed the historical form and function of the river. Changes in climate and large magnitude floods have also caused substantial adjustments to the channel, especially in the middle and lower portions of the watershed. Specific stream reaches have responded to the changes in various ways. Understanding those responses and the successional tendencies of the river is critical to the development of sound restoration projects. Those successional tendencies or channel succession processes (the gradual and orderly processes of change in a stream channel) can be used to predict with some confidence what channel conditions will be like in the future if the current degraded channel conditions are not addressed.

2.4.3 Reach Succession Scenarios

Rivers change when the variables that shape and maintain their form are altered. The factors influencing the adjustment of rivers include both extrinsic controls (e.g. climate, streambed elevational changes) and watershed development activities such as river channelization (e.g. levees), straightening, residential development, water diversions, and riparian vegetation conversion.

These and other changes have dramatically affected how the floodplain functions, how sediment is transported, and the quality of aquatic and riparian habitats. Specific stream reaches have responded in various ways to these alterations. Understanding those responses and the successional tendencies of the river is critical for developing sound restoration projects. Channel succession processes (the gradual and orderly processes of change in a stream channel) can be used to predict future channel conditions if current channel degradation is not addressed. Appendix F discusses Reach Succession Scenarios in more detail and includes conceptual cross-section diagrams that illustrate the probable stream type succession stages. Subsection 3.3 includes an example of how Reach Succession Scenarios are used in the restoration planning process.

2.4.4 Reach Descriptions

Introduction

In addition to time-series analysis of aerial photographs, we completed field reconnaissance and surveys to evaluate the existing river corridor conditions. The following paragraphs describe the river's flood history and the historical, existing, and desired future condition in terms of stream watershed disturbance, stream response, and restoration activities.

Flood History

The expansive floodplain and valley bottom of the Jocko Valley suggest the river has migrated over the valley floor for millennia. Prominent terraces adjacent to the floodplain once provided a wider floodplain for the river and its tributaries. Over the last 10,000 years, the river has eroded through these historical floodplain features, and they have become drier terraces. With each successive period of vertical incision, the river has formed a floodplain by lateral meander extension and floodplain building. Historical floods accessed these floodplains and maintained the processes responsible for creating, destroying, and recreating channel and floodplain features, the riparian corridor, and valley topography.

Conditions and dynamics like active channel migration, historical glaciation, watershed hydrology, and the expansive valley bottom created and maintained a diversity of off-channel habitats including; meander scrolls, sloughs, and spring creeks. Although the historical condition was more stable than the current condition, even under historical conditions the river probably experienced meander cutoffs, large wood debris jams, and avulsion channel formation. These would have created meander scrolls, floodplain ponds, and oxbow lakes. Potholes left by the receding glaciers would have increased the floodplain topography and habitat diversity.

Bedrock outcrops and locally elevated water tables would have created an abundance of shallow wetlands and spring creeks. Consistent water temperature regimes maintained by groundwater-fed spring creeks are known to be influential in supporting native fisheries. Historically, these spring creeks were beneficial to native fishes in the summer when Jocko and Flathead River water temperatures increased. Similarly, the consistent flows and temperatures would have provided refugia for fish during the metabolically stressful winter periods.

Reach Descriptions

Reach One
Lower Delta (3,700 feet in length), from the confluence with Flathead River upstream to the BNSF Railroad Bridge (SW 1/4 of Section 17) (Station 00+00 to 28+50).

Valley Morphology
Reach One is influenced by the expansive Flathead River valley, a valley type VIII under Rosgen (1996). The Jocko River enters the Flathead River valley from the southeast near the town of Dixon, Montana. Some characteristics of this valley are similar to valley type XI, which is typical of delta valley morphology. While historical aerial photos and survey maps do not show a braided, anastamosed channel system, an anastamosed pattern would be consistent with this valley type in an undisturbed condition. The valley gradient is approximately 0.006 feet/foot at the downstream end of the reach.

Historically, flooding by both the Jocko and Flathead Rivers influenced the form and function of the Jocko's channel and floodplain. Synchronized flooding could have created a substantial backwater effect. Today, the operation of Kerr Dam on Flathead Lake and Hungry Horse Dam on the South Fork of the Flathead River affect the timing of peak-flows on the Flathead system, which may now be somewhat desynchronized from those of the Jocko River. Desynchronized flood events may reduce the backwater effect.

Historical Stream Types
The channel occupies a historically active alluvial fan deposited at the mouth of the Jocko River. Historically, the channel was probably a Bc or C stream type but could have been a lower-gradient DA (braided anastamosed) stream type. Multiple existing and remnant channels in the reach suggest that the channel migrated actively during the historical period. Prior to the construction of the railroad, the Jocko River in Reach One may have been an anastamosed D stream type with multiple, well-vegetated, stable channel threads, but no data exist to confirm this. Railroad survey maps from 1883 indicate a single-thread channel, but they do not provide much detail for areas away from the proposed railroad right-of-way.

Watershed Disturbances and River Response
Substantial channel and floodplain modifications in Reach One have impacted the stability of the stream corridor. Meander scrolls up to 1,500 feet from the current channel alignment suggest the river has traversed the alluvial fan over the millennia. Downstream from the railroad bridge, the Jocko River was northeast of its current location prior to the twentieth century. According to the 1883 railroad survey map, the river traversed the existing, well-vegetated floodplain approximately 600 feet to the northeast of its current position.

The construction of the railroad bridge in the late 1800s may have caused the channel to migrate southward. The location of the train trestle and roadbed fill constricted the floodplain, reducing it from a width of approximately 700 feet upstream of the crossing to 100 feet through the crossing. The constriction causes a substantial backwater effect and sediment deposition and may aggravate lateral channel migration downstream from the trestle. Historical aerial photographs have captured the approximately decadal migration of the Jocko River downstream from the railroad crossing.

Time-series analysis of aerial photographs suggests the river has modified its configuration and location. However, the river does not appear to have returned to the location identified during the 1883 railroad survey. Channel modifications (e.g. bank armoring) and riparian vegetation clearing to the south have reduced bank stability, large woody debris inputs, stream shading, and aquatic and riparian cover.

Agricultural practices in this section may also contribute fine sediment, nutrients, and agri-chemicals to both the Jocko and Flathead Rivers.

Time-series analysis of aerial photographs also indicates that the channel may have lengthened over time from lateral migration and bank erosion, but the historical survey data are not detailed enough in this reach to confirm exactly how the length of the channel and channel pattern has changed. The meander-belt width, however, appears to be somewhat narrower than the historical condition (Table 2.4.4-1).

Table 2.4.4-1.
Channel morphology changes over time in Reach One as measured from historical aerial photographs and maps.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 1	2002	2,410	1,600	1.51	367
	1937	1,910	1,600	1.19	400
	1883	2,070	1,600	1.29	600

The BNSF railroad crossing, which marks the upstream extent of the reach, also impacts the stability of the channel and floodplain. Floodplain fill for the railroad bed constricts the channel and disconnects the floodplain upstream and downstream of the grade. It confines flows to the channel and increases the floodplain surface-water elevation during overbank flood events. It is likely that sediment deposition and debris accumulation occur upstream of the railroad crossing because it is undersized.

Existing Channel Conditions
The depositional alluvial fan located at the Jocko River's confluence with the Flathead River also affects the reach. Because the channel is located on an alluvial fan, some deposition is expected, but upstream channel modifications and disturbances have probably increased depositional rates, a pattern suggested by the over-widened active channel and prominent lateral bar features.

Because of an excessive channel width and sediment supply, Reach One has become an over-widened C or D stream type. Continued lateral meander extension will promote the delivery of more sediment. Unless the riparian vegetation recovers substantially, the channel will likely transition from an over-widened C stream type to a braided, sediment-impaired D stream type with poor aquatic habitats, channel instability, and a simplified riparian community.

Channel braiding results in a dynamic channel condition, one in which the river flows in multiple channels during low-flow periods. The result is shallow, simplified habitat prone to solar heating. An active channel avulsion downstream from the railroad bridge is currently threatening to capture the active channel. This would result in a straighter channel alignment, greater water-surface slope, and increased shear stress. Based on the available sediment load, active channel capture by the avulsion channel would accelerate Jocko River instability and increase sediment delivery to the Flathead River.

Summary of Existing Conditions and Trends
Reach One is best characterized by Reach Succession Scenario 2 (Appendix F). It is either in Stage 2 or 3, depending on how the channel is responding to the sediment load. The channel remains connected to the historical floodplain except where bank armoring has increased the native bank height.

Potential Channel Conditions and Recovery Potential
The recovery potential of Reach One is moderate with passive restoration, assuming continued rates of sediment delivery, current land uses adjacent to the channel, and the potential for riparian corridor recovery in the vicinity of the active channel. Reach Succession Scenario 2, Stage 3 is possible with passive restoration (Appendix F). The recovery of vegetation is essential if there is going to be significant reductions in the rates of bank erosion and channel migration. Due to the interaction between the Jocko River and the Flathead River, Reach One will continue to function as a depositional area, which means a certain level of instability is probably inevitable.

Another alternative would be to reactivate a defined floodplain channel to the north of the existing channel, which would improve channel-floodplain connectivity, reduce sediment inputs to the river, enhance riparian and aquatic habitat, and increase the channel length. The existing over-widened channel would be plugged and revegetated to create wetlands and additional floodplain acreage. The existing over-widened channel would be plugged and revegetated to create wetlands and additional floodplain acreage. Recovery potential is high with active restoration.

Reach One Summary
Excessive sediment and impaired aquatic habitats are causing Reach One to function below its potential. The reach is influenced by the backwater created during high flows on the Flathead and Jocko Rivers. Given the existing channel condition and channel processes operating within the reach, the channel will continue to destabilize and transition from an over-widened C stream type to a braided D stream type. Despite these trends, there is a high potential for restoration with active restoration, which would improve channel-floodplain connectivity, reduce sediment inputs to the river, enhance riparian and aquatic habitat, and increase the channel length.

Reach Two
Upper Delta (2,850 feet in length), from the BNSF Railroad Bridge (SW 1/4 of Section 17) upstream to Highway 212 Bridge (Station 28+50 to 56+50).

Valley Morphology
The valley morphology of Reach Two is similar to that of Reach One, except that in Reach Two, the Jocko Valley has a stronger influence on the river than the Flathead Valley. Reach Two is transitional, connecting the expansive Flathead River Valley, with the much more confined Jocko River Valley. The gradient averages 0.006 feet/foot.

Historical Stream Types
Historically, Reach Two was probably a moderately entrenched C stream type that was a transition zone from the upstream Bc stream type to the wider C/D stream types in Lower Delta. The 1937 photos show a C stream type in a Type VIII valley.

Historically, Jocko River floods affected Reach Two more than Flathead River floods. However, synchronized flooding of the two rivers could have created a substantial backwater effect that would have promoted sediment deposition and contributed to alluvial fan formation.

Watershed Disturbances and River Response

Localized channel modifications, floodplain filling, and transportation infrastructure affect the stream corridor. The primary modifications include the Highway 212 Bridge (Station 65+50) and the BNSF Railroad Bridge (Station 57+00) downstream of Highway 212. Floodplain berms between the two bridges have disconnected the channel from its adjacent floodplain, confined high flows between the berms, and raised the local water-surface elevation during high water events. The bridge at the upstream end of Reach One (Station 37+00) has also affected sediment transport. Riparian grazing along the southwest side of the channel has reduced the density of riparian vegetation and resulted in lower levels of bank stability, habitat creation, and stream shading. Table 2.4.4-2 summarizes channel and floodplain modifications in the reach.

Table 2.4.4-2.

Channel and floodplain modifications in Reach Two.

Reach	Encroachment feature	Channel Length (feet)	Affected Channel Length in Reach (Percent)
Reach 2	Channelization	1,605	55 %
Reach 2	Constructed levee	480	15 %

A review of time-series aerial photographs suggests that the Jocko River has maintained a consistent channel alignment and location in the upper half of Reach Two, where the valley is narrower. However, the railroad bridge marking the downstream end of the reach has changed the channel in the lower half. It has shortened with the abandonment of a meander on the south side. Time-series photographs indicate the active channel has migrated north. Sediment deposition upstream of the railroad bridge may have contributed to a channel avulsion and the ultimate capture of the active channel. Although the channel has been shortened, the abandoned meander provides diverse off-channel habitats that benefit fish and waterfowl. The railroad bridge and raised railroad grade paralleling the channel in the upper half of the reach have also encroached on the floodplain and straightened the channel. Although the results are less pronounced than in the lower half of the reach, the channel has changed from the historical C stream type to B and F stream types.

The time-series analysis indicates the channel has been shortened by about 600 to 900 feet, and sinuosity has dropped from about 1.5 to 1.1 (Table 2.4.4-3). The changes have reduced belt widths by about 200 feet on average.

Table 2.4.4-3.

Channel morphology changes over time in Reach Two as measured from historical aerial photographs and maps.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 2	2002	2,810	2,500	1.12	150
	1937	3,727	2,500	1.49	550
	1883	3,463	2,500	1.39	600

Existing Channel Conditions

Floodplain fill for the highway and railroad crossing abutments have converted the historical C4 stream type section to an F stream type with isolated Bc inclusions. Accelerated deposition on the downstream end of Reach Two has created a braided D stream type that has increased lateral channel migration, increased sediment inputs to the channel, and impaired the riparian zone. Channel braiding will continue to contribute to channel instability upstream of the lower railroad bridge.

Summary of Existing Conditions and Trends
The upper portion of Reach Two (Station 32+00 to 56+50) is in Stages 3 and 4 of Reach Succession Scenario 8, depending on the degree of braiding within the confined, though over-widened channel (Appendix F). The historical C stream type has changed to F and D stream types with isolated B inclusions. Floodplain berms and armored banks have isolated the channel from the adjacent floodplain, creating a Stage 3 condition. The lower extent of Reach Two (Station 28+50 to 32+00) is in Stage 2 of Reach Succession Scenario 2. The channel is currently braided, a response to the sediment load caused by the undersized railroad trestle.

Potential Channel Conditions and Recovery Potential
For the majority of Reach Two, recovery would be very slow and incomplete without active restoration measures. In the upper portion, on segments not confined by levees or berms, recovery to Stage 5 of Reach Succession Scenario 8 is possible using passive restoration (Appendix F). The river would eventually develop a narrow floodplain surface adjacent to the channel. In sections confined by levees, the river would probably remain at Stage 3 of Reach Succession Scenario 8 until it was able to erode through fill and reconnect with the floodplain.

In the lower portion of the reach, the channel condition is currently at Stage 2 of Reach Succession Scenario 2, and it will likely remain that way until the railroad bridge fill is modified to allow floodwater conveyance. In its current configuration, the railroad trestle fill will continue to confine flood flows to the active channel, causing a backwater effect and continued sediment deposition. Channel instability caused by channel aggradation will continue unless the bridge is modified.

With active restoration measures on Reach Two, two stream types are possible. The existing segment of F stream type could be reshaped and a bankfull bench constructed to create a flood-prone surface. Floodplain levees could be removed to reconnect the channel and floodplain. The conversion of the F stream type to a Bc stream type would follow Reach Succession Scenario 6. The downstream C/D stream type segment could be converted to a C stream type via Reach Succession Scenario 2. If the railroad crossing at the downstream end of Reach Two precludes this, the channel could be rebuilt as a B stream type. This would improve sediment transport through the railroad bridge. Rock grade control structures proposed for each crossing could also improve sediment transport through the crossings.

Reach Two Summary
Two bridge crossings are causing Reach Two to function below its potential. Floodplain levees confine flood flows to the channel, increasing scour potential and downstream sediment deposition. Although the infrastructure limits restoration treatments, the existing channel pattern and riparian vegetation provide opportunities for improving flood flow conveyance and sediment transport. Primary restoration objectives for Reach Two include reestablishing the fluvial processes necessary to maintain an efficient, stable channel capable of supporting diverse fish habitat.

Reach Three
Bison Range (37,250 feet in length), from the Highway 212 Bridge upstream to the Highway 200 Bridge near Ravalli, Montana (Station 56+50 to 430+00).

Reach Three is divided into fourteen subreaches according to stream type.

Valley Morphology
Influenced by valley type VIII morphology (Rosgen 1996), Reach Three is confined at its upstream and downstream ends. The valley follows an east-west fault at the north end of the St. Mary's Fault

Zone. The fault influences the valley morphology through this reach as well as upstream reaches. Lacustrine deposits and terraces from Glacial Lake Missoula are present along both sides of the valley. The channel was probably located in the middle of the valley floor prior to large-scale channel and floodplain modifications. The relatively narrow valley width constricted the lateral development of the channel in the corridor. Valley gradient averages 0.005 feet/foot.

Historical Stream Types

Historically, Reach Three was probably dominated by C stream types bracketed by short Bc segments where the valley is more confined at the upstream and downstream ends. The railroad 1883 survey maps suggest several short segments may have had a bifurcated or anastamosed channel pattern, but it is difficult to confirm this. The meandering C stream type was probably well-connected with a floodplain that supported a diverse riparian community. Large woody debris contributed by the cottonwood gallery forest would have created diverse fish habitat and influenced stream processes via sediment routing and storage.

Watershed Disturbances and River Response

The primary source of disturbance in Reach Three is agricultural development. To increase agricultural productivity, the river has been straightened and relocated. Floodplain berms adjacent to the southern channel margin limit overbank flows and have disconnected portions of the river from its floodplain. This has increased instream velocities and channel scour during elevated flows. Extensive riparian vegetation manipulation, including the replacement of riparian cover with agricultural crops, has substantially modified the historical gallery forest. Table 2.4.4-4 summarizes channel and floodplain modifications in Reach Three.

Table 2.4.4-4.
Channel and floodplain modifications in Reach Three.

Reach	Encroachment Feature	Channel Length (feet)	Affected Channel Length in Reach (Percent)
Reach 3	Bank hardening – rip rap	1,820	5 %
Reach 3	Channelization	7,520	20 %
Reach 3	Constructed levee	11,685	30 %

Infrastructure has also affected the stream corridor. A railroad crossing in the lower portion of the reach has caused downstream channel instability and resulted in an over-widened channel and mid-channel bar formation. The Highway 200 crossing appears to have limited influence on the channel during most flows, although a large backwater effect is apparent during floods. The levee and abandoned ditch headgate on the south bank about 1,200 feet upstream of the Highway 200 Bridge encroaches on the floodplain and confines flood flows. The railroad grade along the north bank also encroaches on the floodplain, although the impact has been minor.

The Lower J Canal is a prominent feature downstream of the Highway 200 crossing. Riprap in the channel raises the local water-surface elevation, facilitating water flow through the diversion structure. It has increased lateral and vertical channel instability and appears to require regular maintenance.

The railroad, constructed in the 1880s, and additional channelization that occurred between 1940 and 1960 are the dominant disturbances on the remainder of the channel. Based on the time-series analysis of historical photos, several meanders were shortened when the railroad was built. The 1883 railroad survey map is not detailed enough to accurately determine channel length, but the survey indicates the channel was within the railroad right-of-way in five locations. Between 1937 and 1962, berms were built to protect residential and agricultural floodplain infrastructure from high water events. Unimproved roads adjacent to the channel and on the floodplain intercept and divert overland flows. Road maintenance and roadbed stabilization may also influence flood flow routing and channel-floodplain connectivity. The alterations have shortened the channel length by about 5,500 feet (13 percent of total length before channelization) and decreased the sinuosity from about 1.4 to 1.2 (Table 2.4.4-5). Channel straightening has decreased the mean belt width from about 380 feet to 180 feet.

Table 2.4.4-5.
Channel morphology changes over time in Reach 3 as measured from historical aerial photographs and maps.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 3	2002	36,522	30,700	1.19	185
	1937	41,996	30,700	1.37	383
	1883	42,372	30,700	1.38	383

The location and construction of large, fortified fences, built by the Department of Interior to contain bison on the National Bison Range, have long influenced the location and stability of the Jocko River. Substantial concrete barriers or posts have been placed on either side of the Jocko River at numerous locations. Although the posts are no longer strung with barbed wire, they continue to influence fluvial processes.

It is difficult to ascertain the condition and location of the river in Reach Three-d during historical times. Based on the valley width, the extent of the historical riparian corridor, limited portions of the 1883 railroad survey, and an understanding of river function the channel was probably closer to the center of the valley (currently it is at the valley's northern margin). Review of the time-series aerial photographs suggests the channel alignment has not changed since about 1962. However, portions of the 1883 railroad survey of the area where the Jocko is near or crosses the railroad (areas where the channel survey was most accurate) suggest the channel was father south, towards the middle of the valley.

The substantial channel and floodplain modifications that took place during the nineteenth and twentieth centuries have impaired aquatic habitat, altered the sediment transport regime, and reduced riparian function. Since historical times, pool depths have decreased, the frequency of large woody debris has been reduced, in-channel sediment deposition has increased, and the floodplain has been inundated less frequently.

Existing Channel Conditions
Because of its length and complexity, we divided Reach Three into fourteen subreaches based on channel and floodplain characteristics. The following section describes each the subreach, starting at the downstream end.

Subreach Three-a (Station 56+50 to 75+50)
Subreach Three-a extends approximately 1,450 feet upstream of the Highway 212 Bridge. The lower portion of the channel is bordered by the BNSF railroad on the north and is influenced by the armored banks leading to the bridge. Riparian vegetation is sparse on the north side, suggesting a higher, drier surface than the south floodplain which is well-vegetated with a gallery forest. Upstream of the railroad bed, the hillslope forces the river to the south. The BNSF Railroad, the Highway 212 Bridge, an inactive diversion ditch, and a floodplain berm all affect the river.

The subreach is an F or Bc stream type according to Reach Succession Scenario 6 (Appendix F). The reaches are either in Stage 3 or 4 depending on the degree of channel-floodplain connectivity. Where the channel remains connected to the historical floodplain, the channel is in Stage 4. Where floodplain berms and armored banks have isolated the channel from the floodplain, it is in a Stage-3 condition.

Subreach Three-b (Station 75+50 to 105+00)
Subreach Three-b is a reference-condition B stream type approximately 2,700 feet in length. Adjacent valley walls constrict the stream corridor and limit lateral channel migration. The riparian community consists of a narrow strip of cottonwoods and willows on the flood-prone area adjacent to the channel. Agricultural and residential development to the south has reduced the width of the riparian zone. Based on the aerial photos from 1937 and the 1883 survey, the channel alignment, more sinuous than the upstream modified reaches, has not changed over the last 120 years.

Subreach Three-c (Station 105+00 to 132+00)
Subreach Three-c is an over-widened C stream type, potentially transitioning to a D. It is approximately 3,300 feet in length and bracketed by the downstream B reference reach and the upstream railroad crossing. Although it exhibits near-reference-reach conditions and has a diverse floodplain, mid-channel bars suggest sediment transport inefficiencies and may accelerate bank erosion. The southern margin of the belt width is constrained by a lacustrine terrace. The time-series analysis indicates that prior to 1962 the channel was more sinuous and meandered across the entire floodplain. Abandoned oxbows and off-channel springs are evidence of this. Large woody debris recruited from the extensive riparian zone to the north of the channel and distributed throughout the reach diversifies the aquatic habitat. The density of riparian vegetation south of the stream has been reduced.

The 1883 railroad survey in the vicinity of the railroad crossing shows the historical channel southeast of where it is now. Upstream of the railroad grade, a series of ponds and abandoned oxbows mark the historical channel. Similarly, downstream from the railroad grade, the channel was located closer to the middle of the valley in 1883 and 1937 than it is now.

Subreach Three-c is in Stage 1 or 2 of Reach Succession Scenario 2, depending on the channel's response to the sediment load (Appendix F).

Subreach Three-d (Station 132+00 to 183+00)
Subreach Three-d is an F and/or Bc stream type depending on the lateral confinement and is approximately 5,000 feet in length. Channel and floodplain alterations caused by agricultural development, the operation of the National Bison Range, and the location of the railroad are apparent throughout. The river has been relocated to the north edge of the valley and disconnected from its historical floodplain, which was quite expansive. A series of ponds and remnant channel segments suggest past channels were near the valley center. Paleo-channels can be seen where the riparian zone is moderately intact . Riparian logging and the conversion of native-vegetation to agricultural cover types have dramatically reduced the historical riparian forest. The result is reduced woody debris inputs to the river, lowered bank-scour resistance, and diminished aquatic habitat. The channel alignment is straighter than it would have been historically. Consequently, over-bank flows are less frequent, and the channel is dominated by homogeneous riffle habitats. These conditions will probably persist into the future unless active restoration measures are undertaken.

Subreach Three-d is in Stage 3 or 4 of Reach Succession Scenario 4a, depending on the degree of channel-floodplain connectivity (Appendix F). Where the channel has developed a narrow floodplain, it is in Stage 4. Where floodplain berms and armored banks have isolated portions of the channel from the adjacent floodplain, it is in Stage-3. Most of the subreach has probably degraded below the elevation of the historical floodplain.

Subreach Three-e (Station 183+00 to 211+50)
Subreach Three-e is an F and/or Bc stream type depending on the lateral confinement and is approximately 3,500 feet in length. Channel and floodplain alterations caused by agricultural development, the operation of the National Bison Range, and the location of the railroad are apparent throughout. The river has been relocated to the north edge of the valley and disconnected from its historical, expansive floodplain. Remnant riparian vegetation and potential paleo-channels suggest that historically, the river was to the south of where it is now. The channel alignment is also straighter than it was during historical times. Over-bank flows are less frequent, and the subreach is dominated by homogeneous riffle habitats. These channel conditions are likely to persist into the future without active restoration measures.

Subreach Three-e is in Stage 3 or 4 of Reach Succession Scenario 4a, depending on the degree of channel-floodplain connectivity (Appendix F). Where the channel has developed a narrow floodplain, the channel is in Stage 4. Where floodplain berms and armored banks have isolated portions of the channel from the adjacent floodplain, it is in Stage 3. Most of the subreach has probably degraded below the elevation of the historical floodplain.

Subreach Three-f (Station 211+50 to 240+50)
Subreach Three-f is a half-meander-wavelength C inclusion approximately 1,400 feet in length and bracketed by two straightened sections. It appears to be in the same alignment as the historical channel. The subreach may be a relic of the historical channel and riparian area and may merit evaluation as a reference reach. Dense riparian vegetation envelops its entire length. The property is maintained by the Department of the Interior as part of the National Bison Range. It is in Stage 1 of Reach Succession Scenario 2, although sediment loading from upstream straightened reaches may be increasing sediment deposition and channel widening, creating a Stage-2 condition (Appendix F).

Subreach Three-g (Station 240+50 to 250+75)
Subreach Three-g is an F and/or Bc stream type approximately 1,900 feet in length. The actual stream type depends on the degree of lateral channel confinement. The channel and floodplain appear to be intact, but the channel has been relocated to the north side of the valley and probably straightened. It is in Stage 3 or 4 of Reach Succession Scenario 4a, depending on the degree of channel-floodplain connectivity (Appendix F). Where the channel has developed a narrow floodplain, it is in Stage 4. Where floodplain berms and armored banks have isolated portions of the channel from the adjacent floodplain, it is in Stage 3. Most of the subreach is probably below the elevation of the historical floodplain.

Subreach Three-h (Station 250+75 to 260+50)
Located between two F stream type reaches, Subreach Three-h measures approximately 1,300 feet in length and is an over-widened C type. The stream has been in approximately the same location since at least 1937 and probably since 1883. The riparian forest, which is only partially functional, has been modified to the south on a privately owned floodplain. A pond on the outside of the channel meander is separated from the active channel by a narrow strip of floodplain. The property appears to be grazed, suppressing the little riparian vegetation that remains. To the north, the channel is confined by a hill, though the north floodplain, managed by the National Bison Range, has a more extensive riparian forest than that found on the southside. The subreach is in Stage 1 of Reach Succession Scenario 2, although sediment loading from straightened reaches upstream may be increasing sediment deposition and channel widening, creating a Stage 2 condition (Appendix F).

Subreach Three-i (Station 260+50 to 284+00)
Subreach Three-i is an F and/or Bc stream type nearly 2,300 feet in length. The river here is the straightest in all of Reach Three and flows almost entirely through the southern edge of the National Bison Range. It is unclear how the channel was modified to create the existing alignment, however, it is likely that it was relocated and straightened to some extent prior to 1955. The 1937 alignment indicates a much more sinuous channel, and the general alignment was present in the 1883 survey.

Subreach Three-i is in Stage 3 or 4 of Reach Succession Scenario 4a, depending on the degree of channel-floodplain connectivity (Appendix F). Historically, the channel was relocated to the north side of the valley. Where the channel has developed a narrow floodplain, it is in Stage 4. Where floodplain berms and armored banks have isolated portions of the channel from the adjacent floodplain it is in Stage 3. Most of this subreach is probably below the elevation of the historical floodplain.

Subreach Three-j (Station 284+00 to 311+00)
Subreach Three-j is an F and/or Bc stream type that is nearly 2,800 feet in length. The riparian area is fairly extensive because it has been managed by the National Bison Range.

It is in Stage 3 or 4 of Reach Succession Scenario 4a, depending on the degree of channel-floodplain connectivity (Appendix F). The channel has been relocated to the north side of the valley. Where it has developed a narrow floodplain, it is in Stage 4. Where floodplain berms and armored banks have isolated portions of the channel from the adjacent floodplain, it is in Stage 3. Most of the subreach is probably below the elevation of the historical floodplain.

Subreach Three-k (Station 311+00 to 345+00)
Subreach Three-k is, for the most part, a near-reference condition Bc stream type, transitioning into a C type. It is approximately 3,300 feet in length. The narrowing valley bottom constricts the width of the stream corridor, and the riparian corridor is denser on the narrow north floodplain managed by the National Bison Range. The channel alignment has a sinuosity of 1.17. The subreach is characterized by Stage 1 of Reach Succession Scenario 6 (Appendix F). The channel appears to be connected to its historical floodplain.

Subreach Three-l (Station 345+00 to 359+00)
Subreach Three-l is an F and/or Bc stream type nearly 1,500 feet in length. The channel appears to have been straightened, and riparian vegetation is functioning below the historical condition on the southern floodplain due to the conversion of native vegetation to agricultural fields.

The subreach is in Stage 3 or 4 of Reach Succession Scenario 4a, depending on the degree of channel-floodplain connectivity (Appendix F). The channel has been relocated to the north side of the valley. Where it has developed a narrow floodplain, the channel is in Stage 4. Where floodplain berms and armored banks have isolated portions of the channel from the adjacent floodplain, it is in Stage 3. Most of the subreach is probably below the elevation of the historical floodplain due to downcutting.

Subreach Three-m (Station 359+00 to 392+50)
Subreach Three-m is a C reference reach approximately 3,700 feet in length. The channel pattern has moderate sinuosity (1.4) and is well connected to the adjacent floodplain. The intact riparian corridor contributes large woody debris to the stream, provides stream shading, and increases bank stability. Although the channel alignment has been fairly stable over time, we identified some places where there have been channel adjustments. Previous alignments were in close proximity to the current location and within the current Jocko River belt width. Several off-channel habitats appear to occupy past

active channel locations. During field investigations, we identified woody debris recruited from the adjacent floodplain.

The subreach is in Stage 1 and Stage 2 of Reach Succession Scenario 2, depending on the channel's response to the sediment load (Appendix F). Mid-channel bars and channel widening suggest portions are trending towards Stage 2.

Subreach Three-n (Station 392+50 to 430+00)
Subreach Three-n is the farthest upstream subreach of Reach 3. Spanning from the C reference reach upstream to the Highway 200 Bridge, it is approximately 3,100 feet in length and has a sinuosity of 1.14. The 1883 survey indicates that the channel was bifurcated or anastamosed downstream from the Highway 200 Bridge. The northern braid may have occupied an existing spring at the toe of the northern valley limit. The southern braid meandered south of the railroad grade before joining the northern braid at about Station 410+00. The channel was straightened during the construction of the railroad, and during construction of the Jocko River Lower J Canal there were further modifications.

The existing channel is a Bc stream type due to berm placement and channel confinement. There are moderate channel and floodplain modifications in the focus subreach. The Lower J Canal branches off the main stem downstream from the Highway 200 Bridge. The diversion area is characterized by an armored "peninsula" and riprap grade-control feature that raises the local water-surface elevation. The riparian zone is functioning below its historical potential, largely due to vegetation removal on the adjacent floodplain. The subreach is in Stage 3 and Stage 4 of Reach Succession Scenario 4a, depending on channel-floodplain connectivity (Appendix F). The channel has been modified substantially in the vicinity of the Lower J Canal diversion. Bank armoring and levee construction have isolated portions of the channel from the historical floodplain.

Potential Channel Conditions and Recovery Potential
Without active restoration treatments, the impaired subreaches of Reach Three will probably remain impaired for the foreseeable future due to significant channel and floodplain modifications, riparian conversion, and continued sediment delivery. Most are in the entrenched stages of Reach Succession Scenario 4a or 6 (Appendix F). Channel segments in these stages are typically confined by floodplain levees, have been relocated and straightened in the past, and suffer substantial habitat impairment due to river corridor disturbances. Two restoration options are available for Reach Three: reconnect the channel to the historical floodplain or stabilize the channel in the existing location. Active restoration will be required to reconnect these confined reaches with the historical floodplain, or a new floodplain surface will need to be constructed to provide flood relief.

Summary
Reach Three has an array of stream conditions linked to past and current land use practices. In general, the current channel alignment (at the valley's northern edge) has been determined by land use practices that channelized and confined the river. Although the river is perpetually working towards dynamic equilibrium, floodplain berms continue to limit channel-floodplain communication. The conversion of riparian vegetation, which has occurred primarily on privately owned properties, has altered the historical riparian condition and has had substantial effects on the stream corridor. Replacement of the once extensive gallery forest with agricultural plant varieties has reduced the channel's resistance to lateral scour, decreased channel shading, and diminished the frequency and distribution of large woody debris in the reach.

Although the stream corridor has been substantially modified, there is tremendous potential for restoration. For most subreaches, two options exist. The first would return the river to its historical floodplain. This would provide the greatest long-term benefits, but also carries the highest cost. The second would leave the river in its current location and apply restoration treatments such as stabilizing eroding banks, adding woody debris to the channel, and removing existing floodplain berms that currently limit floodwater access to the adjacent floodplain. This option, while less expensive, will be less effective at restoring channel and floodplain functions over the long term.

Reach Four

Ravalli Canyon (16,200 feet), from Highway 200 Bridge upstream to Valley Creek Confluence (Station 430+00 to 593+00).

Valley Morphology

Reach Four lies predominantly in a canyon formed in Precambrian bedrock. The canyon itself may be the result of a fault; however, this is not well documented. The upstream 6,000 feet of the reach transitions rapidly from a valley type VIII morphology in Reach Five (broad alluvial, gentle slope with prominent terraces) to a valley type IV (narrow, gentle slope confined by canyon walls) as the width of the valley bottom decreases to less than 400 feet (Rosgen 1996). The valley bottom is wide enough to contain the river and a narrow floodplain, which is typical of C stream types. The side slopes are steep and highly dissected with low-order (small, dry) tributary inputs. The lower 10,000 feet of valley widens to about 1,000 feet and transitions back into a type VIII valley. The lacustrine deposits from Glacial Lake Missoula in Reaches Three and Five are absent in this canyon. At the downstream end of the reach, the valley begins to widen and bend to the west as it follows a fault line to the confluence with the Flathead River.

Virtually the entire valley bottom has been narrowed and confined by berms or levees. Beginning with the construction of the railroad in the late 1880s and continuing to present with the construction of US Highway 93 and residential and commercial floodplain encroachment, the effective valley width has been reduced to about one half of what it was historically. Rather than construct two railroad bridges to span portions of the river channel, the railroad cut off one large meander between Station 505+00 and Station 535+00. Several other meanders were truncated or abandoned during railroad construction.

Historical Stream Types

Historically, the river was most likely a C4 channel throughout this entire reach, although there could have been short segments of B3c channel types where the valley and floodplain were restricted. The 1883 survey maps show several segments where the river was braided or bifurcated. In these reaches, the historical channel types could have been D4 or D4a channel types (anastamosed condition characterized by stable, well-vegetated braids). Sinuosity, belt width and floodplain width were all much greater historically than they are today.

Watershed Disturbances and River Response

Disturbances in Reach Four include channelization, floodplain encroachment, riparian conversion, and hydrologic modifications related to the diversion of normal annual peak flows (Table 2.4.4-6). The few areas that had an adequate belt width were eliminated when additional levees were built sometime between the late 1800s and 1955. Some of the abandoned channel and other adjacent floodplain areas have been converted to ponds. Residences or businesses have also been built on the floodplain. (Subsection 2.3.2 summarizes the general effects of these various land uses on river function.) Currently about one mile of bank erosion and vegetation removal is affecting channel stability and sediment supplies. Appendix D-5 shows approximately how the channel pattern has changed since 1880.

Table 2.4.4-6.
Channel and floodplain modifications in Reach Four.

Reach	Encroachment feature	Channel Length (feet)	Affected Channel Length in Reach (Percent)
Reach 4	Channelization	12,185	75 %
Reach 4	Constructed levee	65	1 %

The channelization of the river increased gradient, which most likely led to localized downcutting into the remaining floodplain up to the Valley Creek confluence. These processes are discussed in more detail in Subsection 2.3.2.

An analysis of the historical stream patterns (based on the 1937 aerial photos and the 1883 railroad survey maps) compared to the most recent 2002 aerial photos indicate that a number of changes have occurred in response to channel disturbances. As summarized in Table 2.4.4-7, stream length decreased by about 1,400 feet (8 percent) as a result of the railroad construction and decreased again by about 1,000 feet (13 percent) feet due to other floodplain developments between 1937 and 1955. The greatest changes in length occurred in the downstream half of the reach. Sinuosity, which historically was about 1.24, is now about 1.08. Similarly, mean belt width, which was about 400 feet, is now less than 200 feet. The channel has been largely disconnected from its historical floodplain.

Table 2.4.4-7.
Channel morphology changes over time in Reach Four as measured from historical aerial photographs and maps.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 4	2002	15,963	14,800	1.08	180
	1937	16,949	14,800	1.15	300
	1883	18,374	14,800	1.24	400

At the downstream end of the reach, the BNSF Railroad Bridge and the Highway 200 Bridge have affected floodplain width, channel stability, and channel pattern. See Subsection 2.9 for a discussion of bridge effects.

Existing Channel Conditions
Most of this reach has been converted to Bc and F channel types. Where the levees allow for a narrow, well-vegetated floodplain, the stream is a B3c type. Where the levees completely confine the channel, the stream type is an F3 or F4. There is a short reach of C4 type channel between Stations 529+50 and 552+00, but it is somewhat entrenched within a very narrow floodplain. Bank erosion and down-valley migration is common in this segment. The majority of the reach is now riffle habitat. Pools and woody debris are extremely limited and generally poorly developed. Much of the channel lacks riparian vegetation.

Summary of Existing Conditions and Trends
Most of Reach Four is in Stages 3 and 4 of Reach Succession Scenario 4a, depending on whether the channel has formed a narrow floodplain or is confined by the levees (Appendix F). The short reach of channel between Station 540+00 and 570+00 is in Stage 3 or 4 of Reach Succession Scenario 9, depending on whether a C channel has formed within the narrow valley bottom or the channel is an F type (completely confined by levees). Most of the channel is straighter and steeper than the historical channel. Width-to-depth ratios are probably higher than the historical condition, and streambank

erosion is higher for much of the reach due to the levees and lack of riparian vegetation. Direct and indirect channel disturbances have substantially modified the meander geometry from what it was historically. Most of the channel does not have access to a broad floodplain, although narrow floodplain surfaces exist in the Bc segments.

Potential Channel Conditions and Recovery Potential
Most of the reach has limited restoration potential due to levees and floodplain encroachment. The potential stream type for most of the reach would be a B3c channel with a narrow, but densely vegetated floodplain (Reach Succession Scenario 4a, Stage 4) (Appendix F). The large meander cutoff between 505+00 and 535+00 could be reactivated, but it would require constructing four bridges (two each for the highway and railroad), which is unlikely at this point. The upper channel segment between Station 535+00 and 580+00 could be restored to a functioning C4 stream type with some channel construction and stabilization structures. The downstream F types could be converted to B3c types, and the existing Bc types could be improved with habitat enhancements. The entire reach would benefit from implementation of a comprehensive revegetation program.

As noted in Subsection 2.9, the South Valley Bridge should be replaced with a new, bridge properly oriented with respect to the channel alignment. Additional bank stabilization would be necessary to armor the banks through the bridge reach.

Without active restoration, recovery potential would be very slow and incomplete throughout the majority of this reach. Some segments not confined by levees or berms could progress to Reach Succession Scenario 4a, Stage 4 with natural recovery processes. But the entrenched segments would need to erode through the levees and reach a more natural meander pattern before recovery could take place. They would probably not reach full Stage 4 recovery in the foreseeable future. Recovery would be slow and could be compounded by upstream conditions as well as localized disturbances.

Reach Five
Squeque Reach (23,600 feet in length), from the confluence with Valley Creek upstream to the Morin Ditch Diversion (Station 593+00 to 834+00).

Valley Morphology
Reach Five is dominated by valley type VIII morphology (Rosgen 1996). It lies in a wide alluvial valley with multiple glacial outwash terraces bounded by lacustrine deposits from Glacial Lake Missoula. Towards the downstream end, the valley narrows considerably before the river enters the Ravalli Canyon. The constriction, caused by exposed and near-surface bedrock outcrops, may be the result of a fault, but this has not been fully documented. Over time, it has created a backwater effect that has caused the deposition of sediment during significant flood events, creating a broad, low-relief floodplain and meandering channel system. Near-surface bedrock formations force groundwater to the surface, and that has created dense, lush wetlands, side channel spring creeks, and a gaining stream reach. Several large spring creeks enter the main river in Reach Five, including Jocko Spring Creek from the east and Squeque Creek from the west.

Historical Stream Types
The Jocko River historically was most likely a C4 channel throughout this entire reach. The valley bottom was densely vegetated with riparian shrubs and trees, as shown in the 1937 aerial photo. Much of the river appears to have had a very low width-to-depth ratio due to the dense vegetation. Sinuosity, belt width and floodplain width were all much greater historically than they are today. During historical times, the river would have transitioned to a Bc stream type where the valley narrows near the Valley Creek confluence.

Watershed Disturbances and River Response

Disturbances in Reach Five include channelization, floodplain encroachment, riparian conversion, and channel changes due to the diversion of normal annual peak flows. Subsection 2.3 discusses general channel impacts associated with peak-flow diversions. A portion of Reach Five has been channelized via channel straightening or levee construction, most likely to increase agricultural productivity and to protect against flood waters (Table 2.4.4-8). It appears from an analysis of the aerial-photo series (Appendix D-5) that most of the channel changes occurred between 1937 and 1955, the majority probably occurring in the 1940s from channelization and levee construction. One of the most notable alterations is the 4,000 feet of river upstream from the South Valley Road Bridge. At this location, the riparian vegetation was cleared during the 1940s, a racetrack was constructed in the river corridor, and an earthen levee was constructed between it and the river. The modifications cut off a major reach of river. During the 1997 flood, the river eroded through the levee and is now migrating laterally to the west.

Table 2.4.4-8.
Channel and floodplain modifications in Reach Five.

Reach	Encroachment feature	Channel Length (feet)	Affected Channel Length in Reach (Percent)
Reach 5	Bank hardening – rip rap/cars	2,110	10 %
Reach 5	Channelization	1,215	5 %
Reach 5	Constructed levee	4,695	20 %

Although channelization and floodplain encroachment have had an influence on the river corridor, the conversion of riparian vegetation has had the most profound effect on channel stability and floodplain condition. Since the 1940s over 73 percent of the riparian vegetation has been converted from the native gallery forest to simpler communities (Table 2.5.2-1). The 1937 and 2002 aerial photos (Appendix D-4) reveal the extent to which these channel, floodplain, and vegetation modifications have affected the geomorphic stability of the river. Approximately 37 percent of the streambanks have active erosion as a result of channel and riparian alterations (CSKT 2001).

A combination of riparian conversion and mechanical channel modifications have caused accelerated meander abandonment since 1937, resulting in a straighter and steeper channel (Figure 2.4.4-5). A comparison of 1937 and 2002 aerial photos shows that a number of changes occurred in response to channel disturbances. Stream length decreased by about 3,000 feet (12 percent) as a result of the floodplain developments that occurred between 1937 and 1981 (Table 2.4.4-9). Sinuosity, which historically was about 1.39, is now about 1.23. Mean belt width has dropped from about 280 feet to about 160 feet. The channel has been disconnected from its historical floodplain in many reaches where the levees have caused downcutting.

Table 2.4.4-9.
Channel morphology changes over time in Reach Five as measured from historical aerial photographs.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 5	2002	22,495	18,240	1.23	163
	1937	25,302	18,240	1.39	280

The South Valley Road Bridge and associated channel changes have also affected the stream system. Refer to the Bridge Analysis in Subsection 2.9 for more information on these impacts.

Existing Channel Conditions
Frequent channel braiding, accelerated bank erosion, and channel straightening have substantially destabilized Reach Five. Disturbances have caused the river to change from a C4 channel type to a system dominated by D4 segments. Excessive sediment deposition characterizes these D4 and is causing many of the remaining C4 segments to trend towards D4 conditions. Additionally, there are a few short stretches of confined F4 channels within remnant levees. The lowermost section of the reach, near the Valley Creek confluence, has been confined by a levee that restricts the floodplain and protects a pond. Here, the channel is probably an F type.

A repeating pattern of erosion and deposition is occurring throughout most of Reach Five (CSKT 2001). Where berms and levees occur or where meanders are abandoned, the resulting increased energy gradient appears to have caused increased erosion and localized downcutting. Immediately downstream of the levees, where the floodplain widens, the stream deposits the eroded sediment, and the channel becomes braided or is dominated by mid-channel bars. This pattern repeats itself many times throughout the reach.

Summary of Existing Conditions and Trends
Most of Reach Five is characterized by Reach Succession Scenario 2 (Appendix F). Due to excessive bank erosion and excess sediment supply, channel segments are largely in Stage 2. Compared to the historical channel condition, Reach Five is wider, straighter, and steeper, the result of anthropogenic land uses that have disrupted the river's natural stability. Sediment deposition caused instability is common throughout the reach as exemplified by the high width-to-depth ratio, poor aquatic habitat, and accelerated bank erosion. Riparian vegetation removal and conversion has further reduced streambank erosion resistance, thereby facilitating the delivery of more sediment into the channel. A narrowed belt width and substantially altered meander geometry are the effects of direct and indirect channel disturbances. However, the channel is within one foot of accessing the floodplain over the majority of its length, suggesting a high restoration potential. In other segments, the channel remains entrenched from meander cutoffs, channel avulsions, and the bridge crossing. Entrenched sections occur in the following segments:

- Station 590+00 to 601+00 (levee in floodplain)
- Station 655+00 to 696+00 (channel straightening)
- Station 745+00 to 755+00 (South Valley Road Bridge)
- Station 755+00 to 762+00, and
- Station 770+00 to 790+00 (channel straightening near racetrack)

Potential Channel Conditions and Recovery Potential
With the exception of a few short segments, the Jocko River in Reach Five has access to its floodplain. The potential stream type for Reach Five is a C4 channel with access to a broad floodplain. Exceptions occur where there is a bridge, channel avulsion, or meander cutoff (as noted above). There is also a short section of entrenched channel near the Valley Creek cutoff that has the potential to be a B3c channel with a narrow but stable floodplain. The stability in the rest of Reach Five could be improved through bank stabilization, habitat enhancement, and aggressive revegetation. The South Valley Road bridge should be replaced, and the new bridge properly oriented with the channel alignment.

Without active restoration, the recovery potential of the majority of Reach Five would be slow and incomplete. Reach Succession Scenario 2, Stage 3 is possible given natural recovery processes for some of the sections not confined by levees or berms (Appendix F). Decades would be required for full recovery in the segments that have accessible floodplains. In entrenched segments, the Jocko River would need to erode through the levees to develop a more natural meander pattern before complete recovery could occur. For this reason, the entrenched segments would probably not reach full Stage 3 recovery in the foreseeable future. In both the entrenched and channel-floodplain connected reaches, vegetation recovery would be necessary to significantly reduce existing bank erosion rates. Once bank erosion is tempered, the river would need to process the excess sediment deposited throughout the reach. Based on the existing channel and floodplain disturbances, which are substantial, recovery would likely require several decades before a stable river corridor with high quality aquatic habitat, a diverse gallery floodplain forest, and stable channel conditions reestablishes. Recovery rates would be complicated by upstream conditions as well as localized disturbances.

Reach Six
Upper Schall Flats (15,000 feet in length), from Morin Ditch Diversion upstream to the Lower S Canal (Station 834+00 to 969+25).

The downstream terminus of Reach Six is immediately downstream from the Morin Ditch diversion where the valley abruptly widens. The upstream terminus is immediately downstream from the Lower S Canal diversion where the direct influence of the channel alterations ends.

Valley Morphology
Reach Six is dominated by valley type VIII morphology (Rosgen 1996). The valley transitions from a laterally confined, narrow, flat-bottomed valley in the upper 3,000 feet to a wide alluvial valley with multiple glacial outwash and glacial lacustrine terraces. The upper portion of the reach is deeply incised into coarse glacial outwash terraces. The valley does have some characteristics of type VI morphology, which is fault controlled (Rosgen 1996). The river flows primarily along its western edge and intersects several bedrock outcrops, contacting the toe of its western margin. The fault influence ends downstream from the Morin Ditch diversion, where the valley abruptly widens. The valley gradient is approximately 0.006 feet/foot.

Numerous small springs emerge in this reach, primarily at abandoned oxbows in proximity to the bedrock outcrops.

Historical Stream Types
Historically, the river transitioned from a moderately entrenched, B3c stream type in the upper 1,000 feet of the reach where the coarse terraces laterally confine the valley, to a C4 stream type where the valley widens. There may have also been a B3c segment at the lower end of the reach near the Morin Ditch diversion. Unfortunately, the river corridor in the 1937 aerial photo is obscured, and no data are available to confirm the stream type in this area. There are abandoned meanders in the vicinity of the Morin Ditch diversion. The river may have abandoned these channel segments by downcutting into the floodplain in response to channelization and the operation of the Morin diversion.

Watershed Disturbances and River Response
Channelization, hydrologic modification, and the effects of floodplain encroachment are the primary disturbances in this reach. Channelization, apparently undertaken to improve the efficiency of irrigation diversions, dominates. About 1,800 feet of channelization and levee construction was completed on Reach Six, mostly to facilitate the major diversions (Subsection 2.3 discusses the general impacts associated with peak-flow diversion). Residential and agricultural development on the floodplain has suppressed the riparian community. The existing riparian zone is a remnant of what it was historically

and reflects the impacts of logging, other forms of vegetation removal, and vegetation conversion. Over 65 percent of the riparian vegetation has been converted from the native gallery forest to simpler communities since the 1940s (CSKT 2001), and this has significantly affected the geomorphic stability of the river as illustrated in time-series aerial photos from 1937 and 2002 (Figure 2.4.4-6). Figure 2.4.4-6 also shows how the channel pattern has changed over the last 66 years. With the exception of direct channelization and levee construction, the changes appear to have occurred over a long period of time from accelerated natural processes such as erosion and lateral migration, both of which are probably due to the changes in vegetation, flood regime, and floodplain encroachment (processes discussed in more detail in Subsection 2.2). It is apparent from Appendix D-4 that several meanders have been abandoned since 1937, resulting in a straighter and steeper channel. Table 2.4.4-10 summarizes channel and floodplain modifications in Reach Six.

Table 2.4.4-10.
Channel and floodplain modifications in Reach Six.

Reach	Encroachment feature	Channel Length (feet)	Affected Channel Length in Reach (Percent)
Reach 6	Constructed levee	535	5 %

Comparing the 1937 and 2002 aerial photos reveals a number of changes that have occurred in response to channel disturbances (Table 2.4.4-11). While the 1937 aerial photos lack detail in some areas due to missing photos or cloud cover, it appears that stream length and sinuosity may not have decreased significantly since 1937. A few meanders have been cut off, but the channel appears to have compensated somewhat by lateral migration in other areas. Mean belt width has been reduced from about 270 feet to about 160 feet. The channel has probably been disconnected from its historical floodplain in some segments where the levees have caused downcutting.

Table 2.4.4-11.
Channel morphology changes over time in Reach Six as measured from historical aerial photographs.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 6	2002	14,430	11,850	1.22	163
	1937	14,630	11,850	1.23	266

A small secretarial diversion (Station 940+00) created a side channel which captured about one third of the bankfull flow. The large terrace just upstream from the diversion was eroding rapidly and causing deposition near the diversion, which accelerated the capture of the main river. This process was evaluated during the assembly of the JRMP and data and analyses conducted during the development of the plan resulted in a project proposal to stabilize this reach. The project was implemented in the summer of 2006 which stabilized the terrace while constructing a diversion that would provide adequate water for the diversion, but eliminate the associated flood channel from capturing the main river.

Existing Channel Conditions

Watershed disturbances have altered historical stream types in many sections of Reach Six. Figure 2.4.4-6 shows that historically there probably would have been a short segment (less than 500 feet long) of B3c stream type in the narrow valley section just downstream from the Lower S Canal. Below that, the stream would transition into a C channel for most of the rest of the reach. Currently, the upper 3,000 feet of channel start out as a B3c then, because of excess sediment deposition, transition to a braided

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D channel. The river transitions back into a B3c where it appears to have been straightened. At this location, there is evidence of a levee on the east bank near an abandoned meander and cabin. The stream is stable at this point, but habitat is primarily riffle. Just downstream, the channel undercuts the toe of a coarse outwash terrace, which is contributing large amounts of sediment to the stream. Here, the channel changes to a C and D type in response to sediment deposition and the secretarial ditch diversion. The main channel, from the point of diversion to where the secretarial ditch reenters it (Station 940+00 to 895+00), is relatively unstable. There is a major meander that has been abandoned (possibly due to watershed disturbances) since 1937 at Station 910+00 to 902+00. It has become a spring side channel flowing into the main channel.

At Station 909+50, where the secretarial ditch reenters the main channel to approximately Station 881+00, the stream is a more stable C4 type. We designated this subreach as a reference reach because all the natural habitat components are in place, and the stream functions relatively normally. Accelerated bank erosion occurs in places, and the stream is not as stable as would normally occur in this setting, but it is as near to reference condition as any part of Reach Five or Six. The river intersects at least two bedrock outcrops where the channel contacts the western valley wall. The historical aerial photos indicate that the stream has been relatively stable in this short reach, although some down-valley migration and bank erosion have occurred in the last decade.

Between Station 834+50 and 881+00, the stream alternates between a C and D channel type with areas of severe sediment deposition and bank erosion, levees, and abandoned meanders. Comparing the 1937 and 2002 photos shows that the stream is relatively unstable here.

At Station 834+50, just upstream from the Morin Ditch diversion, the channel appears to have been straightened to facilitate the diversion. The valley narrows, forcing the river against the western valley wall. There is what looks like an abandoned meander to the east that could have been active in 1937, but the river corridor is obscured in the aerial photograph. The channel appears to be in its present location in 1955. It is unknown when this meander was active and how the stream has changed in response to the Morin Ditch diversion. However, most likely, the channel has downcut. It is now an entrenched Bc or an F channel confined within the low terrace. It appears that the water users have extended a levee or berm upstream about 400 to 500 feet to divert water while the stream was downcutting. The levee now encroaches on the floodplain.

Summary of Existing Conditions and Trends

Most of Reach Six is in Reach Succession Scenario 2. Segments are either in Stage 2 or 3, depending on how the channel is responding to the changes in sediment supply and channel and floodplain disturbances (Appendix F). However, most of the channel remains connected to the historical floodplain. Exceptions occur where historical meanders have been cut off. Where the river is isolated from its historical floodplain (Station 830+00, 870+00 and 955+00), the reach condition is in Stage 3 or 4 of Reach Succession Scenario 4a. At these locations the river is entrenched into the historical floodplain and has limited ability to construct a new floodplain at its current, lower elevation.

Potential Channel Conditions and Recovery Potential

The potential stream type for this entire reach is a C4 channel with access to a broad floodplain. The exception is the short segment of B channel at the uppermost end of the reach immediately downstream from the Lower S Canal. In most of the reach, the river remains connected to its floodplain or could be reconnected to it by reactivating abandoned meanders. Channel stability in other portions of the reach could be improved by bank stabilization, habitat enhancement, and aggressive revegetation. The secretarial ditch headgate should be reconstructed and the ditch shaped to deliver the appropriate amount of water. Flows exceeding the appropriated amount should remain in the primary channel.

Reach Seven
Jocko Hollow Canyon (1,300 feet), from Lower S Canal upstream to Finley Creek Confluence (Station 969+25 to Station 997+00).

Valley Morphology
The valley morphology of Reach Seven is primarily Type IV that transitions into a narrow Type VIII at the Lower S Canal (Rosgen 1996). The river has incised into remnant Precambrian bedrock and then flows into a narrow alluvial valley confined between high glacial outwash terraces. The gradient is gentle, averaging about 0.006 feet/foot.

Historical Stream Types
Reach Seven is an F stream type from the confluence of Finley Creek downstream to just below the BNSF Railroad Trestle. As the valley begins to widen into a more typical narrow alluvial valley, the river transitions to a B3c stream type with a narrow flood prone area paralleling both sides.

Watershed Disturbances and River Response
With the exception of the Lower S canal diversion, the river corridor has changed very little over time. A review of time-series aerial photographs suggests that in the upper portion of the reach (where it is confined within the bedrock valley walls), the river has maintained a consistent channel alignment and location. The railroad crossing is high above the river and has little or no influence on channel stability. The altered hydrology, which is related to upstream and headwater diversions, has had little effect on this segment because of the stability provided by the bedrock outcrop. The limited length of B channel has probably been reduced in capacity with the reduced peak flows, but with stable banks and a naturally straight channel it remains stable.

At the diversion site (Station 978+00), there have been major channel modifications, which include channel and floodplain encroachment, channel alteration, levee construction, bank armoring, and vegetation removal. Sediment deposition and releases have probably occurred over time with the operation of the diversion. In the vicinity of the diversion, both the channel and the floodplain are highly altered and are candidates for restoration and stabilization. Table 2.4.4-12 summarizes channel and floodplain modifications in Reach Seven.

Table 2.4.4-12.
Channel and floodplain modifications in Reach Seven.

Reach	Encroachment feature	Channel Length (feet)	Affected Channel Length in Reach (Percent)
Reach 7	Channelization	815	30 %

Our analysis of aerial photographs shows that channel morphology characteristics did not change between 1937 and 2002 (Table 2.4.4-13) probably because the river is confined in Reach Seven.

Table 2.4.4-13.
Channel morphology changes over time in Reach Seven as measured from historical aerial photographs.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 7	2002	1,200	1,200	1.00	100
	1937	1,200	1,200	1.00	100

Existing Channel Conditions

As discussed, the existing conditions in this canyon are similar to historical conditions, except at the Lower S Canal diversion site. There is a large natural pool in the canyon just downstream from the railroad crossing that appears to be a popular local fishing site. Pools of this size and depth are uncommon in the Jocko River today. Riparian vegetation in the lower reach appears to be vigorous except at the diversion site, where the channel is an F stream type.

Potential Channel Conditions and Recovery Potential

With the exception of the lower 500 feet near the diversion site, Reach Seven is currently functioning at its potential. At the diversion site, major channel modifications have affected channel stability, riparian vegetation, instream habitat, and floodplain functions. Primary restoration objectives for Reach Seven include reestablishing a stable B3c type channel and floodplain to meet fish and wildlife objectives and providing an efficient, stable diversion.

Reach Eight

Demonstration Reach (16,600 feet in length), from Finley Creek Confluence Upstream to the K Canal (Station 997+00 to 1156+50).

Valley Morphology

Reach Eight is influenced by valley type II and valley type VIII morphologies (Rosgen 1996). The valley transitions from a laterally confined, narrow, flat-bottomed valley to a glacial outwash fan with the channel and floodplain entrenched into outwash terraces. Four to five outwash terraces are visible in the area near the State of Montana's Arlee Fish Hatchery (fish hatchery). The gradient decreases from approximately 0.013 feet/foot at the upstream end of the reach to approximately 0.006 feet/foot at the downstream end. Because of a bedrock outcrop that controls the vertical and lateral extents of the downstream end of this reach, the valley widens continually in a downstream direction. Bedrock is exposed in several locations just upstream from the US Highway 93 crossing and is a dominant feature at the confluence with Finley Creek. The exposure may be the result of a fault, but this is not well documented. Exposed and near-surface bedrock outcrops influence channel and floodplain morphology by constricting the stream corridor at the lower end of the valley. Over time, the constriction has created a backwater effect that caused the deposition of sediment during significant flood events, resulting in a broad, low relief floodplain and meandering channel system. Near-surface bedrock formations have also forced groundwater to the surface, promoting dense, lush wetlands, side-channel spring creeks and a gaining stream reach.

Historical Stream Types

The Jocko River historically transitioned from moderately entrenched B3c stream types where the valley walls laterally confine the floodplain, to C4 stream types where the floodplain becomes flatter and wider. This transition is evident in the 1937 aerial photos, which were taken before many of the human-caused disturbances.

Watershed Disturbances and River Response

Channelization, floodplain encroachment, and riparian vegetation conversion caused by logging, agriculture and grazing have had a profound effect on Reach Eight, especially the lower half, which has been straightened and confined. Over 2,200 feet of channelization and levee construction was completed on this reach in the 1940s in response to a large flood near the fish hatchery. In addition, over 50 percent of the riparian vegetation has been converted from the native gallery forest to simpler communities since the 1940s (CSKT 2001). The changes have significantly affected the geomorphic stability of the river, as illustrated in aerial photos from 1937 and 2002 (Appendix D-4). Appendix D-5 shows how the channel pattern has changed over that time. The most dramatic changes occurred in the late 1940s when two sections of the river were straightened and floodplain levees were constructed. Figure 2.4.4-7 also shows the changes that occurred between the 1937 and 1955 photos and identifies the two straightened sections. Stream length decreased by about 1,300 feet (8 percent) (Table 2.4.4-14), mostly as a consequence of the channel straightening and levee construction near the fish hatchery (Table 2.4.4-14). However, some of the changes due to natural processes related to the channelization are located upstream and downstream of the hatchery. Sinuosity, which historically was about 1.34 is now about 1.24 (Table 2.4.4-15). Mean belt width dropped from about 280 feet to about 130 feet. Where the levees have caused downcutting, the channel has been disconnected from its historical floodplain (Station 994+00 1120+00).

Table 2.4.4.14.
Channel and floodplain modifications in Reach Eight.

Reach	Encroachment feature	Channel Length (feet)	Affected Channel Length in Reach (Percent)
Reach 8	Channelization	400	5 %
Reach 8	Constructed levee	3,270	20 %

Table 2.4.4-15.
Channel morphology changes over time in Reach Eight as measured from historical aerial photographs.

Reach	Photo Year	Stream Length (feet)	Valley Length (feet)	Sinuosity	Belt Width (feet)
Reach 8	2002	16,162	13,050	1.24	132
	1937	17,437	13,050	1.34	276

Existing Channel Conditions

Reach Eight is a transitional section of the Jocko River that links the higher-gradient, confined segments of the river upstream of the K canal with the flatter-gradient, moderately confined and unconfined segments downstream of Finley Creek. It is influenced by the abundant sediment load delivered from the headwaters. As the river leaves the confined valley of the Upper Jocko River and meets the unconfined valley of the Lower Jocko, the channel morphology adjusts to compensate for the changes in valley slope and width. While upstream reaches are B stream types, Reach Eight is composed primarily of Bc and C stream types. However, human modifications of the valley bottom and manipulation of the watershed's hydrology have resulted in the transition of these naturally stable stream types to less stable F types and short braided or D stream types. The segment downstream from the fish hatchery and levees is connected to its floodplain, but it is affected by the abundant sediment supplies from upstream and is trending toward a braided condition.

The F stream types in the reach are the result of the channel being isolated from the adjacent floodplain, which in turn has been caused by actions such as levee placement. Floodplain modifications are most notable in the fish hatchery segment of Reach Eight.

The upper part of the reach, upstream from Station 1120+00, is in Stage 1 or 2 of Reach Succession Scenario 6, depending on whether the channel is entrenched by downcutting or there has been a loss of channel capacity (Appendix F). From Station 1120+00 downstream, the river is in Stage 3 or 4 of Reach Succession Scenario 8, depending on whether the channel is still confined by levees or has eroded the levees and trended towards a braided condition. The channel is not connected to its historical floodplain from segment 1030+00 to 1120+00. Downstream from 1030+00, the channel is connected to the floodplain and is in Stage 4 of Reach Succession Scenario 8.

Potential Channel Conditions and Recovery Potential
Despite the high degree of disturbance in this reach, there is good potential for recovery using active restoration techniques. The desired future condition for the upstream and downstream portions of the reach, where the stream corridor is confined by the narrowing valley, is a Bc stream type (Reach Succession Scenario 6, Stage 1 in Appendix F). Between these two segments, the desired future condition is a C stream type. Reach Succession Scenario 8 describes the transition of the C reaches from the historical to existing channel conditions. Stage 4 of Reach Succession Scenario 8 is a D stream type, while Stage 3 is an F stream type. We propose active restoration techniques to convert these impaired channel conditions to a C channel reconnected with either the historical floodplain or a new floodplain surface. This segment could be restored to Stage 1 if reconstructed at the historical floodplain elevation or Stage 5 if stabilized at the current elevation.

Jocko River Spring Creek Tributaries

Introduction
Jocko Spring and Squeque Creeks in Reach Five and Jocko Hollow Spring Creek in Reach Eight possess unique aquatic environments that once provided off-channel habitats important to the native fish assemblage. Like the lower main stem, they have been impacted by past and present human activities that have altered channel form and function, riparian condition, and aquatic habitat characteristics.

Historical Stream Types
Before their channels were significantly modified, these creeks probably had low width-to-depth ratios and meandering single threaded channel types developed within broad, well-vegetated floodplains. Riparian vegetation maintained lateral channel stability by preventing accelerated erosion. The sinuous, high meander-width ratio provided ample resistance to planform adjustment, resulting in a hydraulically efficient stream type with a high sediment transport capacity. Planform changes were probably more in response to large magnitude floods on the Jocko River than spring creek flow regimes. These creeks are most accurately classified as a gravel-dominated, E stream types (Rosgen 1996).

Watershed Disturbances and River Response
Watershed disturbances such as channelization, floodplain encroachment, and conversion of the native riparian community have modified the form and function, riparian condition, and aquatic habitat structure of all three creeks. However, those disturbances and the way in which the spring creeks have responded to them has varied.

Jocko Spring Creek (Confluence at Station 621+00)
Prior to significant channel modifications, Jocko Spring Creek probably had a low width-to-depth ratio and a meandering, single threaded channel type developed in a broad, well-vegetated floodplain corridor. The structure and composition of riparian vegetation functioned to maintain lateral channel stability by preventing accelerated lateral erosion. The sinuous, high meander-width ratio provided ample resistance to planform adjustment, resulting in a gravel-dominated E stream type (Rosgen 1996) that was hydraulically efficient and maintained a high sediment transport capacity.

Channel and floodplain modifications have impacted the condition of Jocko Spring Creek both upstream and downstream of US Highway 93. Upstream of the highway, high intensity livestock grazing has degraded the riparian shrub community and replaced native sedges with agriculture-related grasses. Riparian vegetation removal has led to lateral bank erosion, chute cutoffs, and overall channel simplification. Channel straightening and floodplain encroachment for agricultural and residential development have altered the historical channel pattern. The most obvious channel changes are in the vicinity of US Highway 93, where the channel was straightened and floodplain berms erected to direct the creek under the highway. Two consecutive ninety-degree meander bends force the channel through the roadfill.

A short channel segment between US Highway 93 and the BNSF Railroad grade has only limited riparian vegetation and has been straightened. The railroad trestle does not appear to be a barrier to fish passage, and the limited volume of sediment and debris transported by the creek appears to pass through the confined crossing.

Downstream of the BNSF railroad crossing, the creek, confined between the US Highway 93 road fill and the Jocko Spring Creek Road, has been substantially straightened, and the loss of riparian vegetation has reduced stream cover and fish habitat.

Downstream of the Jocko Spring Creek Road, the channel planform resembles the historical channel condition, although portions exhibit chute cutoffs, meander abandonment, and channel shortening. Riparian vegetation remains within the belt width, although floodplain vegetation has largely been converted to other types or simplified by agriculture and grazing. Channel stability at outside meanders has decreased with the reduction in riparian vegetation.

As Jocko Spring Creek enters the well-vegetated river floodplain, it appears to be within remnants of the historical channel created by the Jocko River a relationship suggested by the relatively straight planform and increased channel width. The low gradient, well-vegetated floodplain resists planform change, and depending on hyporheic discharge to the spring creek channel, the creek may provide valuable off-channel habitat for Jocko River fisheries and waterfowl. Complex woody debris jams deposited by the Jocko River increase aquatic habitat diversity in these backwater sloughs.

The creek currently displays multiple stages of Reach Succession Scenario 1 (Appendix F). In areas where the channel maintains a narrow width-to-depth ratio and remains connected to the historical floodplain it is in Stage 1, which is probably close to the historical condition. Where the channel is over-widened but remains connected to the historical floodplain, as portions of the creek are downstream from Jocko Spring Creek Road, it is in Stage 2. Upstream from the US Highway 93 crossing, where floodplain berms and road fill confine the creek to a steeper, narrow width-to-depth ratio channel isolated from the historical floodplain, it is in Stage 3. Where flows are completely confined to an over widened active channel, it is in Stage 4. This occurs through the US Highway 93 road fill and bridge crossing, as well as in upstream reaches where the channel has degraded into the historical floodplain. In places where a new, low to moderate width-to-depth ratio channel has become established with the over widened F channel and the channel is connected to a floodplain at a lower elevation than the historical floodplain, it is in Stage 5 or 6, depending on the channel dimensions.

Squeque Creek (Confluence at Station 654+00)
We know little about the channel condition prior to 1937, though agricultural activities and the fluvial processes of the Jocko River have affected it. At some point, the area was drained with ditches, probably to accommodate hay production. The channel dimensions and pattern have fluctuated over time because of surface water inputs from the Jocko River, hyporheic upwelling on the river floodplain, and irrigation return flows. Past grazing and agricultural practices may have straightened and simplified the channel. During the 1997 flood, the creek was affected by overbank flows and corresponding bank erosion and lateral migration. It is no longer connected to the floodplain and the historical wetlands that the spring once supported.

Squeque Spring Creek is currently in Stage 3 or 4 of Reach Succession Scenario 1, depending on whether the individual segment is actively downcutting or is actively widening through bank erosion (Appendix F).

Jocko Hollow Spring Creek (Confluence at Station 1000+00)
Channel straightening, berm construction, and pond development have been the primary disturbance factors influencing Jocko Hollow Spring Creek. The creek originates entirely on the floodplain of the Jocko River from upwellings of shallow groundwater. Although the headwater portion of the creek appears to be functioning at its historical potential, the lower part of the channel in the vicinity of the Jocko River has been significantly modified. There, the channel has been converted to a series of ponds separated by earthen berms and simplified channels associated with the Jocko Hollow Campground. In addition, riparian vegetation in the vicinity of the ponds has been simplified. The close proximity of US Highway 93 and the unimproved Jocko Hollow parking lot probably influence fine sediment delivery to the creek.

The US Highway 93 crossing is probably a barrier to upstream fish migration. Downstream from the crossing, heavy, yearlong grazing that has denuded riparian vegetation and widened and straightened the channel.

The middle reach of the creek has been converted into ponds and ditches. The lower reach is in Reach Succession Scenario 1, Stage 4 (Appendix F).

Potential Channel Conditions and Recovery Potential
E stream types typically have high recovery potentials once they are stabilized and reconnected to their associated floodplain. Potential channel conditions vary among the three spring creeks, as do the various land uses that are currently affecting them. If existing land uses continue and restoration treatments are not implemented, the existing channel conditions will probably continue into the future due to the low stream energy inherent to spring creeks. If existing disturbances were to cease, the creeks would likely progress to Stage 6 of Reach Succession Scenario 1 (Appendix F).

2.4.5 Reference Reach Data Collection and Summary

In the context of stream systems, a reference reach is a segment of river that is functioning at or near its potential in terms of stability and productivity. A stable stream can be defined as a stream that over time and in the present climate, transports the flows and sediment produced by its watershed in such a manner that its dimension, pattern, and profile are maintained without either aggrading, or degrading (Rosgen 1996). This balance, or dynamic equilibrium, maintains the sediment transport capacity of the channel by providing the proper slope and width-to-depth ratios necessary to mobilize and transport sediment during effective and greater discharges.

The designation "reference reach" does not necessarily mean that the reach is undisturbed or pristine. It simply means that the stream represents the most productive and stable conditions found within the area. Disturbances must be taken into account when selecting and using reference reaches. For example, the changes in hydrology documented in Subsections 2.3 and 2.4 affect all the reference reaches within the study area. However, these segments have either adjusted to the changes in hydrology or the stream segment was stable enough that no changes were necessary to accommodate the disturbance.

Reference reaches provide valuable data to assess other, less-functional stream reaches in the same geomorphic setting to determine existing stream condition and trend. Reference reaches are also a major component in developing natural channel design criteria to be used in restoration, habitat enhancement, and stabilization (Rosgen 1998). Reference reach data help in the evaluation of channel metrics characterizing portions of the river that are representative of the historical, unaltered condition. They are functioning at optimal levels and provide the blueprint for rebuilding impaired reaches. For more information on how reference reach data are used for Natural Channel Design, refer to Subsection 3.3.

Within the project area we identified five reference reaches (Table 2.4.5-1). We surveyed channel dimensions in 2002 and evaluated existing sediment transport conditions to determine the capacity of the channel to transport bed material present in the project area. We employed multiple techniques to characterize the existing sediment particle distribution. We conducted field measurements, including channel cross-section dimensions, bankfull elevations, longitudinal profiles of water surface, streambed and bankfull elevations, depositional bar core samples, and Wolman (Wolman 1954) pebble counts to evaluate existing shear-stress levels and particle entrainment based on incipient motion criteria. We used the Shields criterion for predicting thresholds of bed material mobility (Shields 1936) and modeled shear stress estimates using WinXSPRO (USDA Forest Service 1998).

Reference reach conditions were different from impaired river segments with respect to river channel dimensions, profile, and planform attributes. Similarly, fish habitat, riparian condition, and channel-floodplain connectivity of the reference reaches are closer to historical conditions than those the portions of the river corridor that have been influenced by channelization, floodplain encroachment, and riparian conversion.

Table 2.4.5-1.
Locations and descriptions of the five reference reaches in the Jocko River main stem.

Number	Location	Description
1	Station 80+00 (from Station 75+50 to 105+00)	A B4 stream type located in Reach Two. We will use the data gathered here for restoration designs in Reaches Two and Three.
2	Station 380+00 (from Station 359+00 to 400+00).	A C4 stream type located in Reach Three. Data collected here will be used for restoration designs in Reaches One, Two, Three, and Four.
3	Station 880+00 (from Station 870+00 to 895+00).	A C4 stream type located in Reach Six. Data collected here will be used for restoration designs in Reaches Five, Six, and Seven.
4	Station 1180+00 (approximate—the reference reach is located beyond the upstream extent of river station).	A B3 stream type located upstream of Reach Eight. Data collected here will be used in Reaches Seven and Eight.
5	Station 1280+00 (approximate—the reference reach is located beyond the upstream extent of river stationing).	A B3c and C3 stream type. Data collected here will be used for restoration designs in Reach Eight.

2.4.6 Summary

We completed on-the-ground and remote sensing analyses to predict the historical condition and to evaluate the existing and desired future conditions of the river. We considered channel morphology, floodplain development, and riparian conditions in describing the varied states of the river corridor. We predicted future channel conditions based on the existing channel states, probable future channel tendencies (reach succession scenarios), and described preliminary restoration approaches necessary to reach a potential channel condition that would derive the greatest benefits. We also identified and surveyed reference reaches that displayed conditions similar to the historical channel. The data will be used during the restoration-design phase of the Jocko River Master Plan.

The results of our analyses show that although much of the Jocko River has been altered from its historical state, overall it has a high restoration potential based on the valley's relatively low population density, the remaining degree of river-floodplain connectivity, and widespread support from the local community to rehabilitate the river to a more functional condition.

2.5 Vegetation Assessment

2.5.1 Introduction

This subsection details our assessments of the riparian, wetland, and associated upland plant communities of the floodplain on the lower main stem. It describes historical and existing conditions and the methods used for assessing them.

Our assessments concentrated on the ecological floodplain (EFP) of the lower main stem, which is defined as the alluvial portions of the lower main stem and adjacent terraces that either support or probably once supported vegetation and associated hydrology characteristic of riparian and wetland areas in western Montana.

2.5.2 Jocko River Historical Vegetation Conditions

Information Used to Characterize Historical Conditions

The alluvial sections of the lower main stem encompass the widest floodplain areas of the river and have experienced the greatest loss of riparian and wetland plant communities over the past 150 years. It is difficult to determine precisely the extent of vegetative communities along the lower main stem during historical times. Historical maps, photographs, and surveyor's notes describe broad vegetation types and their local coverage. In some cases, dendrochronology and fire-scar studies reveal history. Most of the resources used for this assessment date from approximately 1900 to 1937, and significant human disturbances had already occurred by this time. We used the following specific sources to characterize the type and extent of vegetation during the historical period.

Aerial Photos from 1937

Almost complete aerial photo coverage dating from summer 1937 and taken at a scale of 1:18,000 exists for the lower main stem (USARS 1937). The US Agricultural Research Service took these images in a low-resolution, black and white format. In some cases they are quite dark, which makes it difficult to determine vegetation changes. Coverage is missing for two short sections: (1) just downstream of the Highway 200 Bridge at Ravalli, Montana (the upstream end of Reach Three), and (2) almost all of Reach Seven (Jocko Hollow Canyon). However, despite these limitations, and the fact that the flights were made after the floodplain had already been significantly altered by human settlement, the photos provide the best aerial picture of the historical condition.

Railroad Survey Maps

A Northern Pacific Railroad (NPRR) survey map from 1883 contains some information on the location of woody and herbaceous vegetation (NPRR 1883). The information is generally limited to short descriptive phrases (e.g., brushy bottomland, scattered timber, marshy bottomland) along with map symbols for shrubby or marshy vegetation. The map is only mentioned here, as it yielded no unique information for this assessment. However, it is a resource for specific restoration designs.

GLO Surveys

The U. S. General Land Office (GLO) conducted the original section-line surveys on the Flathead Indian Reservation. From December 1901 to May 1905, they surveyed sections in the vicinity of the Jocko River (Page 1901). These built on an earlier effort in 1872 called the Flathead Guide Meridian Survey, which laid out the township and range lines. All of these surveys have extensive surveyor notes taken at the time of the survey. While the comments about vegetation in the 1872 surveyor's notes are insufficient for our purposes, the later GLO surveyors did make fairly extensive notes regarding vegetation changes on the section lines, recorded in chain lengths (66 feet/chain) from the section corner. This is of particular use where section lines crossed the Jocko River, as they do in 20 places along the lower main stem. From this information, we can determine the width of the riparian scrub-shrub and forest vegetation in the floodplain, as well as the location and width of the river and other floodplain features.

USGS Soil Survey

Soils maps showing the presence or absence of hydric soils can also be used to locate areas that may have been wetlands historically (USDA NRCS 1998, 2002b, 2002c, 2005). While hydric soils are not the sole indicator of past wetlands, their presence combined with other evidence (such as extent of riparian forest cover in 1937 or remnant hydrophytic plants) can indicate a site where a wetland once existed. This is discussed in more detail in Subsection 2.6. Soil map unit boundaries are often delineated by vegetation and hydrology patterns at the time of mapping and may vary in their accuracy.

2002 Aerial Photographs and Hydrogeomorphic (HGM) Cover Type Data

We used April 2002 aerial photographs as a base layer for comparisons of existing and historical conditions (CSKT 2002). This high-resolution photo set and the HGM vegetation cover type layer created by the Master Plan team (CSKT 2003), allowed us to compare current conditions with historical vegetation information from the GLO plat maps, the NPRR survey map, hydric soils maps, and the 1937 aerial photos. Subsection 3.6.3 contains more details about how we made these comparisons.

Historical Cultural Burning Practices

Much has been written and studied about historical human-caused fires. Generally the discussion is focused on forested areas. Fire ecologist Steve Barrett (1981) interviewed many Tribal elders and non-tribal pioneer settlers in the late 1970s. Testimony from those individuals and other research that Barrett conducted indicated that the native peoples of western Montana used fire extensively, especially in low-elevation forests. Other research conducted in the Flathead Indian Reservation and aboriginal lands suggests Indian burning has gone on for over 7,000 years (CSKT 2000b). This information can be used to characterize the effects of cultural burning on the riparian areas and plant communities of the Jocko River.

Historical Photographs

Morton J. Elrod was an early photographer and biologist from Missoula, who took many landscape photographs of areas along the Jocko River and other sites on the Flathead Indian Reservation in the late 1800s and early 1900s. Many of these are located at the University of Montana (UM) Archives, and we have included several for visual reference. We checked other collections for historical photographs, including UM's McKay collection, and the photo archives of the Montana Historical Society, Salish-Pend d'Oreille Culture Committee, and Confederated Salish and Kootenai Tribes (CSKT) Tribal Preservation Department. We use photographs from these collections to illustrate the historical condition of the river.

Discussion

Pre-1900 Vegetative Conditions

Pre-1900 human vegetative disturbances along the Jocko River generally helped maintain the native vegetative community. The Salish, Pend d'Oreille, and Kootenai tribes all conducted cultural burning that influenced successional processes within native plant communities. The impact of those practices on the floodplain is not quantified, but it probably resulted in significant areas being cleared or thinned of woody plants to make them more usable. The Tribes set fires primarily in low-elevation forested areas and intermountain valley grasslands (Barrett 1981). Even if not deliberately set in riparian and wetland areas, those fires would have certainly moved into those areas from surrounding uplands. A large part of Tribal habitation, hunting, food gathering, and horse-grazing took place in riparian areas. Hence, burning those areas was a logical extension of the practice (Figure 2.5.2-1, Elrod 73-98). Barrett's informants stated that Tribal people burned to improve hunting, enhance browse and forage for livestock and game, promote desirable plant species, and clear campsites and trails. White et al. (2006) expand on the reasons for burning and provide further details on how and when the burning was conducted.

Barrett also found specific historical references made by early explorers to riparian burning by tribal people in western Montana valleys. Other research has also indicated that before 1860, areas frequently used by native peoples in western Montana had a mean fire interval of 9.1 years (CSKT 2000b; Barrett 1981). This is logical if the goal is to maintain a specific ecological condition because almost all species of native shrubs and deciduous riparian trees resprout after fire or cutting, and the effects of burning would have been temporary unless conducted routinely.

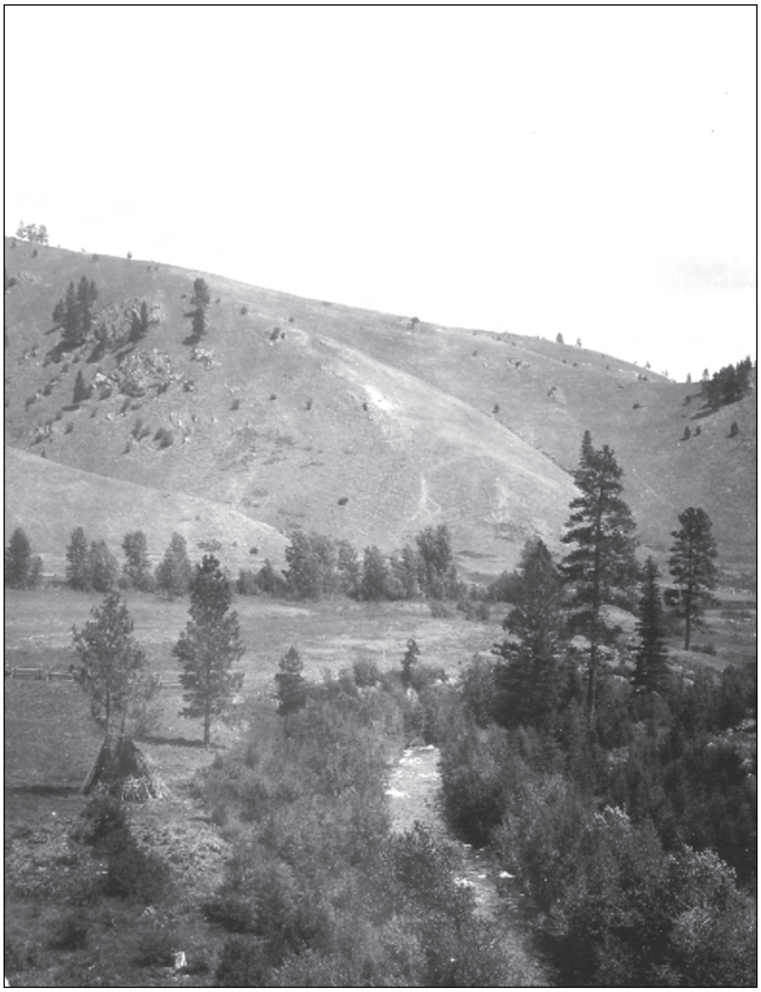

Figure 2.5.2-1.
View upstream of the Jocko River near the main Jocko Canyon mouth, above Teresa Adams Bridge (above Reach Eight), about 1900. The photo was taken by Morton J. Elrod, an early botanist and photographer from Missoula. Note the relatively open stream terrace area, lodge (tipi) constructed of brush, and dense woody cover at water's edge. University of Montana Archives Elrod Collection #73-98.

The practice of cultural burning changed rapidly in the latter half of the eighteenth century. From 1860 to 1900, the Tribes were coerced to settle on allotments. Barrett's fire-ring studies indicate that in 20 stands in western Montana heavily used by Tribal people, the mean fire intervals went from 9.1 years before 1860 to 11.5 years for the period from 1861 to 1910 and to 25.9 years for the period from 1910 to 1980. Active fire suppression began in western Montana about 1910 after numerous severe lightning-caused fires burned throughout much of northern Idaho and western Montana (Barrett 1981). Photographs from the 1890s of other creeks on the reservation, for example Crow and Mission Creek, appear to show an almost impenetrable riparian forest, thick with understory shrubs and vines. Where undisturbed to this day, these creek-side riparian communities are still virtually impenetrable because of heavy tree and shrub growth, poison ivy (*Toxicodendron rhybergii*), and white clematis (*Clematis ligusticifolia*) (Figure 2.5.2-2).

Figure 2.5.2-2.
Typical dense vegetative condition of the black cottonwood/red-osier dogwood (Populus trichocarpa/Cornus stolonifera) riparian forest community type, located at the National Bison Range Jocko River fishing access site adjacent to Highway 200.

Vegetation 1900 to Present

Table 2.5.2-1 shows data derived from the GLO surveyor's notes, part of the General Land Office Surveys conducted in the early 1900s (Page 1901). When compared to similar data from 2002, trends in woody riparian vegetation loss or gain become apparent. While the precise historical extent of dense vegetation or other riparian vegetation types captured by Elrod's photographs is not known, the 1937 aerial photos allowed us to approximate the extent of riparian scrub-shrub and forest communities as of that year. Significant areas of woody plant cover had probably already been lost by 1937, which is about 70 years after European-American and permanent Tribal settlement began in the Jocko River Valley. Table 2.5.2-2 compares the extent of the 1937 and 2002 riparian woody cover, by reach.

Table 2.5.2-1.
Extent of Jocko River riparian scrub shrub and forest (combined), by geomorphic reach break, in 1937 and 2002 compared to the total area of the ecological floodplain (EFP) within each reach. The 2002 data is a compilation of HGM woody cover types 1, 2, 3, and 5, which are conifer-dominated, mature cottonwood, immature cottonwood, and riparian shrub cover types, respectively.

Jocko River Reach	EFP by Reach (acres)	Woody Riparian within EFP,1937 (acres)	Percent EFP in Woody Vegetation, 1937	Woody Community Types (HGM CT 1,2,3,5) (acres)	Estimated Clearing 1937 to 2002 (acres)	Percent EFP in Woody Vegetation in 2002	Percent of Woody Acres Lost
1	122	91	75%	50	41	41%	45%
2	108	64	59%	51	12	47%	20%
3	1437	584	41%	285	299	20%	51%
4	258	85	33%	70	14	27%	17%
5	1507	514	34%	274	240	18%	47%
6	385	156	40%	118	38	31%	24%
7	7	2	33%	3	-1	43%	-30%
8	367	249	68%	194	56	53%	22%
Totals:	4190	1745	42%	1046	699	25%	40%

Table 2.5.2-2.
Summary of the width of Jocko River riparian scrub shrub and forest (combined) on section lines from GLO surveys (1901-1905) and 2002 HGM woody cover types 1, 2, 3, and 5.

Location	Township/Range	Section Line	GLO Width on Section Line (feet)	2002 Width of Woody Vegetation on Section Line (feet)	Change (feet)
Reach 2	18/21	17/20	564	816	252
Reach 3	18/21	20/21	1247	1172	-75
Reach 3	18/21	21/22	1386	1382	-4
Reach 3	18/21	27/22	1912	1380	-532
Reach 3	18/21	27/26	884	312	-572
Reach 3	18/21	25/26	884	465	-419
Reach 4	18/20	31/32	1139	930	-209
Reach 5	17/20	17/16	927	2192	1265
Reach 5	17/20	16/21	3168	2133	-1035
Reach 5	17/20	21/22	3828	1000	-2828
Reach 5	17/20	22/27	3175	918	-2257
Reach 6	17/20	27/34	1534	1175	-359
Reach 8	16/20	1/2	838	533	-305
Reach 8	16/20 and 16/19	12/7	957	960	3

Data used in Tables 2.5.2-1 and 2.5.2-2 reveal broad changes in the extent of woody riparian cover, but are not of sufficient detail to show slight or even moderate changes. The 1937 aerial photos are of limited resolution; the vegetation layer interpreted from them is not as accurate as the HGM cover type polygons developed from the high-resolution 2002 aerial photos. Similar issues exist with the GLO survey information relative to the 2002 HGM cover types. Despite the limitations of the data, it is evident that about a 40 percent decrease in woody riparian cover occurred between 1937 and 2002.

That equates to a loss of woody vegetation in the overall ecological floodplain of about 700 acres. The numbers do not reflect losses to other native vegetation communities, such as inclusions of native upland grasslands in the riparian area or emergent wetland types lost to agricultural practices such as grazing, the installation of drainage ditches, irrigation, plowing, and seeding to pasture grasses.

The GLO survey comparison (Table 2.5.2-1) shows that there has been a significant decrease in riparian woody vegetation along the majority of section lines. In two places where section lines cross the Jocko River floodplain there are significant gains in vegetative cover width. Another three section line crossings show small, and probably statistically insignificant changes (+ or – 100 feet). However, nine section line surveys record significant scrub shrub or forest decreases, ranging from over 200 feet to nearly 3,000 feet (Page 1901). The greatest losses have occurred along section lines in Reaches Three and Five, although the data show losses from near the middle of Reach Three to the middle of Reach Eight. In the middle of this river run, however, Reach Five shows a 1,200-foot increase in woody vegetation. This may have been a herbaceous wetland type that, with the exclusion of fire, converted to a woody-vegetation wetland type. Overall, there appears to have been a loss of 66 percent of woody-riparian vegetation over the past 100 years. While the accuracy of this figure may be limited, the analysis does show that significant amounts of woody-riparian vegetation were lost even before 1937.

Some of the comments made by the surveyors are also informative. U. S. Deputy GLO surveyor E. R. Page repeatedly remarks in his survey notes of riparian areas that he encountered "heavily timbered land and land covered with dense undergrowth and exceptionally difficult to survey (sic)" (Page 1901). This appears to describe the exact vegetation type encountered today within typical, healthy riparian forests along the Jocko River (Figure 2.5.2-2).

Plant Community Descriptions and Change

Historically, the plant communities along the lower main stem would have been the same or similar to those occurring today. The extent and distribution of those communities, however, has been affected by permanent settlement in the Jocko Valley. For descriptions of specific plant communities, refer to the existing vegetative condition descriptions in Subsection 2.5.3.

It is likely, given the type of disturbances native plant communities have been subjected to over the past 150 years, that the number of communities expressed within each reach has been reduced. For example, agricultural practices have almost certainly removed native herbaceous community types from many reaches. These areas were easily converted to pastures and fields with minimal draining and little or no woody plant clearing. They also tend to have productive, organic-rich soils (Figure 2.5.2-3), so they were probably the first lands to be put into agricultural production.

Figure 2.5.2-3.
Plowing of a former wetland area on the Tellier Homestead on Mission Creek, the main drainage north of the Jocko River Drainage, 1920. This was the fate of many wetland types in the Jocko River floodplain as well. Salish-Pend d'Oreille Culture Committee Archive #A-0010.

With the exclusion of fires, communities dependent upon fire for rejuvenation (for example, the quaking aspen/red-osier dogwood (*Populus tremuloides/Cornus stolonifera*) habitat type (Hansen et al. 1995)) eventually die out and are replaced by other riparian types. Communities dependent upon fire to suppress woody competition, like many of the native herbaceous types, are also affected. Similarly, in the absence of fire, non-climax community types like black cottonwood/red-osier dogwood will eventually be replaced by climax conifer-dominated habitat types, such as the ponderosa pine/red-osier dogwood (*Pinus ponderosa/Cornus stolonifera*) or Douglas-fir/red-osier dogwood (*Pseudotsuga menziesii/Cornus stolonifera*) habitat types (Hansen et al. 1995).

Weeds

Weed introductions have had an impact on native plant communities, although those impacts have not been quantified along the Jocko River. Reed canarygrass (*Phalaris arundinacea*), introduced perhaps as early as the 1880s (NRCS 2001), has probably had a greater effect on plant community distribution than any other weed. It was typically seeded on wet pastures to improve hay and forage yields. Reed canarygrass is aggressive, invasive, and tolerates limited shading. More significant is its ability to rapidly colonize a range of hydric conditions, forming large monocultures and almost totally precluding the establishment of woody vegetation. Tribal botanists have observed this occurring in a range of settings along the Jocko River, including recently formed alluvial islands in the main channel and off-channel mesic (moderately moist) and wet habitats. Reed canarygrass has slowed or prevented the recovery of native vegetation on sites released from anthropogenic disturbances over the past 50 years.

Other weeds of concern in riparian areas include two tree species: golden willow (*Salix alba*) and Russian olive (*Elaeagnus angustifolia*). Both were planted on the floodplain, and both have invaded in limited areas. Noxious and invasive plant species that currently occur in the lower main stem are discussed in more detail in Subsection 2.5.3.

2.5.3 Jocko River Existing Vegetation Conditions

Introduction

This discussion of existing vegetation concentrates on the ecological floodplain—alluvial sections of the lower main stem and adjacent terraces that either support, or probably once supported, the vegetation and hydrologic characteristics typical of riparian and wetland areas of western Montana. Valley Creek, Finley Creek, and the upper forks of the Jocko River are not discussed.

Classification Systems Used to Describe Plant Communities

Plant communities, as referenced in this discussion, are relatively homogeneous assemblages of plant species, the distribution of which is determined by landform position, hydrology, soils, wildlife use and movement, and the presence of other plant communities and species. Their distribution may also reflect their age relative to a specific disturbance.

In western Montana, *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen et al. 1995) is the standard habitat-typing manual used to describe plant communities occupying the near-bank area, active floodplain zone, older floodplain terraces, and other wet areas. Plant communities described in Hansen et al. (1995) are discussed in terms of their relationship to plant community succession and their response to natural and human-induced disturbance processes.

The Montana Natural Heritage Program (2003) maintains a plant community database focusing on plant communities that are significant from a conservation perspective. We include information from this database to supplement the information in Hansen et al. (1995).

Disturbance Processes Affecting the Jocko River Floodplain

Along the lower main stem willow (*Salix* species) and young black cottonwood (*Populus trichocarpa*) communities often develop on recently deposited alluvium after floods of sufficient magnitude distribute sediment, scour portions of the floodplain, or cause a channel to avulse. Because black cottonwood is widely distributed throughout undisturbed floodplain areas, it appears that most areas eventually become dominated by a cottonwood overstory, even if they start as a willow-dominated community.

In some stands, ponderosa pine (*Pinus ponderosa*) appears to have established simultaneously with or after black cottonwood. Ponderosa pine is a considerably longer-lived species than cottonwood, and in the absence of stand-eliminating disturbance, it appears to replace cottonwoods, possibly through a process of attrition rather than sequential succession (Hansen et al. 1995).

Quaking aspen (*Populus tremuloides*) occurs in isolated patches within forested riparian areas. The patches probably represent historical fire patterns or other land-clearing disturbances. Existing quaking aspen stands are at different successional stages. Throughout the floodplain most quaking aspen reproduction appears to be vegetative.

Direct human disturbance along the river includes channelization, levee construction, land clearing and leveling, irrigation diversions, grazing, and residential/commercial development. Indirect, human-induced disturbance includes the presence of noxious weeds, alterations in groundwater depth relative to vegetation communities, and alterations in surface water connection to the floodplain. In the absence of direct or indirect human disturbance, the floodplain would probably include a greater proportion of black cottonwood-ponderosa pine-quaking aspen forest. Willows and other shrubs might be present in some areas currently covered by herbaceous vegetation. Native emergent wetland species would be present in higher proportions in areas currently occupied by introduced species or weeds.

Plant Community Descriptions

The following plant communities are currently the most common along the Jocko River (other communities may be present, but cover relatively small areas):

Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/ Cornus stolonifera*) **Community Type**

Black cottonwood, (synonym *Populus balsamifera ssp. trichocarpa*) is the dominant native cottonwood in Montana west of the continental divide. Along the lower main stem, the black cottonwood/red-osier dogwood type occupies portions of the active floodplain and adjacent alluvial terraces. The Montana Natural Heritage Program (2003) summarizes the type as follows:

Black cottonwood/red-osier dogwood Community Type.

> This forest type occupies alluvial terraces of major rivers and streams, point bars, side bars, mid-channel bars, delta bars, an occasional lake or pond margin, and even creeps onto footslopes and lower subirrigated slopes of hilly or mountainous terrain. Many of these sites are flooded in the spring and dry deeply by summer's end; capillary action keeps upper portions of soil profile moist. Other sites are merely subirrigated. *Populus balsamifera ssp. trichocarpa* dominates the overstory with cover values ranging from approximately 12-90 percent, though the modal range, at least in Montana is 40-60 percent. *Populus angustifolia* is a subordinate canopy species in the eastern portion of the range, and *Populus tremuloides* and *Betula papyrifera* occur as subordinates in the western portion. The shrub layer comprises at least 25 percent cover with *Cornus sericea* diagnostic for the type and having anywhere from 1-90 percent cover; other shrub taxa with high constancy include *Symphoricarpos* spp., *Rosa* spp., *Salix* spp., *Crataegus* spp., *Amelanchier alnifolia*, and *Alnus incana*. There are no graminoids exhibiting high constancy, though any one of a number of disturbance-associated exotics can manifest high coverages. *Maianthemum stellatum, Galium triflorum, Solidago canadensis*, and *Equisetum* spp. are the only forbs that exhibit even relatively high constancy across the range of the type. This is a successional community that colonizes moist, newly deposited alluvium exposed to full sunlight; in the absence of fluvial disturbance it is capable of developing into conifer-dominated communities belonging to alliances as diverse as *Thuja plicata, Picea* spp. and *Juniperus scopulorum*. Adjacent wetter sites are dominated by a suite of wetland *Salix* spp., *Alnus incana*, wetland-associated *Carex* spp. often including *Carex utriculata, Carex aquatilis* and *Carex buxbaumii* or *Typha latifolia*-dominated communities. Adjacent drier sites are dominated by *Populus balsamifera ssp. trichocarpa* or *Populus tremuloides* types or any of a vast array of conifer-dominated types that are capable of growing within the elevational zone occupied by the *Populus balsamifera ssp. trichocarpa / Cornus sericea* Forest (Montana Natural Heritage Program 2003).

Ponderosa Pine/Red-osier Dogwood (*Pinus ponderosa/Cornus stolonifera*) Habitat Type

The ponderosa pine/red-osier dogwood habitat type occurs on alluvial benches or terraces of major streams and rivers (Hansen et al. 1995). It is probably a late successional stage of the black cottonwood/red-osier dogwood habitat type on the lower main-stem floodplain in areas where there is enough time between disturbances to allow black cottonwoods to die and create openings for ponderosa pine seedlings.

Associated shrubs include, but are not limited to, western serviceberry (*Amelanchier alnifolia*), red-osier dogwood, common chokecherry (*Prunus virginiana*) and

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western snowberry (*Symphoricarpos occidentalis*). Because the ponderosa pine/red-osier dogwood habitat type occupies a similar landform to that of the black cottonwood/red-osier dogwood community type, many of the species present in one occur in the other.

On the floodplain of the lower main stem, the ponderosa pine/red-osier dogwood habitat type occurs on slightly higher ground than the black cottonwood/red-osier dogwood community. This difference might be a result of greater accumulations of sediment from historical floods. Alternatively, the ponderosa pine/red-osier dogwood habitat type might occur on older floodplain elevations in areas where the river profile has changed.

Ponderosa Pine/Red-osier Dogwood Habitat Type.

Douglas-fir/Red-osier Dogwood (*Pseudotsuga menziesii/Cornus stolonifera*) Habitat Type

This habitat type occurs on well-drained alluvial benches or terraces of major streams and rivers and along smaller streams and creeks (Hansen et al. 1995). Along the lower main stem it is found primarily near the State of Montana Arlee Fish Hatchery (fish hatchery). The riparian area near the fish hatchery is adjacent to a downcut reach of the Jocko River. In addition, groundwater has been diverted from portions of the riparian area for use by the hatchery. Plant species composition throughout this reach is similar to the ponderosa pine/red-osier dogwood habitat type, but also includes a significant proportion of upland vegetation, indicating that the area may be transitioning to upland.

Douglas-fir/Red-osier Dogwood Habitat Type (courtesy Ecological Solutions Group)

Quaking Aspen/Red-osier Dogwood (*Populus tremuloides/Cornus stolonifera*) Habitat Type

On the floodplain of the lower main stem, this habitat type occurs on alluvial terraces adjacent to the river, or near springs and seeps. Plant species richness is high. An overstory of quaking aspen typically dominates an understory of willows and other shrubs. Dominant mid-story shrubs include red-osier dogwood, western serviceberry, Rocky Mountain maple (*Acer glabrum*), birch (*Betula* species), alder (*Alnus incana*), common chokecherry, currant (*Ribes* species), and several species of willow. Understory species composition varies widely depending upon soil moisture (Hansen et al. 1995).

Other quaking aspen-dominated ecological types occupy small areas along the Jocko River floodplain. The quaking aspen/bluejoint reedgrass (*Populus tremuloides/Calamagrostis canadensis*) habitat type may occur where quaking aspen is encroaching on wet meadows. Quaking aspen stands disturbed by livestock grazing may have shifted from the quaking aspen/red-osier dogwood habitat type to the quaking aspen/Kentucky bluegrass (*Populus tremuloides/Poa pratensis*) community type.

Quaking Aspen/Red-osier Dogwood Habitat Type (courtesy Ecological Solutions Group)

Bebb Willow (*Salix bebbiana*) Community Type

The Bebb willow community type occurs on alluvial terraces, moist to wet areas near springs and seeps, and occasionally along major rivers and tributaries (Hansen et al. 1995). Bebb willow is tolerant of browse impacts and, as a result, has become dominant on many livestock grazing sites formerly occupied by more diverse willow communities. Bebb willow is often the only shrub present on a site. Understories are occupied by a variety of herbaceous species.

Bebb Willow Community Type (courtesy Ecological Solutions Group).

It is interesting to note that where the Bebb willow community type occurs near springs and seeps, for example a property adjacent to Reach Six, removing livestock grazing results in a relatively quick growth response by native shrubs. Bebb willow communities appear to be resilient and therefore may be good candidates for use in a passive restoration approach.

Sandbar Willow (*Salix exigua*) Community Type

The sandbar willow community type occupies a wide variety of sites characterized by alluvial deposits, most often where sand is the dominant substrate (Hansen et al. 1995). Along the Jocko River, sandbar willow is scattered throughout the lower reaches, mostly downstream from Jocko Hollow.

Sandbar Willow Community Type (courtesy Ecological Solutions Group)

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Sandbar willow typically grows in nearly monotypic stands that, once established, spread vegetatively. The sandbar willow community type may include small amounts of other shrub species, including red-osier dogwood, common chokecherry, rose (*Rosa* species), and other willow species. A sedge (*Carex* species) understory may be present on sites with appropriate hydrology and where dense sandbar willow stems have trapped fine-textured sediments.

Bog Birch/ Beaked Sedge (*Betula glandulosa/Carex rostrata*) Habitat Type

Along the Jocko River floodplain, the bog birch/beaked sedge habitat type occurs in flat areas relatively distant from the main river channel where high groundwater, organic inputs, and a lack of soil disturbance have combined to allow peat development (Hansen et al. 1995). The Montana Natural Heritage Program(2003) describes the plant community as follows:

Bog birch.

This community type occurs adjacent to beaver ponds, lakes, or marshes, and on seeps, swales, and wet alluvial terraces adjacent to low gradient, meandering streams (Hansen et al. 1995). It is found on fairly wet sites with peat accumulation, indicating a predominance of anaerobic processes. In contrast, some willow stands, like *Salix drummondiana* stands, commonly occur on soils that are better aerated and hence are not usually found in peatlands. Soils are commonly flooded until midsummer, and are saturated year-round on wetter sites. Redox concentrations are present in some mineral soils; redox depletions (gleyed soil) occur rarely. Organic matter accumulations may form floating, quaking mats as this type encroaches onto open water. Drier extremes have shallow organic horizons overlying deeper mineral soil (Montana Natural Heritage Program 2003).

Woods' Rose (*Rosa woodsii*) Community Type

The Woods' rose community type occurs on flat, alluvial areas and in narrow strips at the edge of agricultural meadows at the transition to wetter riparian ecological types (Hansen et al. 1995). It is found in areas that have been heavily grazed and may represent a transition from more complex shrub communities.

Woods' rose.

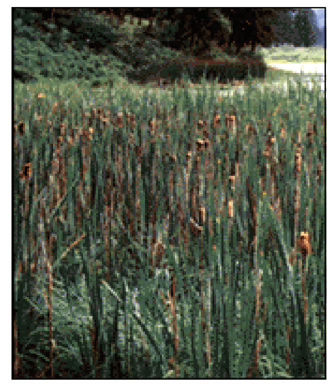
Woods' rose typically dominates and forms thick, nearly impenetrable stands. Associated shrubs include snowberry (*Symphoricarpos* species). Various introduced grass species occur in the understory.

Beaked Sedge (*Carex rostrata*) Habitat Type (synonym for *Carex utriculata*)

The beaked sedge habitat type occurs in flat areas where the soil surface is saturated for much of the growing season (Hansen et al. 1995). Along the Jocko River floodplain, this habitat type is found within open agricultural fields, along the edges of low-gradient side channels and tributary streams, within abandoned meanders and oxbows, and in off-channel peat bogs. The Montana Natural Heritage Program (2003) describes the plant community as follows:

Beaked Sedge Habitat Type (courtesy Ecological Solutions Group)

> This wetland association is found throughout much of the western U.S. Stands occur in montane and subalpine areas around the edges of lakes and beaver ponds, along the margins of slow-moving reaches of streams and rivers, and in marshy swales and overflow channels on broad floodplains. Sites are flat to undulating, often with a hummocky microtopography. The water table is usually near the surface for most of the growing season. There are a wide variety of soil types for this association ranging from saturated organics or fine silty clays to clays over cobbles and alluvium to fine-loamy and sandy-skeletal. Mottling often occurs near the surface because of the high water table. The vegetation is characterized by a moderately dense to dense perennial graminoid layer dominated or codominated by *Carex utriculata* (20 to 99 percent cover). Stands often appear to be nearly pure *Carex utriculata*, but a variety of other graminoid species may be present as well. Other *Carex* species present include *Carex lenticularis* and *Carex microptera*, but usually with low cover. Other graminoid species that may be present include *Calamagrostis canadensis, Glyceria striata*, and *Juncus balticus*. Sparse forb cover can include *Geum macrophyllum, Mentha arvensis*, and *Mimulus guttatus*. Scattered *Salix* spp. shrubs may be present because these riparian shrublands are often adjacent. *Salix* species vary depending on elevation and geography (Montana Natural Heritage Program 2003).



Common Cattail Habitat Type (courtesy Ecological Solutions Group)

Common Cattail (*Typha latifolia*) Habitat Type

The common cattail habitat type occurs in areas where the soil is saturated or submerged during a significant portion of the growing season. Hansen et al. (1995) indicate that it is found along pond margins, ditches, oxbows, and backwater areas. On the floodplain of the lower main stem, it also occupies areas managed for agriculture where groundwater is at the soil surface. These sites may be formerly drained areas where the drainage ditches have filled in, areas that were graded or slightly excavated for agricultural purposes, or natural wet areas where shrub removal has reduced evapotranspiration and changed the hydroperiod.

Cattail habitat types are usually monotypic stands of common cattail. Adjacent communities vary widely, depending upon which landform the common cattail habitat type is occupying. In agricultural fields, adjacent drier plant communities may be dominated by beaked sedge or reed canarygrass. Where the common cattail habitat type occurs in oxbows, shrubs may dominate adjacent plant communities.

Reed Canarygrass Habitat Type (courtesy Ecological Solutions Group)

Reed Canarygrass (*Phalaris arundinacea*) Habitat Type

The reed canarygrass habitat type occurs in open floodplain areas with fine-textured soils. Reed canarygrass can behave as an aggressive, invasive species and is able to grow in habitats formerly occupied by native wet-meadow or shrub communities. It is tolerant of a wider range of soil moisture conditions than most native grasses and grass-like plants (Hansen et al. 1995).

Reed canarygrass is the dominant species and usually forms monotypic, stable stands. Stands that include small components of black cottonwood, rose, nightshade (*Solanum dulcamara*), other grasses, and sedges still function as stable reed canarygrass habitat types. The reed canarygrass habitat type requires active restoration (shade, mulching, herbicide and/or active revegetation) to shift it to a more complex ecological type.

Plant Community Succession Scenarios

Cottonwood Communities

Cottonwood communities occur in response to disturbances. The black cottonwood/red-osier dogwood community type represents a relatively undisturbed, mature assemblage of plant species that develop over time on floodplains along gravel-bed rivers in the northern Rocky Mountains (Hansen et al. 1995; Hauer et al. 2002). As gravel bars deposit along river channels, cottonwood seedlings become established in extremely dense patches, an assemblage described by Hansen et al. (1995) as the black cottonwood/recent alluvial bar community. As the cottonwoods grow, they trap sediment and create substrate for other woody species that require finer-textured soils. Eventually, the community matures into the black cottonwood/red-osier dogwood type.

Other disturbances cause different cottonwood community types to develop. For example, prolonged livestock grazing can shift a black cottonwood/red-osier dogwood community type to a black cottonwood/herbaceous or black cottonwood/snowberry type. In these situations, livestock browse palatable willow and dogwood species, either leaving behind less palatable rose and snowberry, or entirely eliminating the woody shrub layer. Similarly, channel incisement, which results in a lowered water table, can cause a shift from dogwood and willow species to drier shrubs like snowberry and rose. Often, dewatering and livestock grazing occur simultaneously. Mature cottonwoods persist because they resist browse impacts and are phreatophytes, able to tap deeper groundwater than some of the smaller shrub species (Hansen et al. 1995).

In the absence of flood disturbance, some riparian ecologists think the black cottonwood/red-osier dogwood community type will shift to a ponderosa pine/red-osier dogwood habitat type. This appears to be the case on the floodplain of the lower main stem because ponderosa pine seedlings occur within several black cottonwood communities.

Herbaceous Wetland Communities

Herbaceous wetland plant communities, including those dominated by cattails, reed canarygrass, sedges, and bulrush (*Scirpus acutus*), tend to occur on finer-textured, anaerobic soils. These soils often develop where fine-textured silt has deposited in former channels or scour features on the floodplain. Large-scale disturbance processes, where channels are abandoned and then filled, partially account for distribution of herbaceous plant communities. These communities also require groundwater near the surface (Hansen et al. 1995).

Willow and Other Shrub-dominated Communities

These types of plant communities often occur where sand and gravel has deposited either along the river as sidebars or point bars or in old channel or scour features. Soil texture is coarse enough that oxygen is available in the rooting zone. Sandbar willow and Drummond's willow (*Salix drummondiana*) appear to occur in areas subject to frequent scour. Livestock grazing can cause a shift in species composition, usually resulting in a Bebb willow-dominated community (Hansen et al. 1995).

Reed Canarygrass

Maurer et al. (2003) demonstrated that reed canarygrass most effectively replaces native vegetation when natural microtopography is simplified, often as a result of sediment burying native wetland plants and filling the small depressions that support diverse microhabitats. Increases in nitrogen and light also stimulate reed canarygrass.

Bog Birch/Beaked Sedge Community

The bog birch/beaked sedge habitat type will only develop in parts of the floodplain where peat is able to accumulate over time. Peat can only accumulate in the absence of scour events, so these communities develop primarily in areas sheltered from large floods.

Weeds

Noxious weeds are legally defined by the State of Montana as "plants of foreign origin that can directly or indirectly injure agriculture, navigation, fish or wildlife, or public health" (Montana Weed Management Plan 2005). There are currently 27 species listed as noxious in Montana, which infest over 8 million acres throughout the state (Montana Weed Management Plan 2005). At least 12 of the 27 state-listed noxious weed species are present within the Jocko River restoration area (Table 2.5.2-3). Other non-native, invasive plant species (but not defined as noxious) have also become established along the lower Jocko River. Of these species, most were intentionally introduced for agricultural and erosion control purposes, whereas other non-natives were originally seeded or planted for ornamental purposes or were unintentionally introduced (Table 2.5.2-4).

Table 2.5.2-3.
Noxious weed species present in the lower Jocko River watershed.

Scientific Name	Common Name
Centaurea maculosa	spotted knapweed
Cardaria draba	whitetop, hoary cress
Chrysanthemum leucanthemum	oxeye daisy
Cirsium arvense	Canada thistle
Cynoglossum officinale	houndstongue
Euphorbia esula	leafy spurge
Hypericum perforatum	St. Johnswort
Linaria dalmatica	Dalmatian toadflax
Linaria vulgaris	yellow toadflax
Potentilla recta	sulfur cinquefoil
Ranunculus acris	tall buttercup
Tanacetum vulgare	common tansy

Table 2.5.2-4.
A partial list of non-native, invasive plant species present in the lower Jocko River watershed.

Scientific Name	Common Name
Alopecurus pratensis	meadow foxtail
Arctium minus	burdock
Bromus inermis	smooth brome
Bromus tectorum	cheatgrass, downy brome
Carduus nutans	nodding plumeless thistle
Cirsium vulgare	bull thistle
Dactylis glomerata	orchard grass
Dipsacus follonum	common teasel
Elymus repens	quackgrass
Hyoscyamus niger	black henbane
Medicago lupulina	black medic
Phalaris arundinacea	reed canarygrass
Salix alba	golden willow
Solanum dulcamara	climbing nightshade
Trifolium hybridum	alsike clover

Depending on the species and/or their location, infestations of noxious and non-native weed species (hereafter referred to collectively as weed species) have many ecological consequences, including altering hydrologic cycles, increasing erosion, displacing desirable native vegetation, and reducing forage and cover for wildlife (Montana Weed Management Plan 2005). In particular, weed species are highly competitive with native plant species for resources (i.e., water, nutrients, light), and their presence can hinder or prevent the restoration of native plant communities.

Weed species are generally a significant, if not the dominant, component of the existing plant community on protected properties that were formerly under agricultural management. They are often maintained in a prostrate growth form in areas under season-long or year-round grazing regimes due to grazing or trampling. They may also be cropped short or removed in agricultural areas that are frequently mowed, hayed, tilled, or treated with herbicides. Additionally, viable noxious weed seeds may dominate the soil seed bank, especially in areas where non-native plants have persisted for many years. In other words, weed species may not be highly visible on land that is being actively farmed or grazed, but the plants and/or seeds are present, and their populations often expand aggressively once agricultural practices are relaxed or eliminated. The presence of weed species is not necessarily an inherent feature of all agricultural land, but has more to do with the extremely aggressive nature of many weed species and the fact that these species are more tolerant than native plants of the management practices imposed on agricultural land.

Weed species distribution on the floodplain tends to follow hydrologic gradients and drier sites tend to have infestations of spotted knapweed (*Centaurea maculosa*), sulfur cinquefoil (*Potentilla recta*), Saint John's wort (*Hypericum perforatum*), and Dalmatian toadflax (*Linaria dalmatica*). These species are also common on recent alluvial deposits in Reach Eight (a reach more heavily impacted by irrigation withdrawals) and in areas where channel incisement has occurred and the substrate is well drained.

Herbaceous weed species in mesic and wetter sites on the floodplain include houndstongue (*Cynoglossum officinale*), burdock (*Arctium minus*), oxeye daisy (*Chrysanthemum leucanthemum*), teasel (*Dipsacus fullonum*), black henbane (*Hyoscyamus niger*), woolly mullein (*Verbascum thapsus*), and Canada thistle (*Cirsium arvense*). Riparian areas that have had their woody overstory removed are particularly susceptible to weed encroachment.

Existing Vegetation by Reach

The following subsection describes plant community types within the eight Jocko River reaches. After each reach description, a table shows estimated percentage of the total area occupied by each plant community type, the dominant substrate, and comments describing disturbance or notable management conditions.

Reaches One and Two, Jocko River Delta

Introduction

Reaches One and Two extend from the Flathead River to the Highway 212 Bridge. This is a low-gradient reach where the floodplain widens into a delta. It also includes several oxbows and abandoned channels. Fine-textured alluvial sediments and shallow groundwater have created wetlands throughout the floodplain.

Plant Communities Present

Plant community distribution has been influenced by historical sediment deposition patterns at the mouth of the Jocko River. Several abandoned meanders occur, and borrow pits adjacent to the railroad corridor contain standing water and are surrounded by dense shrubs. The river is not entrenched and the floodplain is frequently inundated (Subsection 2.4). As a result, disturbance processes are functioning and creating new substrate, allowing early successional plant communities like the sandbar willow community type to become established in places. Toward the north, the floodplain is dominated by ponderosa pine. In some places it has upland characteristics. Farther north, the site of an abandoned post and pole operation includes sparse or poor riparian habitat. Table 2.5.3-1 summarizes the plant communities in Reaches One and Two.

Table 2.5.3-1.
Plant community distribution in Reaches One and Two.

Plant community	Estimated Percent of reach occupied*	Associated substrate	Condition
Ponderosa pine/red-osier dogwood (*Pinus ponderosa/Cornus stolonifera*) h.t.	8%	Sandy loam	There is some ponderosa pine upland forest mixed in with the riparian forest.
Sandbar willow (*Salix exigua*) c.t.	6%	Sand/cobbles	Varying age classes present, some stands include red-osier dogwood
Black cottonwood/red-osier dogwood (*Populus trichocarpa/Cornus stolonifera*) c.t.	24%	Sandy loam	Most cottonwood stands are mature or older.
Common cattail (*Typha latifolia*) h.t.	4%	Silt	Occurs in abandoned meanders
Woods rose (*Rosa woodsii*) c.t.	12%	Sandy/gravelly loam	
Agricultural herbaceous	29%	Sandy loam	
Developed land	11%		
Water and river channel	5%		

**Remaining cover is either developed land or water.*

Reach Three, Bison Range

Introduction

Reach Three extends from the Highway 212 Bridge near Dixon to the Highway 200 Bridge near Ravalli. The river here is steeper than the downstream reach, and sediments deposited on the floodplain include coarser textured sand. Throughout much of the reach, the riparian forest has been cleared, and the land is being used for agriculture. The Burlington Northern Santa Fe (BNSF) Railway separates portions of the historical floodplain and attendant wetland and riparian communities from the river. In places the river is bounded to the north by the National Bison Range.

Plant Communities Present

A black cottonwood forest dominates, although some areas of ponderosa pine-dominated riparian forest are present. Introduced grasses dominate agricultural areas. Weed species, including spotted knapweed (*Centaurea maculosa*) and teasel (*Dipsacus fullonum*), are also common, and there are small inclusions of shrub- and emergent-dominated wetlands. In these wetland areas, plant communities are associated with organic soils, probably resulting from a combination of groundwater upwelling and past beaver activity. Table 2.5.3-2 describes the plant communities in the reach.

Table 2.5.3-2.
Plant community distribution in Reach Three.

Plant community	Estimated Percent of reach occupied*	Associated substrate	Condition
Black cottonwood/red-osier dogwood (*Populus trichocarpa/ Cornus stolonifera*) c.t.	13%	Sandy loam/silt loam	Species composition indicates low disturbance in remaining stands. Natural regeneration is occurring in some reaches.
Ponderosa pine/red-osier dogwood (*Pinus ponderosa/ Cornus stolonifera*) h.t.	1%	Sandy loam	Species composition indicates moderate disturbance (mostly weeds). Occupies slightly higher position than black cottonwood community and was more likely cleared or logged.
Quaking Aspen/red-osier dogwood (*Populus tremuloides/ Cornus stolonifera*) h.t.	2%	Silt loam	Probably represents historical fire disturbance patches.
Bog birch/beaked sedge (*Betula glandulosa/Carex rostrata*) h.t.	1%	Peat/histosol	Heavily impacted from grazing, but good potential for recovery if grazing eliminated.
Common cattail (*Typha latifolia*) h.t.	2%	Silt loam	Mostly present in disturbed areas or relict side channels.
Woods rose (*Rosa woodsii*) c.t.	4%	Sandy loam	Previously disturbed, probably followed by grazing
Agricultural herbaceous upland	63%	Various	Condition varies depending upon current management.
Developed land	10%		
Water and river channel	4%		

**Remaining cover is either developed land or water.*

Reach Four, Ravalli Canyon

Introduction

Reach Four extends from the Highway 200 Bridge through Ravalli Canyon to the confluence with Valley Creek. The river through this section is steep and confined, except for the lower 15 percent near Ravalli where the floodplain widens. Several ponds have been constructed in the downstream portion of the floodplain. Agricultural use is concentrated near Ravalli. US Highway 93 and the BNSF Railway are located in the floodplain and have cut off several historical meanders of the river, effectively confining the floodplain.

Plant Communities Present

A matrix of black cottonwood and ponderosa pine riparian forest dominates Reach Four. Introduced grasses dominate agricultural areas. Weed species, including spotted knapweed, sulfur cinquefoil (*Potentilla recta*), houndstongue (*Cynoglossum officinale*), and Canada thistle (*Cirsium arvense*) are also present. Shrub- and emergent-dominated wetlands occur near constructed ponds and ditches and other moderately disturbed areas. Table 2.5.3-3 describes the plant communities in the reach.

Table 2.5.3-3.
Plant community distribution in Reach Four.

Plant community	Estimated Percent of reach occupied*	Associated substrate	Condition
Black cottonwood/red-osier dogwood (*Populus trichocarpa/ Cornus stolonifera*) c.t.	16%	Sandy loam/silt loam	Species composition indicates low disturbance in remaining stands. Natural regeneration is occurring in some reaches.
Woods rose (*Rosa woodsii*) c.t.	10%	Sandy loam	Previously disturbed areas
Mixed herbaceous wetland types	3%	Silt loam	Interspersed among agricultural areas
Quaking Aspen/red-osier dogwood (*Populus tremuloides/ Cornus stolonifera*) h.t.	2%	Sandy loam/silt loam	These inclusion probably represent historical fire disturbance.
Agricultural herbaceous upland	22%	Various	Condition varies depending upon current management.
Developed land	36%		
Water and river channel	11%		

**Remaining cover is either developed land or water.*

Reaches Five and Six, Squeque and Lower and Upper Schall Flats

Introduction

Reaches Five and Six extend from the confluence with Valley Creek to the north end of the Jocko Hollow Canyon. We have combined them because they have similar plant communities and land-use patterns. Agricultural use is heavy throughout. Groundwater is near the surface, and several spring creeks share the historical floodplain with the river. It is likely that during the historical period the extent of woody riparian vegetation was up to ten times what it is now, and it may have extended across the floodplain from the Jocko River to Jocko Spring Creek (Section 2.5.2). Vegetation removal, drainage structures, and soil compaction from agriculture probably caused this dramatic shift from historical conditions.

Plant Communities Present

A black cottonwood forest occurs along vegetated portions of the active floodplain. A ponderosa pine riparian forest occupies slightly higher ground along some sections. Quaking aspen, alder, and willow dominate other woody plant communities. Agricultural areas include both wetland and upland plant communities. The wettest areas are occupied by monotypic stands of cattail, while other wet areas support abundant reed canarygrass (in silt loam soils) and beaked sedge (where soil organic content is higher). Patches of teasel are well-established within these wet areas. Introduced grasses, spotted knapweed, and many other non-native, weedy species dominate upland agricultural areas. Table 2.5.3-4 describes the plant communities in Reaches Five and Six.

Table 2.5.3-4.
Plant community distribution in Reaches Five and Six.

Plant community	Estimated Percent of reach occupied*	Associated substrate	Condition
Black cottonwood/red-osier dogwood (*Populus trichocarpa/ Cornus stolonifera*) c.t.	15%	Sandy loam/silt loam	Moderate to high disturbance. Some cottonwood communities are snowberry or herbaceous understory
Ponderosa pine/red-osier dogwood (*Pinus ponderosa/ Cornus stolonifera*) h.t.	5%	Sandy loam	Species composition indicates low disturbance where this type still remains
Quaking aspen/red-osier dogwood (*Populus tremuloides/ Cornus stolonifera*) h.t.	2%	Sandy loam	Occurs in clonal patches, possibly remnant from either fire disturbance or beaver activities.
Bebb's willow (*Salix bebbiana*) c.t.	3%	Silt loam	Dominant remaining willow in willow complex landform position; may indicate grazing-induced plant composition shift
Bog birch/beaked sedge (*Betula glandulosa/Carex rostrata*) h.t.	2%	Peat/histosol	Scattered in pockets of organic soils
Common cattail (*Typha latifolia*) h.t.	3%	Silt loam	Mostly present in disturbed areas or relict side channels.
Beaked sedge (*Carex rostrata*) h.t.	1%	Peat/histosol	Some patches may have potential for willow or bog birch overstory.
Reed canarygrass (*Phalaris arundinacea*) h.t.	10%	Silt loam	Locally abundant, forming monotypic stands.
Agricultural herbaceous upland	46%	various	Condition varies depending upon current management.
Developed land	9%		
Water and river channel	4%		

**Remaining cover is either developed land or water.*

Reach Seven, Jocko Hollow Canyon Reach

Introduction

Reach Seven is short, stretching from the confluence of Finley Creek to the end of Jocko Hollow Canyon. The river is confined between the walls of a narrow, bedrock canyon, and the floodplain is narrow. Plant communities are stable.

Plant Communities Present

Ponderosa pine riparian forest dominates Reach Seven (Table 2.5.3-5).

Table 2.5.3-5.
Plant community distribution in Reach Seven.

Plant community	Estimated Percent of reach occupied*	Associated substrate	Condition
Ponderosa pine/red-osier dogwood (*Pinus ponderosa/ Cornus stolonifera*) h.t.	10%	Sandy loam	Species composition indicates low disturbance.
Bebb willow (*Salix bebbiana*) c.t.	33%	Silt loam	Present adjacent to riparian forest, associated with tributary spring creek
Agricultural herbaceous	10%	various	Heavily disturbed, associated with tributary spring creek.
Developed land	13%		
Water and river channel	34%		

**Remaining cover is either developed land or water.*

Reach Eight, Demonstration Reach

Introduction

Reach Eight is the farthest upstream reach and extends from confluence of Finley Creek to the mouth of the main Jocko River Canyon. It includes aggrading and degrading stream segments of varying steepness. A variety of hydrologic influences are present, and they have helped to create a diverse matrix of riparian and wetland plant communities. Land uses and associated disturbances include agriculture, grazing, and groundwater removal associated with the fish hatchery.

Plant Communities Present

A black cottonwood forest dominates Reach Eight, although there are also significant areas of ponderosa pine- and Douglas-fir-dominated riparian forest. Introduced grasses and spotted knapweed dominate agricultural areas. Bog communities with organic peat soils are present where groundwater upwelling zones create permanently saturated conditions at the soil surface. Table 2.5.3-6 describes the plant communities present in Reach Eight.

Table 2.5.3-6.
Plant community distribution in Reach Eight.

Plant community	Estimated Percent of reach occupied*	Associated substrate	Condition
Black cottonwood/red-osier dogwood (Populus trichocarpa/ Cornus stolonifera) c.t.	30%	Sandy loam/silt loam	Species composition indicates low disturbance in remaining stands. Natural regeneration is occurring in some reaches.
Ponderosa pine/red-osier dogwood (Pinus ponderosa/ Cornus stolonifera) h.t.	10%	Sandy loam	Species composition indicates low disturbance. Occupies slightly higher position than black cottonwood community and was more likely cleared or logged in this reach.
Douglas-fir/red-osier dogwood (Pseudotsuga menziesii/Cornus stolonifera) c.t.	10%	Sandy loam/silt loam	Species composition indicates low disturbance in remaining stands. Most Douglas-fir are young and may indicate a conversion to upland in dewatered reaches.
Bog birch/beaked sedge (Betula glandulosa/Carex rostrata) h.t.	4%	Peat/histosol	Communities relatively undisturbed. Jocko River Campground ponds may have been this type before disturbance.
Other wetland types	5%	Silt loam	Scattered throughout
Agricultural herbaceous upland	30%	Various	Condition varies depending upon current management.
Developed land	5%		
Water and river channel	6%		

**Remaining cover is either developed land or water.*

2. CONDITIONS

2.6 Wetlands and Off-Channel Springs

2.6.1 Introduction

This discussion of wetlands and off-channel springs concentrates on both wetland and ripariain features within the ecological floodplain of the lower main stem. Many factors influence existing wetland patterns—geomorphic setting, water source, hydrodynamics, soils, vegetation, land use practices, and disturbance, for example. In addition, land use patterns and human-caused disturbance have caused significant shifts in wetland abundance, composition, and distribution.

Systems Used to Describe Wetlands

Wetland Classification

Various methods exist for classifying wetlands, including:

1. **The Cowardin System**, Classification of Wetlands and Deepwater Habitats of the United States used by the US Fish Wildlife Service (USFWS) (Cowardin et al. 1979);

2. **The Hydrogeomorphic Classification for Wetlands** (HGM) developed by the US Army Corps of Engineers (Brinson 1993); and

3. A vegetation-based classification, **Classification and Management of Montana's Riparian and Wetland Sites** developed at the University of Montana (Hansen et al. 1995).

Cowardin System

The Wetlands Conservation Plan for the Flathead Indian Reservation, Montana (Price 1999) defines wetlands according to the United States Fish and Wildlife Service (USFWS) definition, which is based on Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). It defines wetland as "the collective term for marshes, peatlands (bogs and fens), wet meadows, seeps and springs, mudflats, swamps, shallow ponds, and other similar landscape units where the soil or substrate is at least periodically saturated with or covered by water" (Price 1999). The system is based primarily on the hydrologic regime and dominant vegetation of the wetland and is limited in that it only classifies the wetland; it does not assess wetland function.

The following USFWS wetland systems and classes occur within the ecological floodplain of the lower main stem (Cowardin et al. 1979):

Wetland Systems

Riverine System

Riverine systems are wetlands or deepwater habitats contained in a channel and not dominated by trees, shrubs, persistent emergents, emergent mosses, or lichen. The limits of the system are the banks of the channel where there is a transition to upland or a wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. In braided streams, the limits are the outermost banks of the depression where the stream braids occur. Riverine systems within the lower main stem are divided into two classes: unconsolidated bottom and unconsolidated shore (defined below).

Palustrine System

The palustrine system includes wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. Wetlands lacking the vegetation listed above are included in this system if all of the following apply: (1) they are less than eight hectares (20 acres) in size; (2) active wave-formed or bedrock shoreline features are not present; and (3) water is less than two meters (6.6 feet) deep in the deepest part of the basin at low water (Cowardin et al. 1979). Palustrine systems within the lower main stem are divided into five classes: forested, scrub-shrub, emergent, aquatic bed, and unconsolidated bottom.

Wetland Classes

Aquatic Bed Class

Areas that fall within the aquatic bed class occur where water is present above the ground level for most, and sometimes all, of the growing season. Vegetation that typically grows on or below the surface of the water dominates this class.

Unconsolidated Bottom Class

The unconsolidated bottom class of wetlands includes areas where water is present above the surface for most, if not all, of the growing season. Unconsolidated bottom areas have less than 30 percent vegetative cover and at least 25 percent cover of material smaller than stones.

Unconsolidated Shore Class

The unconsolidated shore class of wetlands encompasses areas adjacent to the unconsolidated bottom class in all systems. It has less than 75 percent aerial coverage of stones, boulders, or bedrock; less than 30 percent vegetative cover other than pioneering plants; and a water regime of irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded. Beaches, bars, and flats are examples of unconsolidated shore landforms that form by the erosion and deposition of waves and currents.

Forested Class

Areas that fall within the forested class of wetlands have at least 30 percent vegetated cover of woody vegetation that is six meters (20 feet) tall or taller. Forested wetlands typically have an overstory of trees, an understory of young trees or shrubs, and an herbaceous layer.

Scrub-Shrub Class

Areas that fall within the scrub-shrub class of wetlands have at least 30 percent vegetative cover dominated by woody vegetation less than six meters (20 feet) tall that is the uppermost layer of vegetation. This system can include shrubs and young trees and shrubs stunted due to environmental conditions.

Emergent Class

The emergent class of wetlands includes areas dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens), where vegetation is present for most of the growing season.

Hydrogeomorphic Classification for Wetlands (HGM)

The Hydrogeomorphic (HGM) Classification system places wetlands within a class based on their geomorphic setting, water storage, and hydrodynamics. Assessment methods are developed for wetland classes (and/or regional subclasses) rather than wetlands as a whole. This reduces the variability in assessing wetland function that tends to occur when attempting to assess wetlands as a general landform and allows for greater resolution when assessing function (Hauer et al. 2002). The HGM approach can be used to classify wetland systems, but it can also be used to assess function and map wetlands.

The HGM Classification system places wetlands into seven different classes: depression, tidal fringe, lacustrine fringe, slope, mineral soil flats, organic soil flats, and riverine. The classes can be further divided into regional subclasses to refine the classification system. *A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Riverine Floodplains in the Northern Rocky Mountains* (Hauer et al. 2002) is an example of a regional HGM guidebook that assesses the functions of wetlands within a specific HGM class (riverine) and regional subclass (Northern Rocky Mountain floodplains).

Hansen Classification System

Classification and Management of Montana's Riparian and Wetland Sites (Hansen et al. 1995) is a vegetation-based classification system for wetland and riparian areas. This method and the vegetation communities it uses are described further in the Vegetation Subsection of this document (Subsection 2.5). Riparian areas that may or may not be wetland are included in this method, but are not included in other classification systems such as the Cowardin System. This method describes riparian areas as "the green zones bordering lakes, reservoirs, estuaries, potholes, springs, seeps, peatlands (bogs and fens), wet meadows, vernal pools, and ephemeral, intermittent, or perennial streams" (Hansen et al. 1995).

Wetland Function

We used two methods to assess the function of wetlands along the Jocko River including the HGM Wetland Assessment Method for Riverine Systems in the Northern Rocky Mountains (Hauer et al. 2002) and the Evaluation Form for Determining Wetland Functional Value and Effective Wetland Areas in Upper Clark Fork River Superfund Sites (ARCO 1992). Others have used the Montana Riparian and Wetland Research Program Wetland Assessment Method (Montana Riparian and Wetland Association 1993-1997) and the Montana Department of Transportation's Montana Wetland Assessment Method (Burglund 1999) to assess wetland function on portions of the lower main stem.

HGM Riverine

The HGM Classification system is the basis for the wetland functional assessment portion of the HGM method. The Northern Rocky Mountains regional guideook (Hauer et al. 2002) is used in western Montana for assessing riverine systems. It assesses riparian floodplain systems by comparing the level of performance to reference standard wetlands. Reference standard wetlands represent the range of variability that result from natural processes. They establish the basis for what is characteristic and sustainable function. They also provide data to calibrate model variables in the assessment procedure. The method assesses the following eight wetland functions:

1. Surface-groundwater storage and flow,
2. Nutrient cycling,
3. Retention of organic and inorganic particles,
4. Generation and export of organic carbon,
5. Characteristic plant community,
6. Characteristic aquatic invertebrate food webs,
7. Characteristic vertebrate habitats, and
8. Floodplain interspersion and connectivity.

These eight functions are determined from variables ascertained from existing data and data collected in the field. The variables are placed in equations to derive a number or score for each of the functions. The variables include:

1. Proportionality of landscape features,
2. Floodplain habitat connectivity,
3. Geomorphic modification,
4. Macrotopographic complexity,
5. Frequency of surface flooding,
6. Frequency of subsurface flooding,

7. Proportional land use,
8. Decomposition of organic matter,
9. Tree density,
10. Pole cottonwood, willow, shrub, and sapling cover,
11. Herbaceous plant coverage,
12. Large wood debris, and
13. Percent coverage by native plants.

The Master Plan team chose the HGM Riverine functional wetland assessment method to characterize and quantify changes to lower main-stem wetlands brought about by the ARCO mitigation project. The team began conducting wetland functional assessments in the summer of 2003 for several properties within the lower main stem, and the results are discussed in the existing wetlands subsection (Subsection 2.6.3).

Wetland Functional Value and Effective Wetland Area (FEWA)

The Consent Decree for the ARCO settlement specifies that the FEWA wetland assessment method be used to assess wetland functions (ARCO 1992). This methodology is specific to assessing the functional value of wetlands in Superfund Sites in the Upper Clark Fork River Basin. The specificity limits the methodology for application to the Jocko River wetland system, hence the Master Plan team selected the HGM method as an alternative.

Montana Riparian and Wetland Association (MRWA)

The MRWA assessed riparian areas within the Jocko River watershed using their lotic riparian inventory method. Areas assessed included the main stem of the Jocko River and several of its tributaries. The MRWA determined the main stem below Big Knife Creek (upstream of the project area) and the mouth of the river to be “Functioning At Risk” (MRWA 1993-1997).

Montana Wetland Assessment Method

Portions of the Jocko River wetlands adjacent to US Highway 93 have been assessed using the Montana Department of Transportation’s *Montana Wetland Assessment Method* (Burglund 1999). These assessments can be found in the *Wetland Mitigation Report for US 93* (Herrera Environmental Consultants 2003).

Wetland Mapping

Methods of mapping wetlands or wetland characteristics include:

National Wetlands Inventory

The USFWS maps wetland resources throughout the United States with the National Wetlands Inventory (NWI), using the Cowardin system described above. The mapping, not intended for regulatory purposes or to delineate jurisdictional wetlands, is a report on the status of the nation’s wetlands. Some of the wetlands mapped would not be regulated under the Clean Water Act (National Research Council 1995). However, the inventory does provide a starting point to determine where regulated wetland features may occur and what type of features they are, which can serve as a basis for completing wetland delineations and functional assessments. The CSKT Wetlands Conservation Plan (Price 1999) notes that forested wetlands are under-represented in NWI mapping for the reservation. Thick forest canopy tends obscures wetland signatures that are easier to see in emergent or scrub shrub wetlands in aerial photographs used for NWI mapping.

HGM

The HGM method can be used for wetland classification and functional assessment. It can also be used to map wetlands. Hauer et al. (2002) define cover types based on vegetation composition and structure and soils. They are mapped over aerial photographs of the assessment area to determine the relative extent of each within the assessment area. The data collection effort for HGM Riverine functional assessments varies based on the mapped cover types. Vegetation and soils are sampled for native vegetation-dominated cover types (1, 2, 3, 4, 5, and 6), but not for water, unvegetated or developed land cover types (7, 8, 9, 10 or 11). Table 2.6.1-1 defines the eleven cover types.

Table 2.6.1-1.
HGM Cover types for the Northern Rocky Mountains Riverine Regional Guidebook.

Cover Type	Description
1	Mature conifer dominating the canopy, with interspersed mature cottonwood. Soils generally developing an A-horizon.
2	Mature cottonwood dominated (>6-m height and >10 cm dbh), may have early stages of conifers that have not reached the forest canopy or may be entirely devoid of conifers.
3	Immature pole cottonwood 2-6 m in height and <10 cm dbh. May also have interspersion of willow. Soils are generally cobble dominated with fine sediments accumulating over the surface.
4	Cottonwood or willow seedlings and early seral stages up to 2 m in height. Substrate often with exposed cobble, but may also include deposited fines from flooding. Generally, soils are unstained by organics, indicating very early soil development.
5	Filled or partially filled abandoned channel dominated by mix of willows, alder, shrubs, and interspersed herbaceous cover. Also, often the dominant Cover Type along edge of backwaters. Soils are generally composed of deeper fines (>10 cm) with a developing A-horizon.
6	Herbaceous vegetation dominated, but have interspersion of an occasional shrub (<10% cover). This Cover Type is often associated with filled side channel or abandoned back channel, but may be on any surface type.
7	Exposed cobble riverbed during base flow and inundated during most annual high flows. May have sparse herbaceous vegetation or an occasional cottonwood or willow seedling composing <10% cover.
8	Main-channel surface during base flow, may be in a single tread channel or may be braided w/ islands.
9	Off main channel, water at surface during base flow; includes springbrooks, oxbows, scour depressions and ponds, non-flow-through downstream connected channels, and disconnected side channels.
10	Agricultural field, may be a meadow or plowed, often planted and hayed, may have origin as a forested surface, but now logged, or may have been a natural meadow.
11	Domestic or commercially developed land including homes, buildings, gravel pits, transportation corridors, etc.

Source: Hauer et al. 2002

Soils Mapping and Hydric Soils

The United States Department of Agriculture, Natural Resources Conservation Service (USDA NRCS) maps soils throughout the United States. As part of this process, the agency identifies hydric soils, which they define as "... a soil formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part" (USDA NRCS 2004). Hydric soils are a characteristic of wetlands and one of the three parameters for delineating jurisdictional wetlands according to the 1987 US Army Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987).

2.6.2 Historical Wetlands and Off-Channel Springs

Introduction

Tools used to estimate the extent of historical wetlands in the Jocko River ecological floodplain include maps from an 1883 Northern Pacific Railroad (NPRR) survey (NPRR 1883), aerial photographs from 1937 (U.S. Agricultural Research Service 1937), and hydric soils (USDA NRCS 2002b, 2002c) identified in the Lake County and Sanders County Area soils surveys (USDA NRCS 1998 and 2005).

Northern Pacific Railroad maps from 1883 show the Jocko River occupying a larger portion of the ecological floodplain than it does today. Segments of the river were located in areas now cutoff from the main river channel and its floodplain. In other areas, segments of the 1883 channel have become isolated ponds or backwater features, some modified to rear fish. The 1883 NPRR maps were completed prior to railroad construction and show the Jocko River in Reaches One and Two with access to the ecological floodplain. The maps also show seeps in Reach Three that may have contributed to Jocko River floodplain hydrology and associated wetlands. Many of these are currently cutoff from the river and its floodplain by transportation rights-of-way. In Reach Four, the main channel of the river was on what is now the west side of US Highway 93. Today this area contains abandoned backwater ponds that are separated from the main channel. The 1883 NPRR maps of Reaches Five and Six show the river in a similar position to what it is now. The river has been channelized in some locations, but is still located in the ecological floodplain for most of the two reaches. Spring creeks in Reaches Five and Six, however, have been substantially modified since 1883. Jocko Spring Creek meanders and floodplain vegetation have been lost because of the construction of US Highway 93 and the NPRR. Draining for agricultural purposes has eliminated many of the historical features of Squeque Creek. The NPRR maps show that wetlands throughout Reach Seven have not changed much since 1883, probably because the narrow bedrock canyon that bounds the river limits the types of alterations that can be made. The river in Reach Eight was more sinuous in 1883 than today (NPRR 1883).

The 1937 aerial photographs (U.S. Agricultural Research Service 1937) show greater portions of the floodplain with wetland hydrology and vegetation than exists today. In Reaches One and Two the photos show extensive shrub vegetation south of the channel that has since been cleared. In Reach Three, shrub vegetation that probably had wetlands associated with it occupied much of the ecological floodplain. Large areas supporting this type of vegetation have been cleared, and it is likely the land has also been drained (Subsection 2.5 describes historical vegetation). The 1937 aerial photos also show more woody vegetation within the ecological floodplain of Reaches Five and Six than currently exists. The images suggest there were more diverse shrub wetlands in this area. The photos also show that more of the ecological floodplain in Reach Eight was covered by woody vegetation than today. Historically the cleared areas probably supported wetland features such as scrub-shrub wetlands.

The NRCS soils maps (USDA NRCS 1998, 2002a and b, and 2005) reveal that large areas of the Jocko River floodplain have hydric soils (Table 2.6.2-1). Although there is currently only a small overlap of hydric soils and existing wetlands within the ecological floodplain, the overlap may have been greater historically because of the larger extent of riparian vegetation and hydrologic activity. Many direct and indirect disturbances in the floodplain of the lower main stem have altered ecological processes, which has resulted in a decrease in wetland acres.

Table 2.6.2-1.
The area (acres) and the percent of the ecological floodplain (EFP) having hydric soils by Reach in the lower main-stem Jocko River project area.

Project Reach	Area of Hydric Soils by Reach		Area of Non-hydric, floodplain soils		Area of overlap between hydric soils and NWI	
	Acres	Percent EFP	Acres	Percent EFP	Acres	Percent EFP
Reaches One and Two	0	0 %	230	100 %	0	0 %
Reach Three	532	37 %	892	62 %	79	5 %
Reach Four	1	0.4 %	235	91 %	0	0 %
Reach Five	635	42 %	865	57 %	151	10 %
Reach Six	45	12 %	340	88 %	8	2 %
Reach Seven	0	0 %	6	100 %	0	0 %
Reach Eight	245	66.83 %	130	35 %	65	18 %

Disturbance Processes Affecting the Jocko River Floodplain

Direct and indirect disturbances that have altered ecological processes in the floodplain of the lower main stem are discussed in detail in Subsection 2.1. Channelization, dikes, levees, irrigation diversions (and return flow), riparian grazing, and vegetation clearing (riparian logging) have severely altered the natural hydrologic regime in some locations, which in turn has affected the distribution, composition, and function of wetlands. Channelization and levees have restricted overbank flows, reducing the extent of the existing floodplain and reducing hydrologic connectivity of some floodplain wetland features. Vegetation clearing and land leveling for agricultural or livestock use has been a common practice and has reduced historical wetland distribution and altered the vegetative structure of wetlands. Where livestock grazing occurs in shrub-dominated wetlands, shrub coverage has been reduced. Grazing has also impacted trees by removing new recruits that would normally replace some aging tree stands.

Water withdrawals related to irrigation and fisheries activities have altered the hydrology of the floodplain and its wetlands. Irrigation withdrawals have a large impact on the hydrology of the upper reaches of the river, especially upstream from the lower main stem. Within Reaches Seven and Eight, the effect of those withdrawals is still apparent in annual streamflow measurements (see Subsection 2.3). In Reach Eight, near the State of Montana's Arlee Fish Hatchery, groundwater is collected for the hatchery in volumes great enough to increase the depth to groundwater (Subsection 2.2). Several spring creeks and groundwater discharge restore some hydrology to the floodplain system downstream of Reaches Five and Six, reducing the effect that irrigation withdrawals have on the lower reaches of the river (Subsections 2.2 and 2.3).

Indirect disturbances such as weeds and residential and commercial development also affect the floodplain. Noxious and non-native weeds out-compete native plants. Many of the non-natives do not perform the same functions as native species, functions such as binding soils, storing water, and trapping sediment.

In the absence of these direct and indirect human disturbances, the river would probably access a wider area of the floodplain and contain a larger diversity of wetland classes as well as larger areas of forested and/or scrub-shrub wetlands.

2.6.3 Existing Wetlands and Off-Channel Springs by Reach

This section describes wetlands and off-channel springs that occur within each of the eight reaches. The discussion considers the ecological floodplain as a whole (including wetlands) because all of the wetland classes or vegetative cover types within the floodplain contribute to the overall function of the riverine system (Hauer et al. 2002). Wetland area refers to the wetland areas mapped by the National Wetlands Inventory (NWI). Vegetative cover type refers to the HGM cover types described above. Table 2.6.3-1 shows the estimated acreage and percentage of the ecological floodplain occupied by each wetland class as mapped by NWI for each reach. Table 2.6.3-2 shows the acreage and percentage of the floodplain occupied by each HGM vegetative cover type by reach.

Overall Wetland and Off-channel Springs Distribution and Abundance

Trend analysis of available data suggests that there has been an overall decline in wetland acreage on the Flathead Indian Reservation (Price 1999). Most of the losses have been in palustrine forested, scrub-shrub, and emergent wetland and riparian areas dominated by deciduous trees and shrubs. These wetland and riparian types have declined significantly in acreage and quality. Along the lower main stem, many areas once covered by either coniferous or deciduous trees have been cleared and converted to agricultural lands or pasture. Many of these lands were also drained with the construction of ditches, dikes or levees. Transportation corridors have restricted the river's access to portions of the ecological floodplain in some places. In the meantime, other wetland types have been increasing. Deepwater habitat, for example, has increased with the construction of reservoirs. Wetlands in the form of ponds and mudflats have also increased.

Much of the wetland area remaining is found where development or agriculture has not encroached onto the floodplain. It consists of narrow bands of forested and scrub-shrub wetland along the main channel. These areas tend to have abrupt edges along property lines where the land use changes, in most cases to agriculture. In some places where a wider floodplain is intact, larger areas of forested and scrub-shrub wetland and emergent wetland remain along the river channel.

Overall Wetland and Off-Channel Spring Functions

Most wetland systems in the Flathead Indian Reservation have a functional integrity rating of At Risk or Nonfunctioning (Price 1999). The functional integrity of a wetland refers to the quality of the wetland and riparian areas measured by comparing the actual conditions of the system to a reference system (Hauer et al. 2002). The overall loss of wetlands combined with altered wetland and riparian hydrology, soils, and plant communities has resulted in a decrease or loss of wetland function.

Reaches One and Two, Jocko River Delta

Wetlands and Off-channel Springs Present

The ecological floodplain encompasses approximately 229 acres in these reaches and extends from the base of the hills to the north and south of the Jocko River into agricultural lands and transportation rights-of-way. The ecological floodplain is fairly wide at the delta, and wetlands are primarily scrub shrub and emergent wetlands or HGM cover types 3, 4, 5, and 6. Forested areas consisting of cottonwood (HGM cover type 2), occur on the upstream end of Reach Two. Downstream, near the mouth of the river, conifer-dominated areas (HGM cover type 1) are present. NWI mapping did not detect forested wetlands within these reaches even though HGM cover type mapping shows some areas with mature deciduous and coniferous trees (Table 2.6.3-2). NWI mapped approximately 42 percent of the ecological floodplain as wetland (Table 2.6.3-1) (USFWS 1992d). Both reaches are composed entirely of non-hydric floodplain soils (Table 2.6.2-1) (USDA NRCS 2002c, 2005). Reaches One and Two encompass the delta of the Jocko River, which is a depositional area for alluvial sediments.

Table 2.6.3-1.
National Wetlands Inventory wetland distribution in Reaches One through Eight of the lower main stem.

USFWS Wetland System and Class (NWI mapped wetlands)	Reaches One and Two		Reach Three		Reach Four		Reach Five		Reach Six		Reach Seven		Reach Eight	
	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP
Palustine Forested	0	0 %	0	0 %	0	0 %	2	0 %	0	0 %	0	0 %	8	2 %
Palustrine Scrub Shrub	26	11 %	5	0 %	0	0 %	64	4 %	1	0. %	0	0 %	40	11 %
Palustrine Emergent	25	11 %	21	1 %	3	1 %	52	3 %	29	8 %	0	0 %	4	1 %
Palustrine Aquatic Bed	0	0 %	11	1 %	3	1 %	6	0 %	1	0 %	0	0 %	5	1 %
Palustrine Unconsolidated Bottom	0	0 %	0	0 %	4	2 %	0	0 %	0	0 %	0	0 %	0	0 %
Riverine Unconsolidated Bottom	31	13 %	74	5 %	24	9 %	18	1 %	4	1 %	0	0 %	0	0 %
Riverine Unconsolidated Shore	14	6 %	15	1 %	2	1 %	49	3 %	10	3 %	1	15 %	10	3 %
Total Area of EFP	229		1437		258		1507		385		6		367	
Total Percent of EFP mapped as wetland		42 %		9 %		14 %		13 %		12 %		15 %		18 %

Table 2.6.3-2.
HGM cover type area (acres) in Reaches One through Eight of the lower main stem.

Wetland and Off-channel Springs	Reaches One and Two		Reach Three		Reach Four		Reach Five		Reach Six		Reach Seven		Reach Eight	
HGM Cover Types	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP	Acres	Percent of EFP
Cover type 1	17.94	7.80%	13.27	0.92%	0	0.00%	48.16	3.20%	21.65	5.62%	0.67	10.26%	72.47	19.77%
Cover type 2	55.18	24.00%	208.27	14.50%	43.49	16.85%	152.30	10.10%	83.34	21.65%	0.00	0.00%	93.58	25.53%
Cover type 3	1.51	0.66%	2.02	0.14%	0	0.00%	4.94	0.33%	0.12	0.03%	0.00	0.00%	0.00	0.00%
Cover type 4	14.29	6.21%	13.56	0.94%	3.32	1.29%	27.23	1.81%	8.90	2.31%	0.04	0.63%	8.97	2.45%
Cover type 5	26.69	11.61%	61.70	4.29%	26.80	10.38%	69.00	4.58%	13.09	3.40%	2.11	32.56%	27.68	7.55%
Cover type 6	9.57	4.16%	33.22	2.31%	6.37	2.47%	38.11	2.53%	5.97	1.55%	0.00	0.00%	11.14	3.04%
Cover type 7	0.53	0.23%	0.02	0.00%	0.00	0.00%	0.57	0.04%	1.60	0.42%	0.00	0.00%	1.99	0.54%
Cover type 8	6.87	2.99%	47.69	3.32%	19.68	7.63%	28.76	1.91%	14.48	3.76%	2.11	32.54%	15.27	4.17%
Cover type 9	6.18	2.69%	11.35	0.79%	9.44	3.66%	33.04	2.19%	3.82	0.99%	0.09	1.33%	4.71	1.29%
Cover type 10	66.18	28.78%	899.14	62.58%	56.89	22.05%	970.70	64.40%	197.73	51.37%	0.64	9.87%	111.55	30.43%
Cover type 11	24.99	10.87%	146.50	10.20%	92.06	35.68%	134.41	8.92%	34.21	8.89%	0.83	12.80%	19.21	5.24%
Total Area	229.93		1436.75		258.04		1507.22		384.92		6.49		366.58	

2. CONDITIONS

The depositional environment constantly alters surfaces within the floodplain that may prevent the development of hydric soils (USDA NRCS 2002a)**.**

HGM wetland functional assessments were not completed in these two reaches. However, the Montana Riparian and Wetland Association assessed the river near its mouth and found this area to be “Functioning At Risk” (Montana Riparian and Wetland Association 1995). Vegetation has been cleared from some floodplain and wetland areas, and they are now used for agriculture. Some areas have been drained to allow for cultivation. The BNSF Railroad and Highway 212 both run perpendicular to the river, and both have undersized bridges at their crossings that significantly constrict the hydrology. Subsection 2.9 discusses bridges and their impacts within the lower main stem.

Reach Three, Bison Range

Wetlands and Off-channel Springs Present

The ecological floodplain encompasses approximately 1,436 acres and extends south from the base of the hills of the National Bison Range to the forested hill slopes on the south side of the river. Highway 200 passes through the southern edge of most of the ecological floodplain. Throughout much of the reach, riparian forest has been cleared, and the land is now used for agriculture. The BNSF Railroad and Highway 200 separate the river from portions of the ecological floodplain and associated wetland and riparian communities.

NWI mapping did not detect forested wetlands within this reach (Table 2.6.3-1), however, HGM cover types 1 and 2 (mature deciduous and coniferous trees) both occur (Table 2.6.3-2). NWI mapped approximately nine percent of the ecological floodplain as wetland (Table 2.6.3-1) (USFWS 1992d and 1992a). Approximately 37 percent is shown to have hydric soil; the balance has non-hydric floodplain soils (Table 2.6.2-1) (USDA NRCS 1998, 2002a, 2002b, and 2005). Only five percent has both mapped NWI wetlands and hydric soils. The difference between the area of hydric soils and wetland may suggest that larger wetland areas were present historically. Large areas of woody and riparian vegetation have been cleared, which may also contribute to the small proportion of area mapped by NWI as wetland. The draining of portions of the floodplain for agricultural uses has affected wetland distribution. Some wetlands have been filled, and levees have been constructed to protect structures and reduce flood flows on agricultural lands. Some old channel features at the downstream end of the reach have been converted to a connected pond system. At one time, they were part of the main river channel (Subsection 2.2).

We completed HGM wetland functional assessments for three parcels within this reach. Two are located at the downstream end of the reach near the Highway 212 Bridge (CSKT Lease 4515 and CSKT Lease 4513), and one is near the upstream end (Stranahan Parcel) (Table 2.6.3.3). These three parcels rated the lowest of all the parcels assessed along the lower main stem. Much of the reach is channelized by constructed levees along the southern bank of the river. The levees restrict overbank flow to adjacent historical wetland and side channel features. The railroad and highway also restrict hydrologic connectivity. Many of the historical side channels have been lost entirely because they have been drained or their hydrology restricted. Some have been converted to a network of connected ponds. Much of the land within the ecological floodplain has been converted to agricultural uses. A narrow fringe of shrub or forested vegetation along the channel provides a low level of floodplain interspersion and connectivity.

Table 2.6.3-3.
HGM Score for Parcels assessed during summer 2003.

Parcel ID	CSKT Lease 4515	CSKT Lease 4513	Stranahan Parcel	CSKT Lease 5002 (Squeque West)	CSKT Lease 5015 (Squeque East)	CSKT Lease 5037 (Squeque East)	Schall/ Powell Parcel	CSKT Lease 5022	CSKT Lease 5807 (Demonstration Area)	CSKT Lease 5757 (Grazing Exclosure)
Cumulative HGM Score*	5.09	5.09	4.71	5.48	5.36	5.47	5.31	5.17	6.03	5.83
Functional Indices										
Function 1: Surface-Groundwater Storage and Flow	0.56	0.56	0.56	0.66	0.66	0.66	0.66	0.68	0.79	0.79
Function 2: Nutrient Cycling	0.59	0.69	0.56	0.70	0.69	0.69	0.65	0.61	0.78	0.73
Function 3: Retention of Organic and Inorganic Particles	0.49	0.49	0.49	0.57	0.54	0.54	0.58	0.55	0.67	0.67
Function 4: Generation and Export of Organic Carbon	0.81	0.80	0.66	0.84	0.80	0.83	0.79	0.75	0.79	0.72
Function 5: Characteristic Plant Community	0.79	0.74	0.69	0.73	0.69	0.74	0.68	0.68	0.71	0.67
Function 6: Characteristic Aquatic Invertebrate Food Web	0.56	0.56	0.56	0.63	0.63	0.63	0.63	0.58	0.76	0.76
Function 7: Characteristic Vertebrate Habitats	0.73	0.72	0.64	0.75	0.72	0.75	0.72	0.68	0.78	0.72
Function 8: Floodplain Interspersion and Connectivity	0.56	0.53	0.55	0.61	0.63	0.63	0.60	0.64	0.75	0.76

Note: Scores were aggregated to facilitate comparison among reaches. The HGM approach usually emphasizes considering each function independently.

2. CONDITIONS

Reach Four, Ravalli Canyon

Wetlands and Off-channel Springs Present

The ecological floodplain encompasses approximately 258 acres and is constricted through this reach because of the narrow valley floor. Through most of the reach, US Highway 93 is within the ecological floodplain. Narrow bands of forested and scrub-shrub vegetation occur along most of the channel, with residential and commercial development at the downstream end of the reach.

Agricultural lands (cover type 10) and developed lands (cover type 11) make up more than 50 percent of the ecological floodplain (Table 2.6.3-2). NWI did not map forested or scrub-shrub wetland in this reach, however, approximately 25 percent of the reach has tree and shrub-dominated vegetation communities (cover types 1-5). NWI mapped approximately 14 percent of the ecological floodplain as wetland (Table 2.6.3-1) (USFWS 1992a and 1992c). Approximately 0.4 percent of floodplain soils are classified as hydric, and 91 percent are shown as non-hydric floodplain soils (Table 2.6.2-1) (USDA NRCS 1998 2002a). There is no overlap of mapped wetlands with hydric soils in this reach. It is possible that the narrow canyon prevented hydric soils from developing. The narrow canyon promotes frequent scouring and sediment deposition, which upsets the soil layer and may prevent the development hydric soils.

We did not conduct HGM assessments within this reach. Although the historical condition is a narrow confined valley, the functionality has probably decreased because of the additional constriction of the floodplain from the US Highway 93 and the BNSF Railroad. This is particularly evident in some locations such as cutoff meanders where hydrologic connectivity has been greatly diminished or lost.

Reach Five, Squeque/Lower Schall Flats

Wetlands and Off-channel Springs Present

The ecological floodplain encompasses approximately 1,507 acres and is relatively wide through Reach Five, extending east to west from the base of the lowest slopes on both sides of the valley. In many places, US Highway 93 and the BNSF Railroad pass through the eastern portion of the ecological floodplain.

The reach is a gaining reach (Subsections 2.3 and 2.4). There are areas of groundwater upwelling or discharge, and two off-channel springs contribute to the hydrologic function of the river. Jocko Spring Creek, which flows into the river from the east, has been channelized by the US Highway 93 and BNSF Railroad rights-of-way that cross the creek channel. In addition, vegetation has been cleared from along the channel. Squeque Creek is a small spring creek located west of the river and upstream of the confluence of Jocko Spring Creek. It has been substantially altered from its historical condition by ditching and draining for agricultural purposes. Deeply entrenched, it is no longer connected to the river floodplain (Subsection 2.3).

Tree and shrub vegetation occurs along the main channel, sometimes in wide bands. It is likely that during historical times the extent of woody riparian vegetation was as much as ten times greater than it is today. It probably extended across the floodplain from the river to Jocko Spring Creek (Subsection 2.5). Land use practices such as vegetation removal, installation of drainage structures, and soil compaction from agricultural use have altered vegetative communities and wetland composition and distribution.

NWI mapped approximately 13 percent of the ecological floodplain as wetland (Table 2.6.3-1) (USFWS 1992b and 1992c). Approximately 42 percent of the floodplain has hydric soils, while fifty-seven percent has non-hydric floodplain soils (Table 2.6.2-1) (USDA NRCS 1998 and 2002a). The difference between the area of wetland and hydric soil may be a consequence of the large amount of vegetation clearing and draining that has occurred. Roughly 108 acres are mapped as drained hydric soil. This is the only area of drained hydric soil mapped within the ecological floodplain of lower main stem (USDA NRCS 1998 and 2002a).

NWI-mapped, forested wetlands occupy only a fraction of the HGM forest cover types 1 and 2 within the ecological floodplain. The area of NWI emergent wetland is greater than the mapped area of HGM cover type 6 (USFWS 1992b and 1992c). Wet areas in agricultural fields dominated by non-native species, emergent wetland areas were mapped as HGM cover type 10 rather than cover type 6 because of the land use of the area and the predominance of non-native species. Off-channel springs and areas of groundwater upwelling or discharge make up a large part of the HGM cover type 9, as well as some of the palustrine aquatic bed wetland class. Backwater channels actually occupy more area in the ecological floodplain of Reach Five than the main channel of the river (cover type 8). Along the river there are only few areas of exposed alluvium or bare point bars (cover type 7). Many of the point bars have establishing vegetation, including herbaceous (native and non-native species) and young shrub plant communities. Agricultural lands (cover type 10) comprise the largest portion of the ecological floodplain. Many of these have been drained, but some still display wetland hydrologic features such as inundation or saturation for most or all of the growing season (Table 2.6.3-2). In addition, they either lack or have a low proportion of native wetland plant species.

During the summer of 2003, we assessed four parcels in this reach using the HGM approach. They scored in the mid-range of all the parcels assessed along the lower main stem. The Squeque complex (CSKT Leases 5002, 5037, and 5015) is located near the downstream end of Reach Five and occupies approximately 500 acres. Several ditches and backwater channels influence hydrologic function including ditches and drains in areas now used for agriculture. The fourth parcel, the Schall/Powell Parcel, is located upstream from the Squeque complex, at the upstream end of Reach Five. All four parcels have undergone vegetation clearing, but the Schall/Powell Parcel has the largest proportion of agricultural land of the four parcels. Fill was added to raise the ground elevation to support a racetrack within the floodplain at the Schall/Powell Parcel (Subsection 2.4).

Reach Six, Upper Schall Flats

Wetlands and Off-channel Springs Present

The ecological floodplain encompasses approximately 384 acres and is narrow. The ecological floodplain is bound by a hill to the west and is wider to the east, extending to an elevational slope break. To the west, most of the floodplain is heavily vegetated and undisturbed, except for the upstream end where there has been some development. An old racetrack is located in the upstream, west portion of the floodplain. A small amount of residential development is also present there. East of the river, vegetation has been cleared from some areas and parts of the floodplain drained.

NWI mapped approximately 12 percent of ecological floodplain as wetland (Table 2.6.3-1) (USFWS 1992b and 1992c). Approximately 12 percent of the reach has hydric soils; the rest has non-hydric floodplain soils (Table 2.6.2-1) (USDA NRCS 1998 and 2002a). Only two percent of the ecological floodplain has both hydric soils and NWI-mapped wetland. Most of the wetland loss has probably occurred on the east side, although some has taken place in the upstream, west side. NWI does not report forested wetlands within this reach; however, approximately 25 percent of the ecological floodplain is mapped as HGM cover types 1 and 2 (mature conifer and cottonwood trees). Emergent wetland occupies a larger portion of the ecological floodplain than HGM cover type 6. Because of existing land use or a lack of native vegetation, many areas of emergent wetland were mapped as cover type 10, despite having the hydrologic characteristics of wetlands (Tables 2.6.3-1 and 2.6.3-2).

We assessed one parcel using the HGM approach in the summer of 2003 (Table 2.6.3-3). CSKT Lease 5022 received a mid-range score for the parcels assessed along the lower main stem. The greatest factor affecting the score is the amount of agricultural and developed land within Reach 6 as a whole.

Reach Seven, Jocko Hollow Canyon

Wetlands and Off-channel Springs Present

The ecological floodplain, which encompasses approximately six acres, is narrow and dominated by a narrow band of forested vegetation. NWI mapped 15 percent of the reach as wetland (Table 2.6.3-1) (USFWS 1992b). All of the floodplain is mapped as a non-hydric floodplain soil (Table 2.6.2-1) (USDA NRCS 1998 and 2002a). It is probable that the narrow canyon defining this reach did not support much wetland and did not allow the development of hydric soils. There are a few modifications within the floodplain, such as the BNSF Railroad Bridge that spans the canyon, some channelization related to irrigation structures, and the adjacent US Highway 93 right-of-way. None of these factors has significantly altered the extent of the floodplain or changed the wetland and vegetation composition. We did not do HGM assessments within Reach Seven.

Reach Eight, Demonstration Reach

Wetlands and Off-channel Springs Present

The ecological floodplain encompasses approximately 366 acres and is bound by a bedrock terrace at the downstream end and by minor changes in elevation farther upstream. At the downstream end, the southern side of the ecological floodplain is relatively intact. Only a few areas have been cleared of vegetation or have residential or commercial development. Areas of scrub-shrub or bog wetlands are present south of the river near the mouth of the canyon. Most of the northern portion of the floodplain has been cleared of woody vegetation and is now used for pasture and agriculture.

NWI mapped approximately 18 percent of the ecological floodplain as wetland (Table 2.6.3-1) (USFWS 1992b). Roughly 66 percent has hydric soil, thirty-five percent non-hydric floodplain soils (Table 2.6.2-1) (USDA NRCS 1998 and 2002a). Approximately 18 percent has both hydric soils and NWI-mapped wetland (Table 2.6.2-1). Forested wetland and agricultural lands dominate the Reach.

Jocko Hollow Spring Creek is located at the downstream end of the reach. It originates near US Highway 93 south of the Jocko River and flows through the Jocko Hollow Campground. The lower portions are altered by vegetation clearing and the planting of non-native species. The creek flows through ponds in the campground before it crosses under US Highway 93 and into a grazed wetland pasture.

In the summer of 2003, we assessed two parcels using the HGM method (Table 2.6.3-3). The wetlands scored the highest of all the wetlands assessed along the lower main stem. Although water withdrawals by the fish hatchery influence groundwater hydrology, wetland function remains high in the forested and scrub-shrub wetland dominated areas. However, wetland function is virtually gone from adjacent agricultural or cleared lands within the floodplain. Groundwater upwelling or discharge occurs in some areas cleared of tree and shrub vegetation that are now classified as emergent wetland.

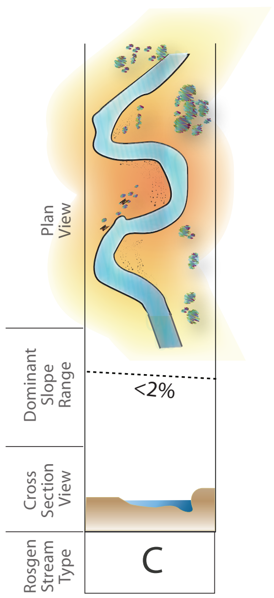
2.7 Fish Habitat Conditions

2.7.1 Historical Fish Habitat Conditions

Historically, the lower main stem was probably dominated by a meandering Rosgen C (Rosgen 1996) or pool-riffle (Montgomery and Buffington 1997) channel type. While there are no quantitative data on the condition of historical fish habitat, it is likely there was high degree of habitat heterogeneity and complexity, an assumption supported by data presented in Subsection 2.5. Those data quantify the shift from woody vegetation to agriculture cover types that occurred between 1937 and 2002.

The following excerpt from an early investigation of Montana and Wyoming streams by Barton W. Everman gives an indication of what historical conditions were like on the lower Jocko River.

> Jocko River—We examined this stream near the railroad station at Ravalli, where it has an average width of about 40 feet and a depth of over 3 feet….The banks are lined in most places by quite a heavy growth of willows, alders, cottonwoods, and other bushes. In some places along the stream are small ponds, well filled with various species of *Algae* and swarming with larval insect life….The water of the river is clear and cold, the temperature at 5 p.m., July 31, being 58°. The Jocko is a very pretty river, and is regarded by sportsmen as a very good trout stream. We found trout quite abundant, as shown by the fact that we caught as many as a dozen at one haul with the 15-foot seine….(Everman 1901).



Historically, the lower main stem was probably dominated by a meandering Rosgen C or pool-riffle channel type.

Although we do not know the exact sample location or climatic conditions on July 31, 1891, an examination of water temperatures collected during 1999-2000 and in 2002 and 2003 on or near 5 p.m. on July 31 each year, suggests that thermal conditions are now substantially warmer in the lower main stem. The average temperature we recorded over the five-year period was 64.5°F (18.1°C) and ranged between 63°F (17.2°C) and 68°F (20°C). This is a difference of 5 to 10°F, depending on the year. This apparent temperature change would be enough to make the lower Jocko River unsuitable or marginal for bull trout in the summer.

Other inferences about historical habitat conditions can be drawn from the average channel width and depth data provided by Everman. In 1891, he stated that the average width of the Jocko River was 40 feet, and the depth was over 3 feet. In fall 2003, average widths and depths in this reach were approximately 60 feet and 1.5 feet, respectively. Again, however, we do not know if Everman collected data in pools or riffles, or both, so we are limited in the conclusions that we can draw. However, a general widening and loss of depth are consistent with the types of habitat changes that result from land uses such as grazing and the removal of riparian vegetation.

Historically, well-vegetated streamside areas would have provided bank stability and overhead cover, resulting in relatively low width-to-depth ratios, low fine sediment levels, and moderate stream temperatures, among other things. Pieces of large wood from adjacent riparian forests of black cottonwood and ponderosa pine would have frequently recruited to the stream. Channel complexity and quality fish habitat in the form of large, deep pools and abundant instream cover would have been created by these inputs of large wood (Mcintosh et al. 2000, Rosenfeld and Hauto 2003).

Changes in meandering channels and occasional channel avulsions created by woody debris jams would have caused channel migrations that would have maintained the interaction between shallow alluvial groundwater aquifers and surface waters over broad areas of the valley. During high over-bank flow events, water would have been stored in alluvial aquifers and then slowly released back into the stream as surface flows receded over the summer. This surface water-groundwater interaction would have maintained base flows and moderated stream temperatures for salmonids during critical periods of the year.

In the past, dynamic stream channel processes would have also promoted lateral stream channel complexity through the formation and maintenance of off-channel habitats such as oxbow wetlands and spring brooks (Trush et al. 2000). Off-channel habitats are vitally important as rearing areas for juvenile fishes. They often support much higher densities of fish than adjacent main channel habitats.

In summary, during historical times the lower Jocko River possessed a rich mosaic of riparian and aquatic habitats that would have supported all life stages of both migratory and resident salmonids.

2.7.2 Existing Fish Habitat Conditions

To assess fish habitat conditions, the Confederated Salish and Kootenai Tribes (CSKT) monitored stream temperatures of the Jocko River and conducted an extensive fish habitat survey. We monitored water temperature because it is a key determinant of bull trout distribution (Reiman and Chandler 1999) and an important variable influencing the distribution and abundance of other cold water species. Water temperature will also be an important component of long-term monitoring plans because it is influenced by land management activities such as riparian vegetation clearing, water withdrawals, and channelization and because it may show a response to restoration actions. We recorded maximum daily water temperatures at five locations along the stream gradient; the thermographs were located at river miles (RM): 0.7, 7.3, 15.7, 17.8, and 25.2 (RM are measured from the mouth).

We assessed instream and riparian fish habitat conditions during base flows in fall 2003 using transect based sampling methods and following the basic approach described by Platts et al.(1983). We collected data on aquatic habitat and riparian characteristics at transect cross sections and along the stream gradient between transects. Sequentially numbered transects were spaced at 197-foot (60-meter) intervals (an average transect spacing of three to four wetted-channel widths) along the axis of the stream channel. We established survey reach breaks at the eight Master Plan reach breaks. We will use this comprehensive habitat survey to: (1) establish a record of existing conditions; (2) review habitat quality for salmonids; (3) evaluate the effects of past and ongoing land uses (i.e., to identify problems and justify changes in management); and (4) establish an existing condition to compare with future surveys and to use for assessing results of proposed restoration actions. Section 4 contains a list and a discussion of the methods used to measure habitat parameters during the survey.

Thermal regimes

Monitoring of stream temperatures in the lower Jocko River during spring through early fall 2003 suggests that maximum daily water temperatures in summer may limit use by bull trout and may be relatively stressful to other salmonids during the warmest summer months (Figure 2.7.2-1). In areas downstream of US Highway 93, maximum daily water temperatures frequently exceeded 15°C (59°F). At the lowermost locations, temperatures were often above 20°C (68°F). Water temperatures peaked at all monitoring sites in mid- to late July 2003, which was extremely hot and dry. Temperatures varied along the stream gradient, with the lowest temperature occurring at the most upstream main-stem station. There, temperatures did not exceed 15°C. The highest temperatures always occurred at the most downstream site. The peak maximum temperature recorded there was approximately 24°C (75.2°F).

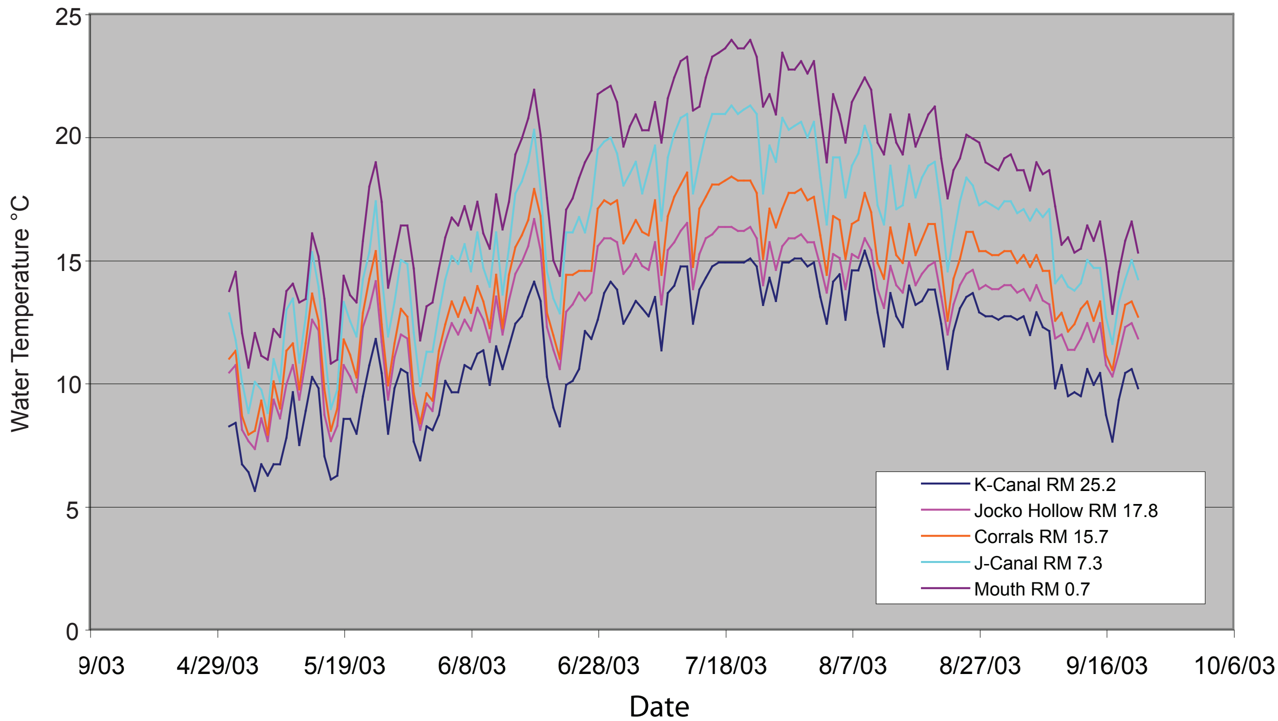


Figure 2.7.2-1.
Water temperatures measured along the stream gradient in the Jocko River during spring through early fall 2003.

Fraley and Shepard (1989) found few bull trout in areas where maximum summer water temperatures exceeded 15°C in the upper Flathead River system. Thus, unless thermal refugia are available in areas of ground water input, the lower Jocko River probably provides very poor habitat for bull trout during the warmest summer months. It is likely that past and ongoing land management practices such as channelization, riparian timber removal, and the operation of irrigation systems have elevated summer water temperatures beyond historical levels. We hypothesize that thermal regimes in the lower main stem could be significantly moderated by both passive and active restoration measures.

Habitat

Instream and riparian habitat conditions vary widely in the lower main stem. Some areas are near their potential, others are in a severely degraded state and functioning well below potential relative to the historical setting. Throughout much of the lower reaches, fish habitat conditions have been substantially modified.

Livestock grazing, the development of transportation corridors, riparian clearing and timber harvest, the introduction and proliferation of non-native plants, channelization, irrigation water withdrawals, and confinement of the stream channel have all compromised fish habitat conditions. Streamside vegetation provides bank cover and stability, moderates local air and water temperatures, traps and filters sediment, and dissipates energy during high stream flows. Removal of this vegetation can result in increased fine sediment inputs and may initiate channel changes. Increased fine sediment levels compromise salmonid spawning habitats by reducing interstitial flow in streambed gravels, diminishing habitat complexity by filling in pools, and reducing prey availability by lowering aquatic invertebrate production.

In addition, the removal of riparian vegetation eliminates sources of large wood. Wood recruited to the stream from streamside areas improves fish habitat complexity by forming and maintaining large, deep pools and by providing overhead cover (McIntosh et al. 2000, Rosenfeld and Huato 2003). Physical alteration and removal of vegetation from stream banks can also result in stream channel adjustments that include widening and degradation.

To examine fish habitat conditions we summarized data collected in each of the eight reach breaks, in a subsection of Reach Eight (demonstration reach) near the State of Montana's Arlee Fish Hatchery (fish hatchery) at ~ RM 19.5 (~station 1040+00), and for the two most downstream C stream type reference reaches: the reference reach at ~ RM 7.5 (station 380+00, near the Lower J Canal in Reach Three) and the reference reach at ~ RM 15.5 (station 880+00, near the middle of Reach Six).

As mentioned, fish habitat conditions vary widely in the lower main stem. Some of this variation is not apparent at the reach level of examination, but large-scale patterns are still evident. Patterns are most obvious when habitat conditions within Reach Eight near the fish hatchery are contrasted with channel conditions within the two C stream type reference reaches.

Large-scale patterns among reaches are particularly apparent in the proportions of macro-habitat types (Tables 2.7.2-1 and 2.7.2-2; Figures 2.7.2-2 and 2.7.2-3). In general, Reaches One, Two, and Six, and the two C stream type reference reaches had the greatest proportions of pools and the largest percentages of their length in primary pools (Tables 2.7.2-1 and 2.7.2-2). This is probably a function of past and ongoing land use because land management activities can have a profound effect on the quantity and quality of pools found in pool-riffle channel types (McIntosh et al. 2000, Rosenfeld and Huato 2003).

Table 2.7.2-1.
Channel and fish habitat characteristics measured during 2003 in Jocko River, Montana; values are means (SE).

Habitat Parameter	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8
Channel Characteristics								
Primary channel (%)	56.0	89.7	96.4	96.0	79.6	80.5	96.2	84.8
Split channel (%)	31.7	0.0	0.0	0.0	5.4	8.3	0.0	5.4
Braided channel (%)	12.4	0.0	2.0	2.1	10.8	7.5	0.0	6.6
Side channel (%)	0.0	9.8	1.5	1.8	4.1	3.5	3.8	3.0
Gradient (%)	0.5	0.5	0.7	0.8	0.6	0.6	0.6	0.9
Width (m)	20.8 (3.1)	19.8 (1.7)	17.3 (0.3)	18.1 (0.5)	17.2 (0.5)	17.3 (0.6)	14.9 (1.2)	13.8 (0.4)
Depth (cm)	42.4 (6.9)	39.8 (3.9)	36.7 (1.1)	37.6 (1.4)	33.5 (1.5)	29.1 (1.4)	37.9 (6.7)	25.5 (1.0)
Thalweg depth (cm)	93.6 (12.3)	69.6 (9.2)	66.4 (1.9)	66.8 (2.4)	69.8 (3.0)	57.0 (2.8)	73.3 (15)	48.1 (2.0)
Stable banks (m/km)	1514 (189)	1521 (147)	1539 (36)	1523 (54)	1519 (45)	1468 (72)	1865 (102)	1544 (45)
Artificial constraint (%)	0.0	14.3	25.4	24.7	11.4	1.5	12.5	6.4
Pool (%)	42.0	20.5	15.6	9.2	16.3	20.2	15.1	15.1
Riffle (%)	40.8	33.2	48.0	47.5	40.4	42.0	51.7	51.7
Run (%)	12.7	33.8	13.7	22.7	24.4	26.2	25.3	25.3
Pocket water (%)	0.0	0.7	2.9	2.8	0.3	0.0	0.0	0.0
Alcove (%)	3.4	6.5	1.6	2.7	0.7	2.1	0.0	0.0
Glide (%)	1.2	5.3	17.9	15.1	17.1	8.0	7.9	7.9
Habitat Characteristics								
Primary pools (% by length)	73.8	36.3	15.1	10.7	17.5	35.9	13.9	10.3
Primary pools (no./km)	13.6	4.7	3.3	2.3	5.5	12.7	5.6	4.4
Residual pool depth (cm)	135.6 (15.0)	127.5 (12)	98.9 (2.7)	81.8 (3.9)	113.8 (3.3)	93.2 (4.9)	103.8 (14)	81.2 (2.5)
Instream cover (%)	9.5 (1.7)	8.9 (1.4)	11.2 (1.0)	11.4 (1.5)	8.2 (1.1)	8.0 (0.7)	9.2 (2.3)	12.5 (1.3)
Bank/overhead cover (%)	6.8 (1.0)	5.4 (1.4)	0.6 (0.1)	1.2 (0.3)	2.9 (0.3)	6.8 (0.8)	5.4 (1.3)	3.2 (0.7)
Undercut banks (m/km)	289 (102.4)	220 (76.1)	178 (22.8)	251 (36.5)	248 (30.8)	289 (35.5)	103 (55.2)	110 (20.4)
Key woody debris (no./km)	0.0	4.8 (2.1)	3.0 (0.7)	3.8 (0.9)	11.4 (1.9)	7.5 (1.4)	1.4 (1.4)	17.5 (2.4)
Coarse woody debris (no./km)	81.8 (20.4)	114.3 (44)	30.3 (3.2)	28.5 (4.4)	88.8 (7.0)	150.5 (19)	47.2 (13)	135.5 (21)
Root wads (no./km)	10.6 (4.1)	9.5 (3.8)	3.5 (0.6)	5.3 (1.3)	14.1 (1.7)	24.2 (4.1)	5.6 (3.1)	12.9 (1.5)
Potential woody debris (no./km)	19.7 (8.9)	48.8 (11.7)	18.1 (1.9)	26.6 (3.2)	21.5 (2.4)	39.2 (5.4)	61.1 (11.5)	63.7 (3.7)
Substrate characteristics								
Bedrock (%)	0.0	0.0	0.0	0.0	0.0	0.4	5.4	0.2
Boulder (%)	0.0	0.0	0.2	1.3	0.0	0.2	0.0	0.1
Small boulder (%)	0.0	0.0	8.6	15.8	0.2	0.2	2.2	12.6
Cobble (%)	0.0	11.0	30.4	27.9	3.7	6.9	16.4	42.6
Small coble (%)	14.9	32.8	38.1	26.3	50.1	43.9	45.4	30.8
Gravel (%)	41.8	36.4	15.2	22.1	30.9	33.6	16.8	6.8
Small gravel (%)	15.7	9.8	0.1	0.7	4.0	3.6	4.2	1.8
Fines (%)	27.5	10.0	7.3	5.9	11.1	11.2	9.6	5.0

Table 2.7.2-2.
Channel and fish habitat characteristics measured during 2003 in Jocko River, Montana; values are means (SE).

Habitat Parameter	Reach Eight near the Fish Hatchery	Reference reach River mile ~ 7.0	Reference reach River mile ~ 15.5
Channel Characteristics			
Primary channel (%)	94.3	94.1	99.4
Split channel (%)	0.0	0.0	0.0
Braided channel (%)	2.7	5.9	0.0
Side channel (%)	1.0	0.0	0.6
Gradient (%)	0.6	0.6	0.6
Width (m)	12.2 (0.7)	16.1 (0.9)	14.5 (1.2)
Depth (cm)	25.7 (1.8)	45.0 (5.3)	32.3 (2.5)
Thalweg depth (cm)	47.9 (3.5)	88.1 (7.9)	61.0 (4.7)
Stable banks (m/km)	1002.5 (124.6)	1522.3 (115.8)	1620.0 (123.8)
Artificial constraint (%)	45.8	3.8	0.0
Pool (%)	5.2	39.2	21.0
Riffle (%)	51.3	26.6	25.0
Run (%)	35.2	15.3	45.7
Pocket water (%)	0.0	0.0	0.0
Alcove (%)	2.0	2.8	0.6
Glide (%)	6.3	16.0	7.8
Habitat Characteristics			
Primary pools (% by length)	12.3	33.6	33.7
Primary pools (no./km)	5.6	6.4	8.3
Residual pool depth (cm)	70.0 (6.3)	141.0 (10.4)	129.0 (14.2)
Instream cover (%)	10.0 (3.1)	14.6 (3.3)	9.3 (3.6)
Bank/overhead cover (%)	2.1 (1.0)	1.9 (0.9)	3.5 (1.0)
Undercut banks (m/km)	52.5 (29.9)	330.8 (97.4)	213.0 (64.5)
Key woody debris (no./km)	16.7 (4.6)	12.8 (5.0)	6.7 (4.4)
Coarse woody debris (no./km)	129.2 (26.4)	89.7 (25.9)	61.7 (21.1)
Root wads (no./km)	13.9 (4.0)	7.7 (2.4)	0.0
Potential woody debris (no./km)	56.9 (8.1)	33.3 (10.0)	31.7 (9.1)
Substrate characteristics			
Bedrock (%)	0.0	0.0	2.1
Boulder (%)	0.0	0.0	0.0
Small boulder (%)	2.9	0.0	0.0
Cobble (%)	49.2	6.0	8.2
Small coble (%)	29.7	40.4	8.2
Gravel (%)	11.0	22.5	32.7
Small gravel (%)	2.4	0.0	47.6
Fines (%)	4.8	31.1	9.4

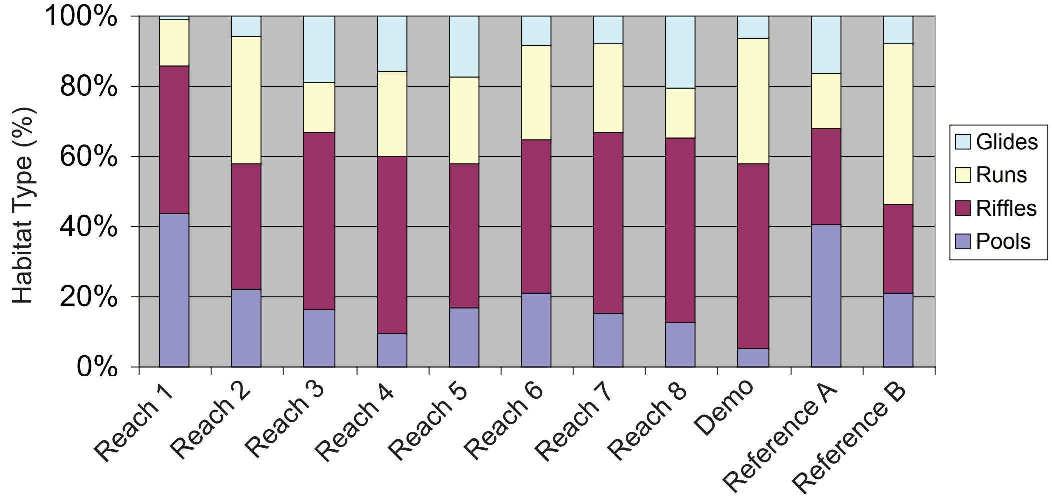


Figure 2.7.2-2.
Percent (%) composition of major habitat types measured at transect cross sections in the lower Jocko River, Montana during 2003.

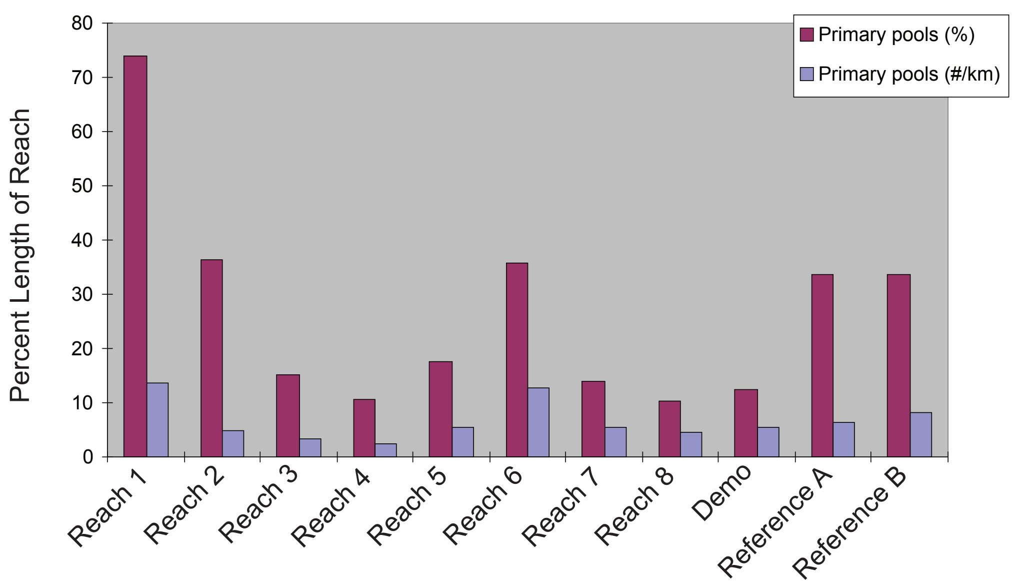


Figure 2.7.2-3.
Percentage (% length of reach) of primary pools and number of primary pools per kilometer (km) in eight Master Plan reaches, Reach Eight near the Fish Hatchery, and two C stream type reference reaches (Station 380+00 and 880+00) in the lower Jocko River, Montana, 2003.

The stream reaches with the greatest proportions of pools also generally had the least amounts of artificial channel constraint (Tables 2.7.2-1 and 2.7.2-2), which is negatively related to the percentage of pools encountered at transect intercept points (Figure 2.7.2-4). Many reaches with artificial constraints (e.g., most of Reaches Three, Four, and Eight, near the fish hatchery) were also channelized, diked, rip-rapped, and probably subjected to riparian vegetation clearing in the past. Straightening and constraining the stream often causes an increase in the local stream gradient, whereas riparian clearing eliminates sources of large woody debris and removes the protection that vegetation provides to stream banks. The importance of wood as a pool forming mechanism can be seen in Figure 2.7.2.5. Pools formed by wood, particularly in low gradient, downstream areas, are on average, deeper than free-formed pools or pools formed by artificial structures (e.g., cars, rip-rap).

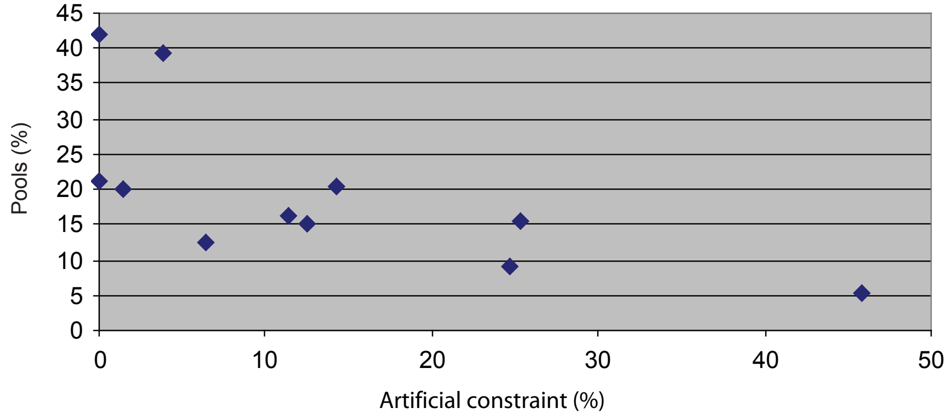


Figure 2.7.2-4.
Relationship between amount (%) of artificial constraint on the stream channel and the percentage of habitat comprised of pools in the Jocko River, Montana, 2003. Data are from the eight Master Plan reaches, two C stream type reference reaches (Stations 380+00 and 880+00), and Reach Eight near the Fish Hatchery.

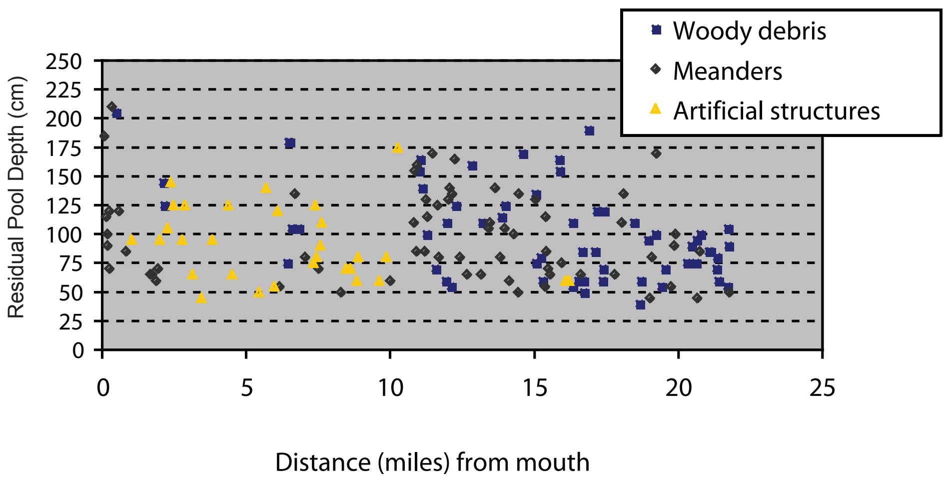


Figure 2.7.2-5.
Location of primary pools along the stream gradient, residual depths associated with the pools, and the pool forming feature in the Jocko River, Montana, 2003.

The combined effects of channelization, channel constraint, riparian timber harvest, and intensive livestock grazing become apparent when the demonstration area within Reach Eight is compared to the two C stream type reference reaches, even though the reference reaches have also been subjected to varying levels of disturbance. Table 2.7.2-2 shows that, based on transect intercept points, the reference reaches have much greater percentages of their length in pool, glide, and run habitats than the demonstration area, which is dominated (51.3 percent) by riffles. Reference reaches also have greater amounts of primary pools. Primary pools comprise approximately 33 percent of the length of the two reference reaches, but only 12 percent of Reach Eight near the fish hatchery (Table 2.7.2-2). Average depth, average thalweg depth, and residual pool depths are also much greater in the two reference reaches, as is the amount of undercut bank, which provides important cover for fish.

The contrast between the reference reaches and the portion of Reach Eight near the fish hatchery clearly demonstrates that channelization, channel constraint, and the removal of riparian vegetation through grazing and logging simplifies fish habitat and leads to a loss of deep, slow water areas that have cover in the form of depth, undercut banks, and overhead vegetation. Many areas of the lower main stem have been and continue to be subjected to these disturbances, making them less suitable for some fish species and some life stages of fish, especially those dependent on slow water habitats and large pools (e.g., large adult fish). Figures 2.7.2-6 and 2.7.2-7 show a generalized conceptual model of how certain land uses alter a C stream type or meandering pool-riffle stream type and simplify channel form and fish habitat. Several segments (e.g., Reach Eight near the Fish Hatchery) of the lower river have undergone changes similar to those depicted in the figures.

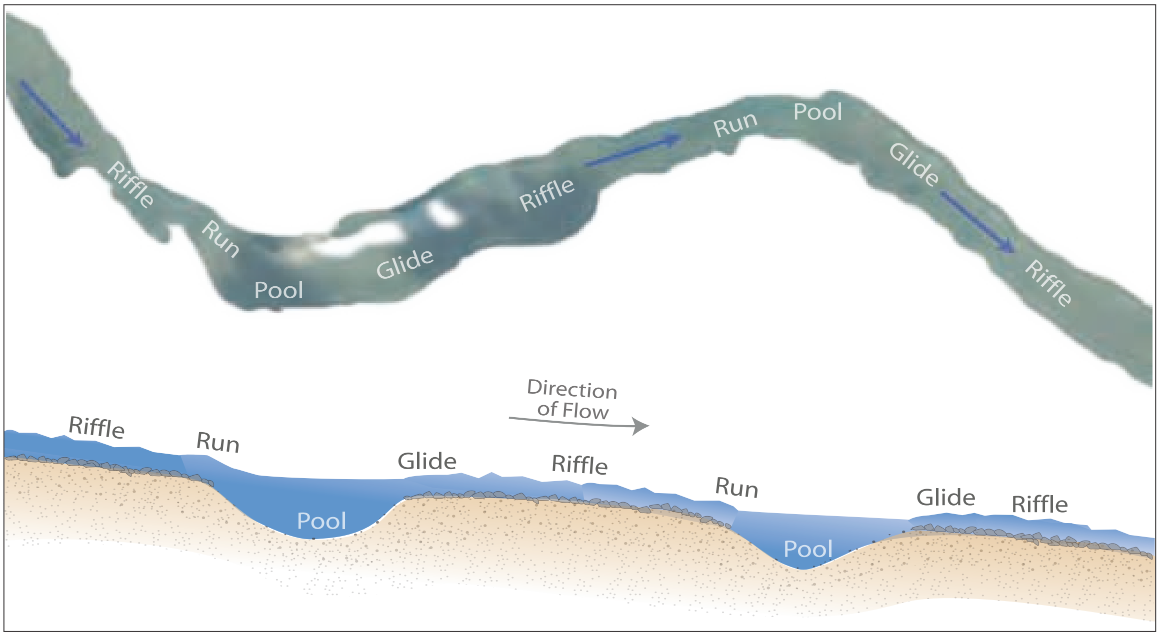


Figure 2.7.2-6.
Profile and plan views of a properly functioning pool-riffle or C stream type, showing diversity and abundance habitats available in these channel types.

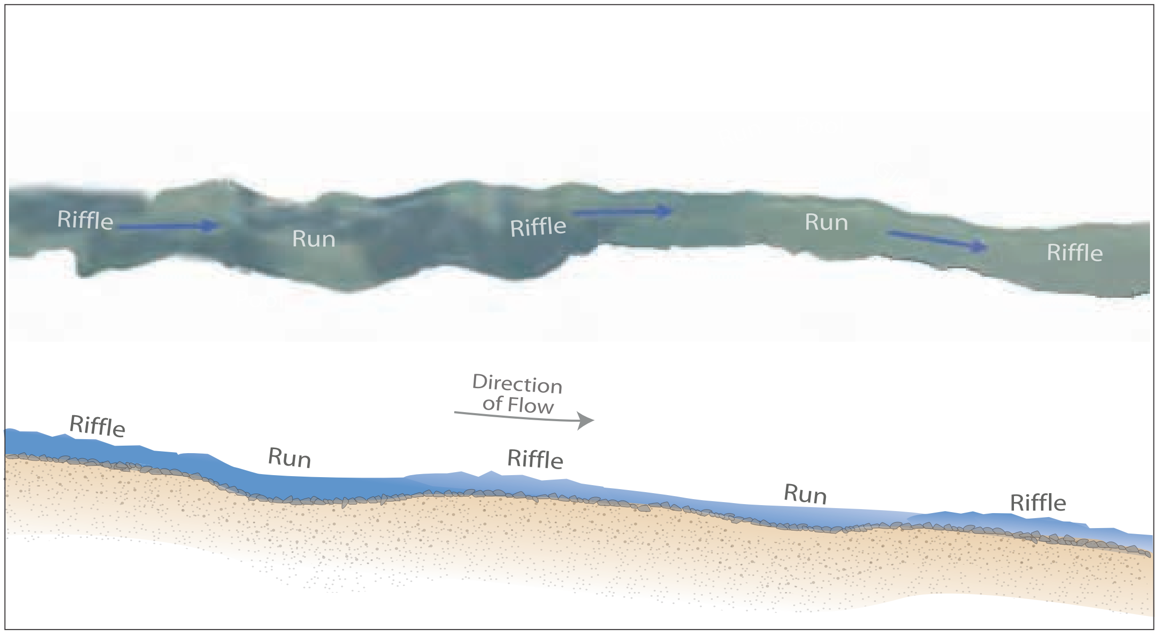


Figure 2.7.2-7.
Profile and plan views of simplified channel form and habitats in an altered valley stream segment.

2. CONDITIONS

Suitability of existing fish habitat relative to regional criteria

We used a subset of performance standards and criteria developed by the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS) to assess the suitability of the lower main stem for salmonids, especially bull trout. Table 2.7.2-3 shows a reach-by-reach comparison of key performance standards relative to suitability for bull trout.

Table 2.7.2-3.

Bull trout habitat suitability based on some key indicators by reach in the lower main-stem Jocko River. Indicators were adapted from criteria developed by USFWS and NMFS for streams east of the Cascade Mountains; FA = functioning appropriately; FAR = functioning at risk; FUR = functioning at unacceptable risk.

Indicator	Reach One	Reach Two	Reach Three	Reach Four	Reach Five	Reach Six	Reach Seven	Reach Eight
Water temperature	FUR	FUR	FUR	FUR	FUR	FUR	FUR	FAR
Large woody debris	FUR	FUR	FUR	FUR	FUR	FUR	FUR	FA
Pool frequency and quality[1]	FUR	FUR	FUR	FUR	FA	FAR	FAR	FUR
Streambank condition	FAR	FAR	FAR	FAR	FAR	FAR	FA	FAR
Average width/max depth[2]	FUR	FUR	FUR	FUR	FUR	FUR	FUR	FUR

[1]Based on frequency of high quality pools (a rating based on size and cover attributes), but without temperature criteria, which would put reaches all in FUR category. [2] We used average thalweg depth for maximum depth.

2.8 Fisheries and Wildlife Resources

2.8.1 Fisheries Resources

The Jocko River fishery is similar to that of many developed western Montana watersheds. Land management activities such as irrigation, agriculture, and development of transportation corridors have impacted the river and how it functions. Past fisheries management practices—namely the introduction of nonnative species—have greatly altered the ecology of the river. Currently, thirteen fish species, four of which are not native, are known to occur in the main stem and three forks of the Jocko River (Table 2.8.1-1).

Table 2.8.1-1.
Fish species and broad distributional patterns in the main-stem Jocko River and North, South, and Middle Forks of the Jocko River.

Scientific name	Common name	Distribution
Catostomidae		
Catostomus catostomus	Longnose sucker	Main stem, Middle Fork
Catostomus macrocheilus	Largescale sucker	Main stem
Cyprinidae		
Ptychocheilus oregonensis	Northern pikeminnow	Main stem
Rhinichthys cataractae	Longnose dace	Main stem
Richardsonius balteatus	Redside shiner	Main stem, Middle Fork
Salmonidae		
Oncorhynchus clarki lewisi	Westslope cutthroat trout	Widely distributed
Oncorhynchus mykiss*	Rainbow trout	Main stem
Prosopium williamsoni	Mountain whitefish	Main stem
Salmo trutta*	Brown trout	Main stem
Salvelinus fontinalis*	Brook trout	Widely distributed
Salvelinus confluentus	Bull trout	Widely distributed
Salvelinus namaycush*	Lake trout	Main stem (2 records)
Cottidae		
Cottus cognatus	Slimy sculpin	Widely distributed

** Introduced species.*

Historically, the only salmonids in the river were mountain whitefish, bull trout, and westslope cutthroat trout. Rainbow trout, brown trout, and brook trout have been introduced and now occur in self-sustaining wild populations. The Jocko River supports both resident and migratory salmonid populations and provides critical thermal refuge for migratory fishes using the Flathead River (CSKT 2001). It is also the primary spawning and rearing tributary for salmonid species in the lower Flathead River (DosSantos et al. 1988; CSKT 2000a).

In general, the lower reaches of the Jocko River (downstream of US Highway 93) support a relatively productive introduced rainbow and brown trout fishery. Native trout are found at very low densities. Native mountain whitefish are widely distributed and relatively abundant. Fish assemblages in the main stem exhibit both longitudinal (upstream-downstream) and horizontal (i.e., off-channel habitats and tributaries) variation. Longitudinal differences in species composition are apparent in catches from two long-term monitoring reaches in the lower Jocko River and from more recent survey data collected along the stream gradient. Samples from spring brooks and off-channel habitats demonstrate lateral differences in fish species composition as well and show that relative to the main stem, these habitats support fish assemblages with distinct differences in abundance and species and size compositions. Fish assemblages in both the main stem and off-channel habitats probably vary seasonally, but little information exists on temporal differences in species or size compositions.

Most of the fisheries information for the lower main stem comes from electrofishing the two long-term monitoring reaches, while the more recent electrofishing survey data come from sampling areas such as off-channel habitats, the demonstration reach, and up-river tributaries. The farthest downstream, long-term, fish monitoring reach (Dixon) is 1.5 miles long. Its lower end is located approximately at river mile (RM) 1 (Station 57+00) in the lower one-quarter of Reach Three. The other long-term monitoring reach (North Valley) is a 1.3 mile long segment. Its downstream end is located approximately at RM 10.0 (Station 537+00) in the upper one-third of Reach Four.

Long-term monitoring at the two main-stem sites shows that non-native fishes make up most of the catch of fish greater than 75 millimeters (mm) total length (TL) in the lower river. *Oncorhynchus* spp. (rainbow and westslope cutthroat trout and hybrids of the two species) dominate the downstream (Dixon) sampling section, while brown trout dominate the upstream (North Valley) section (Figures 2.8.1-1 and 2.8.1-2). Fish classified as westslope cutthroat trout comprised less than four percent of the catch at the two sites and generally made up only one to two percent of the catch. Bull trout were always rare, occurring only three out of twelve years in the Dixon section and two out of eleven years in the North Valley section.

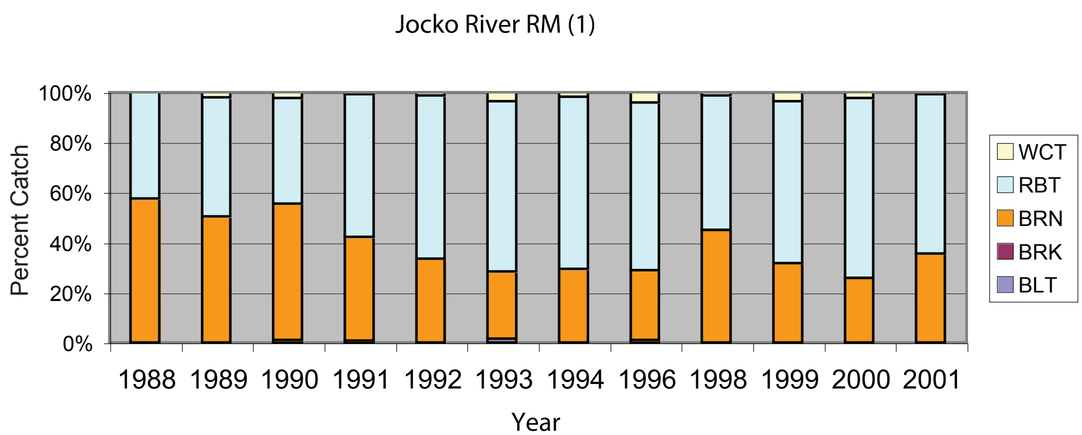


Figure 2.8.1-1.
Long-term species composition (%) of trout in the Dixon sampling section (Reach Three), Jocko River, Montana; WCT = westslope cutthroat trout; RBT is the pooled catch of rainbow trout and hybrids of rainbow and westslope cutthroat trout; BRN = brown trout; BRK = brook trout; and BLT = bull trout.

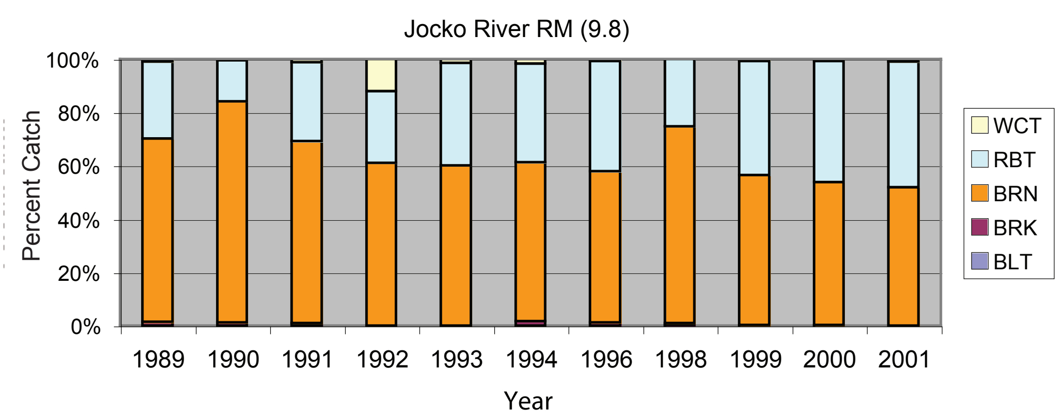


Figure 2.8.1-2.
Long-term species composition (%) of trout in the North Valley sampling section (Reach Four), Jocko River, Montana; WCT = westslope cutthroat trout; RBT is the pooled catch of rainbow trout and hybrids of rainbow westslope cutthroat trout; BRN = brown trout; BRK = brook trout; and BLT = bull trout.

More recently, we sampled the segment proposed for restoration (Demonstration Reach see Fish Habitat Conditions in Subsection 2.7) in Reach Eight to document baseline fish populations prior to restoration activities and to compare species and size compositions with other main-stem data collected in the two long-term monitoring sections. The Demonstration Reach is in a disturbed part of the Jocko River, a segment that has been channelized, heavily grazed, logged, and constrained by berms and levees. These actions have greatly simplified the stream channel, which has resulted in poor fish habitat conditions (Subsection 2.7).

Sampling revealed the effects of habitat degradation on fish populations. While we were unable to estimate fish numbers because we captured too few individuals to conduct a valid mark-recapture population estimate, catches-per-unit-effort (CPUE), a measure of relative abundance, were very low compared to other areas of the main stem.

Brown trout dominated the species composition of the Demonstration Reach, but brook trout and westslope cutthroat trout were more abundant than they were in downstream reaches. They composed roughly three percent and five percent of the catch, respectively. This fits the general trend of increasing abundances of these two species in upstream reaches of the Jocko River and its tributaries. In addition to the low numbers of captures, the size composition of fish collected in the Demonstration Reach also suggests a loss of habitat diversity, particularly pools. The average length of fish captured in this segment was only 152 mm (SD = 6), and 75 percent of fish were less than 189 mm TL. In contrast, in the North Valley sampling section the long-term average fish size was approximately 50 mm larger (200 mm TL) and 50 percent of all fish captured were greater than 185 mm TL. The small size structure of fish in the Demonstration Reach is probably due to the loss of deeper habitats, but it may also be due in part to the segment's longitudinal position, which is farther upstream than the long-term monitoring sections. It may be used less by larger migratory fishes. Monitoring of spawning by large migratory fishes, however, shows that some large fish use the river upstream through the Demonstration Reach for spawning, which suggests that poor habitat may be the primary factor limiting the use of this segment by larger fish.

We also sampled spring creek habitats in three areas during 2003 to determine lateral changes in fish species and size distributions. The three streams we sampled were Jocko Spring Creek, Squeque Spring Creek, and Jocko Hollow Spring Creek. Sampling in these habitats demonstrated that relative to the main stem, they support comparatively high densities of generally smaller size classes (less than 250 mm) of introduced trout species. Jocko Spring Creek is the largest and farthest downstream of the spring creeks. It supports relatively high densities of introduced brown and rainbow trout. While we found only a few brook trout in the lower reaches, their abundance increased in upstream areas.

Squeque Spring Creek is a small, highly modified spring brook located on the west side of the Jocko River just upstream from the confluence of Jocko River and Jocko Spring Creek. Similar to Jocko Spring Creek, Squeque Creek supports relatively high numbers of introduced species, with brown trout being numerically dominant, followed by rainbow trout and brook trout. Jocko Hollow Spring Creek, located downstream of the Demonstration Reach, is the farthest upstream spring creek. From its source at the base of an ancient terrace, it flows approximately 0.5 miles before emptying into the Jocko River in Reach Eight. Similar to the other two spring creeks, Jocko Hollow Spring Creek supports an assemblage of introduced trout. Species composition changes relatively dramatically over the short length of the stream, with rainbow and rainbow x westslope cutthroat trout hybrids and brown trout making up most of the catch in the lower reaches downstream of US Highway 93 and brown trout dominating the area immediately above the highway. Brook trout dominate the two upper-most sections (Figure 2.8.1-3). No rainbow trout or hybrids were detected upstream of the highway. This may be because crossings at access roads or the highway impede fish passage.

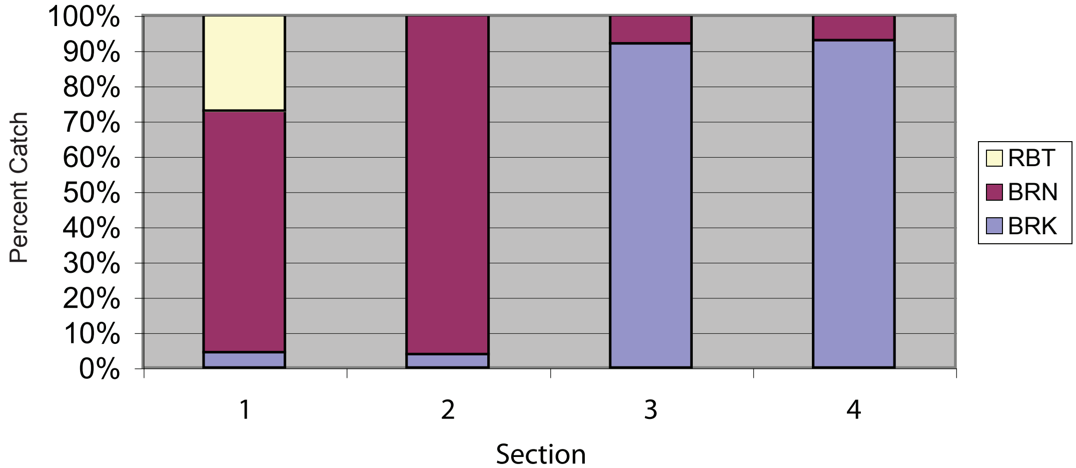


Figure 2.8.1-3.
Longitudinal changes in species composition at Jocko Hollow Spring Creek; sections are numbered beginning at the downstream end.

In summary, spring creek habitats in the lower river appear to be almost exclusively inhabited by introduced species and appear to offer little opportunity for use by native fishes. Further enhancement of the creeks or the creation of these types of habitat should be evaluated on a case by case basis, especially where interaction with native fishes would be a concern.

Anthropogenic impacts are generally less noticeable on the upper reaches of the Jocko River, which is characterized by higher gradients and colder thermal regimes. In the upper Jocko, native trout species are more abundant than brown or rainbow trout. However, brook trout are present and even dominant in some locations. The North, Middle, and South Forks of the Jocko River are native species strongholds, although brook trout are particularly abundant in some reaches of the North and Middle Forks where they compete for space and food with native westslope cutthroat and bull trout.

Bull trout are currently listed as threatened under the Endangered Species Act. The Montana Bull Trout Scientific Group designated the Jocko drainage a "core area" for bull trout in the Middle Clark Fork River Drainage Status Review (MBTSG 1996). Core areas are strongholds for the species because they provide significant spawning and rearing areas (MBTRT 1998). Because it is a core area, the Jocko River is important in the overall recovery of the species within Montana. Bull trout occur primarily in the upper reaches of the river above its confluence with Finley Creek. Although bull trout once inhabited Valley Creek and were likely present in Finley Creek, they appear to have been extirpated from those tributaries.

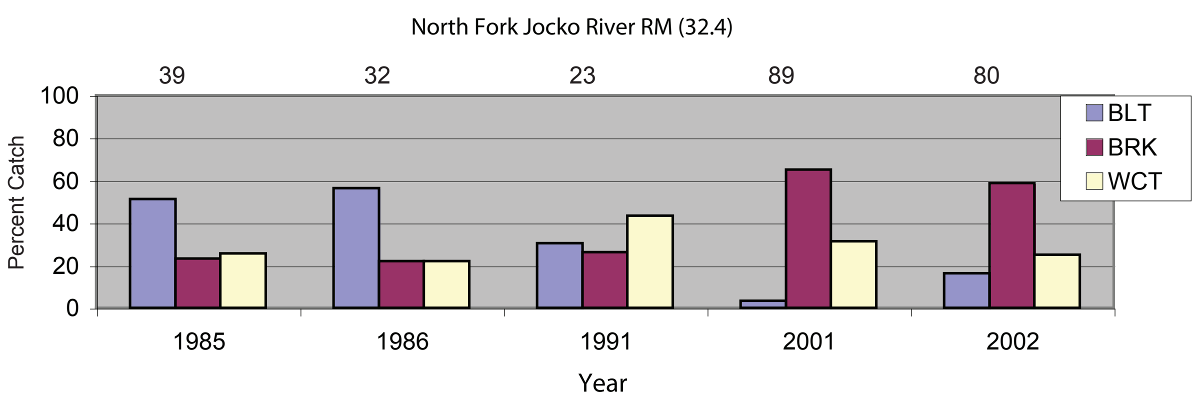
Westslope cutthroat trout are currently not protected under the Endangered Species Act. However, they have been petitioned for listing pursuant to the Endangered Species Act and are classified as a Tribal Species of Special Consideration and a State of Montana Species of Special Concern. The Jocko River watershed supports a relatively healthy population of westslope cutthroat trout. We have identified numerous pure populations (i.e., populations that have not hybridized with introduced rainbow trout or Yellowstone cutthroat trout) above natural and anthropogenic barriers (e.g., culverts and irrigation diversions) in headwater streams. Tributaries such as Agency, Cold, and Big Knife Creeks have pure westslope cutthroat trout populations. In addition, the main-stem Jocko River and upper three forks of the Jocko have pure or mostly pure (greater than 90 percent) populations.

Over the long-term, total densities of trout (all species) in 500 foot-long monitoring sections in the three forks of the Jocko River have typically ranged from 100 to 200 fish 75 to 150 mm TL and from

25 to 100 fish greater than 150 mm TL, with densities in the South Fork somewhat less on average than in the North and Middle Forks. Most salmonids captured in the three forks are small resident forms, with the majority of fish under 200 mm TL. This is probably due to habitat conditions in the upper watershed (e.g. cold thermal regimes, spatial limitations), but it is likely that it also reflects the historical loss of connectivity and the subsequent selection against migratory fishes by barriers to upstream passage caused by irrigation diversions and dams in the lower drainage.

Introduced fish species in the Jocko River Drainage pose a significant threat to bull trout and westslope cutthroat trout. Research has shown that artificial or human caused habitat disruptions increase the vulnerability of indigenous fish assemblages to invasion by introduced fishes (Baltz and Moyle 1993; Moyle and Stato 1991). This is especially true for coldwater, salmonid dominated assemblages when the invading species evolved in warmer thermal regimes and are more tolerant to fine sediment inputs. Research has also shown that brook trout are more widely distributed and westslope cutthroat and bull trout less abundant in more heavily impacted drainages (Griffith 1988; Clancy 1993; Frissell et al. 1995; Huntington 1995). The Jocko River Drainage fits this pattern. Rainbow trout and brown trout dominate the lower reaches, and the most impaired subwatersheds are probably Finley and Valley Creek. In those two tributaries, bull trout have been extirpated, replaced by brook trout and brown trout. Westslope cutthroat trout persist only in the highest reaches of those drainages.

Though the upper reaches of the main stem and the North, Middle, and South Forks of the Jocko River are less impaired, the same trend is apparent. Data from long-term monitoring sections suggest that brook trout are replacing westslope cutthroat and bull trout, especially in the North and Middle Forks of the Jocko River, which are more heavily altered by grazing, roads, logging, and irrigation withdrawals (Figures 2.8.1-4 and 2.8.1-5). The North Fork Jocko River, however, still supports high densities (approximately 20 fish) of bull trout in some 500-foot sample locations upstream of the P5000 road crossing.



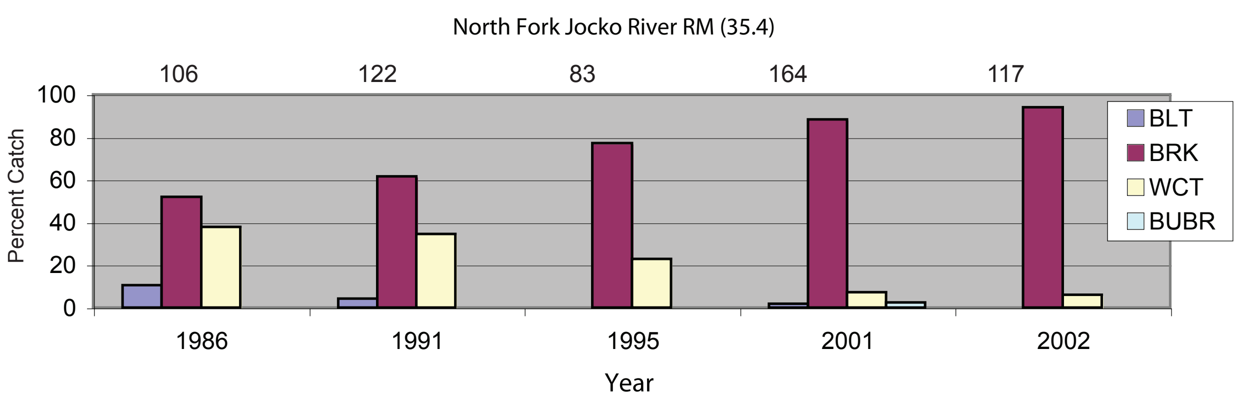
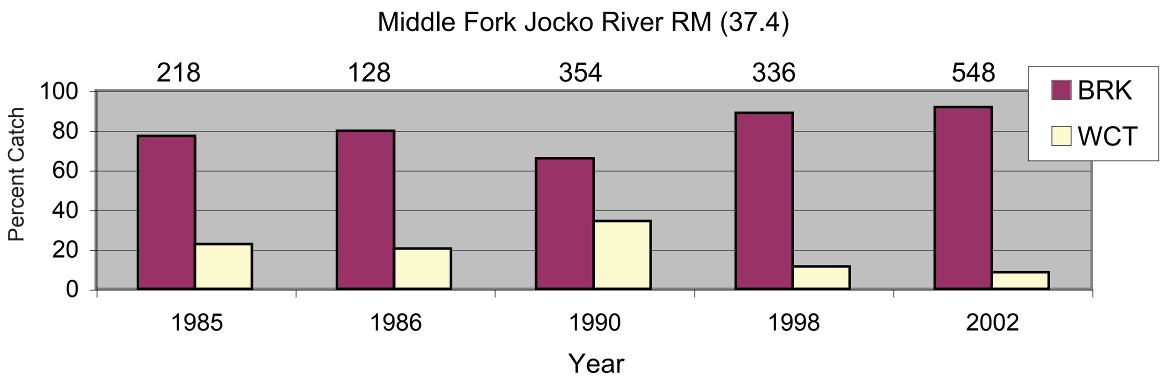


Figure 2.8.1-4 a and b.
Temporal changes in species composition at two long-term monitoring sections in the North Fork Jocko River; numbers above each bar indicate annual catch for that year.

2. CONDITIONS



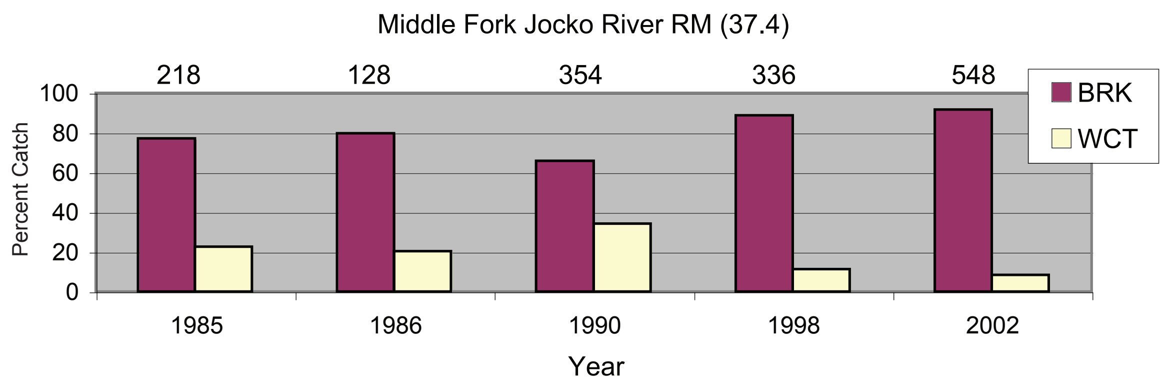


Figure 2.8.1-5 a and b.
Temporal changes in species composition at two long-term monitoring sections in the Middle Fork Jocko River; numbers above each bar indicate annual catch for that year.

The subwatershed that is least impaired by human disturbances—the South Fork Jocko River—generally holds the healthiest populations of native salmonids. Population estimates of juvenile bull trout have exceeded 80 fish in a 500-foot sampling section. However, bull trout also appear to be declining in the South Fork Jocko River, even where introduced species do not appear to be increasing (Figure 2.8.1-6). This bull trout decline could be a long-term response to past logging and road building, but it may also be the result of selection against more productive migratory forms of bull trout.

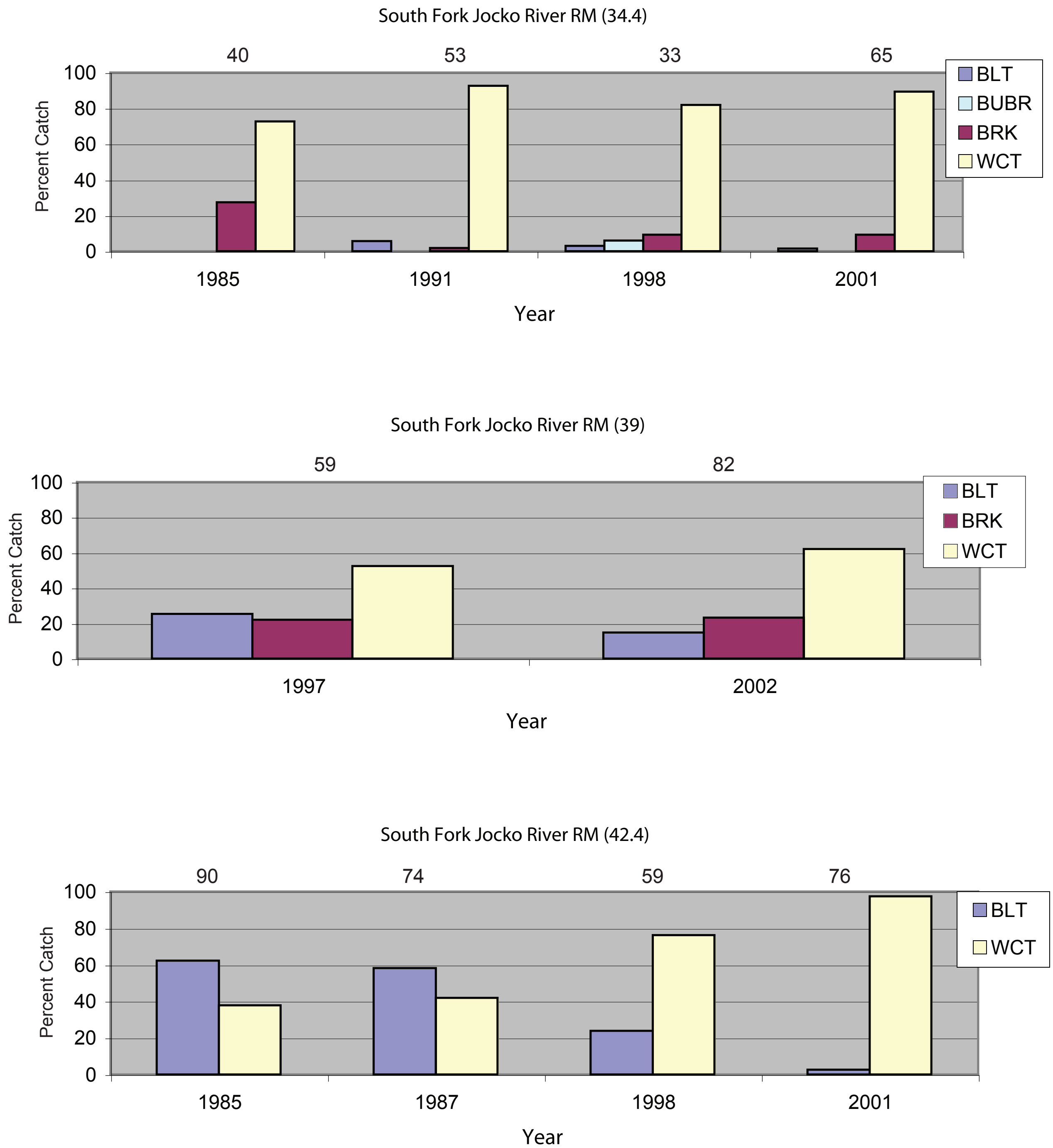


Figure 2.8.1-6 a, b, and c.

Temporal changes in species composition at three long-term monitoring sections in the South Fork Jocko River; numbers above each bar indicate annual catch for that year.

For decades, two irrigation diversions prevented migratory forms of bull and westslope cutthroat trout from moving upstream into the upper main-stem Jocko River and its three forks. The K Canal at RM 25.2 probably acted at least as a seasonal barrier, but more likely prevented upstream fish movement year-round. The Tribes installed a ladder and fish screen at the K Canal diversion in 1996. Evaluations of fish passage at the facility are ongoing. A second irrigation diversion, the S Canal at RM 31, also prevented movement into the Middle and South Forks of the Jocko River since circa 1915. Selective fish passage was provided at this facility in 2002. Bull trout first used the structure in 2003. It, too, is still being evaluated.

2.8.2 Wildlife Resources

Importance of Riparian Habitats to Bird Communities

Riparian habitats like those found along the lower main stem of the Jocko River support the highest diversity of breeding birds of any habitats in the western U.S. (Casey 2000). Riparian areas are also important as migration corridors for all types of birds. At least 134 (55 percent) of Montana's 245 species of breeding birds (including 54 (50 percent) of the 107 priority species) use riparian forests during all or part of the year (Table 2.8.2-1). Riparian shrublands are utilized by 15 priority species. Some species use shrublands just for forage and nest in forests, while others use shrublands for winter cover. The entire life history of obligate species, such as the willow flycatcher (*Empidonax traillii*), revolves around riparian shrublands.

Table 2.8.2-1.
Priority bird species affected by the Jocko River plans (Casey 2000).

Level I	Level II	Level III
Trumpeter Swan	Horned Grebe	Clark's Grebe
Olive-sided Flycatcher	Hooded Merganser	American Bittern
Brown Creeper	Bald Eagle	Black-crowned Night-heron
	Northern Goshawk	Northern Harrier
	Peregrine Falcon	Sharp-shinned Hawk
	Ferruginous Hawk	Killdeer
	Ruffed grouse	Black-necked Stilt
	Columbian Sharp-tailed Grouse	Willet
	Long-billed Curlew	Wilson's Phalarope
	Transient shorebirds	Western Screech Owl
	Vaux's Swift	Short-eared Owl
	Calliope Hummingbird	Rufous Hummingbird
	Lewis's Woodpecker	Downy Woodpecker
	Red-naped Sapsucker	Least Flycatcher
	Willow Flycatcher	Townsend's Solitaire
	Hammond's Flycatcher	Gray Catbird
	Cordilleran Flycatcher	Cassin's Vireo
	Winter Wren	Warbling Vireo
	Veery	Nashville Warbler
	Red-eyed Vireo	Townsend's Warbler
	Lazuli Bunting	Ovenbird
		American Redstart
		MacGillivary's Warbler
		Chipping Sparrow
		Song Sparrow
		Red-winged Blackbird
		Yellow-headed Blackbird
		Cassin's Finch

Historical Bird Communities

No historical data for bird abundance along the Jocko River exist. Many of the species presently found in the river corridor would have been present during historical times. Because historical vegetation conditions influenced historical bird communities (Subsection 2.5.2), we can assume that the more expansive riparian and wetland areas and the interspersion of multiple seral stages that would have resulted from an unaltered hydrologic system (Subsection 2.2) would have provided prime habitat for a diverse bird community.

Historical breeding bird communities consisted of mostly neotropical migrants that select for deciduous habitat. Common eastern species, such as red-eyed vireo (*Vireo olivaceus)*, are only found in Montana along riparian areas with large cottonwood canopies and well-developed shrub understories. Gray catbirds (*Dumetella carolinensis*), yellow-breasted chats (*Icteria virens),* and song sparrows (*Melospiza* *melodia)* utilize thick shrub-vine understories. During historical times, willow flycatchers and yellow warblers (*Dendroica petechia)* would have had much more habitat available because of the extent and diversity of riparian vegetation.

Resident and short-distance migrants also would have been abundant. Oxbows and other floodplain wetlands would have supported many waterfowl species and secretive marsh birds like sora (*Porzana carolina)*, Virginia rail (*Rallus limicola*) and American bittern (*Botaurus lentiginosus)*. Sandhill cranes (*Grus Canadensis)* would have used the wetlands as a stopover in migration. Larger areas of riparian vegetation would have meant a decrease in the amount of edge habitat (the border between riparian and prairie and agriculture habitats). Habitat edges make it easier for brown-headed cowbirds (*Molothrus ater)*, a native nest parasite, to locate nests. With periodic flooding and variation in the stream channel, a large number of snags would have been available for cavity nesters (Table 2.8.2-2). Ruffed grouse (*Bonasa umbellus*) would have been year-round residents, while the now-extirpated Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) would have used the riparian areas as winter cover. Riparian areas would have served as breeding habitat for a large number of raptor species (Table 2.8.2-2). Other raptor species would have wintered and foraged along migration routes. Many owl species would have also used habitat along the Jocko River.

Table 2.8.2-2.

Cavity nesting and raptor species found along the Jocko River corridor.

Cavity Nester	Raptor Species
Hooded Merganser	Sharp-shinned Hawk
Wood Duck	Cooper's Hawk
Western Screech Owl	Northern Goshawk
Northern Pygmy Owl	Red-tailed Hawk
Downy Woodpecker	Rough-legged Hawk
Hairy Woodpecker	Ferruginous Hawk
Lewis's Woodpecker	American Kestrel
Red-naped Sapsucker	
Northern Flicker	
Violet-green Swallow	
Tree Swallow	
Western Bluebird	
Mountain Bluebird	
American Kestrel	
Red-breasted Nuthatch	
Black-capped Chickadee	
House Wren	

Existing bird communities

Existing bird communities include many of the same species that would have been found in historical communities, as well as non-natives like rock pigeon (*Columba livia)*, European starling (*Sturnus vulgaris*), and house sparrow (*Passer domesticus)*. These non-natives use nesting locations and take advantage of forage opportunities that would otherwise be exploited by native species. Some are nest predators. A few native species, like the least flycatcher (*Empidonax minimus*) and Columbian sharp-tailed grouse, are no longer found along the Jocko River.

Habitat patch sizes are smaller than during historical times, and this has led to an increase in edge habitats, which increases nest parasitism and predation. Smaller patch sizes can also result in fewer or more compressed territories, which can lead to lowered production by breeding birds or create population sinks. While red-eyed vireos are still found along Reach Three and willow flycatchers and yellow warblers along Reach Five, and while Lewis' woodpeckers still nest in portions of Reach Eight, their reproductive success may not be what it was during historical times when habitats were intact.

Management Recommendations for Restoration

With many of the same species still occupying the lower main stem, managing bird populations for increased productivity will require maintaining and increasing existing quality habitats and improving degraded habitats by increasing the patch size of forest and shrub habitats, reducing the amount of edge between riparian and agricultural habitats, and ensuring no net loss of mature, deciduous forest downed wood and snags of all sizes.

Non-native species have been established for many years, and eradication attempts are not economically feasible and often have little or no effect. Reintroducing extirpated species, such as Columbian sharp-tailed grouse, would require an effort beyond the scope of this document; however, restoring shrub and winter cover conditions will aid the future recovery of this species.

Species requirements and recommendations for Riparian Deciduous Forest

*Hooded Merganser (*Lophodytes cucullatus*)*

Habitat

Hooded mergansers prefer wooded streams and riparian forests. They nest in cavities located directly over water. The suitability of nesting habitat depends on suitable nest trees, shallow clear water, and high fish and invertebrate prey densities (Dugger et al. 1994).

Management recommendations

Larger riparian stands and braided stream channel complexes are probably the most important buffer to human disturbances. Retention of snags in riparian areas is crucial to nesting success (Casey 2000).

*Bald Eagle (*Haliaeetus leucocephalus*)*

Habitat

Mature forest stands with low to moderate canopy closure provide quality nesting habitat for bald eagles. Forest stands should be 20 acres or larger and located within one mile of water (MBEWG 1991). Stands should include at least two suitable nest trees and live or dead trees as tall as or taller than the surrounding canopy.

Management recommendations

As a listed species under the Endangered Species Act, the Bald Eagle has added protection. A proposal for delisting is currently being prepared. That process will likely begin in 2007.

Bald eagles are particularly sensitive to human disturbance near nesting locations. The Montana Bald Eagle Working Group Management Plan outlines guidelines to be followed to reduce nest failure. One nest is currently active within Reach Five (Figure 2.8.2-1). The Tribes evaluate all human activities occurring between February 1 and August 15 within 2.5 miles of the nest site.

Figure 2.8.2-1
Approximate location of a bald eagle nest in Reach Five.

*Red-eyed Vireo (*Vireo olivaceus*)*
Habitat
A riparian-obligate species in Montana, red-eyed vireos nest in aspen/cottonwood (*Populus tremuloides/ Populus trichocarpa*) bottomland forests (Hutto 1995). Nests are located in deciduous shrubs or trees with sapling undergrowth. Red-eyed vireos eat insects by hover-gleaning over thick understory shrubs (Casey 2000).

Management recommendations
Removal of riparian grazing will increase understory layers and decrease the attractiveness of the sites for cowbirds. Protecting a well-developed canopy layer and promoting cottonwood recruitment will also provide habitat for this species (Casey 2000).

*Western Screech Owl (*Otus kennicottii*) and Downy Woodpecker (*Picoides pubescens*)*
Management recommendations
Both of these species are cavity nesters that require snags of all sizes. Snag recruitment should be addressed to provide habitat sites.

*Least Flycatcher (*Empidonax minimus*)*
Habitat
Least flycatchers, which nest in saplings or young trees, are found in deciduous riparian forests. They use tall, gallery trees in semi-open, second-growth successional stages and are often found near openings such as forest clearings, water, and edges (Casey 2000).

Management recommendations
Least flycatchers are parasitized by cowbirds. Increases in agricultural edges decreases nest success, as does increasing the proximity of agricultural lands. Habitat fragmentation increases avian and mammalian predators.

*American Redstart (*Setophaga ruticilla*)*
Habitat
Dense riparian shrubs, either as an understory, as openings in a forest mosaic, or as contiguous riparian shrubland stands are used for nesting (Casey 2000).

Management recommendations
Parasitism rates by cowbirds are as high as 40 percent for this species (Tewksbury et al. 1998). Increased patch size reduces cowbird parasitism and increases the distance to agricultural lands.

*MacGillivary's Warbler (*Oporornis tolmiei*)*
Habitat
MacGillivary's warblers require late-seral riparian habitat with overstory closures ranging from 0 to 25 percent, mid-story cover (3 to 4.6 meters) at about 80 percent, understory cover (shrub) at about 50 percent, and ground cover ranging from 1 to 20 percent (Casey 2000).

Management recommendations
Removal of grazing and excluding fire would increase habitat potential for MacGillivary's warbler.

General Habitat and Population Objectives for Riparian Deciduous Forest (Casey 2000)
Wherever possible, maintain the dynamic nature of floodplains to accommodate all successional stages of cottonwood forest. Protect existing stands and allow for the recruitment of younger trees.

- On regulated rivers mimic natural flow regimes. Where rivers remain undammed, maintain a natural hydrograph.
- Manage cottonwood forests to preserve mature trees and snags. This may involve using periodic floods or mechanical disturbances to scour substrates, limiting grazing, and increasing flows.
- Protect late successional forest stages (decadent trees, snags, lots of large downed material, wide tree spacing). In many instances, the chance to restore the amount of riparian forest that existed historically has passed. Steps should be taken to protect the best of what remains.
- Encourage a no-net-loss policy for mature cottonwood forests.
- Identify and survey intact blocks of mature cottonwood forest using agency or citizen scientists. Work with agency or private land conservation efforts to place easements on or implement management changes on the largest or most threatened blocks. Designate suitable areas as IBA's (Important Bird Areas) to foster community interest.
- Try to provide continuity in habitat quality by connecting protected/managed parcels via easements, cooperative agreements, or acquisition from willing sellers.
- Protect, reclaim, or recreate oxbow sloughs, braided stream reaches, and backwater areas (Subsection 2.6).

- In all public and private land management programs strive to incorporate and implement appropriate management guidelines for snags, decadent trees, downed trees, shrub cover, ratios of successional stages and other habitat variables.

Species requirements/recommendations Riparian Shrub
*Willow Flycatcher (*Empidonax traillii*)*
Habitat
Willow flycatchers breed in riparian habitats with shrubs a minimum of 1.8 to 2.1 meters tall. Shrub thickets interspersed with openings are used more often than large continuous stands. Overstory may be selected against. Preferred stands are between 10 and 20 acres (Casey 2000). Willow flycatchers feed over open areas and along shrub edges; open water and saturated soils are found in most territories. Foliage densities near nests are approximately 50 to 70 percent, with about 1 meter of cover above them (Casey 2000).

Management recommendations
Reducing fragmentation to reduce parasitism will decrease the greatest threat to willow flycatchers. Populations have increased with other riparian restoration projects (Casey 2000).

*Gray Catbird (*Dumetella carolinensis*)/Warbling Vireo (*Vireo gilvus*)/Song Sparrow (*Melospiza melodia*)*
Habitat
All three species require tall deciduous shrubs.

Management recommendations
The maintenance of tall shrubs combined with management for other sensitive species will provide habitat for these species.

General Habitat and Population Objectives - Riparian Shrub (Casey 2000)
- Riparian shrublands should be an integrated component of any riparian deciduous forest stands targeted for conservation efforts.
- Grazing should be managed or excluded as needed to provide and maintain the structure of riparian shrubland at all elevations.
- Maintenance of riparian shrub habitats should be emphasized in riparian conservation easement efforts.
- Bird monitoring of this habitat should be part of a statewide, stratified, count-based effort specific to riparian systems. It should include demographic monitoring in various landscape contexts. This will allow development of specific population/demographic objectives for priority species.

Amphibians and Reptiles of the Lower Main Stem
The Tribes conducted several amphibian and reptile surveys along the Jocko River between 1993-2000. The four species documented within the lower main-stem corridor include the long-toed salamander (*Ambystoma maculatum*), Columbia spotted frog (*Rana luteiventris*), Pacific chorus frog (*Pseudacris* regilla), and painted turtle (*Chrysemys picta*) (CSKT unpublished data and Werner et al. 1998). Breeding populations of Columbia spotted frogs, Pacific chorus frogs, and painted turtles have been documented at the old Tribal Fish Ponds between the Burlington Northern Santa Fe Railroad and the river and two miles east of Dixon (T18N, R21W, section 21, SE 1/4 section) (CSKT unpublished data and Werner et al. 1998). Evidence of reproducing populations of Columbia spotted frogs has also been documented from Highway 212 east of Dixon downstream to the second railroad bridge (T18N, R21W, section 17, SW 1/4 section) and at the Lower Jocko River Diversion Canal (T18N, R20W, section 31, NE 1/4 section).

Although not officially documented within the lower main stem, it is likely that common garter snakes (*Thamnophis sirtalis*) and western terrestrial garter snakes (*Thamnophis elegans*) occur in this area. Other species that are potentially found in the area include the boreal toad (*Bufo borealis*), western skink (*Eumeces skiltonianus*), rubber boa (*Charina bottae*), racer (*Coluber constrictor*), western rattlesnake (*Crotalus viridens*), gopher or bull snake (*Pituophis catenifer*), and bullfrog (*Rana catesbiana*). Bullfrogs were introduced to the Flathead Indian Reservation and have been documented on the Flathead River between Dixon and Perma, Montana (CSKT unpublished data and Werner et al. 1998). The northern leopard frog (*Rana pipiens*) was once found in the Jocko River Drainage and was documented on the Jocko River one mile west of Ravalli, Montana in 1942. The leopard frog has since been extirpated from the Reservation and most of western Montana.

Mammals of the Lower Main Stem

The entire Jocko ecosystem is an important habitat component for a variety of mammal species. The current list of mammals found on the Jocko River is quite comparable to what would have been found historically, except that present population numbers may be different from historical numbers. Species that utilize the river include beaver (*Castor canadensis*), bobcat (*Felis rufus*), weasels (*Mustela* spp.), mink (*Mustela vison*), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), muskrat (*Ondatra zibethicus*), North American river otter (*Lontra canadensis*), porcupine (*Erethizon dorsatum*), white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocileus hemionus*), elk (*Cervus elaphus*), moose (*Alces alces*), mountain lion (*Puma concolor*) and black bear (*Ursus americanus*) (CSKT unpublished data).

Grizzly bear (*Ursus arctos*), which was listed as a threatened species under the Endangered Species Act in 1975, have also been documented utilizing the river around Valley Creek (CSKT unpublished data). Riparian areas, seeps, and occasionally orchards are used by grizzlies during spring and fall for both feeding and travel corridors. The lower main stem is Situation 3 habitat, where grizzly bear presence is possible but not as common as in Situation 1 or 2 habitats (Situation 1 and 2 habitats are located within the Mission mountain range and along the Mission front).

Resident gray wolves (*Canis lupus*) have not been documented on the reservation. However, transient wolves do travel within the reservation boundaries. With at least three known packs bordering the boundaries and individuals reestablishing territory, these occurrences are likely to increase. The gray wolf is currently listed as a threatened species under the Endangered Species Act, but delisting has been proposed.

Mammal species utilizing the river for food and as a travel corridor include: bobcat, red fox, coyote, raccoon, striped skunk, mountain lion, black bears, and grizzly bears. A few species—beaver, muskrat, and river otter—depend exclusively on the river for survival.

2.9 Infrastructure Effects on the Jocko River Corridor

2.9.1. Introduction

This subsection evaluates the effects of infrastructure on ecological processes and river conditions in greater detail. The purpose of compiling this more comprehensive information is so that when opportunities arise, the structures with the greatest impacts on the river can be modified. Because the reconstruction of US Highway 93 has created immediate opportunities for bridge treatments, we have focused our evaluation on the effects of the bridges. Those evaluations are included in Section 2.9.3. We will complete a detailed evaluation of the effects of the remainder of the infrastructure during the scoping and analysis phase of specific projects and as time allows.

2.9.2 Bridge Assessment

Twelve bridges cross the river within or just above the lower main stem (Table 2.9.3-1). Bridge characteristics vary based on age, ownership, and the stream type. The following sections include both structural and hydraulic evaluations.

Methods

Data collected and analyzed include:

- General bridge geometry (span, abutment shape, pier configuration, and skew);
- Visual inspection of channel condition and sediment transport capability;
- Photographs at or near bankfull discharge (June, 2002);
- Upstream and downstream bank conditions; and
- Preliminary Hydrologic Engineering Center–River Analysis System (HECRAS, USACE) models developed by the US Geological Survey (USGS).

The bridge assessments focused on attributes that typically contribute to impaired river morphology. These include:

- Constriction – bridge span relative to floodway width;
- Skew – the angle between bridge and floodway measured as departure angle from perpendicular; and
- Obstructions – piers, abutments, and deck in the bankfull channel that obstruct flow and debris passage.

To correlate bridge attributes with impaired river morphology, we cross referenced bridges with these attributes and river impairments with hydraulic parameters from the preliminary HECRAS model output.

2.9.3 Observations and Results

The most commonly occurring phenomenon associated with lower main-stem bridges is a backwater effect. Backwater effects resulting from constriction, skew, and obstructions alter river hydraulics both upstream and downstream. Upstream, the water surface elevation increases while velocity and sediment transport capability decreases. Typical effects include sediment deposition, channel braiding, lateral channel migration, and bank erosion. Downstream, supercritical flow and a hydraulic jump can occur. Velocity increases as does sediment transport capability. Typical effects include scour and bank erosion.

Table 2.9.3-1 presents the results of the bridge assessment. We tabulated bridge attributes (constriction, skew, and obstructions), backwater effect, and observed impairments for each of the 12 bridges. These parameters were then used qualitatively to rate the level of impact (no impact, minor impact, or major impact) that each bridge is having on river channel morphology.

Table 2.9.3-1.
The Jocko River bridge assessment summary.

Bridge	River Reach/ Station	Constriction (ft) (Upstream floodplain width – bridge span width)	Skew Angle	River Obstructions	Backwater Effect (ft)	Observed Impairments	Impact
Teresa Adams	Upstream of 8	N/A	0°	None	N/A	None	No Impact
Old Hwy 93	8 1000+00	0[a] 420 - 87[b]	0°	Abutments	0[d] 0[e]	Limited Purpose	Note 1
Hwy 93	8 997+00	220 - 103[a] 285 - 103[b]	15°	2 Piers	0[d] 10[e]	Bridge to be Replaced	Note 2
BN RR#1	986+00 1000	none	< 5°	2 Piers	N/A	None	No Impact
S Valley Cr Rd	5 751+00	595 - 90[a] 730 - 90[b]	45°	Abutments	4[d] 13[e]	Scour, Bank Erosion	Major
N Valley Cr Rd	4 577+00	105 - 80[a] 315 - 80[b]	< 5°	None	3[d] 7[e]	Riprap on downstream Right bank DS RB	No Impact
BN RR#2	4 431+00	0[a] 0[b]	< 5°	2 Piers and Abutments	7[d] 10[e]	Deposition, Scour, Braiding	Major
Hwy 200	4 429+00	0[a] 0[b]	N/A	None	0[d] 0[e]	None	No Impact
BN RR#3	3 131+00	315 -155[a] 315 - 155[b]	< 5°	2 Piers, Abutments and Levees	2[d] 3[e]	Bank Erosion, Scour	Minor
Hwy 212	2/3 57+00	210 - 65[a] 225 - 65[b]	0°[c]	None	11[d] 17[e]	None	No Impact
BN RR#4	2 48+00	0[a] 0[b]	35°	2 Piers and Abutments	2[d] 6[e]	Bank Erosion, Scour	Minor
BN RR#5	1/2 28+00	550 -155[a] 550 - 155[b]	0°	2 Piers and Abutments	14[d] 20[e]	Deposition, Braiding	Major

[a] Modeled at approximate 10-year discharge. Measured from upstream cross section to bridge
[b] Modeled at approximate 100-yearr discharge. Measured from upstream cross section to bridge
[c] Abutments aligned with river, but deck skew measured at 20°
[d] Reported as increase in upstream water surface elevation relative to best-fit water surface profile through bridge at approximate 10-year discharge.
[e] Reported as increase in upstream water surface elevation relative to best-fit water surface profile through bridge at approximate 100-year discharge.
Note 1 The old Hwy 93 bridge was removed in fall, 2006 as a part of the Highway 93 reconstruction project
Note 2 A new bridge replaced this bridge in 2006 as a part of the Highway 93 reconstruction project

Of the 12 bridges evaluated, we determined that five are having no impact, four are causing minor impacts, and three are responsible for major impacts. In general, there was a high degree of correlation between bridge attributes (constriction, skew, and obstructions), backwater effect, and impaired river morphology. As expected and as seen in the preliminary HECRAS model, bridges that caused changes in stream alignment, bankfull cross-sectional area, and floodplain width affected hydraulic parameters in the vicinity of the bridge. The altered hydraulics led to sediment transport problems, changes in bed profile, bank erosion, and high width-to-depth ratios. Individual bridge assessments follow.

Teresa Adams Bridge

The Teresa Adams Bridge is upstream of Reach Eight. Through this reach, the river is a B3 stream type (Rosgen 1996). Although the bridge presents a minor floodway constriction, no impairments were observed. The structure appeared to be in good condition and no river obstructions are present. This bridge does not have a significant impact on the river.

Old US Highway 93 Bridge

The old US Highway 93 Bridge is in Reach Eight, just upstream of the existing US Highway 93 Bridge. Through this reach, the river is a B3c stream type (Rosgen 1996). This bridge was removed in 2006 as part of the US Highway 93 reconstruction.

US Highway 93 Bridge

The US Highway 93 Bridge is in Reach Eight, just downstream of the Old Highway 93 Bridge. Because it will be replaced as part of the US Highway 93 reconstruction, we did not evaluate this bridge, which is designed to convey bankfull discharge between natural bank materials under the bridge span. The bridge is also designed to convey the 100-year flood with no backwater effect. The new bridge span reflects a significant improvement over the previous condition, and potential bridge effects should be very limited.

Burlington Northern Santa Fe Railroad Bridge #1

This bridge is in Reach Seven. The channel here is a G1 type confined within a bedrock gorge (Rosgen 1996). Two bridge piers are located in the bankfull channel, but are not likely to cause impacts because of the stable bedrock geology. This bridge does not have a significant impact on the river.

South Valley Creek Road Bridge

The South Valley Creek Road Bridge is in Reach Five. Reach Five has C4 and D4 stream types (Rosgen 1996). We observed several stream impairments in the vicinity of the bridge, including bank erosion and abutment scour. The single lane structure consists of a wood plank deck and two concrete abutments that lie within the bankfull channel (Figure 2.9.3-1 a and b). Abutment scour, caused by the skew angle (45°±) between the bridge and the river, is a problem on the east abutment. As a result, rip-rap has been dumped along the downstream east bank. We observed bank erosion on the east bank downstream of the rip-rap. For these reasons and because of significant floodplain constriction and backwater effects, this bridge has a major impact on the river.

2. CONDITIONS

Figures 2.9.3-1 a and b.
Scour at the east abutment on the South Valley Creek Road Bridge (a). Bank erosion downstream of the east abutment (b).

North Valley Creek Road Bridge

This bridge is in Reach Four which has B4 and C4 stream types (Rosgen 1996). The bridge span is adequate for the bankfull channel, has ample freeboard, and no piers in the channel. The banks in the vicinity of the bridge are covered with stable vegetation. Other than posing a floodplain constriction and having a minor backwater affect, this bridge has no significant impact on the river.

Burlington Northern Santa Fe Railroad Bridge #2

This bridge is in Reach Four near the intersection of US Highway 93 and Highway 200, where the river is classified as a C4 stream type (Rosgen 1996). The river, in this section of reach four, has a high width-to-depth ratio, pier scour, and sediment transport problems that are exacerbated by several piers and abutments in the bankfull channel. Two abandoned abutments encroach on the river upstream of the bridge and deflect flow. The width-to-depth ratio through the bridge is higher than average for a C4 stream type (Rosgen 1996). We saw evidence of deposition and channel braiding in the vicinity of the structure. Preliminary models indicate that a seven to ten foot backwater effect occurs at discharges between the 10-year and 100-year flood recurrence intervals. This bridge has a major impact on the river.

Highway 200 Bridge

The Highway 200 Bridge is in Reach Four, just downstream from Burlington Northern Santa Fe Railroad Bridge #2. The span of the bridge piers and abutments is enough for the bankfull channel. The bridge has adequate freeboard and the span is adequate for the floodplain. The bridge does not have a significant affect on the river.

Burlington Northern Santa Fe Railroad Bridge #3

This bridge is in Reach Three. River impairments include pier scour and sediment transport problems potentially related to piers and abutments in the bankfull channel. In addition, levees extend upstream for approximately 1,000 feet on both banks. An elevated water surface profile was evident in the HECRAS model through this section. The backwater effect generated by the bridge is reduced to two to three feet because of the upstream levees. We observed a significant drop in the bed profile downstream of the bridge, which is apparently causing supercritical flow conditions and downstream bank erosion. This bridge and its associated levees have a minor impact on the river.

Highway 212 Bridge

The Highway 212 Bridge is in Reach Two. The abutments adequately span the bankfull channel and the bridge has adequate freeboard. Other than the railroad encroaching on the floodplain, we observed no significant morphological impairments. The impacts of the floodplain constriction and significant backwater effect (11 to 17 feet) are likely offset by the stable vegetation that lines both banks upstream and downstream of the bridge. Furthermore, the narrow valley and incised F4/B4 stream type efficiently transports flood discharges and sediment through the bridge (Rosgen 1996). This bridge does not significantly affect river morphology.

Burlington Northern Santa Fe Railroad Bridge #4

BNSF Bridge #4 is in Reach Two. River impairments include upstream bank erosion, pier scour, and sediment transport problems that are probably caused by the skew angle (35°±) between two piers and the bankfull channel. Moreover, the bridge is located on a meander which makes it more vulnerable to erosion and deposition. We also observed evidence of deposition and channel braiding in the vicinity of the bridge. During the field visit we saw an abrupt drop in water surface elevation on the downstream side of the bridge. According to the preliminary HECRAS model, there is only a minor constriction and backwater effect at this structure. The bridge has a minor impact on the river.

Burlington Northern Railroad Bridge #5

This bridge is in Reach One. The river in this area is affected by floods and backwater from the Flathead River and is sensitive to floodplain disturbances like bridges. The delta at the confluence extends through the bridge and affects sediment transport. Obstructions include piers and abutments located in the bankfull channel that, along with the significant constriction and backwater effect, contribute to the impairments. Because of its location on the floodplain of the Flathead River, this bridge has significant influence on river morphology and stability.

2.9.4 Summary

Our structural and hydraulic evaluation of the twelve bridges spanning the river reveal that most create a backwater effect caused by flow constrictions, bridge skew, and in-channel obstructions. Bridge effects on the channel were apparent in the form of bank erosion, bank armoring, upstream deposition, and downstream scour. Correcting the problems associated with the seven bridges that cause minor or major impacts to the river will improve flood flow conveyance, channel and crossing stability, and sediment and debris transport.

2.9.5 Transportation Corridor

Transportation corridors that encroach on the belt width, or active meander zone, have a significant influence on channel planform and can cause geomorphic changes, such as increased channel slope. Corridors can also reduce or eliminate channel and floodplain interconnectivity at higher flows. In these instances transportation corridors can change the valley type, and secondarily the stream type by bounding the river to a more laterally confined valley type.

Transportation corridors can also influence surface and subsurface flows across a floodplain. This is most pronounced where the feature is at a skew angle to the floodplain. As an example, the Highway 93 fill across the floodplain of the river immediately north of Arlee has intercepted ecologically significant groundwater flow, forcing it to the surface where it must be managed almost as a stormwater outfall.

Two transportation features parallel the river from Arlee downstream to the confluence with the Flathead River – the Burlington Northern Santa Fe railroad tracks and the alignments of Highway 93 and Highway 200. The Northern Pacific Railroad, the predecessor to BNSF, constructed a railroad line through the Jocko Valley starting in 1883. Road construction along the current alignment of Highway 93 started in 1908.

The influence of transportation rights-of-way are greatest in confined valley sections, specifically from Ravalli to the mouth. Table 2.9.5-1 tabulates, by reach, river segments where transportation corridors directly influence channel planform.

Table 2.9.5-1.
Length of reach influenced by transportation corridor.

Reach	Length (ft)
3	2275 ft
4	4810 ft
5	765 ft
8	400 ft

This table does not accurately reflect historical impacts associated with transportation corridors. For example, 1883 railroad right-of-way surveys (ARCO program project files) demonstrate that the belt width of the Jocko River occupied the entire alluvial valley from downstream of Ravalli to the mouth. Railroad construction cut off wide meander loops that occupied surfaces now several feet above the river base level.

Unlike bridge structures that can be modified when they reach the end of their design life, transportation corridors are generally permanent. From a restoration perspective, they limit restoration opportunities.

2.9.6 Buildings and other developments

A limited number of structures are located in the delineated floodplain of the lower main stem (Chase and Parrett 2006). One commercial campground, the State of Montana Arlee Fish Hatchery, and approximately 10 homesites and/or small businesses lie within the *hydrologic* floodplain. There are many more structures when one considers buildings that lie within the *ecological* floodplain . Structure protection is a constraint that must be considered because it can influence site-specific restoration plans.

Pond developments are located intermittently along the lower main stem, starting at the upstream end with the State of Montana, Arlee Hatchery settling pond. Open water ponds are not characteristic of the natural geomorphic setting, and their presence generally exerts a detrimental influence on riverine ecology. When considered cumulatively, ponds can influence river thermal regimes by discharging warm water to the river. They can also harbor non-native animal life, and often have berms or other floodplain encroachment features along their margins.

2.9.7 Irrigation and Agriculture Structures

Federal (FAID) irrigation diversions are located at the Lower S Canal in Reach 7, and the Lower J Canal at the upstream end of Reach 3. At both locations, the diversions have long fills adjacent to the river that restrict the extent of the floodplain. The diversions also require fish screens to prevent entrainment in the canal.

There are several private irrigation diversions and pumps located along the Jocko River. These features, although smaller than the FAID diversions, tend to have site-specific impacts.

All irrigation diversions require ongoing maintenance that includes inlet control management, sediment management, vegetative management, and in some instances, instream grade control.

Overall the accumulated infrastructure has had, and continues to have, a significant impact on the active channel, the interconnectivity between the channel and floodplain, and ecological attributes within the floodplain. Infrastructure is a primary constraint that must be addressed as site-specific restoration projects proceed.

2.10 River Ecology and Instream Flow

2.10.1 Overview

The main theme throughout this document is one of evaluating and describing the Jocko River's floodplain in the context of its historic, existing, and desired future conditions. In part this is done to understand the potential for restoration (Section 3) and acknowledge that in all likelihood the Master Plan Team will not be able to restore the lower Jocko River to its historic pristine condition however, restoring to a Desired Future Condition (DFC) that represents a self-sustaining ecology that will achieve our goals of riparian and bull trout recovery is obtainable. A second theme throughout the chapter is how the ecology of a riverine system like the lower Jocko is defined by its hydrograph.

Throughout Section 2 we discuss the effects of transportation infrastructure, floodplain constriction (levees and channelization) (Subsection 2.2), and vegetation manipulation for farming practices (Subsections 2.1 and 2.5) and transportation infrastructure (Subsection 2.9) on the ecology of the lower river. The effects of these actions on the riverine environment are obvious, tangible, and many can be addressed. The changes in ecology that can be attributed to changes of the river's hydrograph are less well understood and harder to quantify, but are potentially much more significant than many other modifications. Many researchers have demonstrated the importance of the natural hydrograph by studying the outcomes of water developments (Frissell and Bayles 1996, Hardy 1998, Ward et al. 1999).

Clearly, the Jocko River's hydrograph has been altered from its historic or natural condition (CSKT 2002) and this may have altered the ecological setting, including channel dimensions (Subsection 2.4) and the expanse of the floodplain (Subsection 2.2). It is beyond the scope of our efforts to document these ecological changes; however, a full body of literature suggests we would expect the stream channel and floodplain to respond to hydrologic changes as substantial as we have documented, particularly in upstream sections of the lower main stem within Reaches Seven and Eight.

For our purposes we can avoid potential problems related to the altered hydrograph while undertaking restoration actions through the use of a reference reach approach (Subsection 2.4.5) in our restoration design process. In this approach we assume that any changes to ecological processes (channel morphology, riparian complexity, i.e., habitat formation and maintenance) brought about by changes to the historic hydrograph have already taken place and are thus represented in the existing natural template provided by the reference reaches. While we think this is a safe assumption, we are equally concerned that our restoration work is dependent upon the existing (modern) hydrograph, which is not protected and thus may be subject to further change in magnitude or shape.

We know that historically, a Rosgen C or pool-riffle channel type dominated the lower Jocko River. Thus, the river regularly accessed the floodplain during flood events that exceeded bankfull discharge. During small to moderate floods (5-to-20-year recurrence interval), the movement of flood waters out onto the floodplain supported many processes, including the scouring and deposition of sediments on floodplain surfaces that were subsequently colonized by early successional plant species; the inundation of floodplain wetlands and slow release of soil moisture back to the river; the seasonal increase of the water table during flood events; and the retention and cycling of fine sediment and nutrients.

Large, infrequent floods (50-year recurrence interval and higher) supported these same processes, but also initiated channel avulsion events, forcing the river channel to an entirely new location and leaving behind abandoned channels that developed into wetland complexes, spring brooks, or other off-channel habitats that are important to the diversity and function of the ecology of the lower Jocko

River. The geomorphology of the expansive lower main-stem floodplain (Subsection 2.4) suggests that the Jocko River channel migrated extensively over the valley floor through a combination of slow active channel migration and rapid channel avulsion processes. These processes resulted in a highly diverse and complex floodplain characterized by oxbow features, secondary channels, and meander scrolls, among other features. Spring channels originating on the valley floor and wetlands supported by groundwater upwelling further contributed to the diversity, creating rich conditions for an abundance of plant species, community types, and seral stages.

In contrast to the historic setting, we have considerable information on the current ecological condition because we can observe and measure it. In addition, we have an accurate assessment of an environmental history in the watershed that can largely explain processes that lead to the existing condition. Timing of major events like the development of the transportation infrastructure, large-scale logging, subsequent large forest fires and the conversion of lands for agriculture are well documented. Much of Section 2 is dedicated to describing the resultant impacts to the floodplain from these events. Perhaps the most significant difference between the existing condition and the historic condition is that the primary mechanism of change was shifted from the hydrograph to anthropomorphic or human inputs.

The earliest human impact on the Jocko River corridor is that of development of modern transportation infrastructure. The railroad, which was built in 1883, has isolated huge portions of the ecological floodplain from the river. Locations where the railroad and more modern road systems cross the Jocko River have resulted in lasting impacts. These impacts are discussed in Subsections 2.4, 2.5, 2.6 and 2.9 and place limits on restoration potential. However, modern policies and construction techniques as demonstrated by ongoing Highway 93 reconstruction suggest some function may even be restored to these areas in the future.

Soon after the development of the modern transportation infrastructure the conversion of the valley to an agricultural base began. This started with the Flathead Allotment Act in 1904 and created a situation where the valley's human occupants were required to make a living off the land. As elsewhere in the arid west, the most productive lands are in the riparian zone. The progressive conversion of the riparian area into agriculture uses is described in Subsection 2.2 and 2.5. Government subsidies encouraged and often paid for the development of the agriculture based economy. The channelization in Reach Three along the National Bison Range is a good example of how government-subsidized programs for agricultural development negatively influenced the ecology of the lower main stem. Negative effects from the agricultural based economy are significant, but compared to transportation corridors, can be more easily addressed because of their more temporary nature. Currently the trend is away from this kind of land use as fewer acres of riparian land in Jocko valley are operated as farms that generate the primary income for a family. This past legacy and the movement away from it allows us the opportunity to restore the floodplain in a broad holistic way.

The existing ecological condition of the lower Jocko River is a reflection of both the watershed's environmental history and its modern hydrograph. Water and sediment yields have fluctuated along with mans' activities and both are currently shifting back to more natural levels due to modern logging practices and protection of key sub-watersheds. Riparian logging is no longer a common practice and intensive farming along the river corridor is phasing out. New environmental laws discourage if not prohibit heavy-handed stream channelization and levee construction. Wetland functions and values are better understood and protected than in the past. More and more the agent of change is shifting back to natural processes driven by the river's hydrograph. With the current approach (described in Section 3) under the ARCO settlement to restore the floodplain, it is important to understand and describe ecological processes that are driven by the hydrograph.

2.10.2 Historic and Existing Hydrologic Regimes

Since its completion in the 1940s, the federal irrigation system has significantly altered the Jocko River's ecology in a number of ways. Most of the agriculture based on the federal irrigation project is not in the floodplain, but on the valley terraces; therefore, many of its negative influences are indirect and related to directly to water withdrawals, rather than mechanical alteration as discussed above. The federal irrigation project has had significant effects on ground water-surface water exchanges and altered the nature of the surface flow regime by changing the timing and volume of stream flows (Subsection 2.3). Because the restoration efforts strive to repair ecological processes, it is important to understand how man-induced changes in the hydrograph affect ecological processes.

We have good sources of information for historical and existing flow regimes using two sources: U.S. Geological Survey stream gage data from the period 1906 through 1918 and Confederated Salish and Kootenai Tribes (CSKT) stream gage data as reflected in the Jocko Basin Hydrology Report (CSKT 2003). The Hydrology Report also naturalizes the hydrology (removes human-caused changes) for the same period. The naturalized hydrology is representative of the historical condition for the water year conditions reflected in the period 1992-2001. Table 2.10.2-1 shows how the hydrology has changed since the irrigation project development and also reflects the current water policy for interim minimum instream flows set by the Bureau of Indian Affairs (BIA) for the protection of trust resources.

Table 2.10.2-1.

A comparison of stream flow statistics for the historical (naturalized), existing (modern), and minimum instream flows (interim ISF) for the Jocko River near Finley Creek.

	Average Water Year		
Hydrologic metric	Historical	Existing	Interim ISF*
1.5-year flood (Q1.5)	1100 cfs	435 cfs	43
2-year flood (Q2)	1304 cfs	595 cfs	43
10-year flood (Q10)	2130 cfs	1475 cfs	43
25-year flood (Q25)	2550 cfs	2060 cfs	43
50-year flood (Q50)	2865 cfs	2550 cfs	43
100-year flood (Q100)	3180 cfs	3095 cfs	43
Duration of flow above Q1.5 for existing flow = 435 cfs	53 days	21 days	0 days
Duration of flow above Q1.5 for historical flow = 1100 cfs	13 days	0 days	0 days
Rate of declining limb June 20 – July 20	22 cfs/day	10.8 cfs/day	0 cfs/day
Summer base flow July 20 – September 20 IQR#	161 cfs – 192 cfs – 226 cfs	108 cfs – 111 cfs – 115 cfs	43 cfs – 43 cfs – 43 cfs
Winter base flow January 1 – March 1 IQR#	45 cfs – 50 cfs – 57 cfs	62 cfs – 64 cfs – 70 cfs	43 cfs – 43 cfs – 43 cfs

** Interim ISF is the court-mandated interim instream flow currently enforced by the BIA for protection of Indian trust resources.*

The values in the above table reveal a pronounced reduction in the magnitude of more frequent floods and smaller changes in less frequent, higher magnitude floods from the historic to current hydrographs. Typically, the receding limb of the hydrograph is also steepened (flows drop more rapidly after they peak). The values also demonstrate that summer base flows have been reduced, with possible implications for summer instream thermal regimes and habitat suitability for salmonids. Higher winter base flows are the expected result of delayed subsurface return from canal seepage and on-farm irrigation. Values displayed are for an average year and would be expected to be more pronounced for a dry year, as well as less so for a wet year.

While it is easy to demonstrate the existing hydrograph is altered from the historical or natural hydrograph, it is more difficult to document the resulting changes in the ecology of the lower Jocko River. We have not performed the types of studies necessary to explicitly quantify the actual changes caused purely by alterations in portions of the hydrograph; however, based on an extensive body of scientific literature we can make well-informed inferences about the physical processes that occurred in response to changes in stream flows brought about by the Federal irrigation project.

Many aspects of the Jocko River floodplain ecosystem have changed as a result of land use and water diversions. Total annual sediment transport has been reduced due to reduced discharge at flows up to the ten year return flow. This has probably resulted in locally increased deposition, although the effect is complicated by local changes in channel capacity, cross-section shape, and reduced bank vegetation that functions to trap sediment. Other local effects may have included simplified instream habitat conditions and vegetation encroachment within the historical active channel. Specifically, reduced sediment transport capacity results in smaller sediment size being moved, causing the channel bed to have a larger proportion of fine sediments, particularly near sediment sources such as unregulated tributaries.

Diversions tend to store sediment during high flows and release sediment during low flows. Effects from this include sediment deposition, embedded substrate, finer bed materials downstream from diversions, simplified habitat, and lower overall biological productivity.

Local channel aggradation can lead to destabilized reaches expressed by avulsions, higher width to depth ratios, and finer channel bed materials. These phenomena, combined with reduced overall flows can result in a greater width to depth ratio, further causing a change in Unit Stream power and also critical shear stress. Reduced total channel capacity and unchanged flood flows can lead to increased bank erosion due to increased shear stress on banks.

Reduced flows in the 1.5 to 2 year return flow range may cause the channel capacity to be reduced due to aggradation, vegetation encroachment and local deposition. This may also result in a corresponding reduction in the active floodplain width (Figures 2.10.2-1 and 2.10.2-2). A channel with reduced capacity will not be able to accommodate larger flood flows without increased erosion and channel destabilization. For example, a 50 year event may respond more like a 100 year event in an atrophied channel.

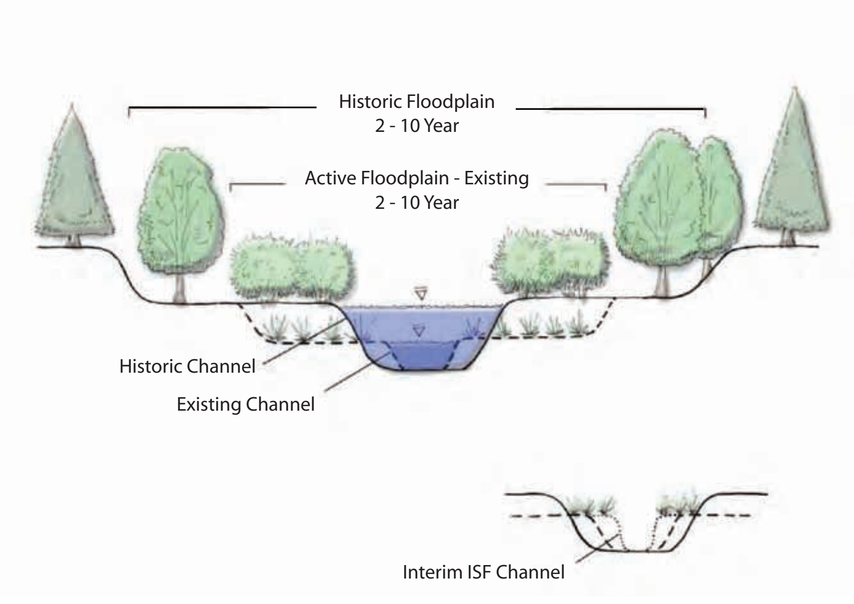


Figure 2.10.2-1.
Conceptual channel adjustment process from historical to existing conditions based on hydrograph changes – cross section view.

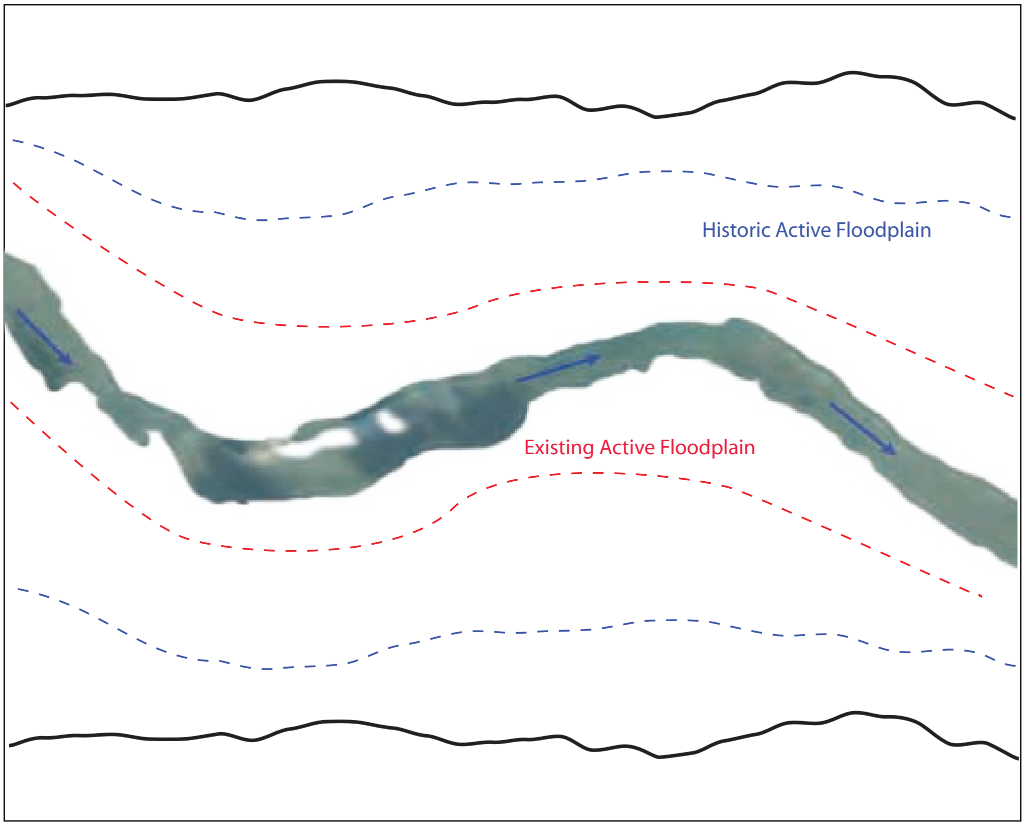


Figure 2.10.2-2.
Conceptual channel adjustment process from historical to existing conditions resulting from changes in the hydrograph – plan-form view.

Channel sinuosity may decrease due to a channel that has become destabilized from increased sediment loads and reduced sediment transport capacity. If sinuosity decreases, channel slope increases, thereby increasing local energy, which can increase both vertical and lateral erosion.

Water temperatures may have increased as water was diverted within reaches where groundwater is not a significant source of instream flow. Water temperature, like bank erosion and channel dimensions above, has also changed as a result of land clearing and grazing practices in the floodplain.

Many riparian trees and shrubs require depositional surfaces where their tiny seeds can germinate without competition from other plants. Flows of enough magnitude occur to establish substrate, but at a reduced frequency. This reduced frequency may have reduced the number and distribution of depositional features, thereby reducing the numbers of tree and shrub stands that become established over a period of several years.

A reduced peak flow duration and possible increased rate of river stage drop after peak flows may have reduced the survival percentage among cottonwood and willow recruits. It is possible that alder recruits may not be affected due to their autumn seed drop which does not correspond with peak flows.

Effects of drought years may be more pronounced due to irrigation withdrawals; this would cause higher mortality in sapling and pole age classes whose roots have not yet reached their maximum depth. Incremental changes in hydroperiod could also result in loss of fringe wetlands and cause changes in inundation/saturation period, which might cause a shift in wetland sub-class. As with many system components, land uses have likely impacted off-channel wetland occurrence and condition more than altered stream flows.

The effects of an altered hydrograph to wildlife/amphibian/invertebrate habitats and connectivity would be greatest to species having marginal niches under the historical flow regime.

As discussed at the beginning of this section and throughout Section 2, many of these effects are hard to demonstrate on the ground because they are masked by past heavy-handed anthropomorphic inputs. In addition, the Jocko River continues to have a hydrograph that generally mimics the pattern of its natural hydrograph in many ways. For example it still receives its higher-level floodwaters, which do much of the ecological work.

Observations made in our reference reaches (Subsection 2.4.5) generally support our hypothesis that the existing (or modern) hydrograph could support enough riverine attributes to achieve ARCO mitigation goals. We selected our reference reaches because they currently express the best remaining habitats (riparian, fish, wildlife, etc…) along the lower Jocko River. By seeking out river reaches that remain in the best condition and using them as our template for restoration, we are able to observe a channel form and floodplain complexity that can serves as a guide for our desired future condition to support restoration scenarios. We say this with the caveat that our ability to restore the system is limited because the ecology has shifted to reflect a new equilibrium with its modern hydrograph. In order to protect our investment in restoration, it is important to at least maintain the system's compromised ecological potential; because of this need, we are concerned about the lack of protection for the existing flow regime given the current policy. Any significant changes in the flow regime would likely result in rendering many of our current restoration actions inappropriate or irrelevant. To make this point we speculate what the lower Jocko River might look like were it to receive only the current interim ISF.

2.10.3 Interim ISF Ecological Condition

This discussion describes a hypothetical riverine ecosystem that would be the result if river flows were held at a constant, as would be the case if the current interim instream flow levels were strictly adhered to. Because interim instream flows are the only currently protected flows, it is conceivable, that all surplus water could be diverted for some unknown future use.

Interim ISF

Interim Instream Flows were set by the BIA in 1986 to minimally protect the CSKTs' fishery resources. These recommendations were needed due to chronic dewatering of streams in certain areas and at some times of the year. In the Jocko drainage, this frequently occurred below the Jocko K canal and often resulted in a dry stream channel until down-valley ground water recharged the channel. The interim ISFs were established with both the Wetted Perimeter or Tennant methods (BIA 1987) and represent minimum flows for fish. Although the Tennant method can be used to recommend flows to protect components of river ecology, this approach was not applied by the BIA. These minimum instream flows are shown for various points along the lower main-stem Jocko River in Table 2.10.3-1.

Table 2.10.3-1.
Interim ISF at various points along the Jocko River

Locations along the Jocko River	Interim Instream Flow
Jocko River below K Canal (at Big Knife Creek)	36 cfs
Jocko River below Lower S Canal (below Finley Creek)	43 cfs
Jocko River below Lower J Canal	76 cfs
Jocko River above Mouth	96 cfs

Interim ISF Channel Morphology

If the existing interim ISF were to be explicitly implemented, major changes would occur in channel morphology and ground-water surface water interactions. Lack of variable flows would result in adjustment of most fluvial processes currently occurring in the system. Sediment transport would be greatly reduced and would be controlled more by direct sources, valley gradients, and underlying geology than variable flows. Lack of scouring flows near the banks of the existing channel would allow vegetation to encroach on the channel, resulting in a narrower channel with a low width-to-depth ratio. This potential condition assumes that most sediment inputs to the reach are derived from lateral migration, bank erosion, and reworking of fluvial sediments. Essentially, at its evolutionary endpoint, the lower Jocko River would look and function similar to a spring creek, not the alluvial system that it currently is. Figure 2.10.3-1 provides a conceptual illustration of these scenarios.

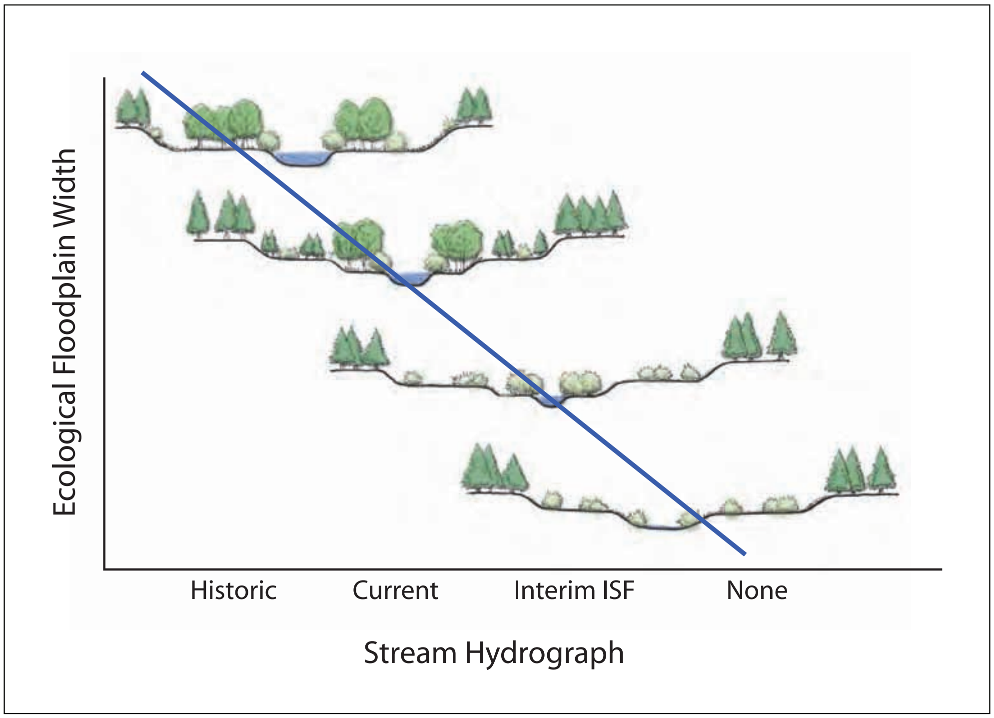


Figure 2.10.3-1.
Conceptual relationship between stream hydrograph and ecological floodplain width.

The most significant changes to the floodplain would be the lack of overbank and floodplain surface flows, and a reduction in the alluvial water table elevation as groundwater adjusts to match lower surface-water levels within the channel. Ephemeral wetlands that currently depend on periodic recharge from the river would disappear, and the only remaining wetlands would be those supported by other groundwater sources, irrigation ditches, and those deep enough to intercept the reduced water table elevation. Even those wetlands would be reduced in size. Reduced flows and the lack of overbank floods would increase the potential of the system to be influenced by beavers because dams would not be washed out and beavers could potentially dam the entire former channel. If beavers were allowed to occupy the system, this could result in the creation of large floodplain wetland complexes.

Interim ISF Floodplain Complexity

Under the interim ISF, key ecological processes that currently support a diverse distribution of vegetation communities would no longer function. These include limited substrate scour and deposition to support cottonwood and willow regeneration and infrequent overbank flows to support wetland plant communities. Fluvial processes might be replaced by beaver activity, which could result in cottonwood stands being replaced by willow complexes interspersed with emergent wetland vegetation. In the absence of beavers, woody riparian plant communities would either shift to drier ecological types or shift to later successional stages that thrive in the absence of disturbance. River reaches that pass through agricultural lands would be dominated by herbaceous, and potentially weedy plant communities. Reed canarygrass would likely thrive along streambanks adjacent to well-established grasslands where floodplain microtopography is limited.

Interim ISF Fisheries Resources

The Jocko River would no longer posses many of the key attributes or functions of an alluvial river system under a steady flow regime. Among the key functions or attributes of an alluvial river are a diverse annual hydrograph, frequent channel substrate mobilization, connectivity of the channel and floodplain, balanced sediment transport processes, and interaction between surface water and ground water (Trush et al. 2000). Native salmonids evolved with these attributes and exploit the diverse habitat provided by a properly functioning alluvial system. Thus, it is probable that a low, monotonic flow would fundamentally alter the main-stem fish assemblage. We hypothesize that strictly implementing the interim ISF would modify the stream in ways (e.g., by warming thermal regimes and allowing accumulation of fine sediments) that would make it less suitable for native westslope cutthroat and bull trout and more favorable for tolerant native taxa (e.g., northern pikeminnow, redside shiner) and introduced taxa, such as brook trout.

2.10.4 Instream Flow and the Desired Future Condition

Throughout this document the DFC is described as one created and sustained by healthy, functioning natural processes. Rather than being a static condition, the desired future condition is dynamic within a range of variation reflected in climatic, geologic, hydrologic, and biological attributes taking into account the continued presence of anthropogenic disturbances and limitations imposed by the presence of existing permanent infrastructure (e.g., bridges). The DFC is the target for restoration activities and is based upon our observations of functioning alluvial attributes in our identified reference reaches (Subsection 2.4.5). Within the context of the relationship between stream flow and the ARCO restoration goals, the DFC is that condition which would be supported by the existing (or modern) hydrograph. Re-stated, the ecological condition to which we are currently restoring is supported be the existing hydrograph. Further, we are concerned that the existing hydrograph is not currently protected by policy.

We believe that this DFC would likely meet USFWS habitat matrix requirements for bull trout (e.g., stream temperatures would not exceed 15º C, pool frequency would be approximately 20 per stream mile, large woody debris abundance would be approximately 20 pieces per mile, and bank stability would be greatly increased). It is anticipated that these habitat conditions, combined with improvements in the upper reaches of the watershed, would allow for the full expression of life history attributes for native fish taxa, especially bull trout. It should be readily apparent that the interim ISF do not support the DFC nor would this flow regime promote bull trout restoration efforts.

2.10.5 Summary

In any pristine fluvial river system, the hydrologic regime defines the floodplain/riparian ecology and is the primary agent of change. Understanding the recent environmental history of the Jocko River watershed, including changes in the hydrograph, is important to recognizing its potential for restoration actions. Over the last century, the Jocko watershed, specifically the lower river reaches, has endured significant impacts from modern human settlement. In this document we describe the historic, the existing (including human impacts), and a desired future conditions (our restoration aspirations) in an ecological context. In this section we acknowledge that the river's current hydrograph defines the current ecological setting. We base our desired future condition (or potential condition) on a reality that is expressed in our reference reaches and is dependant upon the existing hydrograph. This reality recognizes that negative influences such as those imposed by the existing railroad right-of-way and manipulation of the hydrograph by the Flathead Agency Irrigation District (FAID) place limitations on what can be achieved through restoration. This is not meant to endorse these impacts, but to acknowledge them as current constraints. Our working hypothesis remains that the closer we are able to restore to the historic setting, the more advantages we have given the native flora and fauna to persist in the presence of a variable environment and to compete with introduced species.

We have identified reaches along the river corridor that appear to have adjusted to its modern hydrograph and represent many of the primary components of a functioning alluvial river system. Our designs use these reference reaches and attempt to mimic these processes in other areas in need of restoration. Given modern natural resource management, more progressive environmental laws, and the movement of agriculture out of the Jocko River's riparian zones, we are optimistic our restoration goals can be achieved and that the river's hydrograph will once again be the primary mechanism of change in the Jocko River floodplain. However, we are concerned about the river's future without a better water policy that recognizes the need for protection of ecologically based instream flows. Poff et al. (1997) said it best: "the natural flow regime of virtually all rivers is inherently variable and that this variability is critical to ecosystem function and native biodiversity."

Within-year and among-year variation in flows drive processes that periodically reset physical, chemical, and biological functions essential to the ecosystem. Some species do well in wet years, and other species do well in dry years. For this reason, providing a single flow value cannot simultaneously meet the requirements of all species or maintain a fishery. If strictly implemented, the current interim ISFs would not sustain biological diversity or dynamic ecosystem functions because they ignore both intra- and interannual flow variations. We recommend a policy that recognizes the need for protection of habitat-forming processes be established. Further, we recommend that improvements to the existing hydrograph be evaluated and considered when such changes can be expected to benefit conditions for bull trout or other key taxa.

2.11 Literature Cited

For references to this section, go to the Literature Cited Section.