RECLAMATION
Managing Water in the West

Yankee Fork Tributary Assessment
Upper Salmon Subbasin

Custer County, Idaho

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office, Boise, Idaho

January 2012

U.S. DEPARTMENT OF THE INTERIOR

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Cover Photo: View to the southwest looking downstream along the Yankee Fork near river mile 13.8 – Bureau of Reclamation.

Date: September 2, 2010 Photo by: David Walsh

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Acronyms and Abbreviations

BiOp	Biological Opinion
BY	brood year
cfs	cubic feet per second
DPS	Distinct Population Segments
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
ft/s	feet per second
GIS	geographic information system
HUC	hydrologic unit code
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
LIDAR	light detection and ranging
mi^2	square miles
mi/mi^2	miles per square miles
MIS	management indicator species
NOAA Fisheries Service	NOAA's National Marine Fisheries Service
NRCS	Natural Resources Conservation Service
Reclamation	Bureau of Reclamation
RM	river mile
RPA	Reasonable and Prudent Alternative
SNOTEL	Snowpack Telemetry
TA	tributary assessment
TMDL	total maximum daily load
Tribes	Shoshone Bannock Tribes

USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
West Fork	West Fork of the Yankee Fork
Yankee Fork	Yankee Fork of the Salmon River

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Executive Summary

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration contribute to the implementation of salmonid habitat improvement projects in the upper Salmon subbasin to help meet commitments contained in the *2010 Supplemental Federal Columbia River Power System* (FCRPS) *Biological Opinion* (BiOp) (NOAA Fisheries 2010). The BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect listed salmon and steelhead across their life cycles. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation provides technical assistance to states, tribes, federal agencies, and other local partners for identification, design, and construction of stream habitat improvement projects that primarily address streamflow, access, entrainment, and channel complexity limiting factors. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments. This Tributary Assessment (TA) provides scientific information for the Yankee Fork of the Salmon River (Yankee Fork) watershed that can be used to address key limiting factors to protect and improve survival of salmon and steelhead listed under the Endangered Species Act (ESA).

The purpose of this Yankee Fork TA is to provide information that describes (1) the large scale physical processes occurring within the watershed; (2) the basis for delineation of geomorphic reaches within the assessment area; and (3) identifies geomorphic reaches that have the greatest potential for improving physical and ecologic processes, reconnecting isolated habitats, and improving habitat quantity and quality. Subsequent reach-scale and project-scale assessments will need to collect and analyze additional data at an appropriate scale, but these efforts can focus on those valley segments and geomorphic reaches most suitable for and with the greatest potential for habitat improvement.

The Yankee Fork is located in Custer County, Idaho, and is one of the major tributaries to the Salmon River. The Yankee Fork drainage area covers about 122,000 acres and the river flows south about 28 miles from its headwaters in the Salmon-Challis National Forest to the Salmon River near river mile (RM) 368 near Sunbeam, Idaho.

Fish species of interest in the Yankee Fork are as follows:

- Spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) listed as endangered by NOAA's National Marine Fisheries Service (NOAA Fisheries Service) on April 22, 1992 (57 FR 57051) and their threatened status was reaffirmed on June 28, 2005 (70 FR 37160).

- Summer steelhead (*Oncorhynchus mykiss*) listed as threatened on August 18, 1997 (62 FR 43937) and their threatened status was reaffirmed on January 5, 2006 (71 FR 834).

- Bull trout (*Salvelinus confluentus*) listed as threatened on June 10, 1998 (63 FR 31647).

- Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) considered a sensitive species by the U.S. Forest Service (USFS), Region 4. The Yankee Fork has been identified as a "key" watershed for this species (USFWS 1999).

- Pacific lamprey (*Entosphenus tridentatus*) state-listed endangered species in Idaho, designated as a tribal trust species, and a species of "special" concern for the U.S. Fish and Wildlife Service (USFWS) (USFWS 2010).

A limiting factor is a "condition that limits the ability of habitat to fully sustain populations of salmon" (State of Washington 1998 Engrossed Substitute House Bill 77RCW). Limiting factors that were identified in the *Draft Salmon Subbasin Assessment* (NWPC 2004) for the Yankee Fork watershed generally included habitat fragmentation and connectivity, habitat quantity and quality, and water quality. Habitat fragmentation and connectivity, and habitat quantity and quality are the primary limiting factors (Table 1) within the Yankee Fork watershed affecting the abundance, productivity, spatial structure, and genetic diversity of the fish species of concern.

Currently, water quality does not negatively impact the fish species of concern (IDEQ 2003; SBT 2011; Appendix B). Habitat fragmentation, tributary connectivity, and reduced riparian zone structure are factors that lead to reduced carbon inputs to the stream that in turn leads to reduced nutrients available to sustain healthy trophic levels. The reduced nutrients lead to a reduction in primary and secondary production in a system. With lower primary production, there is less food available for the lower trophic levels such as macroinvertebrates, which in turn leads to less food for rearing salmon. Past and ongoing mining activities have impacted the system a great deal. However, these impacts have been most prominent in habitat disturbance and connectivity. Sediment surveys have shown that while there are areas of concern, generally there is a low risk associated from chemical contamination.

Table 1. Summary table of Yankee Fork watershed limiting factors and casual factors.

Limiting Factors	Causal Factors
Habitat fragmentation and connectivity	The relocated channel through the dredge tailings has resulted in a simplified channel configuration that confines flows within the channel and between dredge tailings with little or no channel/floodplain interactions. Historic floodplain areas along the Yankee Fork between Jordan Creek and the West Fork of the Yankee Fork (West Fork) have been disconnected by dredge tailings. These floodplain areas provided important high-water refugia and rearing habitat for juveniles during biologically significant flows. Dredge tailings have disconnected (isolated) Silver Creek and Jerrys Creek from the Yankee Fork. There are some culvert crossings that have been identified by USFS as potential fish passage barriers between tributaries and the Yankee Fork on public lands. Other crossings on private lands have not been evaluated for fish passage barriers and are considered a data gap.
Habitat quantity and quality	Placer mining (i.e., dredging) has altered the fluvial processes that create and maintain complex habitat units. The mining activities have resulted in the removal of riparian vegetation and relocation of the channel through dredge tailings. The most significant impact areas are between Jordan Creek and the West Fork along the Yankee Fork; and to a lesser degree, the dredge tailings from the West Fork to Pole Flat Campground along the Yankee Fork, and some locations along Jordan Creek.

Valley segments and geomorphic reaches were delineated along the Yankee Fork in the middle and lower Yankee Fork subwatersheds; and along lower Jordan Creek in the Jordan Creek subwatershed. The geomorphic reaches were coincident with the valley segments and are located as follows:

- In the middle Yankee Fork subwatershed, three geomorphic reaches were identified (upstream to downstream): (1) Reach YF-6 from RM 16.5 to 13.3; (2) Reach YF-5 from RM 13.3 to 11.7; and (3) Reach YF-4 from RM 11.7 to 9.1.

- In the lower Yankee Fork subwatershed, three geomorphic reaches were identified: (1) Reach YF-3 from RM 9.1 to 6.8; (2) Reach YF-2 from RM 6.8 to 3; and (3) Reach YF-1 from RM 3 to the Yankee Fork/Salmon River confluence.

- Two geomorphic reaches were identified in the Jordan Creek subwatershed: (1) Reach JC-2 from RM 4 to 1.4; and (2) Reach JC-1 from RM 1.4 to the Yankee Fork/Jordan Creek confluence.

The following are summaries of each geomorphic reach:

- **Yankee Fork Reach YF-6**: Chinook salmon and steelhead use this reach for migration, spawning, and rearing. The river is unconfined and has a predominantly straight, free-formed alluvial channel and good channel/floodplain interactions. Physical and ecological processes have been negatively impacted primarily from past timber harvests in the late 1800s and early 1900s along the valley bottoms and margins. The riverine system is on a recovering trend as the vegetation progresses through varying successional stages. Other anthropogenic impacts do not significantly affect physical or ecological processes that contribute to habitat quantity and quality at the reach-scale. Essentially, the reach-scale processes that control channel morphology and habitat structure are within the range of variability that should be expected for this system.

- **Yankee Fork Reach YF-5**: Chinook salmon, steelhead, and other fish species use this reach primarily as a migratory corridor. The river is confined within a V-shaped canyon and the predominant channel type is bedrock with a straight channel planform. There are no anthropogenic impacts that negatively affect reach-scale processes, and the channel morphology and habitat structure are within the expected range of variability for a bedrock channel.

- **Yankee Fork Reach YF-4**: Chinook salmon and steelhead use this reach for migration, spawning, and juvenile rearing. The river is moderately confined with a predominantly straight, free-formed alluvial channel. Channel/floodplain interactions are occurring in the lower section from RM 10.3 to 9.1. Past timber harvests, mining, and development have changed the species assemblage and successional stages from pre-European settlement time in this reach (Overton et al. 1999). Reach-scale processes are strongly influenced by the type of vegetation and successional stage which influences channel morphology and habitat arrangement. There are also localized anthropogenic impacts that affect physical processes and habitat quantity and quality that include: (1) small floodplain areas disconnected by a levee and deflection berm, and (2) a bridge crossing near RM 10.9 (General's Bridge) that constricts the channel. However, the overall impact of these features on reach-scale channel processes and floodplain connectivity are minimal.

- **Yankee Fork Reach YF-3**: Chinook salmon use this reach for migration, spawning, and juvenile rearing, and steelhead use it for migration and juvenile rearing. The river is presently confined by dredge tailings and has a predominantly straight, free-formed alluvial channel. Prior to dredging, much of this reach was unconfined and maintained a straight channel pattern with some meandering channel segments and connected channel/floodplain interactions. The dredging operations involved rerouting the Yankee Fork and disconnecting it from its floodplain; and on the West Fork the lower channel segment was rerouted and artificially constrained by dredge piles. Historically, the Yankee Fork and West Fork confluence area had a broad floodplain in which the two unconfined channels dynamically interacted. The channels migrated across their floodplains which progressively changed where and how the channels converged. These dynamic interactions resulted in varying hydraulic conditions that created and maintained a mosaic of habitat patches. Presently, the new channel configurations and location of channel convergence are now static and the hydraulic conditions no longer create the mosaic of habitat patches.

- **Yankee Fork Reach YF-2**: Chinook salmon and steelhead use this reach for migration, spawning, and juvenile rearing. Presently, the river is predominantly confined by dredge tailings and maintains a straight, free-formed alluvial channel that has a plane-bed and cobble is the dominant substrate. Prior to dredging, this reach was moderately confined by higher surfaces (comprised primarily of glacial outwash), alluvial fans and bedrock, and maintained a straight, free-formed alluvial channel similar to the present channel. The difference between the pre-dredge channel and the present channel is the degree of channel confinement. By increasing channel confinement between dredge piles, the geometry of the cross sectional area of the channel and floodplain has a narrower width which must convey the same peak flows, resulting in increases to water depth, flow velocity, and sediment transport capacity.

  Other significant anthropogenic impacts include: (1) tailing piles disconnecting Jerrys Creek and Silver Creek (perennial tributaries) from the Yankee Fork that most likely provided juvenile rearing habitat for both Chinook salmon and steelhead in the low gradient sections along the valley floor, and steelhead rearing and spawning habitat in the higher gradient sections along the valley wall (Bureau of Fisheries Stream Survey in 1934 that reported many fingerlings observed in the lower quarter mile section of Silver Creek); (2) removal of vegetation and reworking of topsoil within the dredged area leaving behind tailing piles of mixed unconsolidated alluvium with the coarse fraction remaining at the surface; (3) lateral channel migration into the tailing piles has been occurring at a very slow rate and is restricted because the tailings tend to be “self-armoring” as finer materials (i.e., sand and gravel) are eroded and transported downstream leaving behind coarser materials (i.e., cobbles and boulders) along the toe; and (4) the lower section of Ramey Creek has been channelized and peak flows are confined to within the channel and not dissipated across its alluvial fan resulting in increased water depth, flow velocity, and sediment transport capacity.

- **Yankee Fork Reach YF-1**: Chinook salmon, steelhead, and other species use this reach primarily as a migratory corridor. The river flows through a V-shaped canyon and the channel is confined by bedrock and talus. The river has a bedrock channel type with predominantly a step-pool bedform and high sediment transport capacity. There are some anthropogenic impacts from road embankments encroaching on the channel and floodplain, and a bridge crossing that constricts the channel. However, these anthropogenic disturbances do not significantly impact physical processes or habitat quantity and quality at the reach scale.

- **Jordan Creek Reach JC-2**: Steelhead use this reach for spawning and juvenile rearing, and there is some Chinook salmon juvenile rearing habitat. The creek flows through a moderately confined valley segment that is constrained by bedrock with colluvial, glacial, alluvial fan, and landslide deposits. The channel type is predominantly a bedrock channel with alternating plane-bed and pool-riffle bedforms and has a straight channel pattern. Channel slope is about 2.9 percent with a cobble-dominated substrate with boulders and bedrock common. Anthropogenic features that constrict the valley bottom are primarily the Loon Creek Road embankment, mine tailings, and spoil piles. There are three bridge crossings that constrict the channel near RM 3.6, 3.2, and 2.1. However, none of these anthropogenic features have a significant impact on reach-scale channel processes. Essentially, the bedform and in-stream structure and resulting habitat is within the range of variability that should be expected for the channel type and physical characteristics for this reach.

- **Jordan Creek Reach JC-1**: Chinook salmon and steelhead use this reach primarily for juvenile rearing. The creek flows through a V-shaped alluvial valley that moderately confines the channel. Channel type is predominantly a plane-bed, free-formed alluvial channel that has a straight channel pattern indicating a low rate of lateral channel migration. Past dredging and hydraulic mining operations have resulted in the relocation of Jordan Creek. Other anthropogenic impacts include: (1) removal of vegetation along the valley bottom from mining operations and construction of the Loon Creek Road; (2) two bridge crossings that do not significantly impact channel processes because they were built in locations where the channel was already constricted by dredge tailings near RM 0.9 and RM 0.1; (3) a wetland mitigation project that included the removal and/or modification of mine tailings to improve channel/floodplain interactions was completed in 1993 between RM 0.4 and the Custer Motorway Bridge; and (4) channelizing the creek through mine tailings between about RM 0.1 to the Yankee Fork/Jordan Creek confluence.

The following are the geomorphic reaches in order of their potential to improve physical processes and habitat quantity and quality, along with their needs for further assessment:

1. **Yankee Fork Reach YF-3**: The physical and ecological processes have been significantly impacted by dredging operations in this reach. Dredge piles artificially constrain the Yankee Fork and West Fork channels, disconnect relatively large floodplain areas from the Yankee Fork, and have changed the convergence between the Yankee Fork and West Fork from a dynamic interaction that created a mosaic of habitat patches to a static condition that no longer

provides the complex habitat types. A more detailed reach assessment, potentially involving a more complex hydraulic model, is needed to evaluate current physical and ecologic processes, and to evaluate the overall potential to improve these processes and their benefit and risks to the resource.

2. **Yankee Fork Reach YF-2**: The Shoshone Bannock Tribes (Tribes) have worked with consultants and stakeholders on implementing habitat projects in this reach. Alternatives should continue to be pursued to reconnect isolated tributaries and improve channel/floodplain interactions. In addition, the four dredge pond series have the potential to provide replacement of juvenile rearing habitat that was lost when dredging obliterated the lower sections of some tributaries. If flows were increased into these pond series, it would also reduce peak flows in the mainstem Yankee Fork, resulting in a reduction in sediment transport capacity and lower flow velocities, which would improve spawning gravel retention and juvenile fish movement. All relevant environmental parameters, such as those used in NOAA Fisheries (1996) *Matrix of Pathways and Indicators* or U.S. Fish and Wildlife Service’s (1998) *Matrix of Diagnostics/Pathways and Indicators*, should be measured prior to implementation of any rehabilitation project to characterize the current environmental conditions. This information provides an environmental “baseline” that can be used to predict the effects of rehabilitation actions, and to detect changes following implementation of the actions (i.e., effectiveness monitoring).

3. **Jordan Creek Reach JC-1**: A reach assessment is not necessary to address the localized anthropogenic impacts in this reach. Modifications to localized channel constrictions (i.e., mine tailing and road embankments) could be pursued on a case-by-case basis dependent on landowner cooperation. Replanting riparian vegetation (i.e., 30-foot buffer zone) to improve channel boundary roughness and ecologic connectivity could also be considered. It is unlikely these actions would result in a reach-scale improvement that would significantly increase juvenile rearing habitat. Essentially, the in-stream bedforms and structure and resulting habitat are within the range of variability that should be expected for the channel type and physical characteristics. Also, it is unlikely that project implementation is feasible where placer mining activities continue (or are anticipated in the near future). All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

4. **Yankee Fork Reach YF-4**: Physical and ecological processes are negatively impacted primarily from past timber harvests along the valley bottoms and margins. The riverine system appears to be on a recovering trend as vegetation progresses through varying successional stages, albeit at a slower rate due to continued recreational and private landowner usage. Maintaining and actively

managing a riparian corridor (i.e., about 100-foot buffer zone) along both sides of the channel to insure proper species assemblage and improve growth rates would be an appropriate approach for long-term rehabilitation. Addressing localized constrictions along the channel (i.e., levee, deflection berm, and bridge crossings) and identifying potential locations for large wood placements could be pursued on a case-by-case basis dependent on landowner cooperation. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

5. **Yankee Fork Reach YF-6**: Physical and ecological processes have been negatively impacted primarily from past timber harvest along the valley bottoms and margins. The riverine system appears to be on a recovering trend as the vegetation progresses through varying successional stages. Active management of these stands to insure proper species assemblage and improve growth rates would be an appropriate approach for long-term rehabilitation. Potential short-term rehabilitation approaches to increase availability of wood to the system could be pursued on a case-by-case basis which includes: (1) ensuring that wood and sediment inputs from tributaries are not impeded by obstructions (i.e., undersized culverts), and (2) wood placement along the channel and floodplain if the anticipated ecologic benefits outweigh the disturbances to the channel or floodplain. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

6. **Jordan Creek Reach JC-2**: A reach assessment is not necessary to address the localized anthropogenic impacts in this reach. Specific alternatives could be pursued on a case-by-case basis to address the localized anthropogenic disturbances that constrict the channel and/or affect channel boundary roughness and ecological connectivity. Essentially, the in-stream bedforms and structure and resulting habitat are within the range of variability that should be expected for the channel type and physical characteristics. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

7. **Yankee Fork Reaches YF-5 and YF-1**: These geomorphic reaches are primarily Chinook salmon and steelhead migratory corridors. In these reaches the river flows through V-shaped canyons that have bedrock type channels with predominantly step-pool bedforms. There are no anthropogenic features that significantly impact reach-scale channel processes. Therefore, no further assessments are recommended.

1. Overview

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration contribute to the implementation of salmonid habitat improvement projects in the upper Salmon subbasin to help meet commitments contained in the *2010 Supplemental Federal Columbia River Power System* (FCRPS) *Biological Opinion* (BiOp) (NOAA Fisheries 2010). The BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect listed salmon and steelhead across their life cycles. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation provides technical assistance to states, tribes, federal agencies, and other local partners for identification, design, and construction of stream habitat improvement projects that primarily address streamflow, access, entrainment, and channel complexity limiting factors. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments. This Tributary Assessment (TA) provides scientific information for the Yankee Fork of the Salmon River (Yankee Fork) watershed that can be used to address key limiting factors to protect and improve survival of salmon and steelhead listed under the Endangered Species Act (ESA).

The TA is a first step in an approach to evaluate physical and ecological processes occurring at the tributary-scale. The intent is to focus recovery efforts toward the most appropriate spatial scales (i.e., reach or project area) that have the greatest potential to benefit ESA-listed fish species (Figure 1). Additional steps may include reach assessments to further evaluate how physical and ecological processes are affected at the reach-scale or alternatives evaluation, leading to design and construction at the project-scale. Relevant environmental parameters, such as those used in NOAA Fisheries (1996) *Matrix of Pathways and Indicators,* should be measured prior to implementation of any rehabilitation project to characterize the current environmental conditions. This information provides an environmental "baseline" that can be used to predict the effects of rehabilitation actions, and to detect changes following implementation of the actions (i.e., effectiveness monitoring).

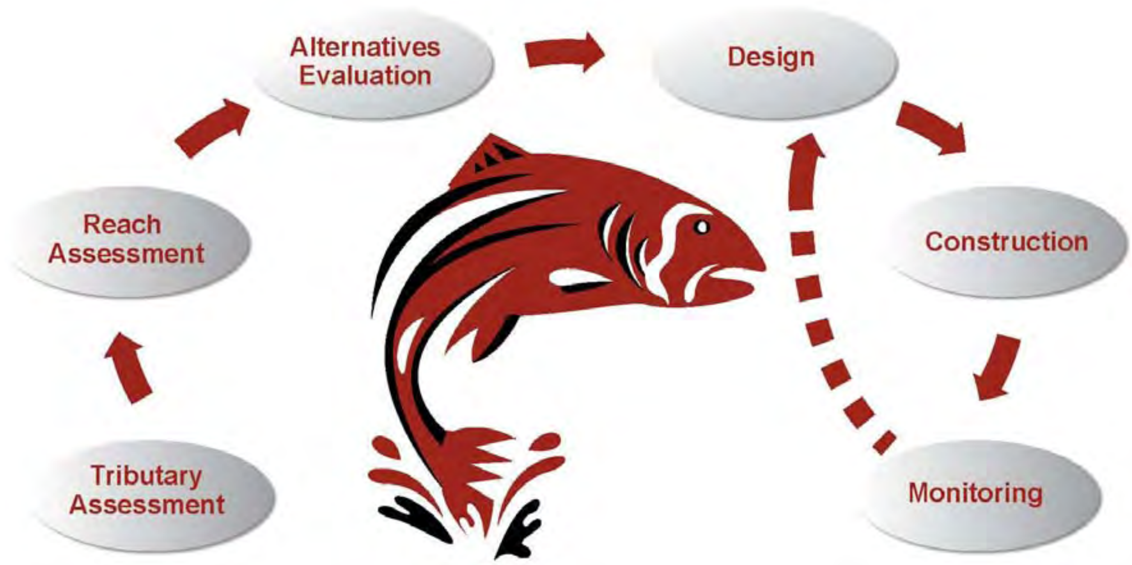

Figure 1. Flow chart illustrating an approach to assess and develop potential rehabilitation actions.

1.1 Purpose

This TA evaluates tributary-scale features and processes for the purpose of understanding how these relatively large-scale components affect physical and ecological processes, and to identify geomorphic reaches with potential for habitat improvement efforts. Subsequent reach-scale and project-scale assessments can focus on smaller-scale components that affect physical processes within valley segments and/or geomorphic reaches that are most suitable for habitat improvement and have the greatest potential to address limiting factors.

This assessment also attempts to answer specific questions that have been previously identified by the Independent Scientific Review Panel:

1. Is there enough information to evaluate and prioritize proposed actions relative to each other within the Yankee Fork watershed? An analysis of watershed conditions was completed using NOAA Fisheries' (1996) matrix of pathways and indicators to identify potential systemic problems within the watershed (Section 7: Watershed Condition). Further analysis was completed to delineate and prioritize geomorphic reaches based on the potential to improve reach-scale processes that address key limiting factors to protect and improve survival of salmon and steelhead (Section 8: Valley Segments and Geomorphic Reaches).

2. What are the existing fish habitat conditions in terms of quality, quantity, and usage? Information on historic and present fish usage was completed at the watershed-scale (Section 6: Watershed Fish Usage and Supplementation). Fish usage, habitat quality and quantity, and geomorphic processes are discussed at the geomorphic reach-scale (Section 8: Valley Segments and Geomorphic Reaches).

3. Have monitoring and evaluation plans been developed and will they be provided? Information on the supplementation and habitat enhancement programs, and monitoring efforts was completed at the watershed-scale (Section 6: Watershed Fish Usage and Supplementation). Evaluation of existing fish populations, specifically juvenile production, are identified as a data gap because analysis of existing fisheries data has not been completed (Section 1.3: Limitations and Data Gaps).

4. What are the impacts and effects from mercury and selenium contamination, if any? Analysis of the impacts and effects of mercury and selenium was completed at the watershed-scale (Section 7.4: Water Quality and Quantity).

Additional questions identified by the Independent Scientific Review Panel that are not addressed as part of this assessment, but should be considered at the reach- or project-scale include the following:

5. Is there enough information to describe and evaluate existing fish populations (juvenile production specifically)?

6. What are the quantitative biologic objectives of any proposed actions?

7. What are the plans for addressing land access and long-term conservation easements in areas where actions are proposed (long-term sustainability of restoration)?

8. What are the benefits and risks associated with proposed actions to fish and wildlife populations/resources?

1.2 Methodology

Work described in this report was accomplished by a multidisciplinary team with expertise in fisheries, hydrology, water quality, hydraulics, cultural resources, geology, and fluvial geomorphology.

Key steps to produce this assessment were to:

- Review existing information to identify data gaps and updates needed to provide technical information relevant to river process and habitat rehabilitation planning.

- Evaluate watershed factors that may limit the optimal biological usage (i.e., water quality).
- Summarize monitoring and evaluation plans presently being conducted in the watershed and proposed future monitoring and evaluation plans.
- Utilize geologic and geomorphic mapping, historical channel migration, and one-dimensional hydraulic modeling to evaluate the coarse-scale habitat-forming physical processes and disturbance regimes from both historical and contemporary contexts.
- Delineate and characterize geomorphic reaches on the basis of geomorphic settings, hydrology, and sediment transport function.
- Describe historic and current fish usage at the watershed-scale, and current fish usage in each geomorphic reach.
- Sequence geomorphic reaches on the basis of physical and ecological processes, and their potential to be physically modified to address the limiting factors.

Key data sets developed and/or utilized in this assessment include 2009 and 2010 LiDAR (light detection and ranging) data and aerial photography, historical aerial photography (1945, 1952, 1966, 2004, and 2010), mining claim plat map (1935), historical channel mapping (1935, 1945, 1953, 1966, 2004, and 2010), geologic mapping (USGS 1995 and Link and Janecke 1999), and watershed-scale mapping of roads, fire history, timber harvest, vegetation, and land use by the U.S. Forest Service (USFS), Salmon-Challis National Forest. In addition, detailed surficial geologic maps were developed specifically for this assessment. A summary of available geographic information system (GIS) data is contained in Appendix A; and a map atlas (*Yankee Fork Tributary Assessment Map Atlas)* was developed to accompany this TA.

1.3 Limitations and Data Gaps

This report is intended for use by interdisciplinary scientists, engineers, and planners focusing on river processes and fish habitat recovery and rehabilitation efforts. Conclusions from this TA are intended to guide future *Reach Assessments* and project development as one tool among many others. The primary use of the TA should be to guide habitat recovery actions toward valley segments and/or geomorphic reaches that have the greatest potential to improve physical and ecological processes that benefit the fish species of concern. This document should not be used exclusively as the basis for project design. Detailed reach and/or site-specific analyses should be conducted to identify the appropriate suite of actions, refine conceptual plans, and develop detailed designs for implementation.

The Independent Scientific Review Panel identified eight questions that in their view need to be answered in order to evaluate and prioritize proposed projects in the Yankee Fork subbasin (Review of the Yankee Fork Floodplain Restoration Project Implementation Plan for 2008 – 2018 [ISRP 2008]). Four of these questions are addressed in this document that pertain to (1) prioritizing geomorphic reaches; (2) documentation of existing habitat conditions; (3) monitoring and evaluation; and (4) water quality, specifically mercury and selenium effects and impacts.

The other four questions that are not addressed in this document pertain to (5) existing fish populations, specifically juvenile production; (6) quantitative biologic objectives for any proposed actions; (7) long-term land access and restoration sustainability; and (8) benefits and risks of proposed actions.

Item (5) existing fish populations, specifically juvenile production, are a data gap due to the lack of analysis of existing fisheries data. There have been over 20 years of fisheries data collected in the Yankee Fork and additional data is presently and will continue to be collected. An analysis of available data is recommended to address, at a minimum, the following: (a) condition of existing fish populations, (b) fish population trends, (c) juvenile outmigration and retention, (d) effects of fish supplementation, (e) comparison of fish populations with similar watersheds (reference watersheds), and (f) determination of in-basin and out-of-basin effects.

The other items (Items 6, 7, and 8) need to be addressed at the appropriate spatial scale. Rehabilitation actions are typically implemented at the reach- or project-scale. Baseline data, including biologic, ecologic, and physical conditions should be collected prior to any actions. Analysis of the baseline data can be used to help quantify the biological objectives and the benefits/risks associated with an action. In reference to “long-term” sustainability of a rehabilitation action, this item is project specific as it pertains to land access. Each rehabilitation action will need to be defined based on the expected project life and negotiated with individual landowners.

2. Introduction

2.1 Geographic Location

The upper Salmon subbasin is the largest in the Salmon River watershed and drains an area of about 14,000 square miles (mi^2) (NWPC 2004). The Yankee Fork is located in Custer County, Idaho, and constitutes one of the major tributaries to the Salmon River. The Yankee Fork drainage area covers about 122,000 acres and the river flows south about 28 miles from its headwaters in the Salmon-Challis National Forest to the Salmon River near river mile (RM) 368 near Sunbeam, Idaho (Figure 2).

2.2 Demographics

Custer County is a rural mountain county that was established in 1881 (named for the General Custer Mine). The county seat is located in Challis, which is also the center of the county's population (http://www.usa.com/Custer-county-id.htm). According to the 2010 census, the county has a population of 4,368 (http://quickfacts.census.gov/qfd/states/16/16037.html).

The Federal Government manages over 93 percent of the land base of the county. In 2005 to 2009, the leading industries in Custer County were agriculture, forestry, fishing and hunting, and mining. Among the employed sector, 52 percent were private wage and salary workers; 27 percent were Federal, State, or local government workers; and 20 percent were self-employed (http://factfinder.census.gov).

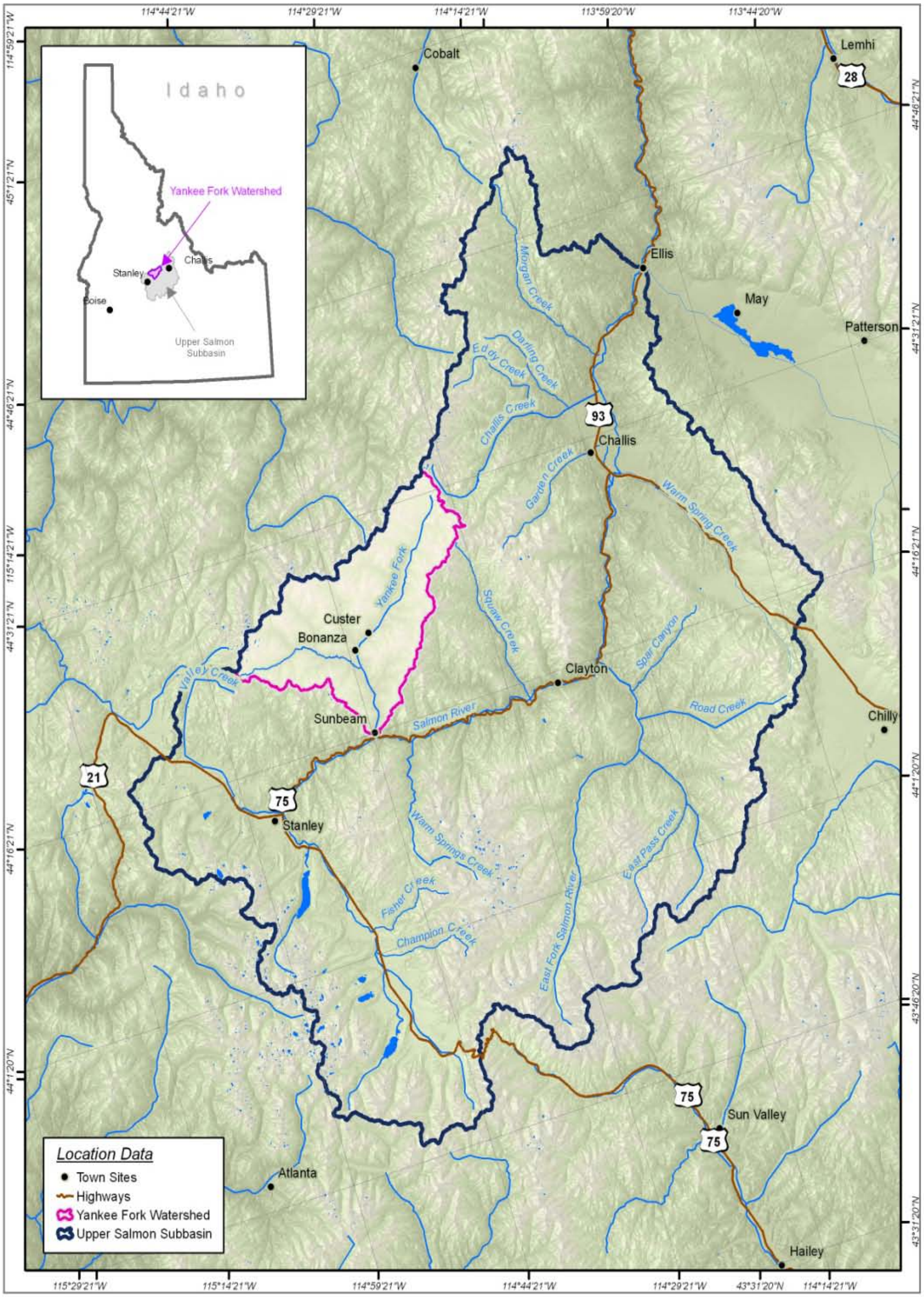

Figure 2. Yankee Fork watershed location within the upper Salmon subbasin.

2.3 Fish Species of Interest

The Yankee Fork watershed fish species of interest are spring/summer Chinook salmon (*Oncorhynchus tshawytscha*), summer steelhead (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), Westslope cutthroat trout (*Oncorhynchus clarki lewisi*), and Pacific lamprey (*Entosphenus tridentatus).*

Spring/summer Chinook salmon are part of the Snake River Evolutionary Significant Units. The Snake River spring/summer Chinook were listed as endangered by NOAA's National Marine Fisheries Service (NOAA Fisheries Service) on April 22, 1992 (57 FR 57051) and their threatened status was reaffirmed on June 28, 2005 (70 FR 37160). The Yankee Fork population is a spring run and is one of eight remaining populations in the upper Salmon River Major Population Group (ICTRT 2010). The Yankee Fork population is small and is made up of just one Major Spawning Area, which encompasses the entire Yankee Fork watershed. Snake River spring/summer Chinook salmon is a focal species for Reclamation under the BiOp, and their distribution within the Yankee Fork watershed is provided in Figure 3.

The Yankee Fork summer steelhead population is part of the Snake River basin Distinct Population Segment (DPS) (CRHRP 2009a). The Snake River basin steelhead DPS was listed as threatened on August 18, 1997 (62 FR 43937) and their threatened status was reaffirmed on January 5, 2006 (71 FR 834).

Bull trout in the Columbia River were listed as threatened on June 10, 1998 (63 FR 31647). The Columbia River population includes bull trout in the Columbia River Basin and its tributaries within the United States with the exception of those bull trout constituting a separate DPS in the Jarbidge River in Nevada. The Yankee Fork bull trout population has both resident and migratory life history patterns.

Westslope cutthroat trout are not an ESA-listed species. In 2003, the U. S. Fish and Wildlife Service (USFWS) determined that westslope cutthroat trout did not warrant listing as a threatened species under the ESA because abundant, stable, and reproducing populations remain well distributed throughout its historic range. However, it is considered a sensitive species by the USFS, Region 4, and the Yankee Fork has been identified as a "key" watershed for this species (USFWS 1999).

Pacific lamprey are not an ESA-listed species, they are a state-listed endangered species in Idaho, designated as a tribal trust species, and a species of special concern for the USFWS (USFWS 2010) and are a tribal cultural resource for subsistence, ceremonial, and medicinal purposes.

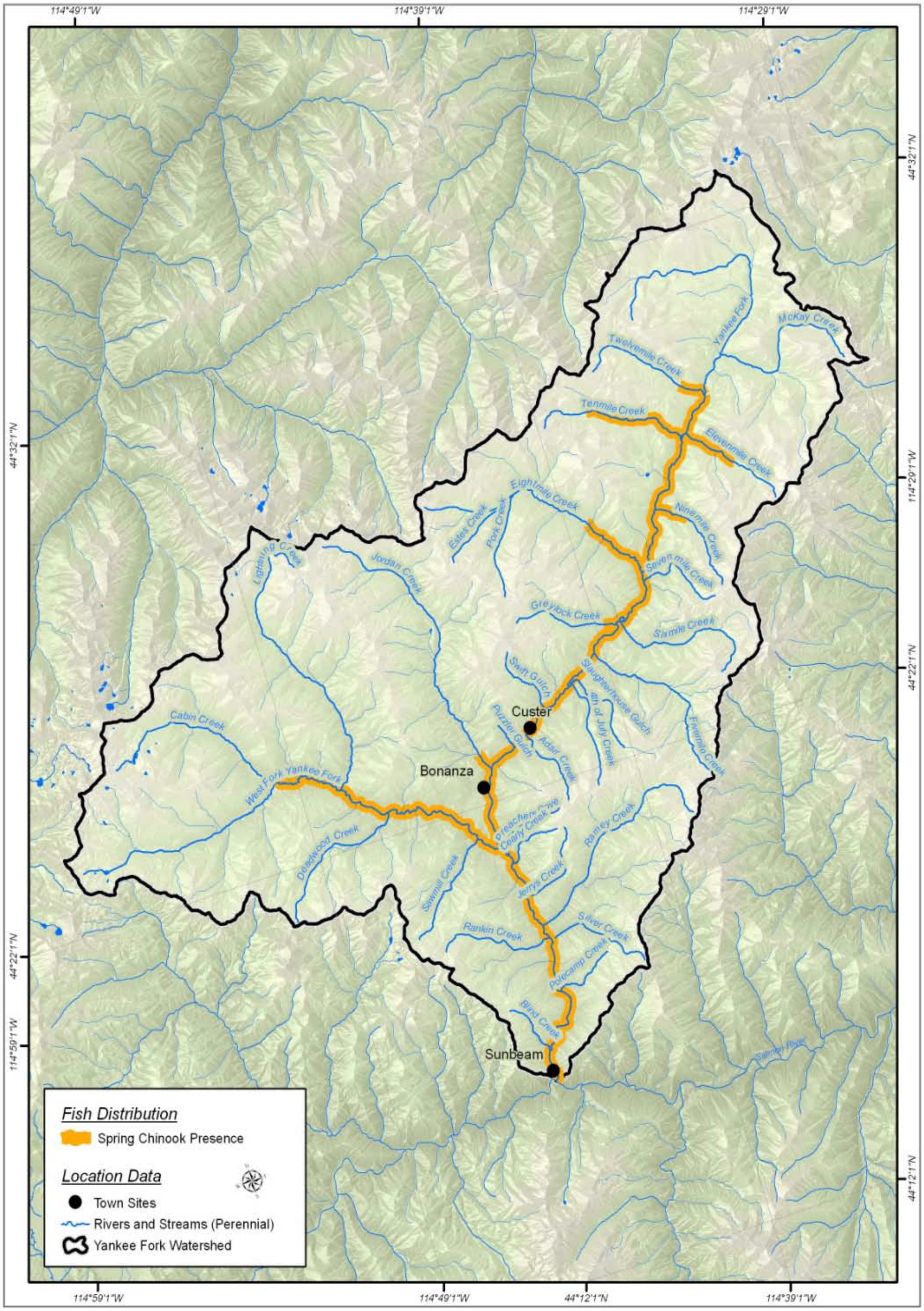

Figure 3. Snake River spring/summer Chinook salmon distribution within the Yankee Fork watershed.

2.4 Chinook Salmon and Summer Steelhead Limiting Factors

Limiting factors are the "condition that limits the ability of habitat to fully sustain populations of salmon" (State of Washington 1998 Engrossed Substitute House Bill 77RCW). Limiting factors that were identified in the *Draft Salmon Subbasin Assessment* (NWPC 2004) for the Yankee Fork watershed generally included habitat fragmentation and connectivity, habitat quantity and quality, and water quality. Habitat fragmentation and connectivity, and habitat quantity and quality are presently the primary limiting factors (Table 2) within the Yankee Fork watershed affecting the abundance, productivity, spatial structure, and genetic diversity of the fish species of concern.

Presently, water quality does not negatively impact the fish species of concern (IDEQ 2003; SBT 2011; Appendix B). Past and ongoing mining activities have impacted the system a great deal. However, these impacts have been most prominent in habitat disturbance and connectivity. Sediment surveys have shown that while there are areas of concern, generally there is a low risk associated from chemical contamination.

Table 2. Summary table of Yankee Fork watershed limiting factors and casual factors.

Limiting Factors	Causal Factors
Habitat fragmentation and connectivity	The relocated channel through the dredge tailings has resulted in a simplified channel configuration that confines flows within the channel and between dredge tailings with little channel/floodplain interactions. Historic floodplain areas along the Yankee Fork between Jordan Creek and West Fork of the Yankee Fork (West Fork) have been disconnected by dredge tailings. These floodplain areas provided important high-water refugia and rearing habitat for juveniles during biologically significant flows. Dredge tailings have disconnected (isolated) Silver Creek and Jerrys Creek from the Yankee Fork. In addition, some culvert crossings have been identified by USFS as potential fish passage barriers between tributaries and the Yankee Fork on public lands. Other crossings on private lands have not been evaluated for fish passage barriers and are considered a data gap.
Habitat quantity and quality	Placer mining (i.e., dredging) has altered the fluvial processes that create and maintain complex habitat units. The mining activities have resulted in the removal of riparian vegetation and relocation of the channel through dredge tailings. The most significant impact areas are between Jordan Creek and the West Fork along the Yankee Fork; and to a lesser degree, the dredge tailings from the West Fork to Pole Flat Campground along the Yankee Fork, and some locations along Jordan Creek.

3. Regional Characteristics

3.1 Setting

The Yankee Fork watershed is within the Northern Rocky Mountains physiographic province which is characterized by a rugged, mountainous landscape that has been dissected by fluvial and glacial erosion (Fenneman 1931). Ecoregion classifications for this area are (1) the Challis Volcanic section of the Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province (Bailey's classification), and (2) the Idaho batholith (Omernik's classification). Vegetation compositions are generally grand fir and Douglas-fir, and at higher elevations Engelmann spruce and subalpine fir occurs. Ponderosa pine, shrubs, and grasses grow in deep canyons (www.nationalatlas.gov).

3.2 Geology

Dominant geologic deposits found in Central Idaho (which are discussed in more detail in Appendix C) include Quaternary alluvium, Tertiary volcanic and plutonic rocks, Cretaceous intrusive rocks, and Paleozoic and Precambrian sedimentary and metamorphic rocks (Figure 4). The plutonic and intrusive rocks are generally medium- to coarse-grained granitic rocks of intermediate composition. Volcanic rocks range from lava flows (fine-grained basalt) to ash-flow tuffs (unsorted, consolidated pyroclastic rocks) to volcaniclastic deposits (unsorted, poorly consolidated to unconsolidated mixes of volcanic and other rock fragments). Sedimentary rocks are generally of marine origin and include carbonate and clastic rocks that are fine- to medium-grained limestones, dolomites, and sandstones. Finally, the metasedimentary rocks are generally fine grained quartz and shale that have undergone metamorphism during multiple episodes of folding, faulting, and intrusion (USGS 1995; Link and Janecke 1999).

Many, if not all, of these geologic formations have been displaced by the northeast trending Trans-Challis fault system that cuts across Central Idaho. This fault zone essentially imparted a controlling effect on the location of volcanic vents, dikes, faults, and mineralization during the Tertiary age Challis Volcanics episode (McIntyre et al. 1982; Kiilsgaard et al. 1986; Janecke 1992). Volcanic landforms created during the Challis Volcanics episode have strongly influenced the locations and drainage patterns of waterways by filling-in canyons with volcanic deposits and from subsidence as magma chambers were vacated during volcanic eruptions.

Alpine glaciations have sculpted the mountainous regions of Central Idaho. Known glaciations include the Potholes glaciation about 20 ka (one ka = one thousand years ago), Copper basin glaciation about 40 ka, and Pioneer glaciation greater than 140 ka (Borgert, Lundeen, and Thackray 1999; Evenson, et al. 1982). Erosion by the alpine glaciers created features like horseshoe-shaped, steep-walled hollows (cirques) high on the side of mountains, and long U-shaped valleys (troughs). Some constructional landforms deposited by the glaciers include crescent-shaped ridges (moraines), terraces along valley walls, and outwash plains on the valley floors. Glacial erosion and deposition can strongly influence drainage patterns at the watershed-scale and imparts controls on valley bottom widths and channel confinement at the valley segment-scale.

Known active faults in the region are presently associated with Basin-and-Range type normal faults that trend north-northwest to northwest. This area of active faults were grouped together as the Central Idaho Seismic Zone that has relatively high earthquake activity along at least six major faults (Madison, Centennial, Beaverhead, Lemhi, Lost River, and Sawtooth faults). Some earthquakes in this seismic zone have produced strong ground motions (or shaking) that have historically triggered landslides and debris flows (IBHS 2009). In the Yankee Fork watershed for example, an ancient landslide once dammed the Yankee Fork downstream of Fivemile Creek in a manner similar to the Hebgen Lake landslide that dammed the Madison River in Montana, but on a smaller scale (USFS Five Mile Geological Area marker). The Hebgen Lake landslide was triggered by an earthquake that generated strong ground motions in 1959 (IBHS 2009).

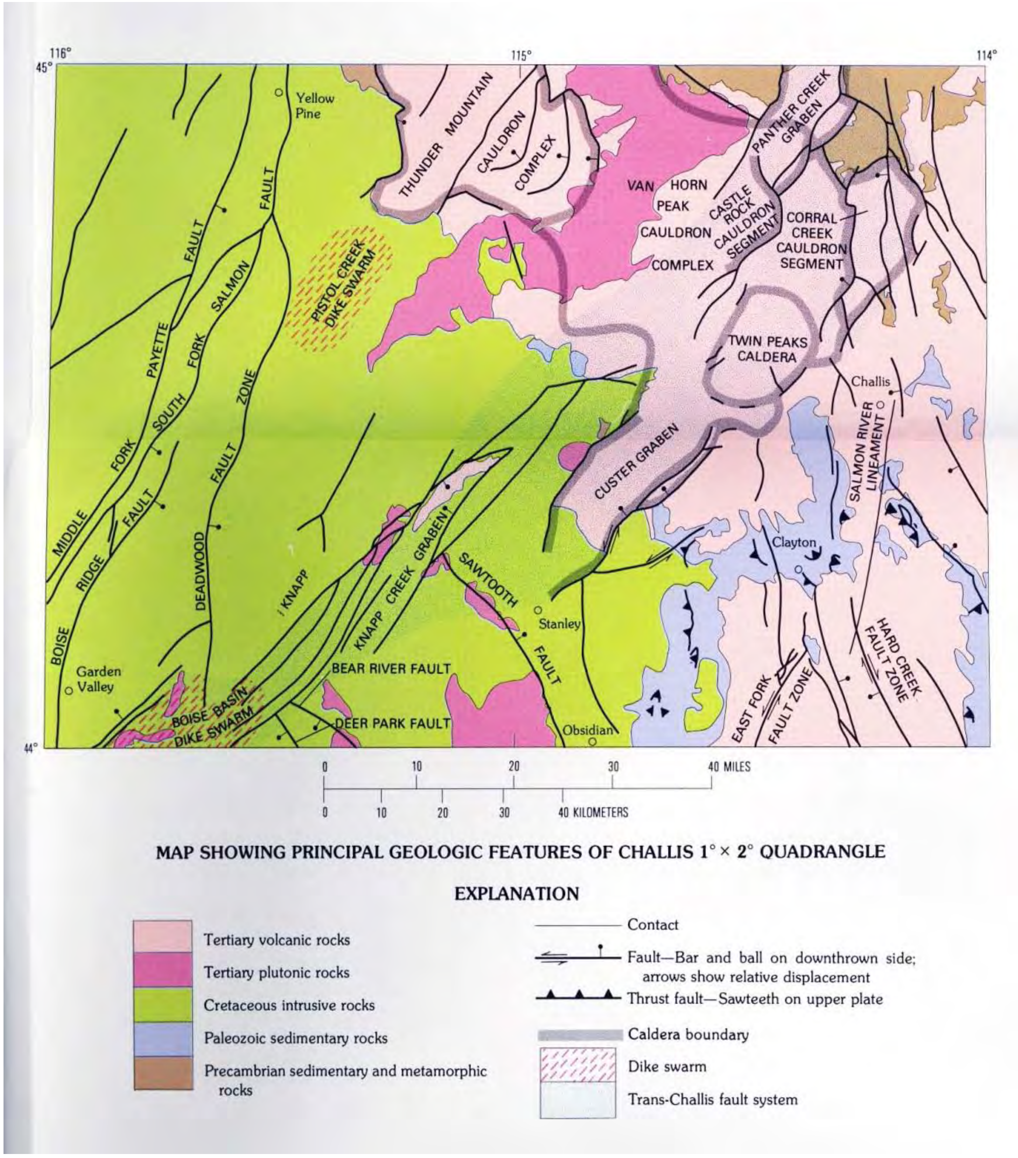

Figure 4. Bedrock and structural geology in the Challis 1° X 2° Quadrangle (USGS 1995).

3.3 Climate

Emmett (1975) described the climate of the upper Salmon River as being influenced by pacific maritime air borne eastward on the prevailing westerly winds. In the winter months, the Aleutian low dominates the weather and produces cloudiness and abundant precipitation. During the summer months, the Pacific high dominates with fair weather, except when moisture-laden air from the Gulf of Mexico is brought in from the south at high levels to produce thunderstorms.

Precipitation is generally enhanced by terrain-enforced uplift of the moist airmasses. Resulting average annual precipitation locally exceeds 60 inches but decreases to 15 inches in “rain shadow” canyon bottoms. Weather is characterized by long, harsh winters and short, cool, dry summers. The majority of precipitation is in the form of snow between the middle of October to the middle of May. Precipitation events during the winter can have a long duration, continuing for more than 24 hours. Spring and summer thunderstorms of high intensity and short duration (less than one hour) can also occur. Temperatures range from minus 50^{o} F to 95^{o} F. Freezing temperatures may occur throughout the year.

Climate projections for the region are that average mean-annual temperature will increase and that the mean-annual precipitation will not change significantly through the 21st Century. Hydrology is expected to be affected in various ways including warmer temperatures expected to diminish snow accumulation and the availability of snowmelt to sustain runoff. Decreased snowpack volume could also result in decreased groundwater infiltration, runoff, and ultimately decrease contribution to baseflows in rivers. However, it is notable that the northern and higher elevations may experience net increases in snowpack, reflecting a general trend toward increasing total precipitation with the projected warming (Reclamation 2011).

4. Cultural Resources and History

4.1 Cultural Resources

The Cultural Resources Inventory Report (Appendix D) documents the range of human use within the Yankee Fork watershed. In practice, cultural resources are categorized into (1) prehistoric resources that represent Native American cultures and societies; (2) historic resources that are sites or properties at least 50 years old; and (3) ethnographic resources that are important to contemporary communities.

4.1.1 Prehistoric Overview

Archaeological evidence indicates humans were present in southern Idaho at the end of the Pleistocene at least 12,500 years ago. These big-game hunters travelled from place to place following their prey and taking advantage of other food and material resources when they were available. The climate changed gradually as the Ice Age ended, giving way to more mild and temperate conditions. As the environment shifted, so did the resources. Some animals moved out of the Salmon River Mountains area in an attempt to stay with cooler temperatures, while other plants and animals better adapted to warmer conditions moved in. People also adapted to the changing environment to survive, and their technologies eventually advanced as well. Hunting implements moved from atlatl (spear-thrower) and dart to bow and arrow as the size and speed of the prey changed from larger to smaller. People also began to focus more on plants and fish for food. These activities and the lifestyles they were associated with are found now as archaeological remains.

4.1.2 Historic Overview

The Lewis and Clark Corps of Discovery passed through central Idaho in 1805 after crossing the continental divide from the east. It was likely the first contact with Euro-Americans for the local Shoshoni, though impacts of Spanish explorations to the south had already changed their lifestyle with the addition of the horse, which was in wide use. Reports from Lewis and Clark on the abundance of fur-bearing animals west of the divide spurred the business of fur trade, and independent fur trappers, as well as several companies (including the Hudson Bay Company and The American Fur Company), made their way into the northwest to explore and exploit the region. In 1822, fur trappers and the Hudson Bay Company began to move into the Salmon River Mountain region, where certain animal populations began a rapid decline due to over-hunting. The discovery of gold in California in 1848 began a western mining craze, leading to an influx of prospectors into Idaho and the discovery of gold there. The increased mining activities along the Yankee Fork necessitated the development of towns and the area's population grew, bringing both the perks and trials of "civilization." A small Chinese contingent made Custer their home. The Yankee Fork area today is largely defined by its mining history and its gold dredge, though other historic influences (i.e., Civilian Conservation Corps and USFS) helped shape the character of this place.

4.1.3 Ethnographic Overview

A number of different aboriginal groups have occupied the Salmon River country. Located at the convergence of two different cultural regions—the Plateau and Great Basin—occupants of this area were influenced by both ways of life and could draw from each the things that most enhanced their own way of living. The group that would later be identified at contact as the Sahaptin-speaking Nez Perce occupied parts of the lower Salmon River and into the lower Snake River basin. Another culture, identified over eight thousand years of continued occupation of the upper parts of the Salmon River, would become known as the Numic-speaking Northern Shoshoni (the local tribe was known as the *Túkudeka*, or *Sheepeaters*). By the contact period, a Northern Paiute tribe known as the Bannock had also taken up residence in the upper Snake River and Salmon River areas. These Shoshone and Bannock bands interacted regularly, and despite speaking different languages, generally lived similarly. All of these tribes contribute to the story of the Yankee Fork area, both in the past and in the present. Contemporary use by Shoshone Bannock Tribal members of the waters and lands within the Yankee Fork drainage include hunting for elk, deer, moose, bighorn sheep, salmon and other fishing, subsistence, camping, and collection of plants for medicinal purposes. The Yankee Fork area also contributes to the continuing practice of ceremonial activities, the sharing of legends, use of traditional place names, and the opportunity to teach younger generations of Tribal members the Tribal history.

4.2 Historical Chronology

The Yankee Fork Historical Timeline (Appendix E) presents a historical timeline of the Yankee Fork watershed categorized as follows: (1) human settlement; (2) roads and transportation; (3) mining; (4) dams and water utilization; (5) timber harvest; (6) livestock and grazing; (7) fire, flood, and landslide occurrences; and (8) fisheries observations. Information for this timeline was extracted from a wide variety of sources. Summaries for some “points-of-interest” in the Yankee Fork watershed are included in the following sections. These summaries were generated using the timeline data in Appendix E and some additional information was added for further clarification.

4.2.1 Gold Discovered in the Yankee Fork

Gold was discovered in the Salmon River drainage in 1861 which spurred a “gold rush” into the region involving upwards of 10,000 miners (Stephens 1991). Joel Richardson led a party of men down the Salmon River to collect samples and identify potential prospects in 1866 or 1867. They stopped at a large tributary entering the Salmon River to wash some gravel, but did not find any gold and they moved on, naming the river the Yankee Fork (Choate 1962; NWAA 2002; and LOYF Historical Association 2005).

In the 1870s, several placer gold deposits were found along Jordan Creek down to the Yankee Fork confluence. Dudley Varney and Sylvester Jordan staked an “exceptional” claim at the mouth of Jordan Creek which they worked for a couple of years before selling the claim to John Morrison (NWAA 2002). The Jordan Creek placers have been intermittently worked since their discovery, and some placer deposits are still being actively worked.

4.2.2 Charles Dickens Mine and Bonanza City

In 1875, the first significant gold bearing quartz vein was found by William Norton in the Jordan Creek drainage. Mr. Norton operated the mine, known as the Charles Dickens Mine, from 1875 until he passed away in 1884. The mine was purchased in 1886 by a British interest and was operated until 1892 (LOYF Historical Association 2005; ISHS 1993). In 1877, Charles Franklin established Bonanza City, the first of the two Yankee Fork towns, to serve as the economic and social center in support of the Charles Dickens Mine and other mining operations in the district. By 1881, the population of Bonanza City peaked at about 600 and after the large mines in the area closed in 1911, Bonanza City became a ghost town (http://www.stanleyidaho.com/custer.htm).

4.2.3 General Custer Mine/Mill and Custer City

In 1876, James Baxter, Elden Dodge, and Morgan McKim located one of the richest lodes, known as the General Custer Mine, on Custer Mountain along the Yankee Fork (NWAA 2002). To support the General Custer Mine operations, Sammy Holman founded

Custer City in 1879. In 1881, the Custer Mining Company completed the General Custer Mill (Figure 5) and began operations to process ore from the General Custer Mine. The mill was located a short distance from Custer City and had the capacity to process 900 tons of ore per month. To fuel the steam engines that powered the mill required over 300 cords of wood per month (http://www.fs.fed.us/r4/sc/yankeefork/pointsofinterest.shtml; LOYF Historical Association 2005).

The mill operated until 1888 when it was closed down due to increases in operating costs (LOYF Historical Association 2005). It was then sold to Dickens-Custer Company in 1888 that intended to use the mill to process ore extracted from the Charles Dickens Mine. The Dickens-Custer Company reportedly operated the Charles Dickens Mine and General Custer Mill until 1892 when operations of the company closed due to the lack of production and financial mismanagement (ISHS 1993).

The General Custer Mill was then purchased by the Lucky Boy Gold Mining Company in 1895 and began processing gold ore from the Lucky Boy Mine in the Adair Creek drainage. The company operated the mill until 1904 when the mill was closed for the last time (LOYF Historical Association 2005). By that point in time, the hills for miles around Custer were denuded of trees because of the huge quantities of wood that had been used for homebuilding, mine supports, and fuel for the mills (LOYF Historical Association 2005).

Figure 5. General Custer Mill 1937 (http://www.fs.fed.us/r4/sc/yankeefork/generalcustermill_l.shtml).

4.2.4 Yankee Fork Gold Dredge

In 1932, the Yankee Fork Placer Mining Company acquired a collection of placer claims covering over five miles of the Yankee Fork. Drill testing to determine mineral values was completed in 1939 by the Silas Mason Company (Packard 1983). In 1940, the Silas Mason Company was renamed the Snake River Mining Company and completed the construction of the Yankee Fork dredge (Figure 6). The dredge began operations in 1940 along the Yankee Fork, but was halted in 1942 by the War Production Board Act, Order #L208. The dredge resumed operations in 1946 after about a four year hiatus (Packard 1983).

In 1947, the Snake River Mining Company stopped the dredging operations and decided to sell the dredge. The Warren Dredging Company purchased the dredge and mining claims from the Snake River Mining Company in 1949 (LOYF Master Plan 2009). Warren Dredging Company began dredging operations in 1950 from about the mouth of the West Fork (Packard 1983). A bedrock ledge about a ¼-mile below Bonanza temporarily halted the dredging and an earthen dam was built in 1950 or 1951 to back-up water to float the dredge over the outcrop (Stephens 1991). Dredging resumed and the dredge arrived at the mouth of Jordan Creek in 1951 or 1952, the limits of all the ground owned by the Simplot Company (Packard 1983). The dredge ceased operation in 1952, coming to rest on the Morrison Claims which was not owned by Simplot Company. The dredge was moved in 1953 from the Morrison Claims to Simplot's property, and eventually the dredge was donated to the USFS in 1966 (http://www.stanleyidaho.com/custer.htm).

Figure 6. Yankee Fork Gold Dredge (http://www.fs.fed.us/r4/sc/yankeefork/pointsofinterest.shtml#dredge).

4.2.5 Golden Sunbeam Group and Sunbeam Hydroelectric Dam

In 1903, the Golden Sunbeam Mining Company formed on Jordan Creek (LOYF Historical Association 2005). From 1906 through 1909, the company extensively developed the Golden Sunbeam group of mining claims, located about four miles up Jordan Creek. A mill was constructed on site, and plans were developed for construction of a hydroelectric dam and corresponding electrical transmission lines to the mining area (Umpleby 1913). Sunbeam Hydroelectric Dam was constructed on the Salmon River above its confluence with the Yankee Fork between 1909 and 1910 (Figure 7). The Sunbeam Mill began full operation using power from the Sunbeam Dam in 1911, but the mill only operated for about two months. The entire Sunbeam enterprise, including mines, mill, and dam was abandoned in 1911 (LOYF Historical Association 2005). From 1912 to 1914, lessees processed the old tailings at the Sunbeam Mill using cyanidation process, and in 1933 old tailings from the Sunbeam dumps were treated by cyanidation (Mitchell 1997). In 1933 or 1934, a channel around the Sunbeam Dam was opened by the Idaho State Game Department, presumably to improve upstream fish passage on the Salmon River (Rodeheffer 1935).

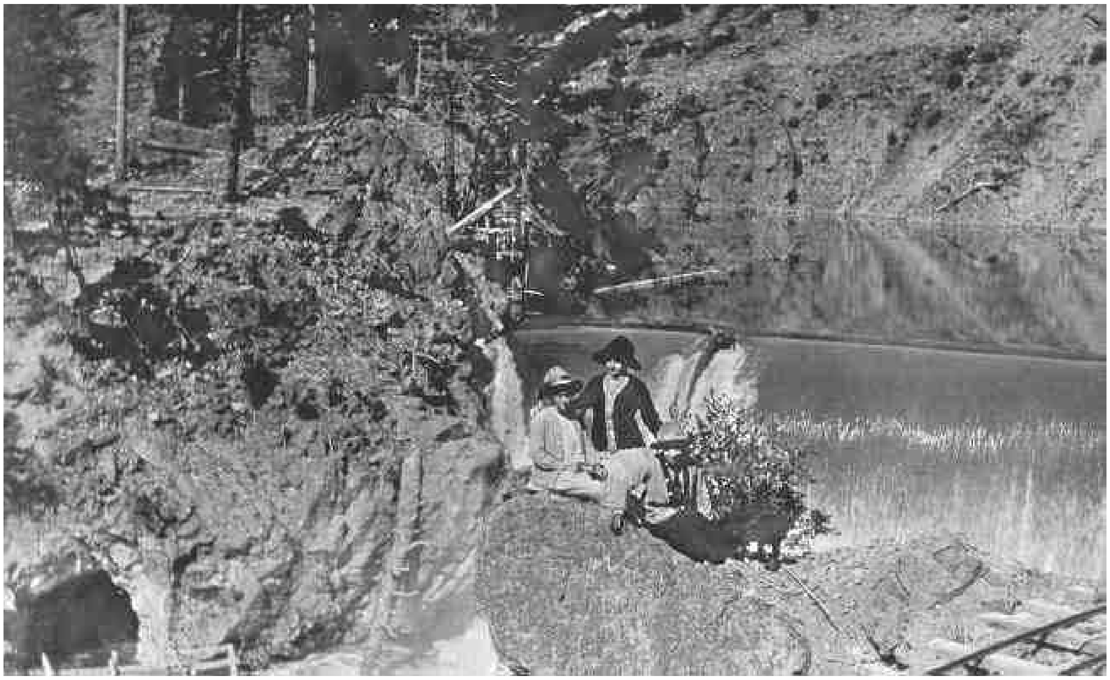

Figure 7. Sunbeam Dam on the Salmon River (http://www.fs.fed.us/r4/sc/yankeefork/sunbeam_l.shtml).

5. Watershed Characteristics

5.1 Geology

The geologic setting controls the topography, directly influences valley- and reach-scale river characteristics such as slope, confinement, soils, and bedforming materials (Montgomery and Bolton 2003), and partially governs hydraulic conductivity between the stream and wetland areas. The geology influences microclimates (i.e., orographic uplift), vegetation composition (i.e., grassland versus forests), and sediment inputs to the stream network (i.e., landslides and debris flows).

Bedrock geology of the watershed is comprised of three geologic units (1) Challis Volcanics, (2) Idaho batholith, and (3) Paleozoic and Precambrian formations (USGS 1995). Descriptions of the rock types, and their strength and durability are as follows and their locations are provided in Figure 8:

- Challis Volcanics are comprised of a range of intrusive and extrusive igneous rocks. The intrusive rocks are found mainly as dikes and plugs that are generally rocks of intermediate composition that have good rock strength and durability. Extrusive rocks are found primarily as flows and welded tuffs. The flows are generally fine-grained dacite and rhyolite that range in rock strength and durability from good to moderate.

- The Idaho batholith is comprised of intrusive igneous rocks that are generally medium- to coarse-grained granites that range in rock strength and durability from good to poor, depending on the degree to which the rock has weathered. Granitic rocks observed in the watershed had good rock strength and durability.

- Paleozoic and Precambrian rocks range from sedimentary to metasedimentary rocks. The sedimentary rocks are generally fine- to medium-grained siltstone and limestone that have poor to moderate rock strength and durability. Metasedimentary rocks are generally quartzite and shale that range in rock strength and durability from poor to good, depending on the grade of metamorphism and the degree of weathering.

The Trans-Challis fault zone cuts across the watershed trending northeast and, to varying degrees, has displaced all bedrock geologic units. The fault zone had a controlling effect on the location of volcanic features within the watershed that formed during the Challis Volcanics episode. The location and alignment of the Twin Peaks caldera (volcanic feature) and Custer Graben (fault-block feature) strongly influences the drainage pattern and location of the Yankee Fork as the stream originates within the caldera and then flows along the southeast bounding fault of the graben for most of its length.

Also associated with the Trans-Challis fault zone was the mineralization of precious metals that occurred along weaknesses in the rock (i.e., shear zones and faults) during the Challis Volcanics episode (Fisher and Johnson 1995). Much of the gold and silver deposits were found, and exploited, along epithermal veins where mineralization was driven by hydrothermal systems (i.e., hot springs and fumeroles) (Nolan 1933; Anderson 1949; Davidson 1960; Davidson and Powers 1959); and in placer deposits where alpine glaciers had eroded the ore-bearing veins and deposited the gold down valley in outwash deposits (i.e., terraces and outwash plains).

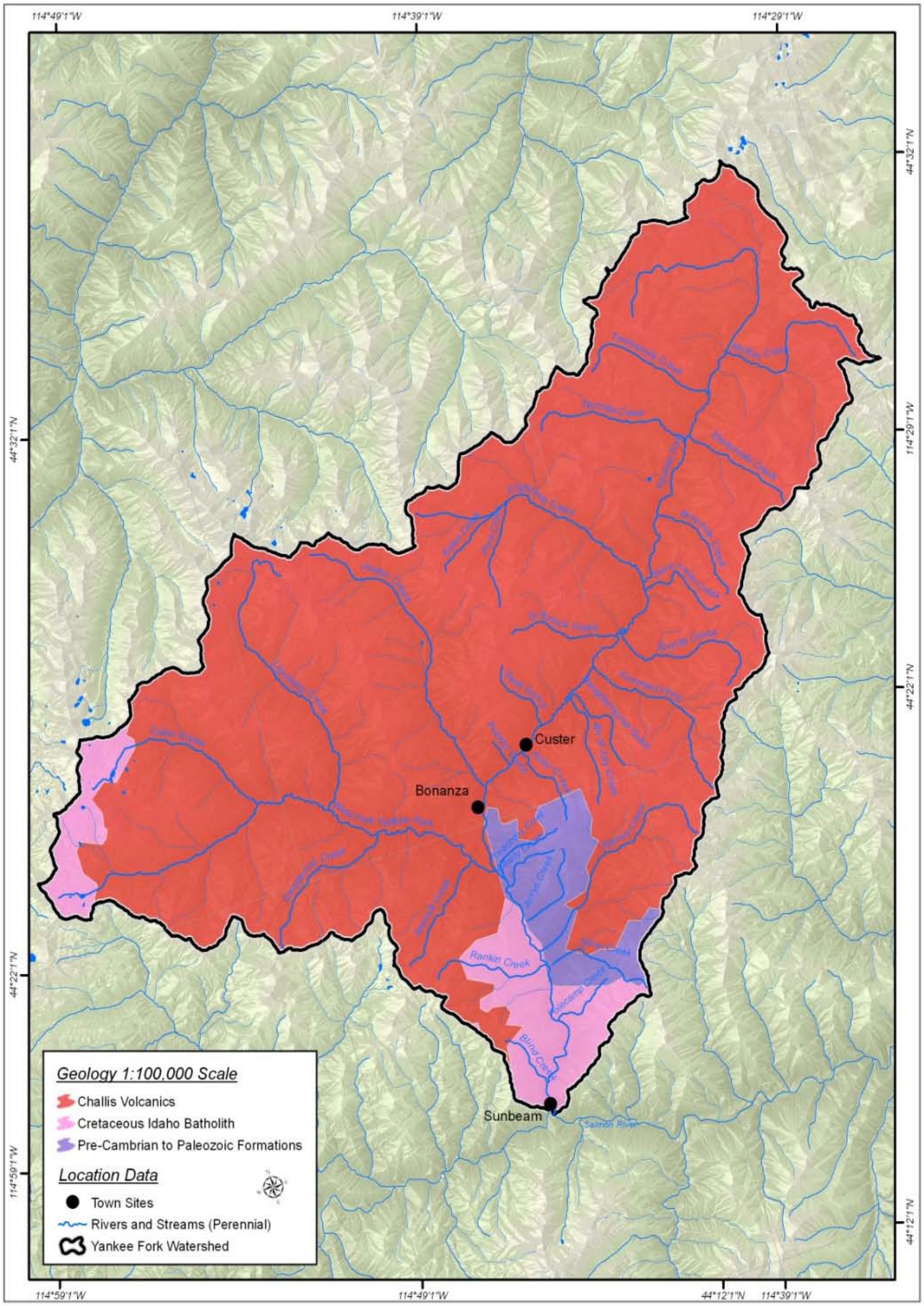

Figure 8. Bedrock geologic units within the Yankee Fork watershed.

The Yankee Fork watershed has experienced at least two of the regional glacial cycles that occurred in the form of alpine glaciations during the Pleistocene (Mackin and Schmidt 1956; Williams 1961). The alpine glaciers deeply eroded parts of the watershed, sculpting U-shaped valleys, and constructing terraces and broad outwash plains. Glacial erosion unearthed precious metals and transported them down valley where they were deposited as alluvium (Fisher and Johnson 1995). These alluvial deposits (i.e., glacial outwash and terraces) are significant in that most of the gold recovered in the watershed was from these Pleistocene-age sediments.

The Yankee Fork and some of its major tributaries have been reworking the Pleistocene sediments through fluvial processes including sediment transport and deposition. In the broad, glacially-carved valleys of the Yankee Fork, West Fork, Jordan Creek, and Eightmile Creek, the modern streams are “underfit” in that they do not possess the necessary stream power to completely rework the valley bottoms that are filled with the Pleistocene-age alluvium that was deposited under higher precipitation and streamflow volume conditions.

The alluvial valley fill (predominantly Pleistocene glacial outwash) contained placer gold, and its exploitation has significantly impacted physical and ecologic processes along the Yankee Fork between Jordan Creek and Pole Flat Campground, and along the lower 1.4 miles of Jordan Creek. Gold dredging and hydraulic mining activities have led to construction and re-routing of the stream channels, change in geomorphic valley bottom constraints that further confine the stream channels, and removal of vegetation along the valley bottoms that disrupts channel forming processes and ecological connectivity. Also associated with the mining activities was the introduction of mercury and other chemical contaminants into the channel network.

5.2 Hydrology

This hydrology section is a summary of the Hydrology Appendix (Appendix F). Some information from the USFS biological assessment report (USFS 2006) has been incorporated where appropriate.

The Yankee Fork watershed is located within the Pacific Northwest Region 1^{st} field hydrologic unit code (HUC) 17, lower Snake subregion (2^{nd} field HUC 1706), Salmon River basin (3^{rd} field HUC 170602), and the upper Salmon subbasin (4^{th} field HUC 17060201). The Yankee Fork watershed (5^{th} field HUC 1706020105) is divided into five 6^{th} field HUC subwatersheds including the upper Yankee Fork, middle Yankee Fork, lower Yankee Fork, Jordan Creek, and West Fork (Figure 9).

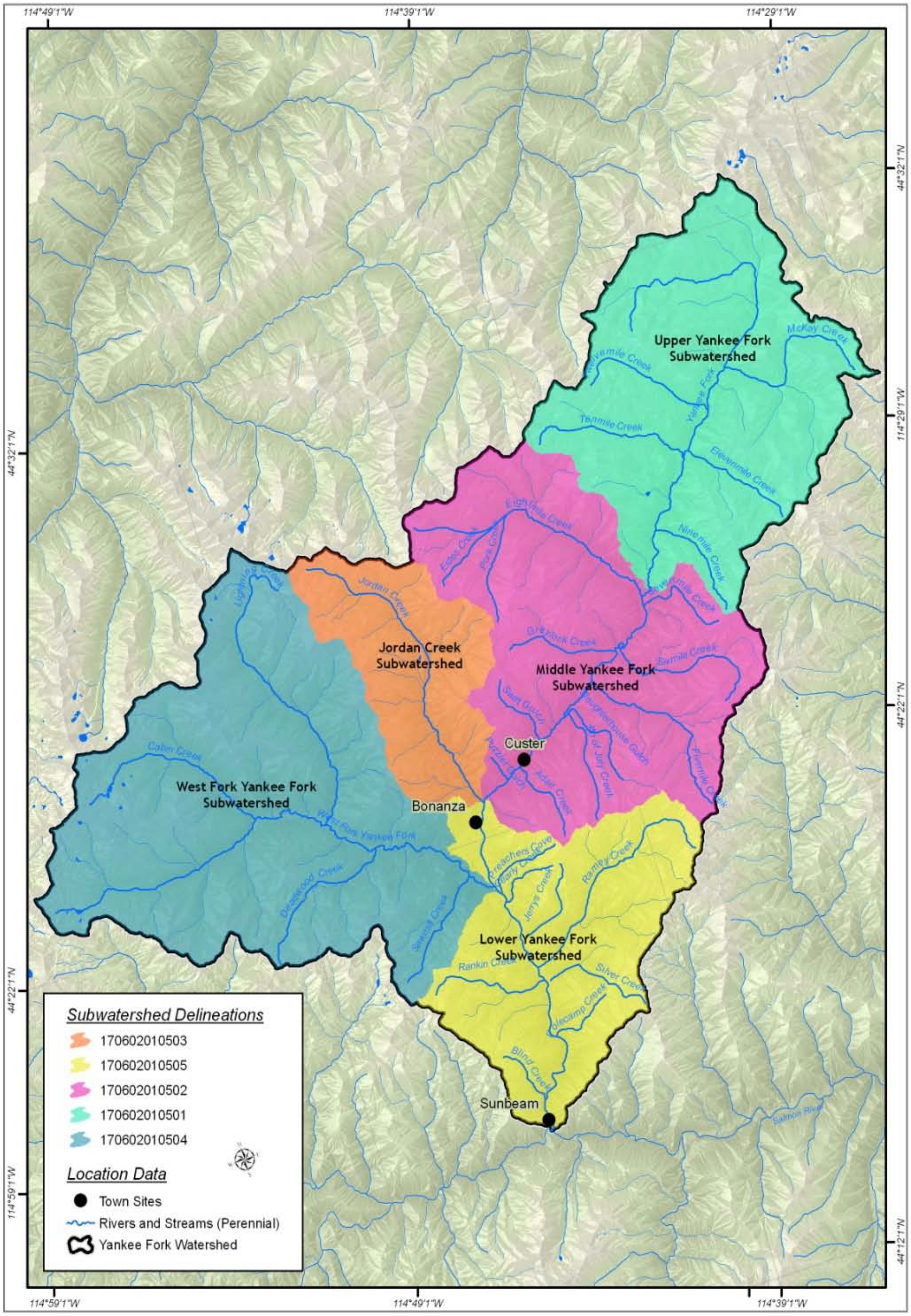

Figure 9. Yankee Fork subwatershed locations.

The watershed has a dendritic drainage pattern, draining about 190 mi^2, and has a drainage density of about 2.71 miles per square miles (mi/mi^2) which is a measure of the amount of stream network necessary to drain the basin. There is an estimated 223.6 miles of perennial stream and 291.3 miles of ephemeral streams within the basin (USFS 2006). Basin relief is about 4,407 feet with a maximum elevation of about 10,329 feet at The General peak and a minimum elevation of about 5,922 feet at the confluence with the Salmon River.

Water rights in the Yankee Fork watershed for the diversion of surface and groundwater consist of 38 domestic rights with a total diversion rate of 1.34 cubic feet per second (cfs) divert from tributaries, groundwater, and springs within the watershed. A total of 10 mining and industrial water rights with a total diversion rate of 17.86 cfs divert from Jordan Creek, Yankee Fork, groundwater, and tributaries. There are six recreation and wildlife water rights with a total diversion rate of 25.5 cfs diverting from the Yankee Fork and groundwater. The State of Idaho also holds minimum streamflow rights with a 2005 priority date for Eightmile Creek, Lightening Creek, and Yankee Fork.

The U.S. Geological Survey (USGS) operated a streamflow gage (USGS Gage No. 13296000) on the Yankee Fork near RM 0.5 between May 1921 and February 1949. The drainage area above the gage site is approximately 189 mi^2. Mean annual flow at the gage was 197 cfs and the mean annual peak flow is 1,603 cfs. The maximum daily average flow was 3,360 cfs on June 12, 1921 and the minimum daily mean flow was 10 cfs on December 5 and 6, 1927.

The annual hydrograph (Figure 10) illustrates that annual peak flows occur during spring runoff from May through June and base flows of approximately 30 cfs can extend from September through March. Based on the flow exceedance curve, a flow rate of 200 cfs is equaled or exceeded 20 percent of the time and a flow rate of 500 cfs is equaled or exceeded 10 percent of the time. Peak flow and low flow statistics determined by the USGS are summarized in Table 3 and Table 4, respectively.

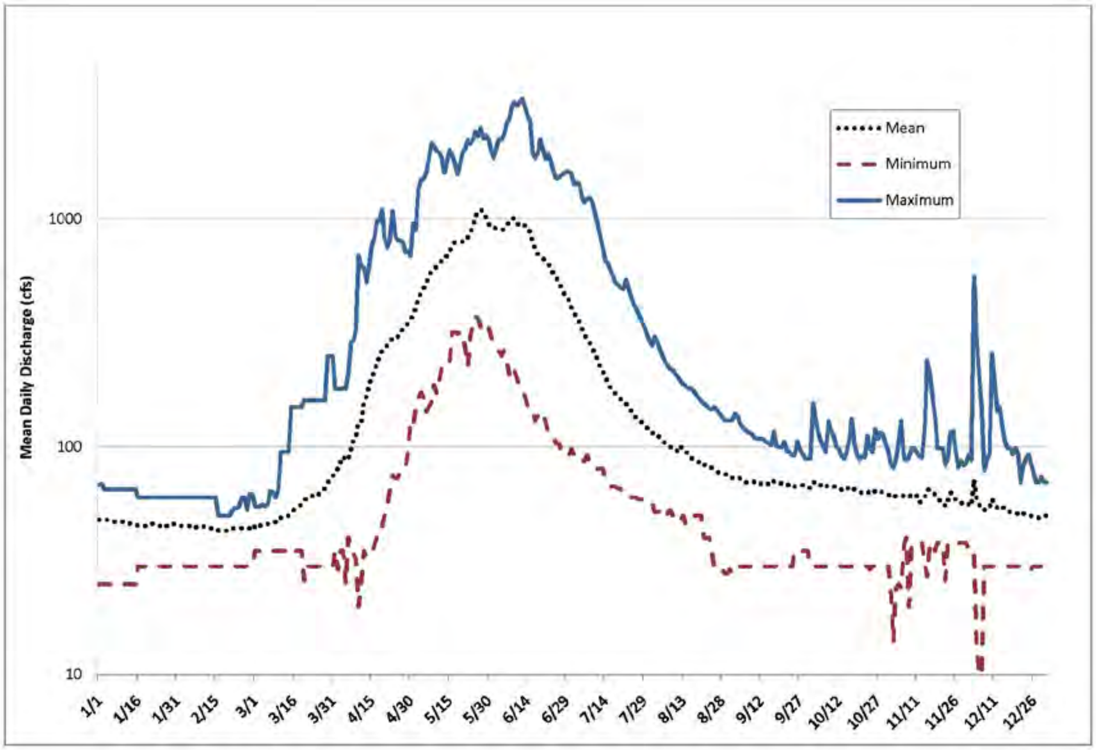

Figure 10. USGS 13296000 Gage Annual Hydrograph (Period of Record 1922-1949).

Table 3. USGS 13296000 Peak Flow Statistics Estimated by Berenbrock (2002) (Period of Record 1921-1949, 1974).

High Flow Statistic		Discharge, cfs
Recurrence Interval, years	Probability of Occurrence, %	
2	50	1,470
5	20	2,240
10	10	2,780
25	4	3,490
50	2	4,030
100	1	4,590
200	0.5	5,160
500	0.2	5,940

Table 4. USGS 13296000 Low Flow Statistics Estimated by Hortness (2006) (Period of Record 1921-1949).

Low Flow Statistic	Discharge, cfs
1Q10 – 1-day, 10-year low flow	19.8
7Q10 – 7-day, 10-year low flow	29.2
7Q2 – 7-day, 2-year low flow	37.9
30Q5 – 30-day, 5-year low flow	34.9

The Natural Resources Conservation Service (NRCS) operates a Snowpack Telemetry (SNOTEL) site within the Yankee Fork watershed at the Mill Creek Summit at about elevation 8,800 feet. The period of record for this station is from October 1978 to the current year (2011). Average annual precipitation measured at this site is 30 inches with the highest precipitation months between November and June. Maximum and minimum average annual air temperature at this site is 45.7 and 18.6^{o} F, respectively. Peak snow water equivalent occurs between mid-April and late-May, declining rapidly during the months of May and June.

In 1985, the USFS began operating a Remote Automatic Weather Station in Bonanza near elevation 6,410 feet. The period of record for this weather station is from May 1985 to the current year (2011). Average annual precipitation is 14.7 inches with the highest precipitation months occurring in fall and spring. Maximum and minimum average annual air temperature is 54.8 and 22.1^{o} F, respectively.

5.3 Soils

Soil development in the watershed is dependent on the youthful nature of the geology, topography, and generally cool, arid climate. The soils that have developed on the extrusive igneous rocks of the Challis Volcanics occur predominantly on lower elevation mountains and foothills. Slopes are moderately steep or steep and the soils that formed in the Challis Volcanics, excluding rhyolite and tuff, have an argillic (clay) horizon overlying a calcic (carbonate) horizon. These soils are more than 35 percent rock fragments and examples include the Dawtonia, Dacant, Custco, Gaciba, and Resoot complexes (NRCS 2006). Other soils that formed in tuff are weakly developed, contain lime, and are highly erosive. Soil examples include the Frailton, Gradco, and Farvant complexes. For soil example descriptions the reader is referred to *Soil Survey of Custer-Lemhi Area, Idaho, Parts of Blaine, Custer, and Lemhi Counties* (NCRS).

5.4 Sediment Sources and Inputs

The steep slopes and erosive soils in the watershed are susceptible to mass wasting processes. High intensity thunderstorms are known to trigger shallow landslides and debris flows. And although very infrequent (on the order of decades to centuries), ground shaking from earthquakes occurring in the region can also trigger landslides.

Summer storm events are common in the watershed and high-intensity thunderstorms can trigger shallow slides and debris flows, especially in areas where intensive/severe fires have burned and in the headwater areas where colluvial and alluvial materials have accumulated in depressions (i.e., colluvial hollows). In 1994, 1996, 2001, 2002, and 2003, thunderstorms caused landslides and debris flows in Fivemile Creek, Sixmile Creek, Ninemile Creek, Preachers Cove, Jerrys Creek, and several unnamed tributaries. Some of these debris flow events reached the Yankee Fork and caused changes to the channel morphology. For example, the debris flows from unnamed tributaries across from Pole Flat Campground in 2003 and 2004 deposited coarse sediment and wood in the channel along river right that constricted the channel, forcing flows toward the left bank where it is presently eroding the dredge tailings. Some of these sediment inputs contain a high percentage of fine materials that can cause high turbidity and siltation, which generally have short-term negative impacts to fish habitat (on the order of days or weeks). However, these types of events provide the necessary gravel and wood inputs to the system that benefit the fish species over the long-term (months or years).

Surficial geology mapping (Appendix G) shows that landslides are fairly common throughout the watershed and can provide large volumes of material to the system that are capable of creating long-term channel changes (on the order of decades to centuries). An example of such a landslide event is the canyon area between Fivemile Creek and Swift Gulch where the Yankee Fork was impounded by a landslide for potentially a long period of time based on the extent and depth of lake deposits, before incising through the landslide deposit. More commonly, these landslides provide smaller volumes of material to the system. These smaller landslides appear to be fairly common in the West Fork, Jordan Creek, and upper drainages northwest of the Yankee Fork, and may be associated with weakened rocks (i.e., shear zones and hydrothermal alterations) along the Trans-Challis fault zone.

5.5 Vegetation

5.5.1 Historic Mining Disturbances

Historic vegetation species assemblage and successional stages have been significantly impacted by mining activities and construction of support networks. With the discovery of gold in the watershed in 1873 a mining boom began as prospectors flocked to the Yankee Fork watershed (Yarber 1963; Mitchell 1997). Bonanza and Custer townsites sprang-up in the late 1870s to support the mining operations and laborers. Several ore processing mills were constructed to support hard-rock mines and operated between 1875 and 1942.

During this period, timber was extensively harvested to support the mining industry. For example, much of the lumber used in building Custer and Bonanza was harvested from Lavalle Creek (now Sawmill Creek) in the West Fork drainage (USFS 2006). Timber was harvested along the valley bottoms and walls to fuel the ore processing mills that required large volumes of wood. By 1916, the Intensive Land Classification for the Challis National Forest reported that along the Yankee Fork, “most of the good timber was taken out years ago for mining use and for cordwood” (USFS 2006).

Additional information on anthropogenic disturbances in the watershed (i.e., road densities and livestock grazing) is included in the Watershed Condition – Section 7.0.

5.5.2 Present Species Assemblage

The vegetation in the Yankee Fork watershed is a mosaic pattern of coniferous forest interspersed with natural sagebrush/grass steppe openings, talus slopes, rocky outcrops, and mesic or riparian areas (Figure 11). Sagebrush/grass steppe is dominated by big sagebrush, fescues, and wheatgrasses. Forest vegetation is comprised of lodgepole pine, Douglas fir, Engelmann spruce, subalpine fir, whitebark pine, and occasional ponderosa pine. Primary deciduous trees are quaking aspen and black cottonwood. Repetitive fire intervals have reduced the competition from grasses, shrubs, and other trees and with the reduction and near elimination of these cyclical disturbances, conifers continue to encroach into the sagebrush-grass openings (USFS 2006).

Vegetation in riparian areas consists of aspen, willow, alder, sedges, rushes, grasses, and mesic forbs, often mixed with an overstory of coniferous tree species compatible with the higher moisture regime. Wet meadow areas occur infrequently within the riparian areas along watershed streams with low gradients, spring areas, and small natural basins.

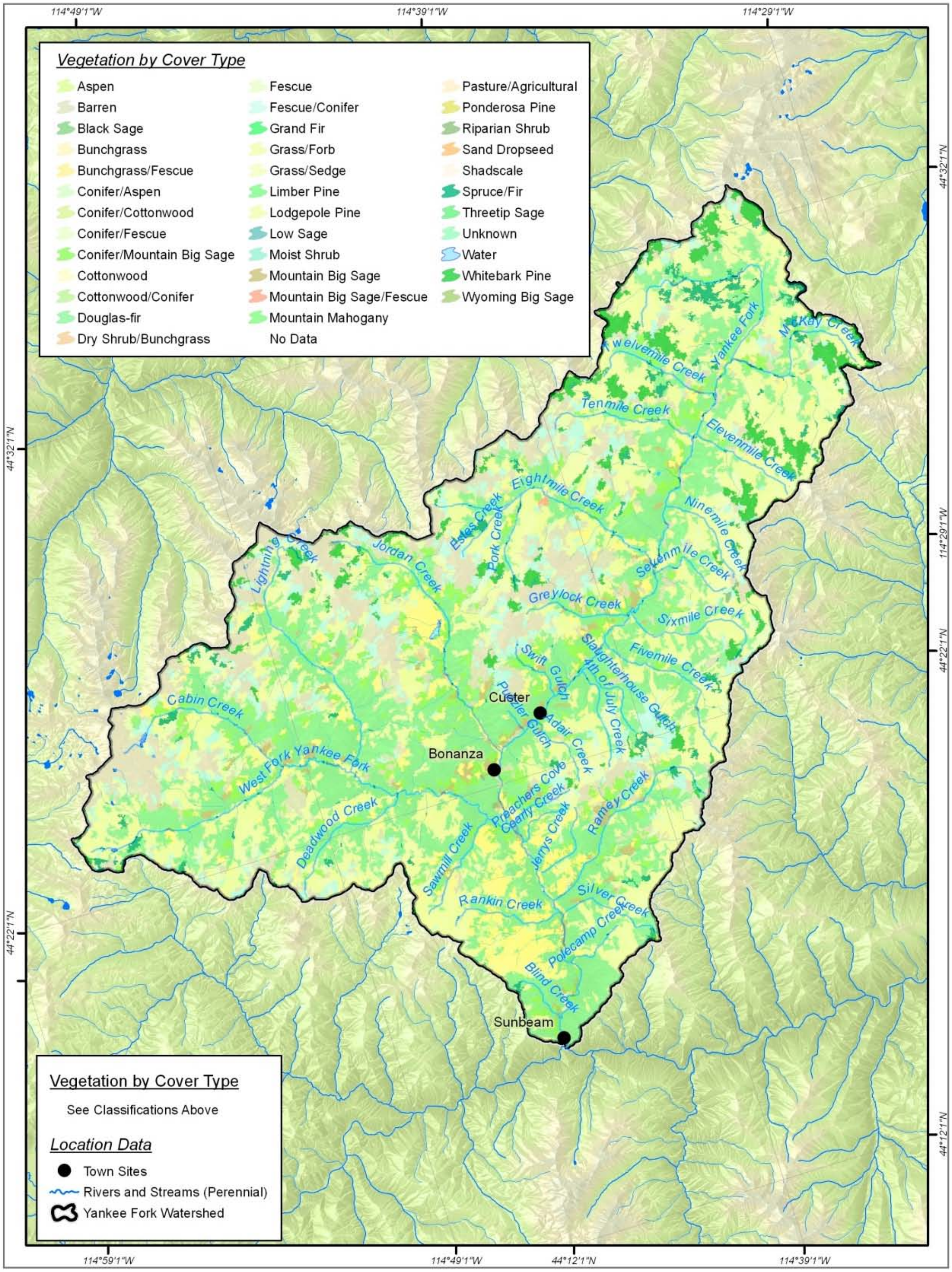

Figure 11. Yankee Fork watershed vegetation by cover type.

5.5.3 Wildland Fires

Since the early 1900s, the USFS fire-control policy has been immediate action to suppress wildfires. Suppression efforts, along with other activities that excluded fire, have resulted in changes in the landscape and ecosystems. Historic fire frequencies associated with Douglas fir and probably lodgepole pine habitat types found in the watershed average 36 years; presently, the fire frequency in the area exceeds 100 years. For sagebrush/grassland communities, the historic fire frequency ranged from 15 to 50 years with an average of 35 years; presently, fire frequency now exceeds 80 years. Abnormally high amounts of standing dead/down and live fuels are accumulating and higher intensity wildfires are predicted with potentially severe effects (USFS 2006).

Wildland fires that have occurred within the watershed in the last 30 years include the East Basin, Eight Mile, Rankin, Zane, and Potato fires that have burned a total of about 28,760 acres (Table 5). About 10 percent of the Potato Fire and less than 5 percent of the East Basin, Rankin, and Zane fires burned outside of the watershed (USFS 2006).

Table 5. Fire history and acreage burned.

Fire Name	Year	Reported Acreage Burned	Geographic Locations
East Basin	1985	3,500 acres	Rankin Creek middle and upper drainage; Sawmill Creek upper drainage
Eight Mile	1999	107 acres	Small ridge top area in unknown drainage of Eightmile Creek
Rankin	2000	6,710 acres	Rankin Creek drainage; Jerrys Creek drainage; Ramey Creek lower third along south aspect
Zane	2006	218 acres	Small ridge top area in unknown drainage of West Fork
Potato	2006	18,225 acres	West Fork lower half of drainage; Deadwood Creek lower half of drainage; Lightning Creek lower third of drainage; Jordan Creek lower half along east aspect

5.5.4 Insect Infestations and Disease

Infestations of mountain pine beetle, western spruce budworm, Douglas fir bark beetle, and dwarf mistletoe are most notable in stands of lodgepole pine in the West Fork subwatershed as well as Eightmile Creek, Tenmile Creek, Elevenmile Creek, and the upper Yankee Fork. There is significant fuel loading on the ground from remnants of an extensive mountain pine beetle outbreak from the early part of the 1900s. Another infestation of mountain pine beetle began to increase in 2000 due to the reduction in precipitation throughout the area. These beetles are responsible for killing many acres of primarily lodgepole pine (USFS 2006).

6. Watershed Fish Usage and Supplementation

The Yankee Fork is a major tributary to the Salmon River in the Columbia River Basin and is an important spawning and rearing stream for anadromous fish species. Fish species of interest include Chinook salmon, steelhead, bull trout, westslope cutthroat trout, and Pacific lamprey, and their historic and present use of the Yankee Fork watershed are summarized in the following sections. For more detailed information the reader is referred to Appendix H.

6.1 Historic Fish Use

Historical data pertaining to anadromous fish species using the Yankee Fork watershed is limited and inferences have been made based on Columbia River fish returns and anecdotal accounts. In 1910, Sunbeam Dam was constructed on the mainstem Salmon River immediately upstream of the Yankee Fork which obstructed migratory fish species to an unknown degree until removal in 1934 (Ecovista 2004).

The Yankee Fork Ranger District (USFS 2001) suggest that salmon, steelhead, bull trout, and westslope cutthroat trout populations were historically strong based on anecdotal accounts and research completed for the Upper Columbia River Basin aquatic science report. Pacific lamprey presence (or absence) in the Yankee Fork watershed is based on inferences from available information.

6.1.1 Chinook Salmon

Adult spring/summer Chinook salmon returning to the Columbia River between 1881 and 1895 were estimated to be between 2.3 and 3.0 million. Declines in the Columbia River salmon populations began in the late 1800s as a result of overfishing (Chapman 1986).

By the early 1900s, environmental degradation from mining, grazing, logging, and agriculture had caused substantial declines. Construction of dams on the mainstem Snake River and the Columbia River further reduced the distribution and abundance of Snake River Chinook salmon and their escapement to the Salmon River.

An average of 125,000 adults per year entered Snake River tributaries from 1950 through 1960. Returns of spring/summer Chinook salmon continued a steady decline in the 1970s, reaching low points in the mid-1990s before rebounding slightly in 2000, primarily as a result of good river and ocean conditions (Ecovista 2004).

Reiser and Ramey (1987) found that over 6 percent of Chinook salmon redds historically found in the upper Salmon River basin were located in the Yankee Fork watershed. Chinook salmon redd counts have declined from 400 per year in the 1960s to as low as 3 in 2006 (Bellmore and Baxter 2009).

6.1.2 Steelhead

The Columbia River Basin had one of the world's largest populations of steelhead (Ecovista 2004). Historical estimates of the pre-European steelhead run in the entire Columbia River Basin were about two million fish. Wild steelhead abundance declined steadily from 1962 to 1976, and abundance was depressed but stable during the late 1970s and 1980s. Wild steelhead abundance in 1993 through 1996 was the lowest ever recorded (Ecovista 2004).

Historically, the Yankee Fork watershed supported productive populations of steelhead (Tardy 2009). An estimated 25 percent of the steelhead in the Columbia River Basin may have originated in the Salmon subbasin (Mallet in Ecovista 2004). However, smolt-to-adult return rates have decreased from above 4 percent in the 1960s when four dams existed in the Columbia River system to less than 2 percent in the 1970s after eight dams were in place (Tardy 2009).

6.1.3 Bull Trout

Historically, bull trout were distributed throughout the upper Salmon River basin, and although they were never as abundant as other salmonids, they were more abundant and more widely distributed than they are today (Ecovista 2004). This species was listed under the ESA in 1998 as threatened because of general declines in their populations primarily due to habitat threats. Bull trout in the Salmon River basin fall into the "upper Snake" recovery unit and in 2010 the Yankee Fork and several of its tributaries were designated by the USFWS as critical habitat for bull trout (75 FR 63898). Designated critical habitat receives protection against Federal agencies carrying out, funding, or authorizing the destruction or adverse modification of critical habitat. Information on bull trout population productivity and abundance in the Yankee Fork watershed is currently limited and considered a data gap.

6.1.4 Westslope Cutthroat

Cutthroat trout are estimated to occur in 85 percent of their historical range (Ecovista 2004) including the Yankee Fork watershed. The Yankee Fork Ranger District (USFS 2001) suggested that westslope cutthroat trout populations were historically strong based on anecdotal accounts and research completed for the Upper Columbia River Basin aquatic science report.

6.1.5 Pacific Lamprey

According to the USFWS (2010), historic runs of Pacific lamprey in the Coumbia River Basin numbered in the hundreds of thousands at Bonneville Dam as recently as 1965, but the distribution and abundance of lampreys have been reduced by construction of dams and diversions as well as degradation of spawning and rearing habitat. Historically, Pacific lamprey likely occurred in the Yankee Fork.

6.2 Present Fish Use

6.2.1 Chinook Salmon

The Yankee Fork is an important spawning and rearing system for spring/summer Chinook salmon. Spawning is distributed broadly throughout the population boundaries, extending from approximately one mile upstream of the Yankee Fork/Salmon River confluence to the headwaters area and the West Fork (USFS 2006). Anthropogenic disturbances (i.e., gold dredging) along sections of the Yankee Fork and Jordan Creek have eliminated or degraded much of the rearing and spawning habitat (Reiser and Ramey 1987).

Adult spring/summer Chinook salmon enter and ascend the Columbia River between March and July and reach the upper Salmon River (about 850 miles upriver) in late July and August. Adult fish hold in deep pools within the main Salmon River and then move into the smaller tributaries (including the Yankee Fork) in late July and August to begin spawning (USFS 2006). Spawning occurs in the Yankee Fork in August and September. Adult Chinook salmon die within a short time after spawning and carcasses can often be observed in close proximity to newly constructed redds. Spring Chinook salmon eggs remain in the gravel with winter and early spring water temperatures determining the actual time of emergence. This typically occurs by mid-March to late April (USFS 2006). Young salmon emerge from redds in the spring and will rear in a variety of environments from small, infertile streams to large rivers. Starting during fall, but also throughout the winter, juveniles will immigrate from the Yankee Fork to the Salmon River. Juveniles spend approximately one year in fresh water before smolting and migrating approximately 850 miles to the Pacific Ocean between April and June (Reiser and Ramey 1987). Yankee Fork Chinook salmon typically spend two years in the ocean before returning to the Columbia River on their return as adults (USFS 2006). Table 6 shows the “phenology” of spring Chinook salmon within the Yankee Fork.

Table 6. Summary of Chinook salmon life stages - Yankee Fork.

Species	Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook	Adult Staging												
	Peak Spawning												
	Incubation												
	Juvenile Rearing												
	Smoltification (out migration)												

6.2.2 Steelhead

The Yankee Fork was designated as critical habitat for Snake River basin steelhead in 2006 and is an important spawning and rearing stream. Steelhead population trends in the Yankee Fork are largely unknown. The only direct count of natural origin steelhead occurs at the Sawtooth Fish Hatchery weir located on the Salmon River, upstream of Stanley. The average number of natural-origin returns to the Sawtooth Hatchery weir between 1986 and 2007 was 34 fish (CRHRP 2009b). Capture of juvenile steelhead in Jordan Creek indicates that natural reproduction is occurring in Jordan Creek (USFS 2006).

Adult steelhead migration requirements are generally similar to those described for spring Chinook. Steelhead enter and ascend the Columbia River in June and July, arriving near their spawning grounds several months prior to spawning (USFS 2006). However, adult holding takes place over a much longer period (from fall arrival in the Snake River drainage until spring spawning). Most adult steelhead have moved into tributary streams (such as Yankee Fork) by November. However, some adults hold in the Salmon River until February or March before moving into natal streams to spawn. Unlike other anadromous salmonids that return from the ocean to spawn and subsequently die, steelhead have the ability to migrate back to the ocean after spawning (kelting) and to return and spawn again. Juvenile rearing lasts approximately two to seven years prior to ocean emigration. Table 7 shows the “phenology” of steelhead within the Yankee Fork.

Table 7. Summary of steelhead trout life stages - Yankee Fork.

Species	Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Steelhead	Adult Staging												
	Peak Spawning												
	Incubation												
	Juvenile Rearing												
	Smoltification (out migration)												

6.2.3 Bull Trout

Fluvial (migratory) bull trout distribution occurs in the Yankee Fork and West Fork, and many of the tributary systems of the Yankee Fork. Fluvial bull trout use the Yankee Fork and West Fork, while smaller tributaries (i.e., Jordan Creek) support only small, if any, resident populations. Bull trout have been documented by the USFS, Idaho Department of Fish and Game (IDFG), and the Shoshone Bannock Tribes (Tribes) within the mainstem Yankee Fork, the West Fork, McKay Creek, and several other tributaries. Large bull trout have been observed spawning in the lower reaches of small headwater tributaries (i.e., Tenmile Creek) (USFS 2006). Schoby and Curet (2007) documented that the majority of upper Salmon River basin bull trout spawning migrations made by tagged bull trout in 2003 were into the Yankee Fork.

Gamett and Bartel (2008) found bull trout at 34 percent of sites sampled on the Yankee Fork Ranger District. While many sites in the Yankee Fork watershed were sampled by the Salmon-Challis National Forest for fish presence in 2007, few were sampled using a method that would allow the estimation of fish density, measured as fish per hundred square meters. The Yankee Fork and the West Fork sites yielded estimated bull trout densities of zero fish per hundred square meters. This is not at all surprising, given the size of these bodies of water and the known habits of the bull trout species (Gamett and Bartel 2008).

Bull trout are designated as a management indicator species (MIS) for the Salmon-Challis National Forest. Subsequently, a series of MIS monitoring sites have been established across the Forest to monitor trends in bull trout populations. Species density estimates and length frequency distribution graphs were generated for each site. One MIS site is located on McKay Creek and is the only MIS site in the Yankee Fork watershed. Estimated bull trout densities for years 2007 through 2010 are as follows: 2007 – 4.1 fish/100m^2, 2008 – 3.8 fish/100m^2, 2009 – 2.3 fish/100m^2, and 2010 – 6.0 fish/100m^2. The estimated densities of bull trout in McKay Creek are considered to be within average to high ranges (USFS 2004).

Major concerns for bull trout in the upper Salmon River basin include the disconnection of tributary streams from mainstem rivers, degradation of riparian habitat, dewatering due to irrigation withdrawals, unscreened irrigation ditches, and the introduction of non-native species. In the Yankee Fork, major concerns are disconnection of tributary streams, and degradation of riparian habitat.

Bull trout in the Yankee Fork have both resident and migratory life history patterns. Resident bull trout complete their entire life cycle in a tributary stream. Migratory bull trout spawn in tributary streams where juveniles rear for up to 4 years before migrating to a river or lake. Migrating bull trout return to spawning tributaries from the end of June into October. Spawning occurs between mid-August and early November (Schoby and Curet 2007). Resident and migratory bull trout can be found together in spawning grounds and can spawn together (Ecovista 2004). Offspring can express either life history. Bull trout can live longer than 12 years and prefer the coldest water. All life stages of bull trout are associated with complex forms of cover and pools.

6.2.4 Westslope Cutthroat Trout

The Yankee Fork has been identified as a “key” watershed for Westslope cutthroat trout (USFWS 1999). Survey data indicate that the populations are stable within the upper Salmon basin, and that there are sizable populations existing within the Yankee Fork mainstem and its tributaries (USFS 2006). These populations evidently were able to sustain themselves in tributaries, perhaps becoming a resident fish population rather than a migratory population. Cutthroat trout have much different life history requirements than anadromous fish, and were likely to maintain themselves in the tributaries while activities (dredging) occurred in the mainstem Yankee Fork.

6.2.5 Pacific Lamprey

Presently, remnant populations persist in the Salmon River basin but their distribution and abundance are unknown for the most part, making assessment of this species distribution and habitat conditions difficult. Investigations by the IDFG (Hyatt et al. 2006) show that Pacific lamprey distribution is currently confined to the mainstem Salmon River downstream of the North Fork Salmon River. Four sites in the Yankee Fork were sampled for lamprey in 2005 with none being observed (IDFG 2006).

6.3 Supplementation and Habitat Enhancement Programs

The following is a brief overview of the Tribes supplementation and habitat enhancement programs occurring in the Yankee Fork. Full reports are included as Appendix I.

In response to the declining populations of Chinook salmon and steelhead in the Yankee Fork, the Tribes have implemented supplementation and habitat programs that are working to increase the number of Chinook salmon and steelhead returning to the Yankee Fork. The Tribes are interested in the Yankee Fork to increase the viability and production of the populations, increase harvest potential for members of the Tribes, increase knowledge of fishery management techniques, and facilitate adaptive management.

Future efforts by the Tribes will be to maintain all program operations; develop the Crystal Springs Fish Hatchery near the Fort Hall Indian Reservation that will be used to provide supplementation for the Upper Salmon tributaries including the Yankee Fork; install weirs and Passive Integrated Transponder tag array for additional migration and survival estimates for juveniles; continue to obtain tissue samples from migrating juveniles and returning adults; monitor physical and biological indicators; and evaluate the effectiveness of habitat actions to address limiting factors.

6.4 Estimates of Chinook and Steelhead Density

Kiefer et al. (1990) indicated that potential spring Chinook and summer steelhead smolt production in the Yankee Fork drainage could be as high as 425,000 and 59,000 smolts, respectively. However, impacts to the Yankee Fork previously mentioned in this report have resulted in substantially less fish produced. The current low production level for Chinook and steelhead is supported by snorkel survey, redd survey, and screw trap information.

The Yankee Fork drainage was separated into seven strata for fish sampling purposes (Tsosie et al. 2009). To capture population estimates by subwatershed, fish sampling strata were grouped based on their geographic locations (Table 8). Figure 12 shows the location of the fish sampling strata with respect to the Yankee Fork subwatersheds.

Table 8. Fish sampling strata and geographic locations.

Fish Sampling Strata	Location Description	Subwatershed
Strata 1 – Yankee Fork	Yankee Fork mouth to Polecamp Creek	Lower Yankee Fork Subwatershed
Strata 2 – Yankee Fork	Polecamp Creek to West Fork	Lower Yankee Fork Subwatershed
Strata 3 – Yankee Fork	West Fork to Jordan Creek	Lower Yankee Fork Subwatershed
Strata 4 – Yankee Fork	Jordan Creek to Eightmile Creek	Middle Yankee Fork Subwatershed
Strata 5 – Yankee Fork	Eightmile Creek to McKay Creek	Upper Yankee Fork Subwatershed
Strata 6 – West Fork	Mouth to Cabin Creek	West Fork Subwatershed
Strata 7 – Jordan Creek	Mouth to upstream of Grouse Creek Mine	Jordan Creek Subwatershed

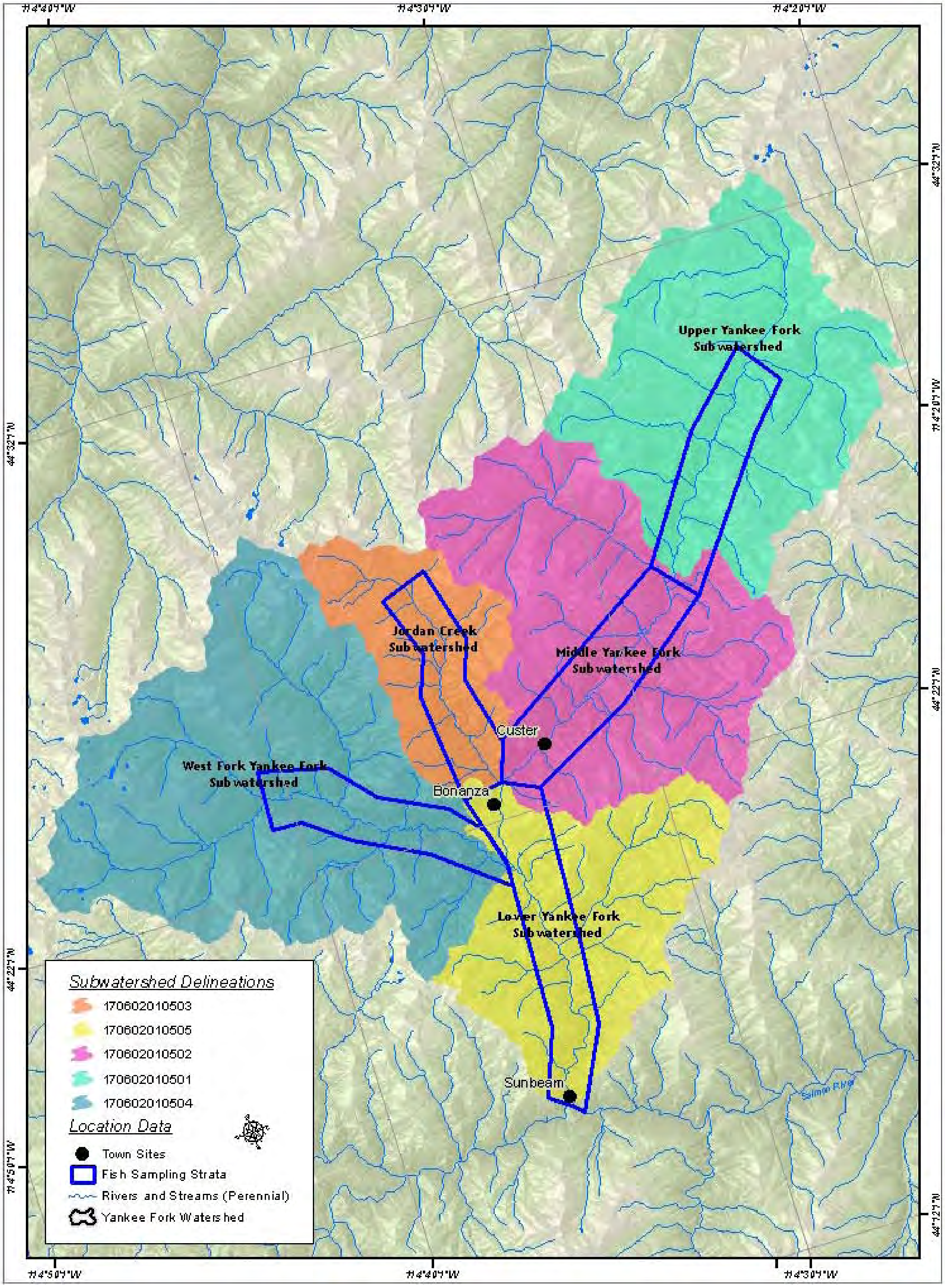

Figure 12. Yankee Fork drainage showing locations of subwatersheds and fish sampling strata.

6.4.1 Snorkel Surveys

Summer densities of juvenile spring Chinook salmon and summer steelhead were estimated by snorkeling riffle-pool sites between 1984 and 2008 as indicated by Tsosie et al. (2009). Mean density (number of fish/100 m^2) by stratum was estimated by averaging the density of fish at each of the six sites per stratum. This information was then summarized on a subwatershed basis (Lower Yankee Fork, Middle Yankee Fork, Upper Yankee Fork, West Fork, and Jordan Creek). Based on the average fish density per 100m^2 shown in Figure 13, the Yankee Fork stock of naturally-producing spring Chinook salmon is severely depressed and well below the estimated carrying capacity of 425,000 smolts. Summer steelhead are also well below the 59,000 smolt carrying capacity.

Figure 13 also shows that the Middle Yankee Fork subwatershed had the highest fish densities for juvenile Chinook salmon. The mainstem Yankee Fork in this subwatershed has not been dredged, and has a moderately confined to unconfined channel with good channel/floodplain interactions. It is not surprising that the majority of spawning habitat is located in this subwatershed. The Lower Yankee Fork subwatershed had nearly three times lower fish densities than the Middle Yankee Fork subwatershed. The mainstem Yankee Fork in this subwatershed has been dredged, and much of the channel has been artificially confined by dredge tailing piles with little channel/floodplain interactions. Historically (pre-dredging), the mainstem Yankee Fork had a moderately confined to unconfined channel between Jordan Creek and the West Fork with good channel/floodplain interactions; and a confined to moderately confined channel between the West Fork and Pole Flat Campground. Based on the surficial geology and natural channel confinement (pre-dredging), the lower section of the Yankee Fork from the West Fork to the Yankee Fork/Salmon River confluence probably never provided the same level of production as the Middle Yankee Fork subwatershed.

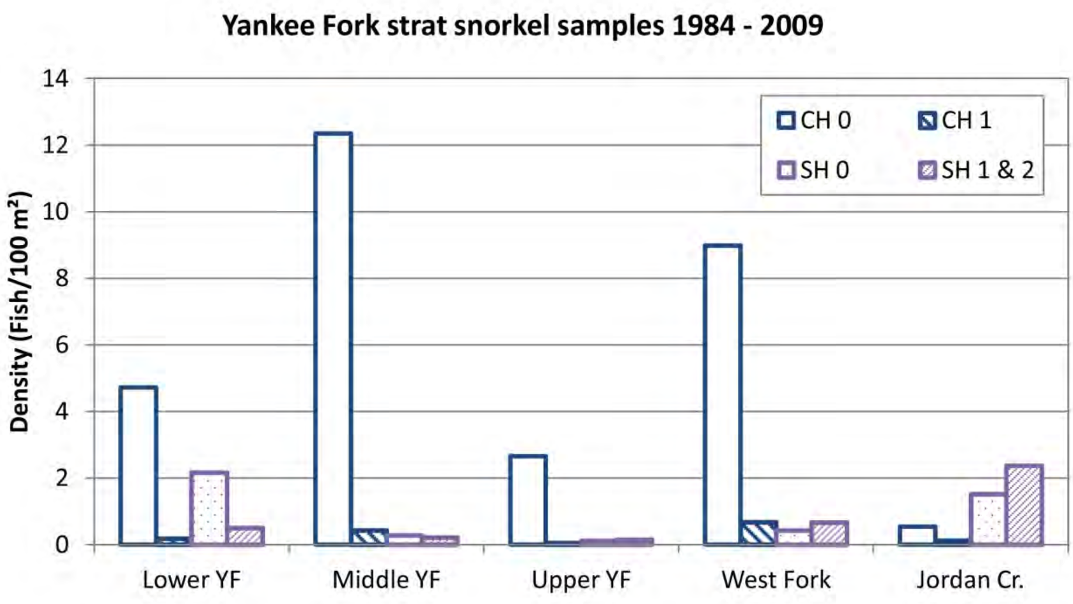

Figure 13. Yankee Fork stratified ("strat") snorkel survey samples from 1984 to 2009 by subwatershed.

6.4.2 Redd Surveys

Annual spawning ground surveys conducted by the IDFG and the Tribes for spring Chinook salmon in the Yankee Fork drainage reflect severely depressed juvenile Chinook salmon numbers as also indicated by the snorkel surveys. Survey data indicate that the Yankee Fork redd counts have ranged from 615 redds in 1968 to zero redds in 1995 (Figure 14). There has been a continuing decline of redds from 1969 through 2007 that has also been documented throughout the rest of the Salmon River drainage (USFS 2006).

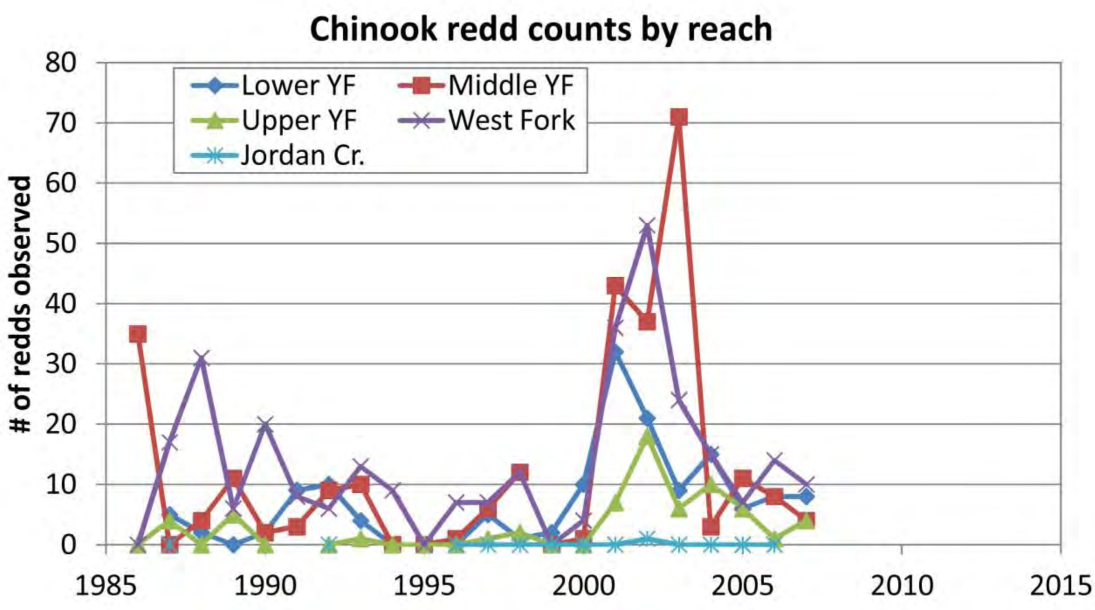

Figure 14. Yankee Fork redd counts by subwatershed.

6.4.3 Screw Trap Operations

Since initiating Yankee Fork screw trap operations in 2009, approximately 534,024 brood year (BY) 2008 and 129,661 BY 2009 juvenile Chinook salmon were estimated between April and November of 2009 (Figure 15). Survival estimates for BY 08 natural Chinook salmon parr and pre-smolts migrating from Yankee Fork equaled 0.121 percent to Lower Granite Dam (Tardy and Denny, 2010). Assuming this survival as the minimum, 64,617 out of 534,024 natural parr and pre-smolt juveniles survived to Lower Granite Dam. Tardy (2009a) indicated that juvenile Chinook salmon densities increased dramatically in 2009 as a result of adult outplanting activities in 2008.

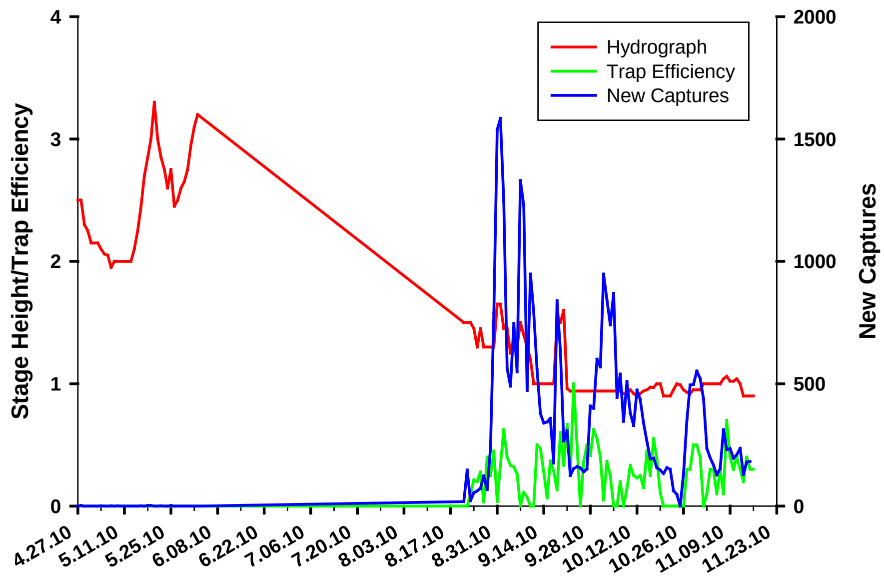

Figure 15. Yankee Fork hydrograph, trap efficiency, and emigration timing of juvenile Chinook salmon, 2010.

According to Tardy and Denny (2010), during the period of April 27 to June 2 and August 21 to November 16, 129,733 BY09 Chinook salmon juveniles emigrated past the Yankee Fork rotary screw trap. In all, Tardy and Denny (2010) estimated 46 BY09 Chinook salmon fry emigrated between April 21 and June 2, 15,114 BY09 parr from August 21 to August 31, and 114,509 BY09 pre-smolt from September 1 until trap removal on November 16, 2010. Due to insufficient mark/recapture data, estimates for BY08 smolt migrants could not be calculated. Tardy and Denny (2011) assumed BY09 fry and parr estimates to be extreme minimums as the trap was installed for only half the fry migration period and for only ten days during the parr stratification period due to trap loss in early June (Figure 16).

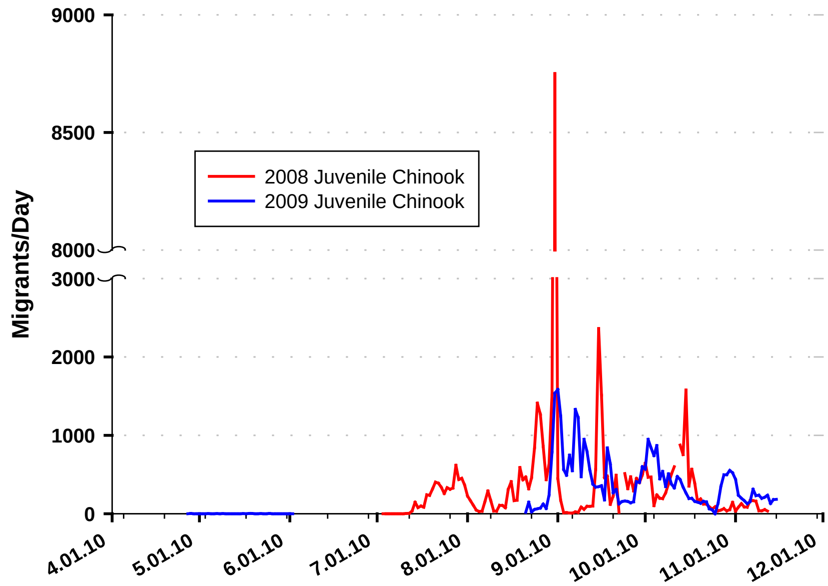

Figure 16. Juvenile Chinook salmon captures per day.

In 2009, the Yankee Fork screw trap was installed on July 2 and operated for 133 days until removal on November 13. During the period of July 3 through November 13, 534,024 BY08 Chinook salmon juveniles (parr and pre-smolt) were estimated to have migrated downstream past the rotary screw trap (Tardy and Denny 2011). Due to late acquisition and installation of the screw trap, estimates for BY07 smolt and BY08 fry migrants could not be calculated. Cormack/Jolly-Seber minimum survival estimate for BY08 natural Chinook salmon parr and pre-smolt migrating from Yankee Fork equaled 0.121 (0.0197) to Lower Granite Dam. Assuming this survival as the minimum, 64,617 out of 534,024 natural parr and pre-smolt juveniles survived to Lower Granite Dam.

Juvenile production, as evidenced by snorkel surveys, is a reflection of low redd counts (spawner returns). Adult supplementation initiated by the Tribes in 2008 and 2009 resulted in an increase of redds in the Yankee Fork (653 in 2008 and 409 in 2009). The adult supplementation program did result in increased juvenile Chinook salmon production as evidenced by the numbers of fish caught in the Yankee Fork screw trap during 2009 and 2010 trap operations. Screw trap catch rates of juvenile Chinook salmon dropped off substantially in 2011, likely a result of no adult spring Chinook salmon being available for the Tribes Yankee Fork Chinook Salmon Supplementation Program in 2010.

7. Watershed Condition

In this section, NOAA Fisheries' (1996) matrix of pathways and indicators was used to describe the functional condition pertaining to watershed-scale components as recommended in the *Salmon Subbasin Management Plan* (Ecovista 2004). Road density and location, anthropogenic disturbance history, water quality and quantity, and habitat access indicators were used to identify potential systemic problems, if any, within the watershed that limit or threaten aquatic habitat. The matrix of pathways and indicators provides guidance on thresholds that should be considered, and refined for the individual watersheds, to assess the condition ratings of the indicators as properly functioning, at risk, or not properly functioning.

7.1 Road Density and Location

There are about 113 miles of road open to all motor vehicles in the Yankee Fork watershed, and most of these are "improved" gravel-surface roads. Access roads to many mining claims (and some all-terrain vehicle trails) are "unimproved" in that they were "cut-and-fill" or surface trail type roads and do not have added surfacing material. The watershed road density, excluding mining access roads, is about 0.85 mi/mi^2 and these roads are generally located along stream corridors. The most frequently used roads are the Custer Motorway (USFS Road No. 013) and the Loon Creek Road (Forest Road 172). Magnesium chloride ($MgCl^2$) is applied, as needed, to the Custer Motorway (USFS Road No. 013) from Pole Flat Campground to the Yankee Fork gold dredge, and from the dredge to the Grouse Creek mine on Loon Creek Road (Forest Road 172) (Figure 17). This application is necessary for dust abatement and compliance with the State of Idaho air quality standards (USFS 2006).

Roads can directly affect natural sediment and hydrologic regimes in several ways (i.e., altering streamflow, substrate composition, and riparian conditions). The watershed road density in the Yankee Fork (excluding mining access roads and all-terrain vehicle trails) is less than 2 mi/mi^2 which indicates there have been minimal impacts to the drainage networks that would alter peak flows, baseflows, and/or flow timing. Several roads located on the valley bottoms adjacent to streams, which are not improved or treated to reduce dust drift, contribute fine sediment to the waterways. Fine sediment (particles less than 0.85 mm in diameter) can fill the interstitial spaces between coarser substrate particles that affect survival of (1) embryos and alevins by reducing water circulation through redds in spawning gravels, and (2) juveniles by reducing interstitial spaces between cobbles (embeddedness) that are used for over-wintering habitat (Bjornn and Reiser 1991; Hillman and Giorgi 2002).

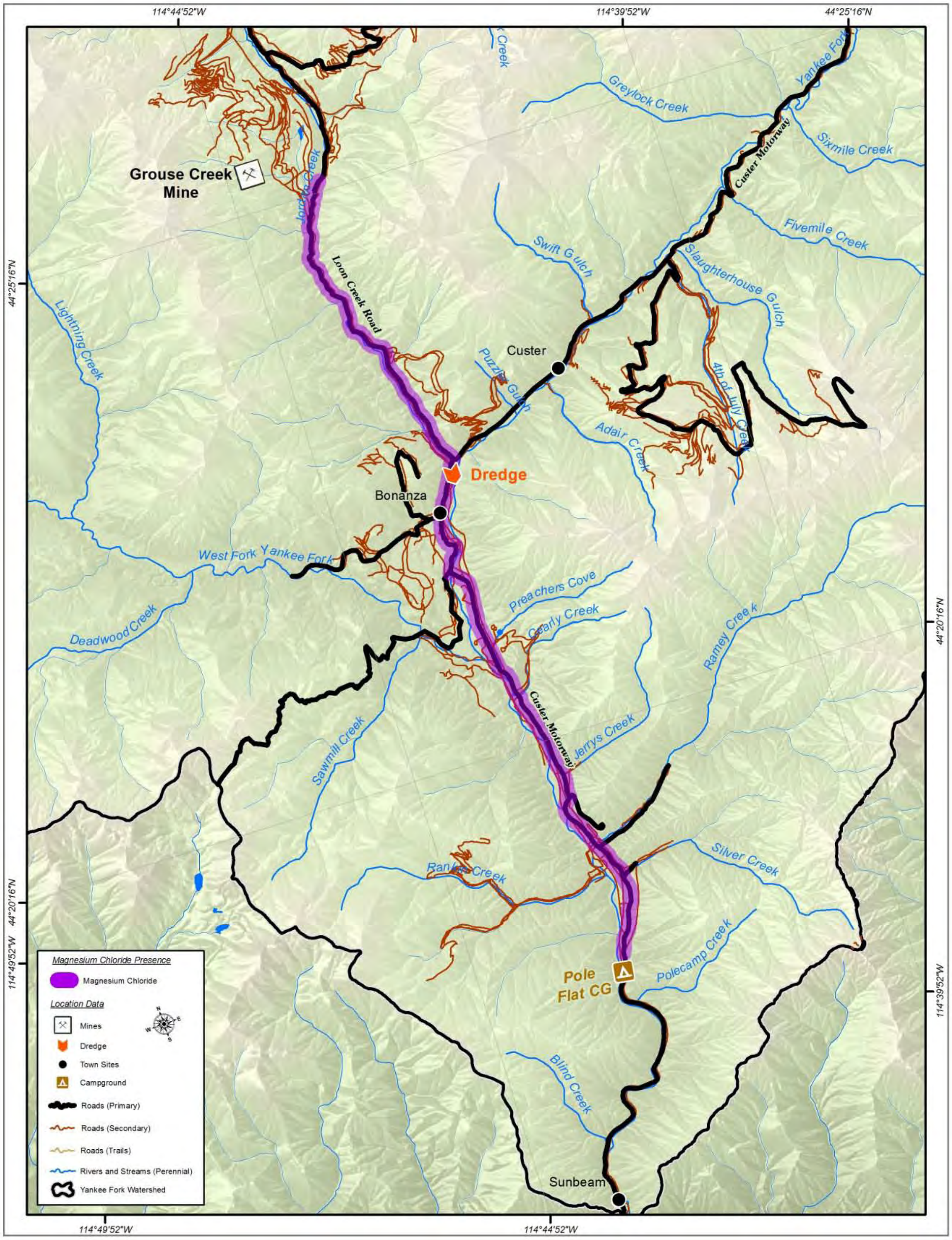

Figure 17. Location of roads treated with magnesium chloride ($MgCl^2$) for dust abatement.

7.1.1 Road Density Conclusions

Although road densities (0.85 mi/mi^2 excluding mining access roads and all-terrain vehicle trails) are low within the Yankee Fork watershed, there are several roads that are valley bottom roads and adjacent to waterways. The thresholds contained in the matrix of pathways and indicators for properly functioning are: (1) less than 2 mi/mi^2 of road, and (2) no valley bottom roads. For at risk, the thresholds are: (1) 2 to 3 mi/mi^2 of road, and (2) some valley bottom roads. Presently, this road density indicator is at risk based on roads being located on the valley bottoms and adjacent to fish-bearing streams. An analysis of all roads, including mining access roads and all-terrain vehicle trails, is needed to provide further clarification on the actual effects roads may have on waterways, erosion potential, and habitat quality.

7.2 Anthropogenic Disturbance History

7.2.1 Mining Activity

Gold was discovered in 1873 in the Yankee Fork near Jordan Creek (Yarber 1963; Mitchell 1997). Following the discovery of gold, there was a mining boom as prospectors began to exploit the many hard-rock and placer deposits. Bonanza City and Custer townsites were built in the late 1870s to support the miners working several of the hardrock mines. Ore processing mills were constructed in several locations including the Yankee Fork near Custer and in Jordan Creek. Many of the early hard-rock mines and mills operated between 1875 and 1942.

Placer gold deposits were first tested by the Souther Dredge Company in 1899 along the Yankee Fork from Jordan Creek to about 2 miles downstream (Engineering and Mining Journal 1900). By 1939, many of the placer mining claims along the Yankee Fork from Jordan Creek to Pole Flat Campground had been leased or acquired by the Snake River Mining Company that had plans for dredging the claim (Iowa Group Placer Claim). A large floating dredge was assembled and worked the claim from 1940 to 1952, with hiatuses between fall 1942 and spring 1946 during World War II, and fall 1947 and spring 1950. In addition, the lower 1.3-mile section in Jordan Creek (Morrison Group No. 1 and 2 Placer Claim) was also dredged, most of which was probably done using a drag-line dredge (“doodlebug”).

In 1992, a permit was granted to Hecla Mining Company to create an open-pit bulk-mineable gold mine at the old site of the Sunbeam Mine that operated in the early 1900s on Jordan Creek. The mine was renamed the Grouse Creek Mine and operated between 1994 and 1997 (USFS 2006; Frost and Box 2009).

Mining activities in the watershed have primarily impacted water quality and channel structure. Hard-rock mines exploited epithermal veins that contained gold and silver selenides that resulted in an increased volume of selenium compounds exposed to chemical weathering and transport to waterways during runoff. Many of the mines (hard-rock and placer) and ore mills used mercury amalgamation processes to recover gold that inherently exposes waste materials to the mercury. A few mines used cyanide leaching processes to recover gold from low-grade ore which also exposed waste materials to the cyanide. In the past, these mining activities and gold recovery processes have increased the availability of selenium, mercury, and cyanide to waterways. Presently, these chemical contaminants do not negatively impact water quality or aquatic species, but there is a potential risk that concentrated "pockets" of these chemicals are buried in the mine and dredge tailing areas that could eventually be released into the waterways.

Dredging activities have left the valley bottoms of the Yankee Fork (Jordan Creek to Pole Flat Campground) and Jordan Creek (lower 1.4 miles) covered by dredge tailing mounds. The dredge(s) altered, and in most cases obliterated, the Yankee Fork and Jordan Creek channels and new channels were subsequently constructed through the dredge tailings. As a result, the dredge tailings presently provide artificial valley bottom constraints that confine flows to within the channels, disconnect channel/floodplain interactions, and disconnect tributaries in several areas.

Significant changes to channel structure and channel/floodplain interactions have occurred on the Yankee Fork between Jordan Creek and the West Fork. Historically, this area likely had an unconfined channel with a straight-to-meandering channel pattern and functioning channel/floodplain interactions based on the 1945 aerial photographs. Presently, the Yankee Fork channel and the lower West Fork channel are confined with a straight channel pattern and channel/floodplain interactions are largely disconnected. Available juvenile rearing habitat and high water refugia, and adult spawning habitat have decreased, and stream energy is no longer dissipated over the floodplain.

Mine tailing piles disconnect Jerrys Creek and Silver Creek (perennial tributaries) from the Yankee Fork that historically may have provided juvenile rearing habitat for both Chinook salmon and steelhead in the low gradient sections along the valley floor, and steelhead rearing and spawning habitat in the higher gradient sections along the valley wall. For example, the Bureau of Fisheries Stream Survey in 1934 reported many fingerlings were observed in the lower ¼-mile section of Silver Creek (USDC 1934).

Jordan Creek and Ramey Creek were channelized through dredge tailings near their downstream ends. Flows are confined to within the channel and stream power is no longer dissipated over a functioning floodplain (or alluvial fan).

7.2.2 Livestock Grazing

Grazing in the subwatershed began in the late 1800s with the settlement of the towns of Custer and Challis. Sheep grazed the Yankee Fork Unit until the 1940s. Cattle still graze in the Yankee Fork Unit, but the extent of livestock use has declined significantly since the 1950s (USFS 2006).

Livestock grazing in the Yankee Fork headwater areas has significantly changed through time and management practices. Before the 1940s, livestock were able to graze on an "open-range" with direct access to riparian areas. Since the 1950s, livestock grazing has decreased due to "controlled" access and utilization of riparian areas for grazing are monitored (or excluded). Vegetation monitoring by the USFS near the head of the Yankee Fork and McKay Creek show that the vegetation has been primarily improving from 1966 to 1987 (USFS 2006).

Grazing was halted in 2011 by the 2011 Annual Operation Instructions (AOI) for the Garden Creek C&H allotment that states under Section VIII – Special Considerations for the 2011 grazing season that "No grazing or trailing will occur in the Yankee Fork Unit; and this unit has been removed from the action area within the Garden Creek Allotment Biological Assessment. The Forest will complete consultation in this unit in the future before grazing resumes" (USDA 2011).

The riparian corridors are important in creating and maintaining channel form and function, thermal regime (i.e., shading), and ecological connectivity. In the moderately confined and unconfined valley segments in the Middle and Upper Yankee Fork subwatersheds, historic livestock grazing of the riparian corridors and access to the channel probably resulted in channel widening from removal of vegetation along the channel and trampling along the banks to access water, in addition to increased fine sediment and nutrient inputs. Presently, the USFS is excluding livestock grazing in the Garden Creek C&H allotment located in the Middle and Upper Yankee Fork subwatersheds and will complete consultation before grazing resumes. The riparian vegetation has and continues to improve in density and vitality along stream corridors that were grazed and is trending toward a properly functioning condition.

7.2.3 Timber Harvests

During the mining boom in the late 1800s and early 1900s, timber was extensively harvested to support the mining industry. The 1916 Intensive Land Classification for the Challis National Forest, states that along the Yankee Fork, "most of the good timber was taken out years ago for mining use and for cordwood." In addition, most of the lumber used in building Custer and Bonanza was cut in Lavalle Creek (now Sawmill Creek) that enters West Fork near Bonanza. There are also indications that many side drainages along the Custer Motorway were logged during this time period (USFS 2006).

Presently, there is little logging activity occurring in the watershed. From about the early 1980s to 2006, there was just over 100 acres of timber harvested in the watershed (Table 9). No large or mature trees appear to have been harvested during this timeframe.

Table 9. Timber harvests in the Yankee Fork watershed.

Subwatershed	Interval (Years)	Harvest (Acres)	Successional Stage
Middle Yankee Fork	Unknown	5.7 acres	Seedling
Lower Yankee Fork	1983-1987 (Bonanza) 2006 (Pole Flat)	76.7 acres	Sapling/Pole
Jordan Creek	1987	12.5 acres	Pole
West Fork	1993 (?)	10 acres	Pole

Sources: Salmon-Challis National Forest Timber Sale Harvests geodatabase 2010, and USFS 2006

Historic logging activities impacted physical and ecologic processes associated with the riverine systems in many ways that include; (a) timber removal from the valley bottoms and walls, and side drainages would have increased sediment supply and delivery to the channel network due to erosion associated with the disturbed areas; (b) loss of large and mature trees would have depleted the quantity and quality of wood supplied to the channel network which would have resulted in decreased in-stream complexity and habitat; and (c) removal of woody vegetation along stream corridors would have destabilized streambanks resulting in channel widening and/or increased lateral channel migration rates.

More recent timber harvests (1980s to present) have been minor with the removal of seedling-to-pole size trees. Vegetation density and coverage along the stream corridors and valley walls have been improving, except in areas where dredge tailings persist. With the improving riparian and upland vegetation conditions, sediment supply and delivery to the channel network should trend towards more natural levels of variability. As the vegetation progresses from small tree to mature tree successional stages, larger wood sizes will become increasingly more available to the channel networks and should result in an increase in channel complexity, and improved habitat quantity and quality.

7.2.4 Anthropogenic Disturbance History Conclusions

Mining activities have resulted in the most significant anthropogenic disturbances in the watershed. Water quality has been negatively impacted by chemical contaminants in the past (Rodeheffer 1935), and there remains the potential risk that these chemical contaminants from tailings and processing areas could eventually be released into the waterways. Further discussion on this indicator is contained in Section 7.4 *Water Quality and Quantity* of this report.

The dredged area along the Yankee Fork valley bottom between Jordan Creek and Pole Flat Campground, and the lower 1.4-mile section of lower Jordan Creek are the most negatively affected areas based on physical and ecological processes. Valley bottoms were cleared of vegetation and are now predominantly barren mounds of dredge tailings with isolated patches of vegetation resulting in fragmentation of terrestrial and aquatic ecological interactions. The construction of the Yankee Fork channel and channelization of tributaries through the dredge tailings has further confined these channels and reduced channel/floodplain interactions, disconnected tributaries, and increased flow velocities basal shear stress within the channel. Impacts to aquatic habitat include: (1) loss of juvenile rearing habitat and high water refugia; (2) reduction in spawning habitat; (3) isolation of tributaries that historically provided juvenile rearing habitat; and (4) increased flow velocities and basal stress in several channels. Further discussions at the reach-scale are presented in Section 8 *Valley Segments and Geomorphic Reaches* of this report.

Past livestock grazing and timber harvest practices impacted (1) channel form and function; (2) streambank stability; (3) sediment supply and delivery; (4) thermal regimes; and (5) ecological connectivity. Current USFS management practices preclude livestock grazing and timber harvest activities on their administered lands. The indication is that vegetation density and coverage along stream corridors and valley walls have been improving, except in areas where dredge tailings persist. The improving riparian and upland vegetation conditions have positively impacted sediment supply and delivery processes to the channel network by reducing erosion and providing streambank stability. In addition, as vegetation grows and progresses from small tree to mature tree successional stages, larger wood sizes will become increasingly more available to the channel networks.

The condition rating for anthropogenic disturbance history is at risk due to negative impacts from past and present mining activities.

7.3 Riparian Reserves

The USFS evaluated the condition of riparian conservation areas by 6th field HUC subwatersheds. The upper Yankee Fork, middle Yankee Fork, and West Fork subwatersheds were reported to be at or near natural levels for riparian vegetation (USFS 2006). In the dredged areas in the lower Yankee Fork and Jordan Creek subwatersheds, there is a thin riparian corridor that is fragmented due to the dredge tailings.

7.3.1 Riparian Reserves Conclusions

The overall condition rating for Riparian Reserves (or Riparian Conservation Areas) is functioning at risk due to the impacts from dredging (USFS 2006). The lack of a riparian vegetation corridor being re-established along waterways in the dredge tailing areas, and the lack of connectivity between vegetation patches has negatively impacted ecological connectivity for both aquatic and terrestrial species.

7.4 Water Quality and Quantity

7.4.1 Overall Water Quality

All waters of the State of Idaho are designated for agricultural and industrial water supplies, wildlife, and aesthetics (IDEQ 2003). The Idaho Department of Environmental Quality (IDEQ) has further designated the beneficial uses for the Yankee Fork water body as follows: domestic water supply; cold water biota; salmonid spawning; primary contact recreation; and special resource water (IDEQ 2003).

Water impairments listed on the 1998 303(d) include the following (IDEQ 2003):

- Yankee Fork from Jordan Creek to Salmon River, about 9 river miles listed for sediment and habitat alteration.
- Yankee Fork from Fourth of July Creek to Jordan Creek, about 2.9 river miles listed for sediment and habitat alteration.
- Yankee Fork within Forest boundaries is listed for sediment.

The *Upper Salmon River Subbasin Assessment and TMDL, January 2003* (IDEQ 2003), found that "*the biological signal is that the Yankee Fork is in Full Support of beneficial uses for coldwater biota and salmonid spawning. Full Support does not indicate that spawning habitat is in optimal condition. Perturbance of habitat is not a recognized pollutant for which a TMDL is prepared*." As a result of these findings, the Yankee Fork is solely listed for Habitat Alteration and will continue to be monitored for changes in beneficial use support. Additionally, a total maximum daily load (TMDL) for sediment was determined to not be warranted at that time.

In the *Department of Environmental Quality Working Principles and Policies for the 2008 Integrated (303[d]/305[b]) Report* (IDEQ 2009), the Yankee Fork from source to mouth was classified as Category 2, which means the water body was found to be fully supporting those beneficial uses that were assessed. The Yankee Fork from its source waters to Jordan Creek was classified as Category 4c which means the water body was identified as impaired due to physical habitat alterations but did not require preparation of a TMDL. In the Draft 2010 Integrated Report, the Yankee Fork from its source to Jordan Creek has been proposed for delisting for physical substrate habitat alterations and sedimentation/siltation because applicable water quality standards were attained and the original basis for listing was found to be incorrect (IDEQ website: http://www.deq.idaho.gov/water-quality/surface-water/monitoring-assessment/integrated-report.aspx).

7.4.2 Fine Sediment

The NOAA Fisheries Service's Matrix of Pathways and Indicators (NOAA Fisheries 1996) is not currently incorporated into the State of Idaho Water Quality Standards or the Water Body Assessment Guidance. Presently, TMDLs are not prepared based on risk. They are only intended to address beneficial uses and meet the intent of the Clean Water Act (IDEQ 2003). Some information was available on fine sediment (Table 10), but was found to be inconclusive and therefore identified as a "data gap" in which more information was needed (IDEQ 2003).

The following is a summary on fine sediment from a Salmon-Challis National Forest Biological Assessment for potential effects (USFS 2006). The Challis National Forest Plan identified a sediment standard of 30 percent fines. Below this threshold, habitat is considered to be at full capability and the substrate condition ceases to be a limiting factor. The highest fine sediment measurements collected in the Yankee Fork watershed were in Tenmile Creek, McKay Creek, and the Yankee Fork below Tenmile Creek. Surface fines (fine sediment) are not considered a limiting factor; core sampling data indicates averages of 14 to 28 percent fines at depth.

Table 10. Salmon-Challis National Forest Core Sampling Sediment Data (USFS 1999).

Core Sampling Sediment Trends – 1995 to 1999 – Mean Percent (%) Fines					
Stream/Station	1995	1996	1997	1998	1999
Yankee Fork 1A	27.1	20.5	19.6	27.8	24.1
Yankee Fork 2A	15.6	29.5	14.9	22.6	27.5#
Yankee Fork 3A	13.2	29.1	5.3	14.7	24.2#
Yankee Fork 4A	40.6	36.1	27.4	25.2	32.7*
Yankee Fork 5A	31.5	29.7	23.6	21.0	15.7*
WF Yankee Fork	21.9	-	27.5	18.1	25.1
Jordan Creek 0A	26.2	32.1	18.4	13.9	15.3*
Jordan Creek 1A	17.6	-	-	-	-
Jordan Creek 2A	16.0	22.5	18.0	17.5	21.1#
Jordan Creek 3A	14.3	23.5	16.7	10.9	23.1#
Jordan Creek 4A	13.5	-	-	-	-
Fivemile Creek 1A	14.3	-	20.8	28.8	11.7
Tenmile Creek	32.3	-	36.9	28.5	33.7
McKay Creek 1A	19.0	-	29.3	33.2	30.1#

#Significant increase over the five-year period (1995-1999).
*Significant decrease over the five-year period (1995-1999).
Stream in **bold** are 303(d) listed for sediment.

7.4.3 Surface Water Temperature

Table 11 and Table 12 summarize the water temperature thresholds used by the Salmon-Challis National Forest and IDEQ. Water temperature monitoring by the Salmon-Challis National Forest indicate that the maximum weekly (7-day average) maximum temperature at most water temperature monitoring stations along the mainstem Yankee Fork and West Fork exceeded the temperature limits set by the USFS. The 2001 Yankee Fork Watershed Analysis explains that water temperatures are generally less than 57º F within most reaches (USFS 2006). Water temperatures are warmer during the late summer period in the Yankee Fork below Jordan Creek and fish seek refugia in cooler tributary streams (i.e., West Fork where water temperatures are generally 37 to 41º F). Water temperature is not considered limiting in most surface waters, with the exception of the dredged area on the Yankee Fork below Jordan Creek (USFS 2006).

Table 11. USFS water temperature standards for salmonids (USFS 2006).

Use Metric	Salmonid Incubation	Salmonid Juvenile Rearing	Salmonid Spawning
MWMT[1]	36-41º F (2-5º C)	39-54º F (4-12º C)	39-48º F (4-9º C)

[1]MWMT = Maximum Weekly (7-day average) Maximum Temperature

Table 12. IDEQ water temperature standards for cold water use (http://www.deq.idaho.gov/water-quality/surface-water/temperature.aspx).

Use Metric	Cold Water	Salmonid Spawning	Bull Trout
MDMT[1]	72º F (22º C)	55º F (13º C)	N/A
MWMT[2]	N/A	N/A	55º F (13º C)
MDAT[3]	66º F (19º C)	48º F (9º C)	N/A

[1]MDMT = Maximum Daily Maximum Temperature
[2]MWMT = Maximum Weekly (7-day average) Maximum Temperature
[3]MDAT = Maximum Daily Average Temperature

Detailed thermal imaging was conducted in 2010 along the Yankee Fork between RM 16.4 and 3.4, Jordan Creek between RM 4 and 0, West Fork, and Rankin Creek in August 2010 (Watershed Sciences 2010). Complete analysis of the data and trends are included in Appendix J. The following is a brief summary of the analysis within the TA area (Yankee Fork and Jordan Creek).

Along the Yankee Fork mainstem between about RM 16.4 and 3.4, water temperatures generally ranged from 48 to 56º F. Eightmile Creek (RM 16.4) and Jordan Creek (RM 9.1) were noted to contribute warmer waters to the mainstem. The West Fork had an insignificant influence on water temperature in the Yankee Fork. Some tailing pond outlets contributed warmer waters, but most contributed cooler waters. Several smaller tributaries and springs contributed cooler waters and their locations were noted in the analysis.

In Jordan Creek between about RM 4 to the Yankee Fork confluence, water temperatures generally ranged from 49 to 60º F. Along the lower ½-mile of the creek, water temperatures exceeded 59º F. A mine discharge outlet near RM 4 contributed significantly warmer waters to Jordan Creek. Inflows from tributaries contributed predominantly cooler waters with only a few exceptions.

Warm water temperatures and their effects on habitat quality are a concern primarily in the Yankee Fork downstream of Jordan Creek. In general, warm water contributions to the Yankee Fork come from Jordan Creek and some tailing pond outlets. There are also several smaller tributaries, springs, and tailing ponds that contribute cooler waters to the Yankee Fork. Locations of warm and cool water sources should be considered when evaluating alternatives to improve habitat such as reconnection of isolated habitats that could maximize refugia for fish seeking cooler waters.

7.4.4 Chemical Contaminants

Selenium naturally occurs as varying compounds in many volcanic rocks and soils, and can be concentrated by hydrothermal processes associated with volcanism. Weathering and erosion processes can liberate the soluble forms of selenium which can be readily transported by runoff. Mining of the epithermal veins to recover precious metals may have produced higher concentrations of selenium by increasing the surface area of the source rock that is exposed to weathering (Frost and Box 2009).

Low to moderate concentrations of mercury were most likely deposited by hydrothermal processes during the Challis Volcanics episode, but there are no indications that high concentrations naturally occur (i.e., cinnabar deposits) (Fisher and Johnson 1995). However, elemental mercury was used in some areas where the extraction and processing of ore and placer deposits occurred. Varying concentrations of elemental mercury could be anticipated wherever placer mining, hard-rock mining, and ore processing have occurred throughout the watershed (Frost and Box 2009).

The effects of selenium and mercury on aquatic life were assessed for this TA (Appendix B). Background selenium concentrations appear to have low to no risk to aquatic life in the system based on available information (Frost and Box 2009). Bioaccumulation of selenium appears to be occurring through the food chain, suggesting a slight elevated risk of toxicity to aquatic life based on Environmental Protection Agency (EPA) guidelines (EPA 2004, Rhea et al. 2008). Anadromous fish populations may be at lower risk of selenium bioaccumulation, while resident fish populations may be at a higher risk for selenium bioaccumulation. This difference in risk is due to the length of time (period) and life stage(s) they utilize the watershed which directly influences the fish's rate of selenium bioaccumulation.

Mercury levels found in fish and fish tissues obtained do not indicate any considerable contamination. Studies (Rhea et al. 2008; Frost and Box 2009) suggest there is little bioconcentration of mercury from the sediments to the fish tissues. According to the EPA and State of Idaho human health concern criteria, there is little or no risk to human health and the aquatic environment from mercury in the fish tissues of the second trophic level fish that were analyzed.

Life histories of anadromous and fluvial fish species need to be considered in the evaluation of the potential harmful effects of selenium and mercury concentrations. These fish spend most of their lives outside of the watershed which may help protect them from accumulating harmful concentrations. The result is that the body burdens of these fish are most likely an integration of toxic loads from other water bodies.

There remains a potential risk of chemical contamination from past and present mining activities (i.e., selenium, mercury, cyanide, etc.). Past mining activities are known to have had negative water quality impacts. For example, Rodeheffer (1935) reported “that creek (Jordan Creek) is so badly polluted by several small mines along its course that no fish or fish foods are found.” Pollution control efforts have been implemented at the Grouse Creek Mine which is being reclaimed to control discharge of cyanide from leaking tailings ponds into Jordan Creek, and Preachers Cove ore processing site on the Yankee Fork near RM 7.3 has been reclaimed (IDEQ 2003).

Presently, there are no chemical contaminants which affect water quality that are not within IDEQ standards. However, some chemical contaminant sources related to past and present mining activities pose a risk that contaminants may become available to the channel network. Therefore, water quality continues to be a “threat” to aquatic species (primarily due to chemical contamination).

7.4.5 Water Quantity

The USGS streamflow gage (USGS Gage Number 13296000) discharge statistics for the period of record (May 1921 to February 1949) include the following:

Mean annual flow	=	197 cfs
Mean annual peak flow	=	1,603 cfs
Maximum daily average flow	=	3,360 cfs (June 12, 1921)
Minimum daily mean flow	=	10 cfs (December 5 and 6, 1927)

The Tribes have been taking periodic instantaneous stream discharge measurements since 2006 in the lower part of the watershed. The USGS is planning to install a continuous data collector at the historic gaging station site on the Yankee Fork so that future monitoring of hydrograph changes will be possible.

There are no dams that regulate flows in the watershed, and there is no evidence of a change in hydrograph timing, peak flow, or base flow from the available records. Total surface water and groundwater withdrawals based on water rights within the Yankee Fork watershed are about 46 cfs, or 23 percent of the mean annual discharge (197 cfs).

Water quantity is an indicator of available habitat for salmonids in a waterway. Thresholds associated with determining the functional condition of water quantity are vague (i.e., adequate versus inadequate instream flows). Presently, water quantity appears to be adequate since the Yankee Fork and primary fish-bearing tributaries maintain year-round instream flows.

7.4.6 Water Quality and Quantity Conclusions

Water quality presently meets IDEQ standards. Additional consideration was given to water quality indicators described in NOAA Fisheries 1996 matrix of pathways and indicators. Conditions of these indicators based on the suggested thresholds in the matrix of pathways and indicators were all found to be currently functioning properly although there was some variability for the fine sediment and surface water temperature indicators. Although the chemical contamination indicator is currently within the properly functioning threshold, there are some chemical contaminant sources related to past and present mining activities that may become available to the channel network through natural and anthropogenic disturbances; thereby, posing a threat to aquatic species. The ongoing mining activities and presence of elemental mercury from past mining in the watershed justifies a condition rating of at risk for chemical contamination.

Instream flows (water quantity) are currently sufficient to maintain year-round access through the Yankee Fork mainstem to other fish-bearing tributaries (i.e., West Fork, Jordan Creek, Eightmile Creek, etc.). There are no dams regulating flows and there is no evidence showing a change in the hydrograph timing, peak flow, or base flow for the period of record. Therefore, based on current information, the water quantity indicator is functioning properly.

7.5 Habitat Access

There are no man-made physical barriers present on the mainstem of the Yankee Fork that prevent fish passage. However, some tributaries have been disconnected by man-made physical barriers (i.e., dredge tailings) that were generally discussed in the *Mining Activity* subsection of *Anthropogenic Disturbances*. These disconnected tributaries and channelized sections are discussed in more detail at the reach-scale in Section 8 *Valley Segments and Geomorphic Reaches* of this report.

7.5.1 Habitat Access Conclusions

The threshold provided in the matrix of pathways and indicators for properly functioning is that there are no man-made (physical) barriers that restrict fish passage. At the watershed-scale, this threshold implies that there are no mainstem, man-made physical barriers such as large water storage dams that prevent fish access into the watershed or a large area of the watershed. Since there are no man-made physical barriers that prevent watershed access, the habitat access indicator is properly functioning.

7.6 Habitat Elements

The Biological Appendix (Appendix H) includes an analysis of habitat conditions from several stream surveys dating back to 1934. The following is a summary covering the TA area.

The U.S. Bureau of Fisheries conducted a stream survey of the Yankee Fork in 1934 (Rodeheffer 1935). Information from this report indicated that the Custer Motor Highway followed the entire length of the Yankee Fork and McKay Creek. Stream temperatures on the Yankee Fork did not exceed 60º F and flow decreased greatly during the latter part of summer. In the lower section of Yankee Fork, Rodeheffer (1935) found that the stream substrate was almost entirely made up of large stones and boulders. Above Fivemile Creek, he mentions that the stream substrate is composed largely of gravel and that salmon spawn in this region. According to Rodeheffer (1935), good pools were lacking, but spawning areas were excellent.

Two recent stream surveys completed in the Yankee Fork watershed show some similarities to those of Rodeheffer (1935). In 2001, the USFS conducted a R1/R4 Fish Habitat Inventory on the Yankee Fork mainstem. This survey was completed from the mouth of the Yankee Fork upstream to the confluence with Jordan Creek. Results of the survey indicated a lack of pools and high width/depth ratios. Spawning and rearing habitat were identified as in poor condition in the dredged area and in fair to good condition upstream of the dredge tailings and in the West Fork. The 2001 survey also found that pool frequency, pool quality, large woody debris, and instream cover were limiting for juvenile rearing habitat.

In 2010, a Level II Stream Inventory Survey was conducted by the Wallowa-Whitman National Forest La Grande Ranger District using protocols listed in the *Pacific Northwest Region, Region 6, Stream Inventory Handbook, Level I & II, Version 2.10* (USFS 2010). The survey covered the mainstem Yankee Fork between about RM 17.1 and 2.6 (Appendix K), and Jordan Creek between about RM 3.6 to its confluence with the Yankee Fork (Appendix L). The purpose of this inventory was to identify existing stream channel, riparian, and aquatic ecosystem conditions for the Yankee Fork and Jordan Creek within the TA area.

Results of the 2010 Level II stream habitat survey for the Yankee Fork and Jordan Creek indicated that overall, stream habitat conditions have not changed substantially between the 2001 R1/R4 Fish Habitat Inventory and the 2010 Level II Stream Habitat Survey, and likely have changed only within Reach 3 since the 1934 survey.

7.6.1 Habitat Elements Conclusions

The Riparian Management Objectives and other similar objectives (i.e., matrix of pathways and indicators) provide guidance on the desired quantity and condition of habitat elements. Knowledge of fluvial processes and habitat potential is left to the investigator, or evaluator, to determine the habitat elements that are appropriate based on the geomorphology and hydraulics of the river. For this TA, a condition rating of habitat elements at the watershed-scale is not appropriate due to the area of the watershed surveyed; variability in valley and channel confinement; and variability in channel types that strongly influence which habitat elements would be expected (i.e., large wood and pool frequency). Condition ratings are generally applied at the valley segment or geomorphic reach when a Reach Assessment is conducted. With that said, brief discussions on the applicability of the habitat elements and desired objectives (or matrix of pathways and indicators threshold) for each geomorphic reach are in Section 8 *Valley Segments and Geomorphic Reaches* of this report.

7.7 Watershed Condition Summary

The most significant impacts in the watershed that affect physical and ecological processes are from mining activities, especially in the Lower Yankee Fork and Jordan Creek subwatersheds (Table 13). Due to the mining impacts, an at risk condition rating was given for the following indicators: (1) anthropogenic disturbance history; (2) riparian reserves; and (3) water quality. The road density and location indicator also received an at risk condition rating due to several roads being located on the valley bottoms and adjacent to waterways.

Table 13. Watershed condition summary.

Watershed Pathway or Indicator	Condition Rating	Comments
Road density and location	At risk	The watershed appears to have a low road density (less than 2 mi/mi^2); but these calculations do not include mining access roads or all-terrain vehicle trails; and there are several roads located on the valley bottoms and adjacent to waterways

Watershed Pathway or Indicator	Condition Rating	Comments
Anthropogenic disturbance history	At risk	Mining activities in the lower Yankee Fork and Jordan Creek subwatersheds have negatively impacted riverine processes
Riparian reserves	At risk	Riparian reserves are at or near natural levels throughout most of the watershed; the exceptions are in the dredged reaches in the lower Yankee Fork and Jordan Creek subwatersheds
Water quality and quantity	Water quality – at risk Water quantity – properly functioning	There remains a threat to water quality and aquatic species due to potential chemical contaminants associated with past and present mining activities
Habitat access (Yankee Fork mainstem)	Properly functioning	There are no man-made fish passage barriers along the mainstem Yankee Fork preventing fish migration into the watershed
Habitat elements	Not rated	The desired habitat elements to meet thresholds in the Riparian Management Objectives or matrix of pathways and indicators need to be considered at the valley segment or reach scales; therefore a condition rating is not provided at the watershed-scale

8. Valley Segments and Geomorphic Reaches

The Yankee Fork is a 5th field HUC watershed that has been divided into five 6th field HUC subwatersheds. These subwatersheds include the upper Yankee Fork, middle Yankee Fork, lower Yankee Fork, Jordan Creek, and West Fork. The TA area is located in the middle Yankee Fork, lower Yankee Fork, and Jordan Creek subwatersheds. The upper Yankee Fork and West Fork subwatersheds were not included in the geomorphic reach prioritization because they are within the jurisdiction of the Salmon-Challis National Forest, and the geomorphic reach prioritization objectives in the TA were primarily focused on privately owned lands.

Valley segments were analyzed to identify significant differences in valley form, type, gradient, and confinement (Appendix G). The following valley classifications were used in this analysis:

- Valley form from Naiman et al. (1992) as recommended by Hillman (2006).
- Valley type from Bisson, Buffington, and Mongomery (2006).
- Valley confinement from Hillman (2006) and ODFW (2010).

Further analysis was completed to help identify and delineate geomorphic reaches. Valley segments influence the overall channel type in a natural system, but in disturbed systems channel types may have changed within the valley segment due to anthropogenic impacts. In this analysis, the channel type classifications are based on the works of Montgomery and Buffington (1998) and the dominant channel type is described and, where appropriate, a range of channel types may be described for each geomorphic reach:

- Colluvial channel – channels that typically occupy headwater portions of a channel network and occur where drainage areas are large enough to sustain a channel for the local ground slope.
- Bedrock channel – channels with very little alluvial bed material or valley fill, and are generally confined by valley walls and lack floodplains.
- Free-formed alluvial channel – alluvial channels that exhibit a wide variety of bed morphologies and roughness configurations that vary with slope and position; channels can further be defined by the channel bedform; cascade, step-pool, plane-bed, pool-riffle, or dune-ripple.
- Forced alluvial channel – channels with external flow obstructions, such as large wood, wood complexes, and bedrock outcrops, that force local flow convergence, divergence, and sediment impoundment that form pools, bars, and steps.

Results from a steady flow one-dimensional hydraulic model using Hydrologic Engineering Center – River Analysis System (HEC-RAS) were used as a predictive tool to analyze the hydraulic conditions for the TA area (Appendix M). The model estimated water surface elevation, flood inundation area, shear stress, and flow velocity along 17 river miles of stream channel including 13 river miles along the Yankee Fork and 4 river miles along Jordan Creek. The objectives of the hydraulic modeling were to:

a. Estimate the water surface elevations for the 2-, 10-, and 100-year recurrence interval flood discharges.

b. Estimate the average channel shear stress for the 2-year recurrence interval flood discharge.

c. Estimate the average velocity of flow in the main channel during the 2-year recurrence interval flood discharge.

d. Estimate the flood inundation areas for the 10- and 100-year recurrence interval flood discharges, approximately equivalent to the valley constraints and the base flood elevation, respectively.

8.1 Valley Segment Morphologies

8.1.1 Yankee Fork

Along the Yankee Fork longitudinal channel profile (Figure 18) the channel slope is steepest in the upper headwater area and then progressively decreases in gradient in the downstream direction. There are three prominent perturbations along the channel slope that are controlled by geologic features. The slope deviation between about RM 28 and 25 in the upper Yankee Fork section is the basal section of a glacial cirque, which was excavated by alpine glaciers. Between about RM 15 and 12 in the middle Yankee Fork section, the change in slope is the result of a landslide deposit that blocked the river, impounding a lake until the river was able to incise through the deposit. Finally, the steepening of slope between RM 3 and 0 in the lower Yankee Fork section is related to river incision most likely associated with the Idaho batholith uplift and base-level change along the mainstem Salmon River creating a V-shaped canyon.

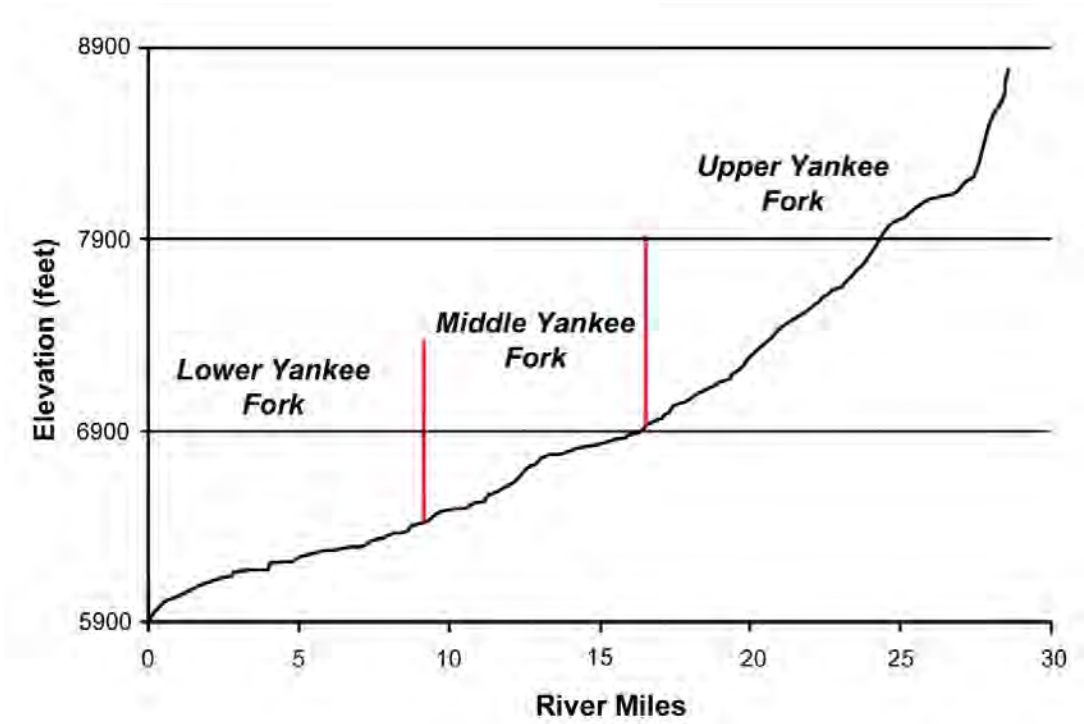

Figure 18. Yankee Fork longitudinal channel profile showing subwatershed locations.

8.1.2 Jordan Creek

The channel slope is steepest in the headwater area and then progressively decreases in gradient in the downstream direction (Figure 19). The steep channel slope between RM 8 and 6.4 and flatter slope between RM 6.4 and 4 resulted from the erosion of alpine glaciers. Glaciers formed in the steeper section (RM 8 to 6.4) eroding a steep-walled recess (cirque) and then flowed down the valley eroding a U-shaped trough (RM 6 to 4). The stream has been eroding through the Challis Volcanics creating a V-shaped bedrock canyon from RM 4 to 1.4, and depositing alluvium between about RM 1.4 and the Yankee Fork/Jordan Creek confluence.

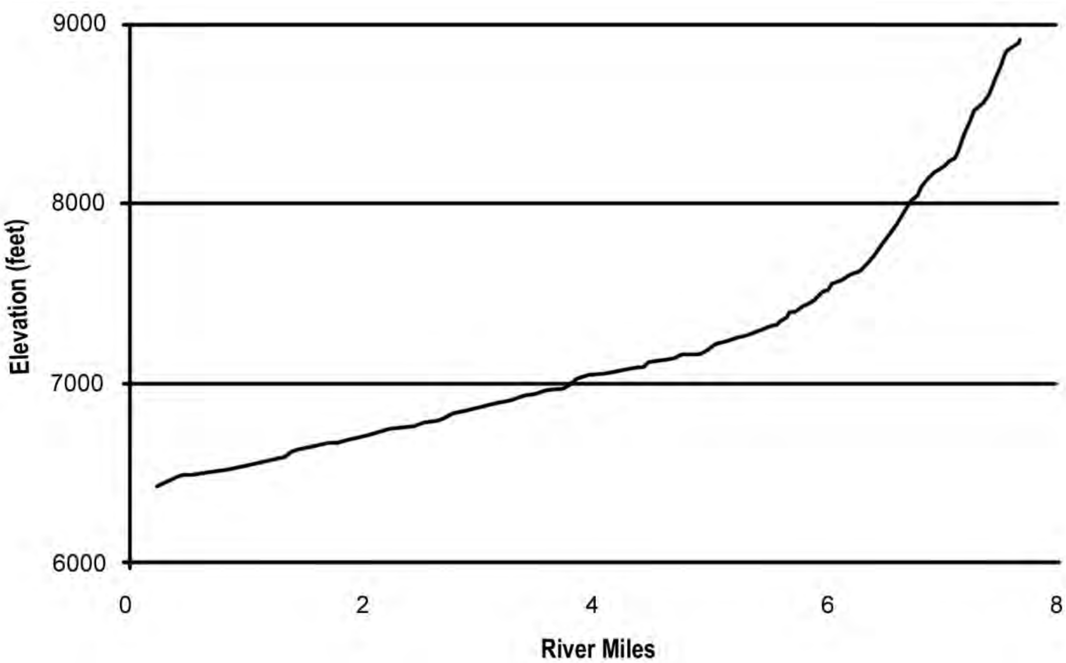

Figure 19. Jordan Creek longitudinal channel profile.

8.2 Middle Yankee Fork Subwatershed

8.2.1 Geomorphic Reach Delineations

The middle Yankee Fork subwatershed is located between about RM 16.3 and 9.1 with a drainage area of 44.3 mi^2 and a drainage density of about 1.56 mi/mi^2. Bedrock geology is the Challis Volcanics that are offset by the northeast trending Trans-Challis fault system which controls the location of the southern bounding fault along the Custer graben. The valley's north-northeast orientation coincides with these geologic structures that control the location and position of the Yankee Fork. Alpine glaciers and a landslide have influenced the valley form, type, and confinement which influence the channel type, slope, and bedform (Table 14 and Figure 20).

The analysis showed that the valley segments and geomorphic reaches are coincident based on geologic history, geomorphic process, and channel morphology. Figure 21 shows the location of the geomorphic reaches and is an index map for each of the geomorphic reach maps.

Table 14. Middle Yankee Fork geomorphic reach delineations and associated channel morphology.

River Miles	*General Valley Location*	Geomorphic Reaches	*Valley Form*[1]	*Valley Type*[2]	Valley Confinement[3]	Valley Gradient	*Channel Reach Type*[2]	Channel Bedform Type[2]	Channel Slope	Dominant Substrate Size Class[4]
RM 16.3-13.2	***Upper Section***	***Reach YF-6***	U1: U-shaped trough	Alluvial	Unconfined	0.76 percent	***Free-formed alluvial channel***	Pool-riffle	0.66 percent	Gravel
RM 13.2-11.6	***Middle Section***	***Reach YF-5***	V3: V-shaped bedrock canyon	Bedrock	Confined	2.34 percent	***Bedrock channel***	Step-pool	2.24 percent	Bedrock
RM 11.6-9.1	***Lower Section***	***Reach YF-4***	V4: Alluvial mountain valley	Alluvial	Moderately Confined	1.20 percent	***Free-formed alluvial channel***	Plane-bed	1.10 percent	Gravel

[1]Classification based on Naiman et al. (1992) as recommended in Hillman (2006)
[2]Channel type classification based on Montgomery and Buffington (1993)
[3]Monitoring Strategy for the Upper Columbia Basin (Hillman 2006)
[4]From Stream Inventory Survey 2010 (Appendix K) and USFS (2006)

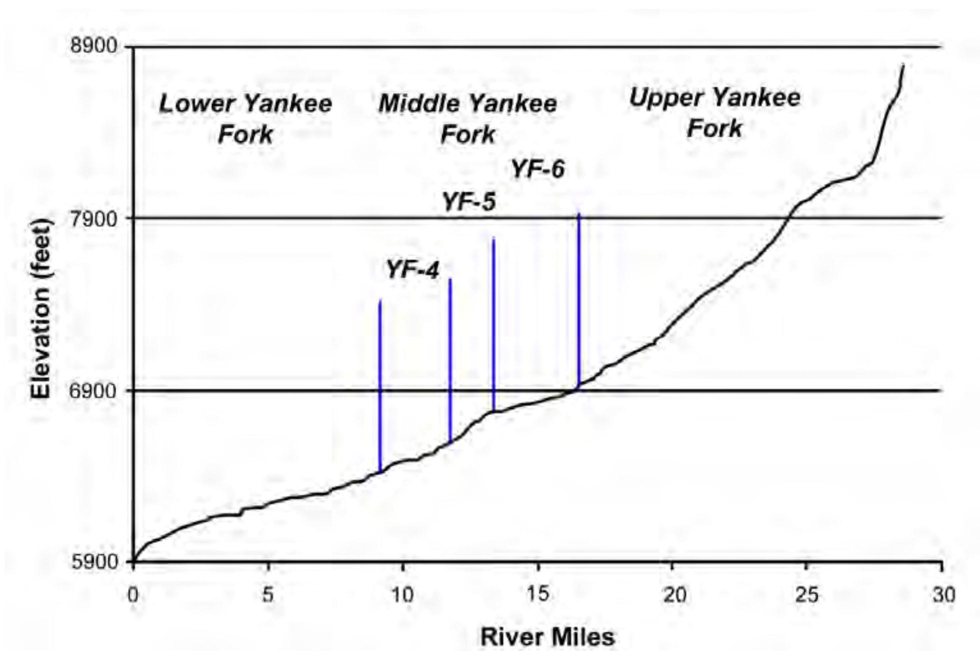

Figure 20. Middle Yankee Fork subwatershed longitudinal channel profile with reach locations.

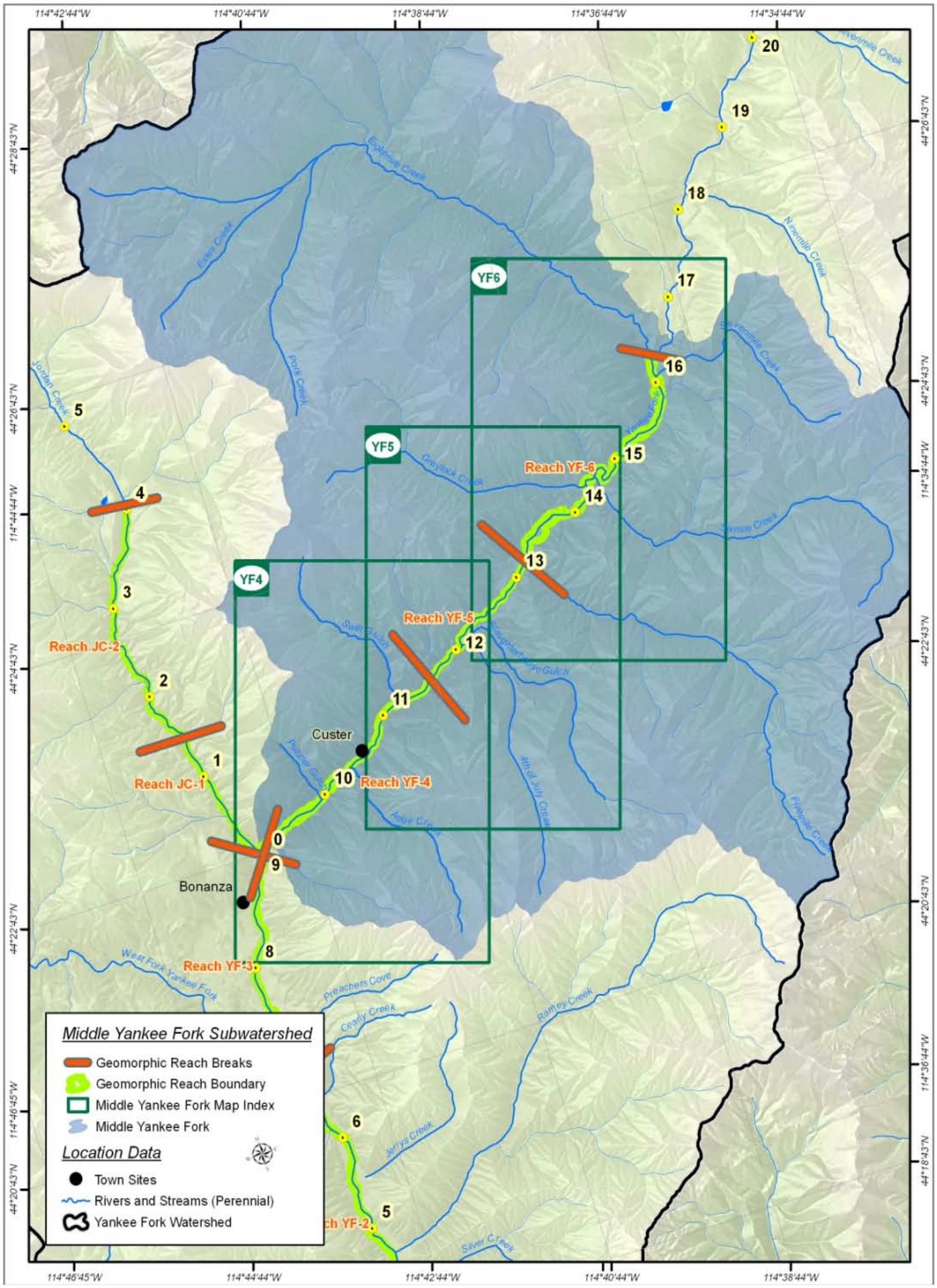

Figure 21. Middle Yankee Fork subwatershed index map with geomorphic reach breaks.

Geomorphic Reach YF-6

Geomorphic Reach YF-6 (Figure 22) is located between about RM 16.5 and 13.3, in an unconfined valley segment. The river has a channel slope of about 0.7 percent that is influenced by glacial outwash deposits and a landslide downstream in Geomorphic Reach YF-5. The landslide impounded the river long enough to create a lake that subsequently filled with sediment and resulted in a relatively flat slope. Channel pattern is predominantly straight with an overall sinuosity of about 1.15 and there are some channel segments that do have meandering channel patterns. The overall rate of lateral channel migration is considered to be low-to-moderate based on these channel patterns (Beechie et al. 2006). The channel type is predominantly a free-formed alluvial channel along the straighter channel segments. There are some channel segments trending towards a forced alluvial channel type where there has been lateral channel migration and flows interact with wood complexes (i.e., logjams) and vegetated bars.

The one-dimensional hydraulic modeling shows that the active channel/floodplain interactions are connected and the channel can access adjacent floodplain areas, oxbows, and side channels. Streamflows begin to access adjacent floodplains, oxbows, and side channels at the 1.11-year recurrence discharge. The average shear stresses in the main channel during the 2-year recurrence discharge is approximately 0.5 pounds per square foot (lb/ft^2) which indicates the river is capable of transporting gravels up to about 1.3 inches in dimension. There are two minor peaks in shear stress. At RM 15.6, the channel is constrained on the left bank by a steep valley wall and at RM 14.4 downstream of the alluvial fan deposits from Greylock Creek, velocities have increased where the channel is constrained by a steep embankment on river left. The average flow velocity in the main channel of Reach YF-6 during the 2-year recurrence discharge is 4.7 feet per second (ft/s).

Local coarse sediment inputs are from lateral channel migration and tributaries. The channel is reworking the floodplain deposits through lateral channel migration. Where the channel comes into contact with the lake deposits that are typically underlain with glacial outwash, erosion is occurring and contributing gravel with sand and fines to the system. There are five perennial tributaries and several ephemeral drainages that are providing sediment inputs. Perennial tributaries are providing sediment pulses during high flow events and serve as conduits for episodic debris flows. These perennial tributaries include: (a) Eightmile Creek near RM 16.3 on river right; (b) Sevenmile Creek near RM 16 on river left; (c) Sixmile Creek near RM 14.4 on river left; (d) Greylock Creek near RM 14.3 on river right; and (e) Fivemile Creek near RM 13.2 on river left. Greylock and Fivemile creeks, may also be contributing fine sediments from the erosion of lake deposits near their downstream ends. Ephemeral tributary sediment inputs are primarily from debris flows associated with high intensity thunderstorms. Ephemeral drainages that show evidence of these debris flows occur near RM 16.3 on river right, RM 16 on river left, RM 15.8 on river left, RM 15.6 on river left, RM 15.4 on river right, and RM14.7 on river left.

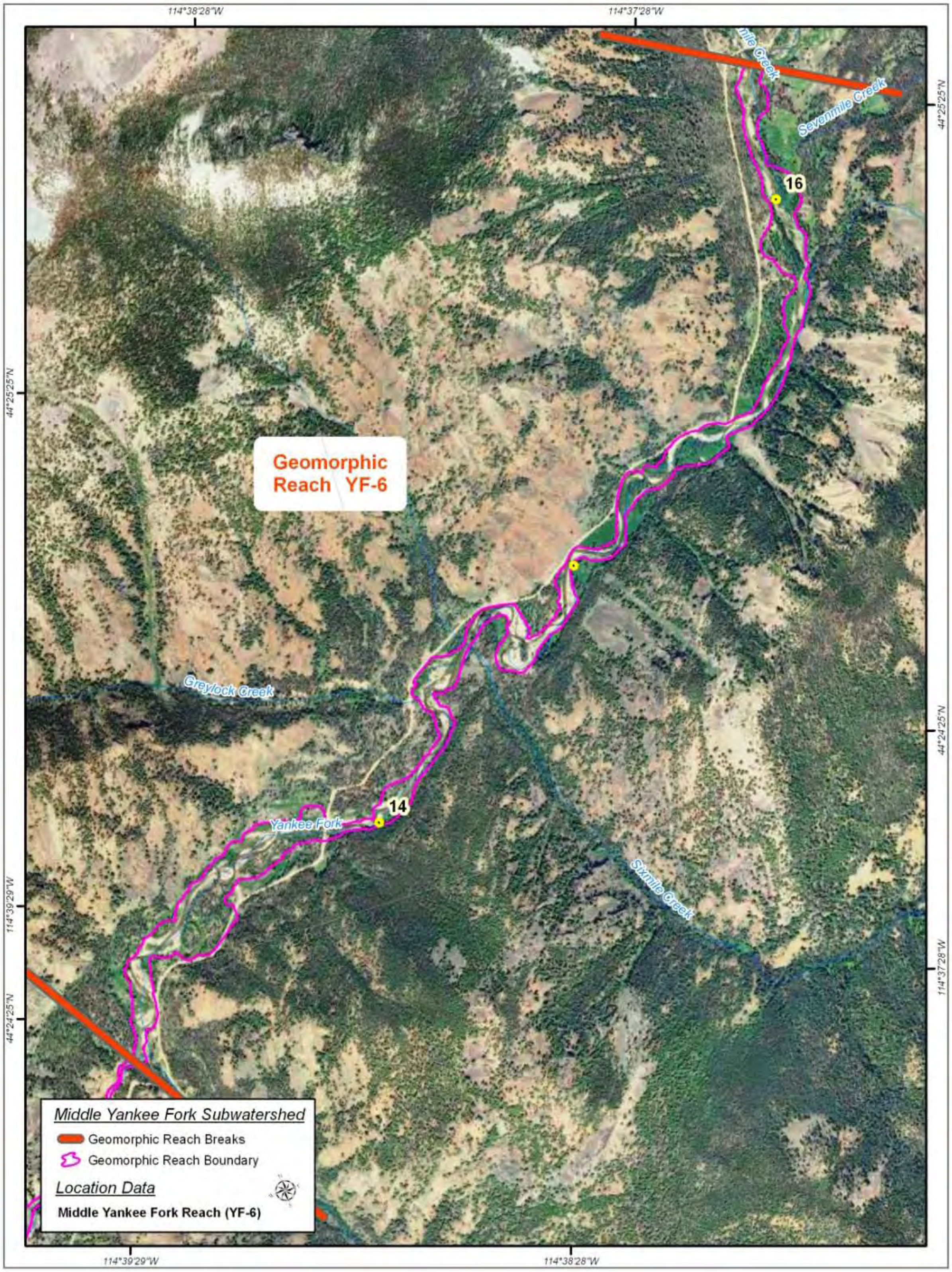

Figure 22. Yankee Fork Geomorphic Reach YF-6 in the middle Yankee Fork subwatershed.

Anthropogenic Disturbances

Historic timber removal from the floodplain and adjacent valley walls to support the mining boom in the late 1800s and early 1900s most likely depleted the number of large trees (i.e., ponderosa pine, Douglas-fir) available to the channel for recruitment. The removal of mature timber, and potentially fire suppression and insect kill, may have changed the vegetation assemblage that historically occupied this area prior to European settlement (Overton et al. 1999), enabling the encroachment of other species (i.e., lodgepole pine) which provides smaller wood sizes to the channel. Wood complexes comprised predominantly of lodgepole pines do create variability in channel processes that affect sediment deposition, scour, and habitat (Figure 23). However, larger wood sizes would more effectively contribute as a “forcing agent” to create a higher degree of channel variability and habitat complexity.

Other anthropogenic disturbances that have affected channel/floodplain processes include road embankments along the Custer Motorway adjacent to the channel, the Fivemile Creek Bridge crossing near RM 13.9, and dispersed campsites. Road embankments have encroached on the river in some locations and placement of bank protection along sections of the embankments affect lateral channel migration and bed scour along hard-points in localized areas. The Fivemile Creek Bridge causes artificial channel confinement, disconnects localized floodplain areas, and appears to create a backwater condition upstream of the bridge by imparting hydraulic controls at the 2-year and above recurrence floods. Campsites adjacent to the river impact riparian vegetation needed for bank stability and channel boundary roughness, and may provide additional fine sediment inputs to the river. However, at the reach-scale these anthropogenic disturbances affect a relatively small percentage of the geomorphic reach and modifications (or rehabilitation actions) would not significantly benefit fish production or abundance.

Figure 23. View to the southwest near RM 14.9 showing forced alluvial channel variability. *Wood complexes influence variability in channel processes and habitat complexity. Lake and glacial outwash deposits (eroded high bank in the background) are common in this geomorphic reach and provide sediment inputs of predominantly gravel to fines.* Bureau of Reclamation photograph by Dave Walsh, September 2, 2010.

Fish Usage, Channel Condition, and Habitat Elements

Chinook salmon and steelhead use this geomorphic reach for spawning and juvenile rearing, and as a migratory corridor. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation.

The following channel condition and habitat elements are from the 2010 stream inventory survey conducted by the USFS. The stream inventory survey divided the geomorphic reach into two habitat reaches based on tributary inflows (Table 15). Stream type classification for both habitat reaches was Rosgen (1996) C-stream type defined as a single-threaded channel that is slightly entrenched with moderate to high width-to-depth ratios, high sinuosity, and gravel channel material.

Table 15. Geomorphic Reach YF-6 stream inventory survey habitat reaches and channel condition.

River Miles	Habitat Reach	Geographic Description	Rosgen Stream Type	Average Wetted Channel Width	Average Bankfull Width	Average Floodprone Width
RM 16.4 – 14.4	Reach 9	Eightmile Creek to Sixmile Creek	C	26 feet	56 feet	121 feet
RM 14.4 – 13.2	Reach 8	Sixmile Creek to Fivemile Creek	C	28 feet	54 feet	128 feet

The number of pools per mile ranged from 18.3 to 19.3 with deep pools (greater than 3-feet depth) comprising about 60 to 65 percent of pool habitat (Table 16). Wood frequency for all wood measured ranged from 36 to 56 pieces of wood per mile.

Table 16. Geomorphic Reach YF-6 stream inventory survey habitat elements.

Habitat Reach	Dominant Substrate	Number of Pools Per Mile	Number of Pools > 3 Feet Deep Per Mile	Average Residual Pool Depth	Total Number of Wood Per Mile
Reach 9	Gravel (2-64 mm)	19.3	11.6	2.7 feet	56
Reach 8	Gravel (2-64 mm)	18.3	11.9	2.7 feet	36

Discussion and Potential Habitat Actions

The channel in this reach is unconfined with a channel slope of about 0.7 percent and the channel pattern is predominantly straight with an overall sinuosity of about 1.15. Channel type is predominantly a free-formed alluvial channel with a low-to-moderate rate of lateral channel migration. Channel/floodplain interactions are predominantly connected throughout the reach with two exceptions. These exceptions are a bridge and embankment approaches near RM 13.9, and an embankment at the head of a meander near RM 13.7. The bridge and its approaches confine the channel and disconnect small floodplain areas, and the embankment placed at the head of the meander deflects the river and prevents the channel from accessing the meander. Other anthropogenic disturbances (i.e., Custer Motorway) do not significantly impact channel processes.

Pool frequency for this reach was determined to be 18 to 19 pools per mile based on the 2010 Stream Inventory Survey. The channel is predominantly an unconfined, straight channel with small channel segments exhibiting a meandering channel pattern. Montgomery and Buffington (1993) determined that channels with pool-riffle bedforms generally have a pool every 5 to 7 channel widths. In this reach the average channel width (bankfull) is about 55 feet, so the expected pool frequency is about 14 to 19 pools per mile. The observed pool frequency was at the upper range of expected variability (19 pools per mile) for an unconfined, predominantly straight channel with pool-riffle bedforms.

This reach has the highest frequency of wood within the bankfull channel. The total number of wood per mile for all size classes ranged from 36 to 56 pieces per mile. Wood recruitment potential by lateral channel migration is good. The vegetation along the active channel and floodplain consist predominantly of riparian shrubs with upland trees that are in a shrub/seedling and small tree successional stages. Overstory vegetation is comprised of lodgepole pine and willow, and understory vegetation is comprised of lodgepole pine, subalpine fir, willow, and grass/forbs. Historically, this reach had mature pines interspersed throughout the valley bottom that were available for channel recruitment. During the mining boom in the late 1800s and early 1900s, timber was cleared from the valley bottoms and margins to be used in milling operations and construction.

Physical and ecological processes have been negatively impacted primarily from past timber harvests along the valley bottoms and margins. The riverine system appears to be on a recovering trend as the vegetation progresses through varying successional stages. Active management of these stands to insure proper species assemblage and to improve growth rates would be an appropriate approach for long-term rehabilitation.

Potential short-term approaches, that may not significantly improve fish productivity, are to increase availability of wood to the system that would improve channel complexity and aquatic habitat could include (1) ensuring that wood and sediment inputs from tributaries are not impeded by obstructions (i.e., undersized culverts), (2) wood placements along the channel and floodplain, with the caveat that the anticipated ecologic benefits outweigh the disturbances to the channel or floodplain, and (3) rehabilitating vegetation in dispersed campsite areas adjacent to the channel.

Geomorphic Reach YF-5

Geomorphic Reach YF-5 (Figure 24) is located between about RM 13.2 and 11.6 and is confined within a canyon. The river has incised a V-shaped canyon through a landslide deposit that filled the river corridor with slide-blocks and large boulders from RM 13 to 12.5, and smaller materials (boulders to gravel) from RM 12.5 to 11.8. Due to the oversized materials, the predominant channel type is bedrock with a straight channel planform. The channel slope is about 3.8 percent from RM 13 to 12.5, and then decreases to about 1.7 percent between RM 12.5 and 12 and about 1.2 percent between RM 12 and 11.6. Channel bedforms are primarily step-pools in the higher gradient section (greater than 2 percent) and transitions to a plane-bed in the lower gradient section (2 percent or less).

Hydraulic modeling shows that the channel slope is variable, but generally decreases in slope in the downstream direction. The channel slope from about Fivemile Creek to upstream of Slaughterhouse Gulch averages about 3.8 percent and is controlled by essentially bedrock (slide-blocks greater than 5-feet in diameter decreasing to boulders). The channel slope decreases to about 1.7 percent upstream of Slaughterhouse Gulch to Custer Bridge and further decreases to about 1.2 percent from Custer Bridge to the geomorphic reach break near RM 11.6 as the dominant bed material sizes decreases from boulders to cobbles and gravels.

Average channel shear stresses vary through the reach as slope changes occur. Shear stresses exceed 5 lb/ft^2 as the river flows through the steep canyon segment which indicates the river is capable of transporting small boulders up to 13 inches in dimension. Shear stresses decline to less than 2 lb/ft^2 which indicates the river is capable of transporting cobbles up to 5 inches in dimension at the lower end of the reach. The average flow velocity in the main channel of Reach YF-5 during the 2-year recurrence discharge is 7.5 ft/s.

Coarse sediment sources, excluding inputs from upstream, are primarily from debris sloughing from the canyon walls, and contributions from two perennial tributaries and several ephemeral drainages. The perennial tributaries include: Fourth of July Creek and Slaughterhouse Gulch that flow into the mainstem near RM 12.1 on river left. Ephemeral drainages primarily provide sediment input as debris flows. There is evidence of debris flows near RM 12.5 on river right, RM 12.4 on river right, RM 12.1 on river right, RM 11.9 on river right, and RM 11.8 on river left.

Figure 24. Yankee Fork Geomorphic Reach YF-5 in the middle Yankee Fork subwatershed.

Anthropogenic Disturbances

There are no anthropogenic disturbances within the canyon (Figure 25), but there are some disturbances below the canyon related to road embankments along the Custer Motorway adjacent to the channel, and the Custer Bridge crossing near RM 12. The Custer Motorway was constructed, for the most part, along the valley walls in this reach, but does encroach on the channel near RM 11.7. Modeling results suggest that the Custer Bridge creates backwater conditions by imparting hydraulic controls during the 10-year and higher recurrence flood event. However, the overall impacts to reach-scale channel processes from these anthropoenic features are negligible.

Figure 25. View to the west near RM 13.2 showing bedrock channel. *The channel is in essentially a bedrock canyon and has developed predominantly a step-pool bedform.* Bureau of Reclamation photograph by Dave Walsh, September 2, 2010.

Fish Usage, Channel Condition, and Habitat Elements

Chinook salmon use this geomorphic reach primarily as a migratory corridor and for spawning where small patches of gravel are retained. Steelhead use it primarily as a migratory corridor to reach more suitable spawning habitat upstream. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation.

The following channel condition and habitat elements are from the 2010 stream inventory survey conducted by the USFS. The stream inventory survey divided the geomorphic reach into two habitat reaches based on tributary inflows (Table 17). Stream type classification for the upstream habitat reach 7 between about RM 13.2 and 12.5 is a B-stream type (Rosgen 1996) defined as a single-threaded channel that is moderately entrenched with a moderate width/depth ratio and sinuosity, and has bedrock as its channel material. The downstream habitat reach 6 between about RM 12.5 and 11.2 is a C-stream type (Rosgen 1996) defined as a single-threaded channel that is slightly entrenched with moderate to high width-to-depth ratios, high sinuosity, and gravel channel material.

Table 17. Geomorphic Reach YF-5 stream inventory survey habitat reaches and channel condition.

River Miles	Habitat Reach	Geographic Description	Rosgen Stream Type	Average Wetted Channel Width	Average Bankfull Width	Average Floodprone Width
RM 13.2 – 12.5	Reach 7	Fivemile Creek to about Slaughterhouse Gulch	B	29 feet	39 feet	57 feet
RM 12.5 – 11.2	Reach 6	About Slaughterhouse Gulch to Swift Gulch	C	31 feet	41 feet	59 feet

The number of pools per mile ranged from 23 to 36 with deep pools (greater than 3-feet depth) comprising 52 to 89 percent of pool habitat (Table 18). Wood frequency for all wood measured ranged from 14 to 38 pieces of wood per mile.

Table 18. Geomorphic Reach YF-5 stream inventory survey habitat elements.

Habitat Reach	Dominant Substrate	Number of Pools Per Mile	Number of Pools > 3 Feet Deep Per Mile	Average Residual Pool Depth	Total Number of Wood Per Mile
Reach 7	Bedrock (>4096 mm)	36.4	32.4	3.7 feet	38
Reach 6	Gravel (2-64 mm)	23	11.9	1.9 feet	14

Discussion and Potential Habitat Actions

This geomorphic reach is in a confined, V-shaped canyon that has high energy and high sediment transport capacity. Channel type is predominantly a straight, confined bedrock channel with a 3.8 percent gradient that transitions to a straight, alluvial channel with a 1.2

percent gradient. Channel confinement, slope and little-to-no sinuosity suggests an A-stream type that transitions into an F-stream type (Rosgen 1996) is more appropriate for this geomorphic reach. Channel/floodplain interactions are connected where small floodplains have developed.

The number of observed pools per mile ranged from about 23 to 36 based on the 2010 Stream Inventory Survey. Pool spacing in confined, predominantly bedrock controlled channels is variable (Montgomery and Buffington 1993) and the use of pool spacing based on channel widths is not applicable.

Vegetation along the banks of the active channel is sparse between about RM 13.2 and 12.8, and is comprised primarily of upland trees along the steep slopes. Riparian vegetation becomes more prominent along the banks starting near RM 12.8 to the end of the reach.

This geomorphic reach has a confined, bedrock channel that transitions to an alluvial channel with no anthropogenic features impacting reach-scale channel processes. There are two natural waterfalls within the upper section that are passable by fish. Since the fish of interest primarily use this geomorphic reach as a migratory corridor and no fish passage barriers are present, there is no need for further assessment.

Geomorphic Reach YF-4

Geomorphic Reach YF-4 (Figure 26) is located between RM 11.6 and 9.1 in a moderately confined valley segment. Average channel slope is about 1.1 percent and the channel pattern is predominantly straight which indicates that a relatively low rate of lateral channel migration is occurring. Channel type is a plane-bed, free-formed alluvial channel that has a gravel with cobble substrate.

Hydraulic modeling shows that the channel is confined within its banks in the upper segment between RM 11.6 and 11.0 and flows begin to access adjacent floodplains between RM 11.0 and 9.1 during the 1.11-year recurrence discharge. The average shear stress in the main channel during the 2-year recurrence discharge is approximately 1.0 lb/ft^2 which indicates the river is capable of transporting gravels up to 2.6 inches in dimension. There are five locations where average shear stresses exceed 2 lb/ft^2. At RM 11.3 and 10.5 the channel is constrained by the valley wall on river left, and at RM 10.1 and RM 9.7 the channel is constrained by the Custer Motorway on river right. Earth fill may have been placed at the dispersed camping site on river right at RM 9.5 that potentially constrains the channel in this segment. The average flow velocity in the main channel of Reach YF-4 during the 2-year recurrence discharge is 4.6 ft/s.

Local coarse sediment input is predominantly from lateral channel migration causing bank erosion and to a lesser degree from tributaries. Bank erosion is occurring where the channel is in contact with alluvial fan deposits (RM 11.3 to 11.2 on river right), along the outside of meanders (RM 11 to 10.9 on river right and RM 9.2 to 9.1 on river left), and along unvegetated banks near dispersed campsites (RM 10 on river right). There are three perennial tributaries that provide sediment pulses during high flow events and serve as conduits for episodic debris flows. These tributaries include Swift Gulch near RM 11.2 on river right; Adair Creek near RM 10.4 on river left; and Jordan Creek near RM 9.1 on river right. Ephemeral drainages that show evidence of debris flows that can potentially provide sediment inputs include unnamed drainages near RM 11.3 on river right, and a few between RM 10 and 9.9 on river left.

Figure 26. Yankee Fork Geomorphic Reach YF-4 in the middle Yankee Fork subwatershed.

Anthropogenic Disturbances

Past timber harvests removed trees from the valley bottom and adjacent valley walls to support the mining boom in the late 1800s and early 1900s. For example, the General Custer Mill was located directly upstream of Custer townsite and operated between 1881 and 1904. The mill had the capacity to process 900 tons of ore per month and required over 300 cords of wood per month to fuel the steam engines that powered the mill. Following the closure of the mill, it was noted that the hills for miles around Custer were denuded of trees (LOYF Historical Association 2005). The past removal of mature timber, and potentially fire suppression and insect kill, has changed the vegetation assemblage (and successional stages) that historically occupied this area prior to European settlement (Overton et al. 1999). Vegetation strongly influences reach-scale processes such as wood delivery to the channel and bank reinforcement by roots that influence channel morphology and habitat arrangement. Loss of mature vegetation along the active channel can result in channel widening, increased channel migration and loss of channel roughness, as well as the loss of nutrient inputs that drive aquatic production.

Hydraulic mining occurred in the Adair Creek drainage probably in the early 1900s. This mining activity must have delivered large sediment pulses to the Yankee Fork. These sediment pulses have probably been transported through this reach with some sediment storage occurring where floodplain/channel interactions are connected. After 70 or more years, the present channel appears to have reached a dynamic equilibrium between its current sediment and flow regimes.

Other anthropogenic disturbances that have affected channel/floodplain processes include General's Bridge near RM 10.9 that confines the channel and exerts hydraulic control at the 10-year and above recurrence floods; a levee placed near RM 10.3 to protect a mining operation disconnects channel/floodplain interactions; and a deflection berm that protects a mining operation placed near RM 10 that restricts lateral channel migration and confines the channel (Figure 27). The overall impact of these anthropogenic features on channel processes and floodplain connectivity at the reach-scale is minimal, and rehabilitation of these areas probably would not significantly increase fish production in this reach.

Figure 27. View to the southwest near RM 11.1 showing floodplain clearing associated with development. *Mining activities have been occurring along river left (left foreground in photo); the residential development is protected from overbank flow by a levee along river right (center of photo); and General's Bridge that provides access to the mining site constrains the channel.* Bureau of Reclamation photograph by Dave Walsh, September 2, 2010.

Fish Usage, Channel Condition, and Habitat Elements

Chinook salmon and steelhead use this geomorphic reach for spawning and juvenile rearing and as a migratory corridor. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation.

The following channel condition and habitat elements are from the 2010 stream inventory survey conducted by the USFS. The stream inventory survey identified one habitat reach that covered most of the geomorphic reach between Swift Gulch and Jordan Creek (Table 19). Stream type classification for habitat reach 5 between about RM 11.2 and 9.1 is a C-stream type (Rosgen 1996).

Table 19. Geomorphic Reach YF-4 stream inventory survey habitat reaches and channel condition.

River Miles	Habitat Reach	Geographic Description	Rosgen Stream Type	Average Wetted Channel Width	Average Bankfull Width	Average Floodprone Width
RM 11.2 – 9.1	Reach 5	Swift Gulch to Jordan Creek	C	34 feet	46 feet	58 feet

Observed pool frequency was about 7 pools per mile with deep pools comprising about 33 percent of pool habitat (Table 20). Wood frequency for all wood measured was about 5 pieces of wood per mile.

Table 20. Geomorphic Reach YF-4 stream inventory habitat elements.

Habitat Reach	Dominant Substrate	Number of Pools Per Mile	Number of Pools > 3 Feet Deep Per Mile	Average Residual Pool Depth	Total Number of Wood Per Mile
Reach 5	Gravel (2-64 mm)	7.2	2.4	1.8 feet	5

Discussion and Potential Habitat Actions

The channel in this reach is moderately confined with a slope of about 1.1 percent and the channel pattern is predominantly straight with an overall sinuosity of about 1.08. Channel type is predominantly a plane-bed, free-formed alluvial channel with a low-to-moderate rate of lateral channel migration. The stream inventory survey (2010) classified this geomorphic reach as a C-stream type (Rosgen 1996), but the moderate channel confinement, low sinuosity and low channel gradient indicates that a B-stream type classification (Rosgen 1996) is more appropriate.

Channel/floodplain interactions are predominantly connected throughout the reach with minor exceptions. These exceptions include a levee placed near RM 10.3 that disconnects a small area of floodplain, and a deflection berm placed near RM 10 that disconnects a small area of floodplain and slightly confines the channel. The overall impact of these anthropogenic features on channel processes and floodplain connectivity at the reach-scale is minimal, and rehabilitation of these areas probably would not increase fish production.

Pool frequency for this reach was determined to be about 7 pools per mile based on the 2010 stream inventory survey. Moderately confined, plane-bed channels with gravel and cobble substrate typically form an “armor layer” as flows winnow out finer particle sizes (i.e., fines, sand and gravel) leaving behind a layer of coarser particle sizes (i.e., cobbles and boulders). The armor layer inhibits pool development (scour) when flows are not sufficient to mobilize the armoring particles, or in the absence of channel-spanning structures or significant channel constrictions (Montgomery and Buffington 1997; Bisson, Buffington, and Montgomery 2006). The pools observed in this geomorphic reach were primarily lateral scour pools located at meanders where flows are concentrated along vegetated streambanks with two exceptions. The exceptions were (1) a mid-channel scour pool at General’s Bridge (approximately RM 10.9) and (2) landslide dam pool upstream of where coarse sediment entered the channel from a talus slope (approximately RM 10.5).

Wood frequency was determined to be about 5 pieces of wood per mile. Wood, like sediment, is transported through this geomorphic reach or temporarily stored along the channel margins where it only interacts with the channel during channel forming flows and does not directly contribute to pool or side channel formation. The vegetation along the active channel and small floodplain areas consist predominantly of riparian shrubs and small trees intermixed with upland trees that are in shrub/seedling and small tree successional stages. Lodgepole pine, alder, and grass/forbs comprise the overstory and understory vegetation. Historically, this reach probably had mature pines interspersed throughout the valley bottom that were available for channel recruitment. The timber was cleared from the valley bottoms and margins during the mining boom in the late 1800s and early 1900s to be used in milling operations and building construction.

Physical processes may have temporarily been impacted from past mining activities in this geomorphic reach. Moderately confined, plane-bed channels generally represent a transition between supply- and transport-limited morphologies, and the degree to which these channels are confined influences their response to external factors (Montgomery and Buffington 1998). For example, the hydraulic mining that occurred in the Adair Creek drainage (probably in the early 1900s) must have delivered pulses of sediment to the Yankee Fork. The channel’s initial response to these pulses was probably channel widening during channel forming flows. However, in confined and moderately confined channels stream energy cannot be dissipated across a floodplain during peak flows, so the stream energy is translated into increased basal shear stress resulting in an increase in sediment transport capacity. After 70 or more years, the present channel appears to have reached a dynamic equilibrium between its current sediment and flow regimes.

Presently, physical and ecological processes are negatively impacted primarily from past timber harvests along the valley bottoms and margins during the mining boom in the late 1800s and early 1900s. Similar to geomorphic reach YF-6, the riverine system appears to be on a recovering trend as vegetation progresses through varying successional stages. However, the recovering trend is probably occurring at a slower rate due to continued recreational and private landowner usage. Maintaining and actively managing a riparian corridor (i.e., 100-foot buffer zone) along both sides of the river in this geomorphic reach to insure proper species assemblage and to improve growth rates would be an appropriate approach for long-term rehabilitation. This type of strategy would provide the following benefits: (1) increased availability of wood for channel recruitment, (2) improved root reinforcement of stream banks and increased channel boundary roughness, (3) increased nutrient inputs that help drive macroinvertebrate production, and (4) ecological connectivity for aquatic and terrestrial species reliant on riverine systems.

8.3 Lower Yankee Fork Subwatershed

8.3.1 Geomorphic Reach Delineations

The lower Yankee Fork is located between about RM 9.1 and the Yankee Fork/Salmon River confluence near the town of Sunbeam. The lower Yankee Fork drainage area is about 29 mi^2 and the drainage density is about 1.45 mi/mi^2. Bedrock geology consists predominantly of the Challis Volcanics except between RM 3 and the Yankee Fork/Salmon River confluence where the Idaho batholith crops out. The valley has a north-south orientation except for the lower section where it trends north-northwest through the Idaho batholith downstream of a fault that separates the two geologic rock units.

Three valley segments were delineated along the Yankee Fork mainstem (Table 21) based on cross-sectional valley forms: (1) U-shaped trough with an alluvial valley type in the upper section; (2) U-shaped trough with an alluvial valley type in the middle section; and (3) V-shaped bedrock canyon with a bedrock valley type in the lower section. Although the upper and middle sections have the same valley form, geologically they are significantly different and there is a change in channel slope near RM 6.9. In the lower section there is a change from the Challis Volcanics to the Idaho batholith bedrock types near RM 3 and the channel slope steepens (Figure 28).

The analysis showed that the valley segments and geomorphic reaches are coincident based on geologic history, geomorphic process, and channel morphology. Figure 29 shows the location of the geomorphic reaches and is an index map for each of the geomorphic reach maps.

Table 21. Lower Yankee Fork geomorphic reach delineations and associated channel morphology.

River Miles	*General Valley Location*	Geomorphic Reaches	*Valley Form*[1]	*Valley Type*[2]	Valley Confinement[3]	Valley Gradient	*Channel Reach Type*[2]	Channel Bedform Type[2]	Channel Slope	Dominant Substrate Size Class[4]
RM 9.1-6.9	***Upper Section***	***Reach YF-3***	U1: U-shaped trough	Alluvial	Moderately Confined	1.05 percent	***Free-formed alluvial channel***	Plane-bed	1.00 percent	Cobble
RM 6.9-3.0	***Middle Section***	***Reach YF-2***	U1: U-shaped trough	Alluvial	Confined	0.68 percent	***Free-formed alluvial channel***	Plane-bed	0.64 percent	Cobble
RM 3.0-0	***Lower Section***	***Reach YF-1***	V1: V-shaped moderate gradient bottom	Bedrock	Confined	1.17 percent	***Bedrock channel***	Step-pool	1.13 percent	ND

[1]Classification based on Naiman et al. (1992) as recommended in Hillman (2006)
[2]Channel type classification based on Montgomery and Buffington (1993)
[3]Monitoring Strategy for the Upper Columbia Basin (Hillman 2006)
[4]From Stream Inventory Survey 2010 (Appendix K) and USFS (2006)
ND – Not determined

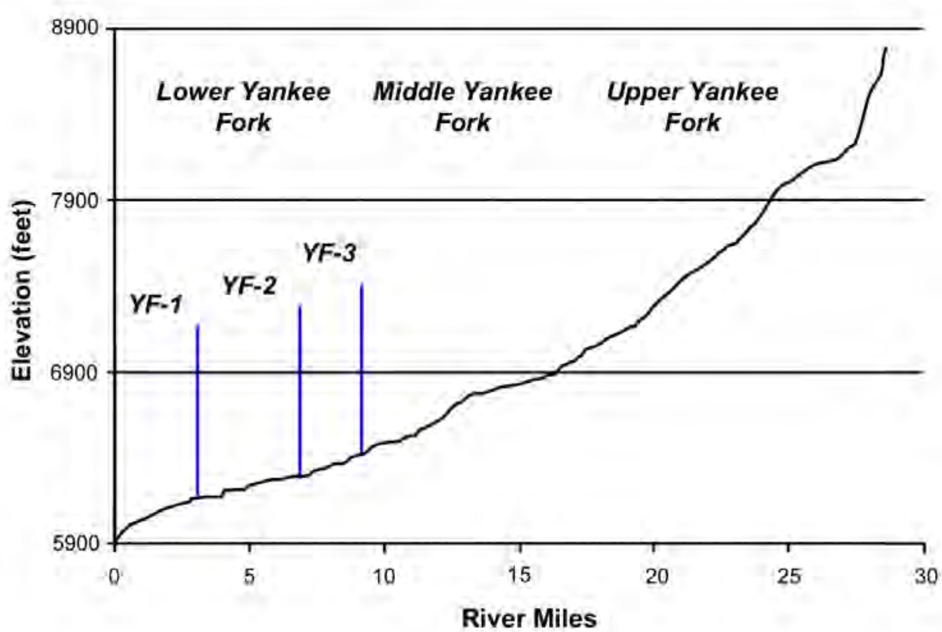

Figure 28. Lower Yankee Fork subwatershed longitudinal channel profile with reach locations.

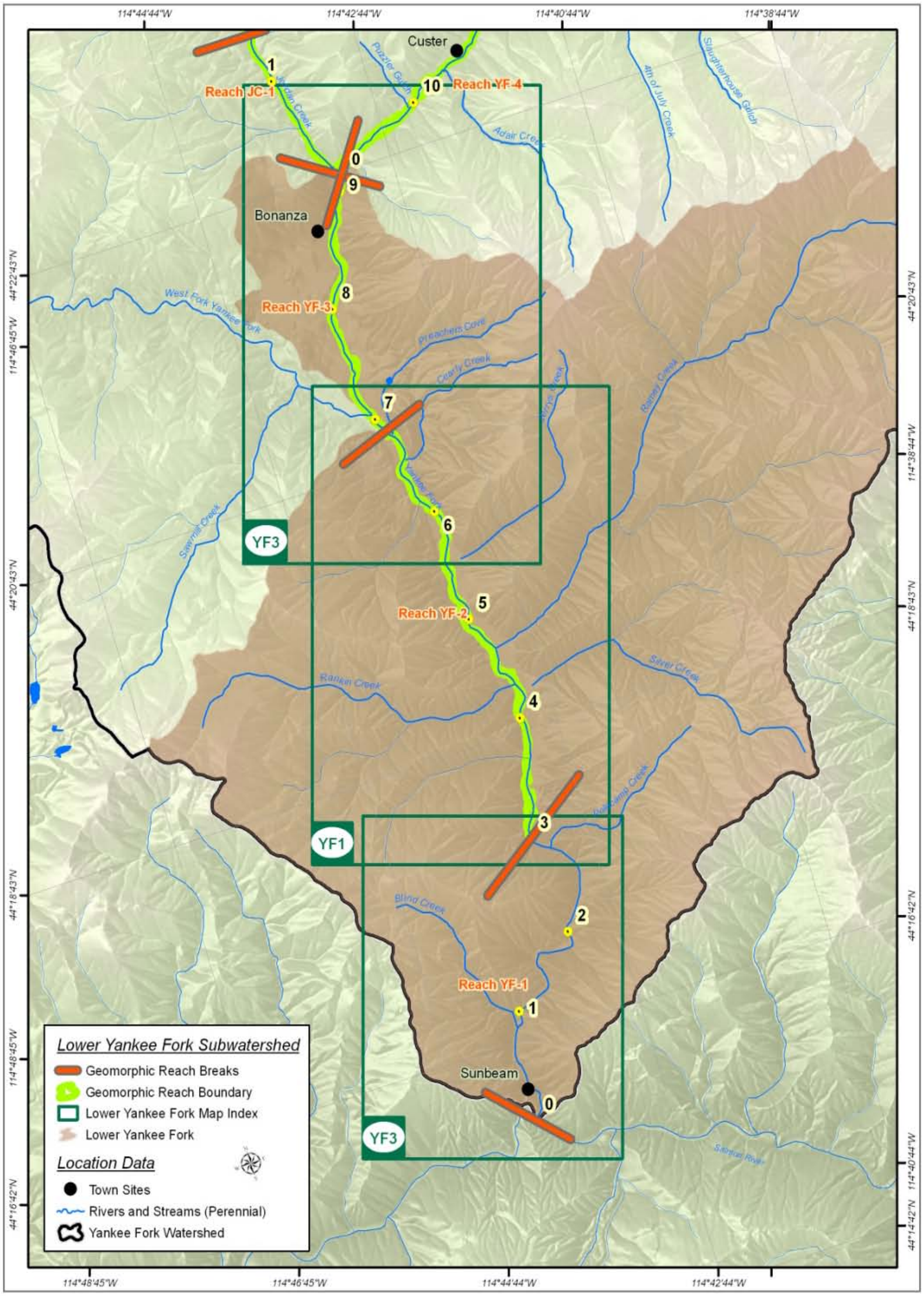

Figure 29. Lower Yankee Fork subwatershed index map with geomorphic reach breaks.

Geomorphic Reach YF-3

Geomorphic Reach YF-3 (Figure 30) is located between about RM 9.1 and 6.9 in a moderately confined valley segment that is artificially constrained by dredge tailings throughout most of the reach. The channel type is a plane-bed, free-formed alluvial channel with a straight channel pattern and sinuosity is about 1.05. Channel slope is about 1 percent with a cobble-dominated substrate. Prior to gold dredging in the 1940s, much of this geomorphic reach was moderately confined to unconfined and maintained a straight-to-meandering channel pattern with a sinuosity of about 1.10 based on analysis of the 1945 and 2010 channel alignments.

In the early 1900s, the Yankee Fork and West Fork confluence area had a broad floodplain in which the two unconfined channels dynamically interacted. The channels migrated across their floodplains which progressively changed where and how the channels converged. The dynamic interactions resulted in varying hydraulic conditions that created and maintained a mosaic of habitat patches. Gold dredging along the Yankee Fork in the 1940s and 1950s involved rerouting the Yankee Fork and disconnecting it from the broad floodplain; and on the West Fork the lower channel segment was rerouted and artificially constrained by dredge piles. The Yankee Fork and West Fork confluence was relocated downstream of the unconfined channel segment (broad floodplain) to a moderately confined channel segment. These new channel configurations and location of channel convergence are now static and the hydraulic conditions no longer create the mosaic of habitat patches.

Hydraulic modeling shows that the present Yankee Fork is primarily confined within its banks by valley walls and dredge piles. Overbank areas are small and the Yankee Fork begins to access adjacent floodplains during the 10-year recurrence flood. A levee between RM 8.9 and RM 8.6 on river right protecting a gravel mining operation contributes to river confinement. Fill placed at an abandoned road crossing at RM 8.0 encroaches into the floodplain area on river left and river right. Dredge piles disconnect floodplain areas from the river channel on river right resulting in channel realignment and potential scour between RM 7.8 and RM 6.9 above the confluence with the West Fork.

The average shear stress in the main channel during the 2-year recurrence discharge is approximately 1.5 lb/ft^2 which indicates the river is capable of transporting large gravels up to 3.9 inches in dimension. There are five peaks where shear stress is greater than 3 lb/ft^2. At RM 8.6, the channel is constrained by levees on river right. At RM 8.1 downstream of Bonanza Bridge, the channel is constrained by the valley wall on river right and dredge piles on river left. At RM 7.9 downstream of the abandoned bridge crossing, the channel is constrained by the valley wall on river right. At RM 7.7, the channel is constrained by dredge piles on river right and a topographic constraint created by an earth fill embankment on river left. At RM 7.5, the channel is constrained by dredge piles on river right. The average flow velocity in the main channel during the 2-year recurrence discharge is 5.1 ft/s.

Local coarse sediment inputs are primarily from two perennial tributaries and an ephemeral drainage. The perennial tributaries are Jordan Creek near RM 9.1 on river right and Preachers Cove near RM 7.4 on river left, which are providing sediment pulses during high flow events. An ephemeral drainage that is unnamed near RM 8.3 on river left is providing sediment primarily as episodic debris flows. Other sediment sources include bank erosion occurring along river right near RM 7.9 where the river flows against a glacial terrace and near RM 7.4 on river left where the river flows against an alluvial fan and river right where it flows against dredge tailings.

Figure 30. Yankee Fork Geomorphic Reach YF-3 in the lower Yankee Fork subwatershed.

Anthropogenic Disturbances

The most significant anthropogenic disturbance in this geomorphic reach was from a floating gold dredge that worked alluvial deposits across the valley floor in the 1940s and early 1950s. The dredging operation required the removal of woody vegetation within the limits of the placer claim. Next, the channel had to be manipulated (i.e., impounded and rerouted) to keep the dredge afloat as it worked its way upstream and across the valley floor. Finally, the separation process to extract the gold resulted in a bimodal particle-sized distribution and the manner in which the spoils were ejected left finer particles stratified between coarser particles forming tailing piles.

Historically (pre-dredging), the valley bottom constraints were from higher surfaces (comprised predominantly of glacial outwash), alluvial fans, and bedrock. From about RM 7.5 to 6.9, the channel was unconfined and the river had developed a broad floodplain and channel/floodplain interactions were connected (Figure 31). The river had a straight-to-meandering channel pattern that indicates a low-to-moderate rate of lateral channel migration was occurring. Channel type was a free-formed alluvial channel with some vegetated islands and wood complexes creating flow convergence and divergence. The floodplain contained riparian shrub and upland tree species that contributed to the development of channel morphology and habitat structure.

Figure 31. View is to the north looking upstream from near RM 6.8 toward the Yankee Fork and West Fork confluence (Smith 1911). Photograph taken by Maven Sawyer, winter of 1910.

In the 1945 aerial photographs, the channel flowed along the right valley wall between RM 9.1 and 8.4 and a new channel was constructed through the dredge tailings along the left valley wall by the 1966 aerial photographs. Between about RM 8.3 and 7.5, the channel has essentially remained in the same location based on the 1945 to 2010 aerial photographic record; however, in order for the dredge to have operated in this location, the channel had to be at least temporarily impounded or otherwise manipulated to support the floating dredge. From RM 7.3 to 6.8, the channel was rerouted away from the West Fork confluence and disconnected from floodplain areas by dredge tailings sometime between 1945 and 1952 (Figure 32 and Figure 33).

Little to no channel change has occurred within this reach since the channel was constructed through the dredge tailings between 1945 and 1952. The constructed channel alignment had slightly more sinuosity than the present (2010) channel alignment. Channel confinement between the dredge tailings and the lack of channel/floodplain interactions constrain the flows to within the channel, translating stream power downstream and increasing sediment transport capacity resulting in simplification of in-stream structure and reduction of aquatic habitat. Over the last 58-year time period, the channel has adjusted by slightly straightening to pass discharges and sediment more efficiently.

Other anthropogenic disturbances that are less significant in the geomorphic reach include development in the lower section of Jordan Creek, a levee between RM 8.9 and 8.6, and Bonanza Bridge near RM 8.3. There has been some development near the mouth of Jordan Creek where the gold dredge now resides and the creek has been channelized from the Jordan Creek Bridge along the Custer Motorway to the confluence with the Yankee Fork. A levee has been placed downstream of Jordan Creek to protect a gravel processing operation that prevents flows from accessing the low bench upon which the operation is located. Bonanza Bridge appears to create backwater conditions by exerting hydraulic control on the channel at the 2-year and above recurrence floods.

Figure 32. 1945 aerial photograph of West Fork and Yankee Fork confluence.

Figure 33. 2010 aerial photograph of West Fork and Yankee Fork confluence.

Fish Usage, Channel Condition, and Habitat Elements

Chinook salmon use this geomorphic reach for spawning and juvenile rearing, and as a migratory corridor. Steelhead use this reach for juvenile rearing and as a migratory corridor. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation.

The following channel condition and habitat elements are from the 2010 stream inventory survey conducted by the USFS. The stream inventory survey identified one habitat reach that covered the entire geomorphic reach between Jordan Creek and West Fork (Table 22). Stream type classification for habitat reach 4 is a C-stream type (Rosgen 1996) defined as a single-threaded channel that is slightly entrenched with a moderate to high width-to-depth ratio, high sinuosity, and cobble channel material.

Table 22. Geomorphic Reach YF-3 stream inventory survey habitat reach and channel condition.

River Miles	Habitat Reach	Geographic Description	Rosgen Stream Type	Average Wetted Channel Width	Average Bankfull Width	Average Floodprone Width
RM 9.1 – 6.9	Reach 4	Jordan Creek to West Fork	C	40 feet	54 feet	90 feet

The number of pools per mile was 4 with deep pool comprising about 33 percent of pool habitat (Table 23). Wood frequency for all wood measured was less than 1 piece of wood per mile.

Table 23. Geomorphic Reach YF03 stream inventory habitat elements.

Habitat Reach	Dominant Substrate	Number of Pools Per Mile	Number of Pools > 3 Feet Deep Per Mile	Average Residual Pool Depth	Total Number of Wood Per Mile
Reach 4	Cobble (64-256 mm)	4.0	1.3	2.1 feet	< 1

Discussion and Potential Habitat Actions

Prior to gold dredging in the 1940s and 1950s, this reach was moderately confined to unconfined and maintained a straight-to-meandering channel pattern with an overall sinuosity of about 1.10 based on analysis of the 1945 and 2010 channel alignments. Channel type was a free-formed alluvial channel with plane-bed to pool-riffle bedforms.

Some vegetated islands and wood complexes contributed to flow convergence and divergence. Channel/floodplain interactions were connected and the floodplain was vegetated with riparian shrubs and upland trees. Valley bottom constraints were from higher surfaces (comprised predominantly of glacial outwash), alluvial fans, and bedrock that moderately confined the channel except between about RM 7.5 and 7.1 where the channel was unconfined. The Yankee Fork and West Fork confluence area located between about RM 7.3 and 7.1 had a broad floodplain in which the two unconfined channels dynamically interacted. These interactions resulted in varying hydraulic conditions that created and maintained a mosaic of habitat patches that significantly benefited the fish.

Presently, the channel in this reach is moderately confined with a channel slope of about 1 percent. Channel pattern is straight with an overall sinuosity of about 1.05 and has a very low rate of lateral channel migration. Channel type is a plane-bed, free-formed alluvial channel with a cobble substrate. The stream survey conducted in 2010 indicated that this was a C-stream type (Rosgen 1996), but due to the channel being artificially confined by dredge piles and low sinuosity, the stream is more characteristic of a B-stream type that is moderately entrenched with stable banks and has a riffle dominated channel. The Yankee Fork and West Fork confluence has been relocated downstream of the unconfined channel segment (broad floodplain) to a moderately confined channel segment. These new channel configurations and location of channel convergence are now static and the hydraulic conditions no longer create the mosaic of habitat patches.

The anthropogenic features that artificially constrain the channel are primarily the rerouted and constructed channels through the dredge piles. The following are locations and effects of these features:

- Channel segment RM 9.1 to 8.3: Channel constructed along left valley wall adjacent to dredge tailings. The constructed channel is confined between the dredge tailings and left valley wall with small patches of accessible floodplain.

- Channel segment RM 7.8 to 7.5: Channel constructed near center of valley bottom. Channel is constrained between dredge tailings (river right) and a high terrace (river left) adjacent to the 1945 (pre-dredge) channel alignment.

- Channel segment RM 7.4 to 6.9: Channel constructed along left valley wall. Channel is constrained between dredge tailings (river right) and alluvial fan (river left). Historic channel alignment and floodplain areas present in 1945 have been disconnected by dredge tailings.

Other anthropogenic features that locally confine the channel and/or disconnect floodplains include the following: (a) elevated road embankments (historic bridge approaches) near RM 8 confine the channel and disconnect small floodplain areas along both sides of the channel; and (b) dredge tailings near RM 7.8 confine the channel.

Pool frequency for this reach was determined to be about 4 pools per mile based on the 2010 stream inventory survey. Moderately confined, plane-bed channels with cobble substrate are typically armored. The armor layer inhibits pool development (scour) when flows are not sufficient to mobilize the armoring particles, or in the absence of channel-spanning structures or significant channel constrictions (Montgomery and Buffington 1997; Bisson, Buffington, and Montgomery 2006). Pool types identified in this reach include: (1) pools scoured where the Yankee Fork and Jordan Creek converge near RM 9.1; (2) lateral scour pools on the outside channel bends; (3) mid-channel scour pool downstream of a transverse bar comprised of boulders; and (4) a plunge pool scoured downstream of a bedrock outcrop.

Wood frequency was determined to be less than 1 piece of wood per mile. Wood, like sediment, is transported through this reach or temporarily stored on high bars along the channel margins where it only interacts with the channel during channel forming flows and do not directly contribute to pool or side channel formation. The vegetation along the active channel and small floodplain areas consist predominantly of riparian shrubs and small trees that are in shrub/seedling and small tree successional stages. Removal of the riparian and upland vegetation for the dredging operations, and the lack of suitable soils for regeneration, depleted the availability of wood for recruitment by the channel.

Physical and ecological processes have been significantly impacted by the gold dredging along the Yankee Fork. The dredging operation removed all woody vegetation in the claim area, rerouted the channels (Yankee Fork and West Fork) through dredge piles that artificially constrain the channels, disconnected relatively large floodplains from the Yankee Fork, and changed the interactions between the Yankee Fork and West Fork confluence area that historically was dynamic and created a mosaic of habitat patches to a static condition that no longer provides the complex habitats. There are multiple options to significantly increase and/or improve the reach-scale processes that create and maintain habitat patches. Therefore, a reach assessment is recommended to further refine and quantify present conditions versus historic (pre-dredge) conditions, changes to physical and ecologic processes, and the habitat potential for this reach. At a minimum, a more thorough analysis is needed to determine the following: (a) if the Yankee Fork and West Fork confluence processes and channel/floodplain interactions were rehabilitated to pre-dredging conditions, what would be the benefits, and risks, to the physical and ecological processes and to the resource, and (b) conceptually, what are some viable alternatives, and their limitations, for reconnecting channel/floodplain interactions throughout the reach.

Geomorphic Reach YF-2

Geomorphic Reach YF-2 (Figure 34) is located between RM 6.9 and 3 in a confined valley segment that is artificially constrained by dredge tailings throughout most of the reach. The channel type is a plane-bed, free-formed alluvial channel with a straight channel pattern and sinuosity is about 1.07. Channel slope is about 0.6 percent with a cobble-dominated substrate. Prior to gold dredging in the 1940s, much of this geomorphic reach was moderately confined by higher surfaces (comprised primarily of glacial outwash), alluvial fans, and bedrock and maintained a straight channel pattern.

Hydraulic modeling shows that the Yankee Fork is predominantly confined and there is a lack of overbank areas and side channels along the main channel due to valley wall and dredge piles. Channel/floodplain interactions occur downstream of Jerrys Bridge at RM 5.7 during the 10-year recurrence discharge.

The average shear stress in the main channel through Reach YF-2 during the 2-year recurrence discharge is approximately 1.3 lb/ft^2 which indicates the river is capable of transporting large gravels up to 3.4 inches in dimension. There are six locations where shear stress is greater than 2 lb/ft^2. At RM 6.6 downstream of the confluence with the West Fork and Virginia's Bridge, the channel is confined by the valley wall on river left. At RM 6.0, the channel is approaching Cabin Bridge with riprap placed on river right. At RM 5.6, the channel is constrained by dredge piles on river left. At RM 5.2, the channel is constrained by the valley wall on river right. At RM 4.8, the channel is constrained by dredge piles on river right. At RM 3.7, the channel is constrained by dredge piles on river left and a debris flow from an unnamed tributary on river right. The average flow velocity in the main channel of Reach YF-2 during the 2-year recurrence discharge is 5.1 ft/s.

Local coarse sediment inputs are primarily from bank erosion along the outside edge of meanders suggesting the channel is slowly migrating. Other sources include three perennial tributaries and seven ephemeral drainages. The perennial tributaries are West Fork near RM 6.8 along river right, Ramey Creek near RM 4.6 along river left, and Rankin Creek near RM 4.3 along river right. Unnamed ephemeral drainages along river right that provide sediment inputs primarily as debris flows are located near RM 6.3, RM 6.1, RM 5.1, RM 3.6, RM 3.3, RM 3.1, and RM 3.

Two perennial tributaries along river left are presently disconnected from the Yankee Fork by dredge tailings and no longer supply sediment to the mainstem. These tributaries include Jerrys Creek near RM 5.5 and Silver Creek near RM 4.2. Cearley Creek near RM 6.5 and an unnamed tributary near RM 6 are connected to a series of dredge ponds that are adjacent to and connected to the Yankee Fork, but the sediment is deposited in the ponds and does not reach the Yankee Fork mainstem.

Figure 34. Yankee Fork Geomorphic Reach YF-2 in the lower Yankee Fork subwatershed.

Anthropogenic Disturbances

The most significant anthropogenic disturbance in this geomorphic reach was from a floating gold dredge that worked the alluvial deposits across the valley floor in the 1940s and early 1950s. The dredging operation required the removal of woody vegetation within the limits of the placer claim. Next, the channel had to be manipulated (i.e., impounded and rerouted) to keep the dredge afloat as it worked its way upstream and across the valley floor. Finally, the separation process to extract the gold resulted in a bimodal particle size distribution and the manner in which the spoils were ejected left finer particles stratified between coarser particles forming tailing piles.

Historically (pre-dredging), the channel was moderately confined based on valley bottom constraints from glacial terraces and outwash, alluvial fans, and bedrock (Figure 35). The river had a relatively straight channel pattern that indicates a low rate of lateral channel migration was occurring. Channel type was a plane-bed (USDC 1934), free-formed alluvial channel with a cobble-dominated substrate. There were small-to-moderate sized patches of floodplain accessible to the river during high flows, but these floodplain areas were not extensive (Figure 36), and qualitatively appear similar to their present (2010) extent (Figure 37). In addition, three perennial tributaries were connected to the Yankee Fork that included Cearley Creek, Jerrys Creek, and Silver Creek.

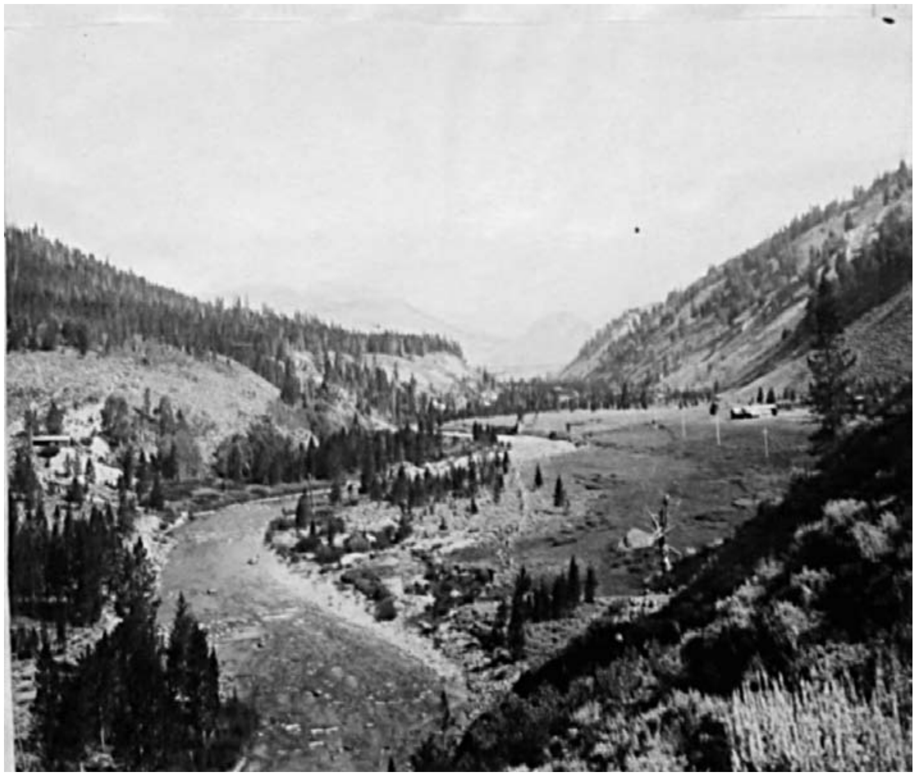

Figure 35. View is to the north looking upstream from glacial terrace near RM 5.2 at Jerrys Creek alluvial fan (Smith 1911).

Figure 36. 1945 aerial photograph of Yankee Fork near Jerrys Creek. *Note the floating dredge in the lower center of the photograph and the dredge tailings deposited across the valley floor.*

Figure 37. 2010 aerial photograph of Yankee Fork near Jerrys Creek.

The most significant impacts in this geomorphic reach are removal of vegetation and isolation of two perennial tributaries from the Yankee Fork due to dredge piles. These tributaries include Jerrys Creek near RM 5.5 and Silver Creek near RM 4.2 both on river left. The flow contributions from these tributaries to the Yankee Fork are probably similar to historic levels, however, the contributions are through subsurface flow because the porous dredge tailing bury the outlets of these tributaries. The loss of sediment inputs to the mainstem from these tributaries may have reduced the availability of gravels to form spawning areas. However, the primary impact is the loss of available habitat due to the dredge tailings creating a fish passage barrier into these drainages. Prior to dredging, the lower reaches of these tributaries where they flowed over the Yankee Fork valley floor probably provided juvenile rearing habitat (USDC 1934). Past fish usage in the upper sections of these drainages are unknown, but may have included spawning and rearing habitat for steelhead and bull trout.

Parallel to the Yankee Fork are four series of dredge ponds. Flow into the ponds is from tributaries, groundwater flow, and surface water diversions from the Yankee Fork. Ongoing efforts by multiple parties are exploring alternatives for improving connectivity between the pond series to the mainstem and tributaries to provide replacement of juvenile rearing habitat.

Other anthropogenic disturbances that affect channel processes are from Custer Motorway bridge crossings. The Custer Motorway crosses the Yankee Fork in four locations. Virginia’s Bridge at RM 6.8 appears to create a backwater condition by exerting hydraulic control at the 100-year recurrence flood. Cearley Creek Bridge at RM 6.5 and Cabin Bridge at RM 6.0 impart negligible hydraulic controls during the 10-year and above recurrence discharge. Jerrys Bridge at RM 5.7 appears to create a backwater condition by exerting some minor hydraulic control at the 2-year and higher recurrence floods. Also associated with these crossings are the placements of bank protection (riprap) that is hydraulically “smooth” in that stream energy is not dissipated. Typically, riprap concentrates the stream energy against the banks which effectively traps the flow and the energy is translated downstream. The overall impact of these anthropogenic features on channel processes and floodplain connectivity at the reach-scale is minimal, and rehabilitation of these areas probably would not significantly increase fish production in this reach.

Fish Usage, Channel Condition, and Habitat Elements

Chinook salmon and steelhead use this geomorphic reach for spawning and juvenile rearing, and as a migratory corridor. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation.

The following channel condition and habitat elements are from the 2010 stream inventory survey conducted by the USFS. The stream inventory survey identified three habitat reaches that covered the entire geomorphic reach between the West Fork and Polecamp Creek (Table 24). The stream inventory survey classified the reach as a C-stream type (Rosgen 1996) defined as a single-threaded channel that is slightly entrenched with a moderate to high width-to-depth ratio, high sinuosity, and gravel-cobble channel material.

Table 24. Geomorphic Reach YF-2 stream inventory survey habitat reaches and channel conditions.

River Miles	Habitat Reach	Geographic Description	Rosgen Stream Type	Average Wetted Channel Width	Average Bankfull Width	Average Floodprone Width
RM 6.9 – 5.4	Reach 3	West Fork to Jerrys Creek	C	46 feet	66 feet	100 feet
RM 5.4 – 4.3	Reach 2	Jerrys Creek to Rankin Creek	C	58 feet	92 feet	140 feet
RM 4.3 – 2.6	Reach 1	Rankin Creek to about Polecamp Creek	C	47 feet	72 feet	92 feet

The number of pools per mile ranged from 6 to 9 pools with deep pools comprising about 90 percent of pool habitat (Table 25). Wood frequency for all wood measured ranged between 0 and 7 pieces of wood per mile.

Table 25. Geomorphic Reach YF-2 stream inventory survey habitat elements.

Habitat Reach	Dominant Substrate	Number of Pools Per Mile	Number of Pools > 3 Feet Deep Per Mile	Average Residual Pool Depth	Total Number of Wood Per Mile
Reach 3	Gravel (2-64 mm)	8.0	7.4	2.8	0
Reach 2	Cobble (64-256 mm)	6.4	5.3	1.8	1
Reach 1	Gravel (2-64 mm)	8.5	7.8	3.0	7

Discussion and Potential Habitat Actions

The channel in this reach is confined with a channel slope of about 0.6 percent and the channel pattern is predominantly straight with an overall sinuosity of about 1.07. Channel type is primarily a plane-bed, free-formed alluvial channel with a low rate of lateral channel migration. The stream inventory (2010) classified this geomorphic reach as a C-stream type (Rosgen 1996), but the channel confinement, low sinuosity and low channel gradient indicates that a B-stream type classification (Rosgen 1996) is more appropriate.

Prior to dredging, the channel was moderately confined between glacial terraces, alluvial fans, and bedrock based on surficial geologic mapping, mining claim plat map, and aerial photography. After the valley bottom was dredged, the constructed channel was confined between dredge piles, glacial terraces, alluvial fans, and bedrock. There has been some lateral channel migration where the channel is less confined by the dredge piles. Relatively small floodplains have developed through lateral channel migration that have good channel/floodplain interactions and provide some high water refugia and rearing habitat for juveniles. Where the channel is strongly confined by dredge piles, there has been almost no lateral channel migration and flows are contained within the channel resulting in an increase in stream power.

Pool frequency was determined to be about 7 pools per mile based on the 2010 stream inventory survey. Confined, plane-bed channels with gravel and cobble substrate typically form an "armor layer" that inhibits pool development (scour) when flows are not sufficient to mobilize the armoring particles, or in the absence of channel-spanning structures or significant channel constrictions (Montgomery and Buffington 1997; Bisson, Buffington, and Montgomery 2006). Pools observed in this reach were (1) lateral scour pools located at meanders where flows are concentrated along streambanks that primarily have riprap, wood complexes, tailing piles or bedrock (i.e., RM 6.5, RM 5.7, RM 4.8 and RM 3.6); (2) mid-channel scour pool where flows are constrained by bridge abutments resulting in bed scour (i.e., Cabin Bridge near RM 6); (3) slow water pools upstream of channel constrictions (i.e., RM 3.7 and RM 3.5); and (4) a pool scoured where the Yankee Fork and West Fork converge near RM 6.8.

Wood frequency was determined to be less than 3 pieces of wood per mile. Wood, like sediment, is transported through this reach or stored where floodplains are connected to the channel. The wood, especially wood complexes, do contribute to pool and side channel formation where it interacts with the channel during channel forming flows. The vegetation along the active channel and floodplains consist predominantly of riparian shrubs and small trees intermixed with upland trees that range from small tree to large tree successional stages. Lodgepole pine, Douglas fir, alder, saplings, and grass/forbs comprise the overstory and understory vegetation. Historically, this reach had more mature pines interspersed throughout the valley bottom that were available for channel recruitment. Timber was cleared from the valley bottoms and margins in the late 1800s and early 1900s during the mining boom. In the 1940s and 1950s, all timber and woody plants were removed within the limits of the placer mining claim during the dredging operations.

Anthropogenic features provide channel constraints throughout most of the reach. Primary features are the constructed channel through dredge tailing mounds that confine the channel. The following are locations and effects of these features:

- Channel segment RM 6.7 to 6.5: Channel constructed along left valley wall and adjacent to dredge tailings. The constructed channel is confined between dredge piles on river right and the valley wall on river left with patches of accessible floodplain.

- Channel segment RM 6.5 to 6: Channel constructed along right valley wall and adjacent to dredge tailings. The constructed channel is moderately confined between dredge piles (river left) and glacial terrace and alluvial fan deposits (river right) with patches of accessible floodplain.

- Channel segment RM 5.7 to 5.4: Channel constructed through dredge tailings. Channel is moderately confined by dredge piles with patches of accessible floodplain.

- Channel segment RM 5.4 to 5.1: Channel constructed along right valley wall adjacent to dredge tailings. Channel is confined between dredge piles (river left) and glacial terrace and alluvial fan deposits (river right) with patches of accessible floodplain.

- Channel segment RM 4.9 to 4: Channel constructed along right valley wall adjacent to dredge tailings. Channel is moderately confined between dredge piles (river left) and glacial terrace, alluvial fans, and bedrock (river right) with patches of accessible floodplain.

- Channel segment RM 4 to 3.3: Channel constructed along right valley wall adjacent to dredge tailings. Channel is confined between dredge piles (river left) and glacial terrace, alluvial fans, and bedrock (river right) with patches of accessible floodplain.

Other anthropogenic features that locally confine the channel and/or disconnect floodplains include the following: (a) bridge crossings near RM 6.8, RM 6.5, RM 6, and RM 5.7, (b) the Custer Motorway road embankment along the valley wall that encroaches on the channel near RM 5.1, (c) a road embankment (historic bridge location) that transects the valley bottom, confining the channel and disconnecting small floodplain areas near RM 5, and (d) the Custer Motorway road embankment that disconnects a small floodplain area near RM 3.2. Two perennial tributaries, Jerrys Creek and Silver Creek, have been disconnected from the Yankee Fork by dredge tailings.

In addition, the dredging operations have left four dredge pond series that parallel the Yankee Fork. Pond series 4 begins upstream of Virginia's Bridge near RM 6.8. A diversion structure on river right directs surface water into a series of dredge ponds and surface water returns to the Yankee Fork downstream of Cearley Creek Bridge near RM 6.4. Pond series 3 begins upstream of Cearley Creek Bridge at RM 6.5 with a diversion structure on river left. Flow from these ponds returns to the Yankee Fork downstream of Cabin Bridge near RM 5.9. Pond series 2 begins with a diversion structure on river right near RM 6.0 upstream of Cabin Bridge and returns to the Yankee Fork downstream of Jerrys Bridge near RM 5.5. Pond Series 1 begins downstream of Silver Creek with no surface water diversion and connects to the Yankee Fork on river left through a culvert under the Custer Motorway near RM 3.5. Flow into these series of ponds is from tributaries, groundwater flow, and surface water diversions from the Yankee Fork.

Physical processes have been impacted by past dredging activities in this reach. Prior to dredging (1945 aerial photographs), the Yankee Fork was moderately confined primarily between glacial outwash terraces and alluvial fans with a straight, plane-bed channel morphology. Presently, the Yankee Fork is confined primarily between dredge piles with a straight, plane-bed channel. The increase in channel confinement has resulted in an increase in sediment transport capacity because the stream energy cannot be dissipated across a wider cross sectional area during peak flows which translates into increased basal shear stress and higher flow velocities. However, there has not been a dramatic impact to channel processes because the straight, plane-bed channel morphology is similar to the pre-dredging condition and active lateral channel migration is occurring as evidenced by active bank erosion throughout much of the reach.

Ecological processes have been significantly impacted as a result of the dredging operations. Jerrys Creek and Silver Creek are disconnected from the Yankee Fork by dredge piles and fish can no longer access these drainages. The dredging operations also removed all the vegetation within the placer claim area leaving behind mounds of unconsolidated alluvium. Vegetation is recovering in areas where roots can intercept water primarily along the river and where fine sediments are accumulating on floodplains.

The Tribes have worked with consultants and stakeholders on implementing habitat projects in this reach. Alternatives should continue to be pursued to reconnect the isolated tributaries and improve channel/floodplain interactions. In addition, the four dredge pond series have the potential to provide replacement of juvenile rearing habitat that was lost when dredging obliterated the lower sections of some tributaries. Increasing flows into these pond series would also reduce peak flows in the mainstem Yankee Fork resulting in a reduction in sediment transport capacity and lower flow velocities which would improve spawning gravel retention and juvenile fish movement. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

Geomorphic Reach YF-1

Geomorphic Reach YF-1 (Figure 38) is located between RM 3.0 to the Yankee Fork/Salmon River confluence in a V-shaped canyon confined by bedrock and talus. The river has a bedrock channel with a step-pool bedform and a slope of about 1.1 percent. Two perennial tributaries contribute flows to the Yankee Fork. These tributaries include Polecamp Creek near RM 2.8 on river left and Blind Creek near RM 0.9 on river right. There are minimal overbank areas and most are accessible to the channel. The road embankment does encroach on the channel in some locations and there is one bridge crossing, Flat Rock Bridge, near RM 1.9. The bridge and road embankments do not have significantly impact channel processes in this reach.

Chinook salmon and steelhead use this geomorphic reach primarily as a migratory corridor and for some juvenile rearing. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation. No fish passage barriers or habitat deficiencies have been identified for this geomorphic reach.

The channel is in a confined canyon that has high energy and high sediment transport capacity. No anthropogenic disturbances significantly impact channel processes. The reach is utilized by Chinook salmon, steelhead, and bull trout as a migratory corridor, and provides very little juvenile rearing habitat. No fish passage barriers or habitat deficiencies have been identified for this reach.

Since the bedrock canyon is primarily a migratory corridor with no fish passage barriers and no real potential to change or develop additional habitat, there is no need for further assessments of this reach.

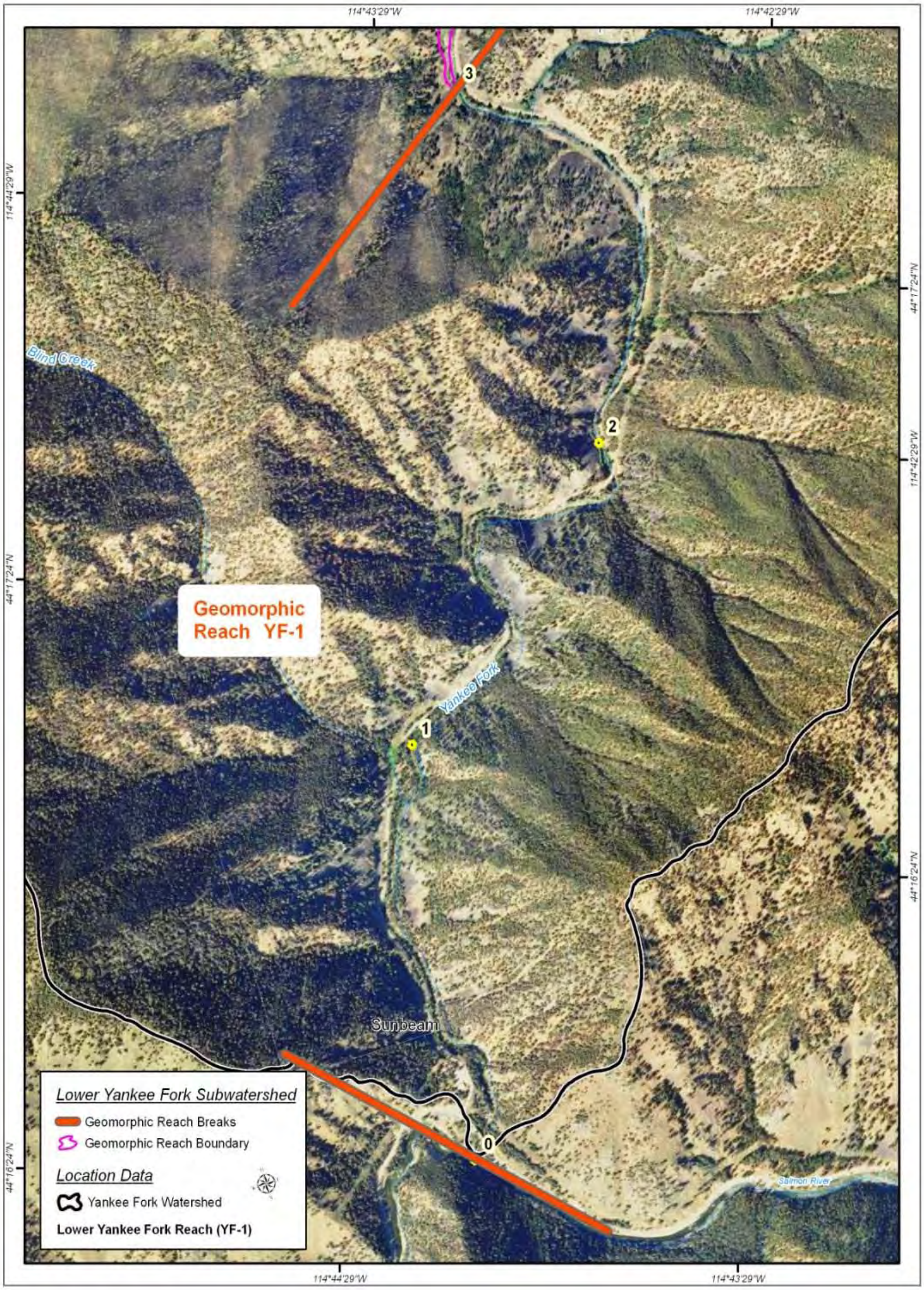

Figure 38. Yankee Fork Geomorphic Reach YF-1 in the lower Yankee Fork subwatershed.

8.4 Jordan Creek Subwatershed

8.4.1 Geomorphic Reach Delineations

Two geomorphic reaches were identified along Jordan Creek in the TA area based on physical processes and channel morphology (Table 26). The longitudinal channel profile (Figure 39) shows the geomorphic reaches within the channel network. Locations of the geomorphic reaches are provided in Figure 40. Details associated with each geomorphic reach are discussed in the following sections.

Table 26. Jordan Creek geomorphic reach delineations and associated channel morphology.

River Miles	*General Valley Location*	Geomorphic Reaches	*Valley Form*[1]	*Valley Type*[2]	Valley Confinement[3]	Valley Gradient	*Channel Reach Type*[2]	Channel Bedform Type[2]	Channel Slope	Dominant Substrate Size Class[4]
RM 4.0-1.4	***Middle Section***	***Reach JC-2***	V3: V-shaped bedrock canyon	Bedrock	Moderately Confined	3.30 percent	***Bedrock channel***	Step-pool to plane-bed	2.90 percent	***Cobble - gravel***
RM 1.4	***Lower Section***	***Reach JC-2***	V4: Alluvial mountain valley	Alluvial	Moderately Confined	2.62 percent	***Free-formed alluvial channel***	Plane-bed to Pool-riffle	2.50 percent	***Cobble - gravel***

[1]Classification based on Naiman et al. (1992) as recommended in Hillman (2006)
[2]Channel type classification based on Montgomery and Buffington (1993)
[3]Monitoring Strategy for the Upper Columbia Basin (Hillman 2006)
[4]From Stream Inventory Survey 2010 (Appendix L) and USFS (2006)

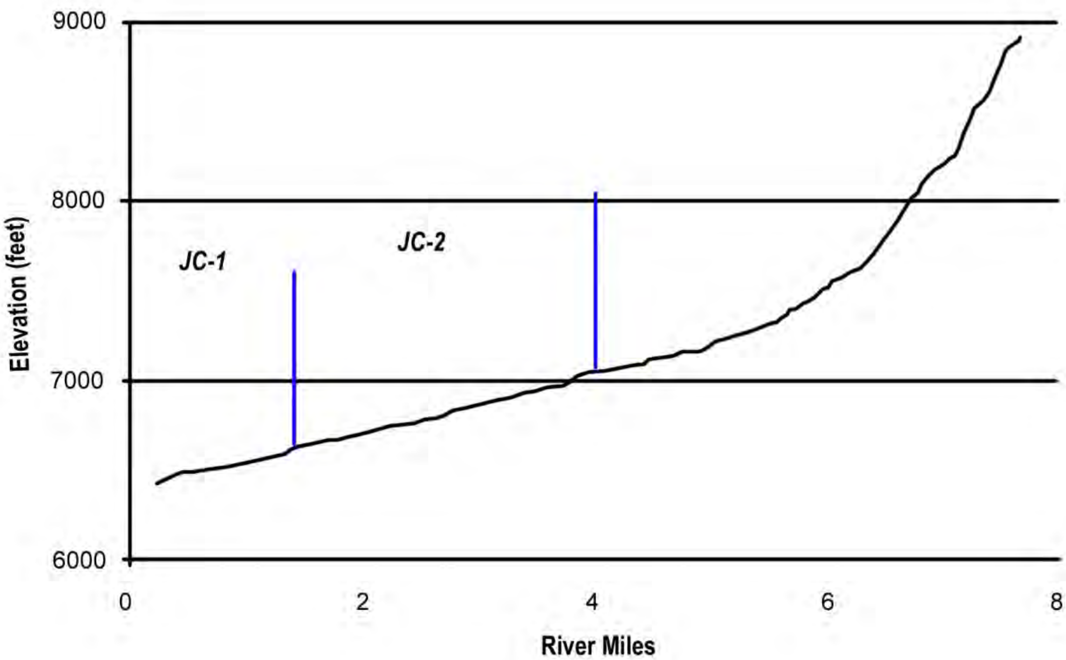

Figure 39. Jordan Creek subwatershed longitudinal channel profile with reach locations.

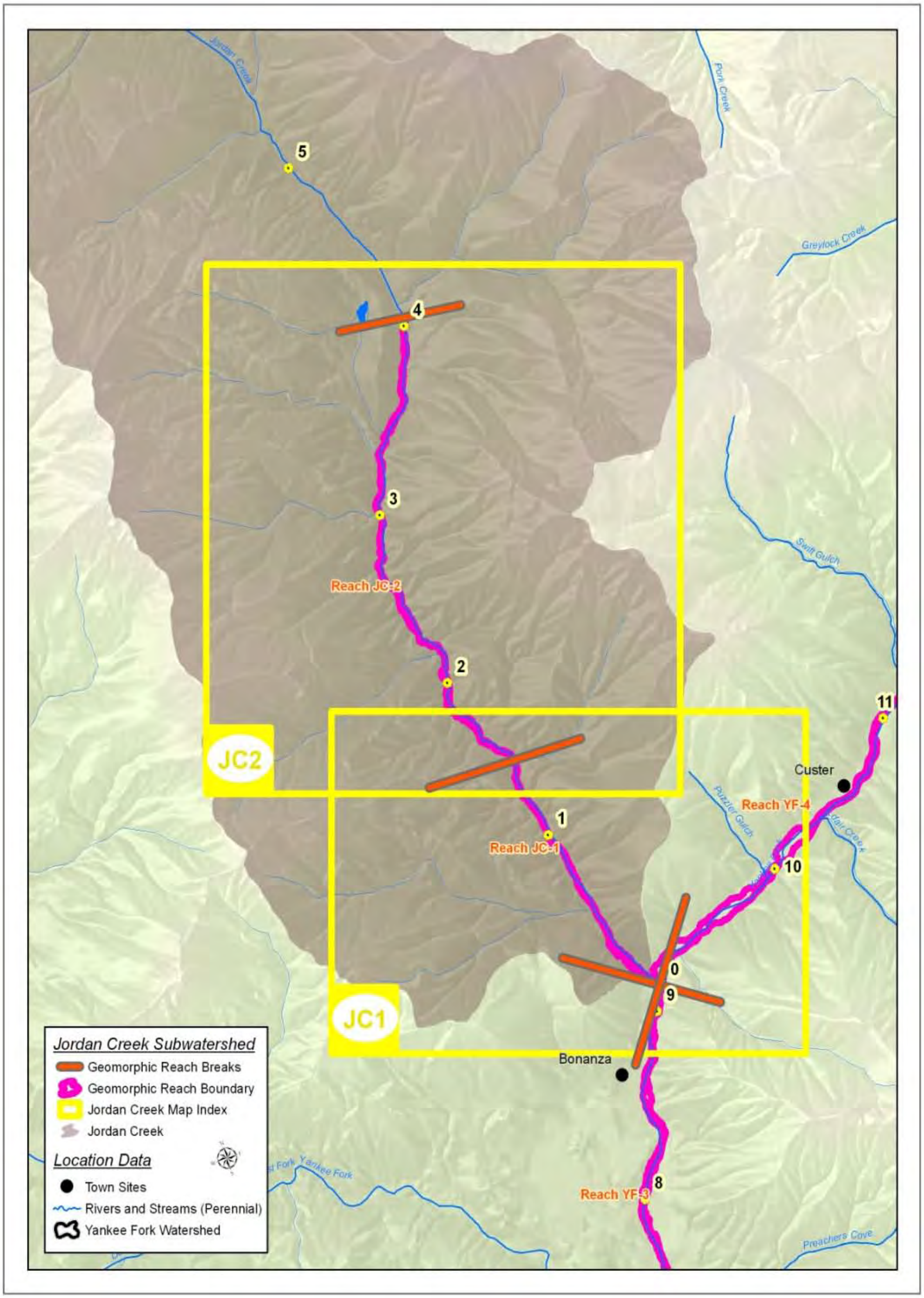

Figure 40. Jordan Creek subwatershed index map with geomorphic reach breaks.

Geomorphic Reach JC-2

Geomorphic Reach JC-2 (Figure 41) is located between RM 4.0 and 1.4 in a moderately-confined valley segment that is constrained by bedrock with colluvial, glacial, alluvial fan, and landslide deposits that further constrain the channel. The channel type is predominantly a bedrock channel with alternating plane-bed and pool-riffle bedforms and has a straight channel pattern. Channel slope is about 2.9 percent with a cobble-dominated substrate with boulders and bedrock being very common.

Hydraulic modeling shows that overbank areas (floodplain) are limited and Jordan Creek is generally confined within its channel banks through the reach. There are floodplain areas where Jordan Creek begins to access during the 2-year recurrence discharge near RM 3.6 to 3.4, RM 3.2 to 3.0, RM 2.6 to 2.4, and RM 2.1 to 1.7.

The average shear stress in the main channel during the 2-year recurrence discharge is approximately 2.0 lb/ft^2 which indicates the creek is capable of transporting cobbles up to 5.2 inches in dimension. There are three locations where shear stress is greater than 4 lb/ft^2, high enough to mobilize a median sediment size of 10.4 inches. At RM 3.4 and RM 2.8, the channel is constrained by the valley wall on river left and the Loon Creek Road on river right. At RM 1.5, the channel is constrained by the valley wall on river right. The average flow velocity in the main channel during the 2-year recurrence discharge is 4.8 ft/s.

Local coarse sediment inputs are predominantly from bank erosion along the toe of colluvial deposits that are underlain with bedrock and some alluvial fan deposits along outside meanders. Very little lateral channel migration and meandering occurs in this reach due to bedrock and oversize materials (i.e., boulders) adjacent to the channel. Other sources are episodic debris flows from ephemeral drainages that are in contact or connected by culverts with the active channel.

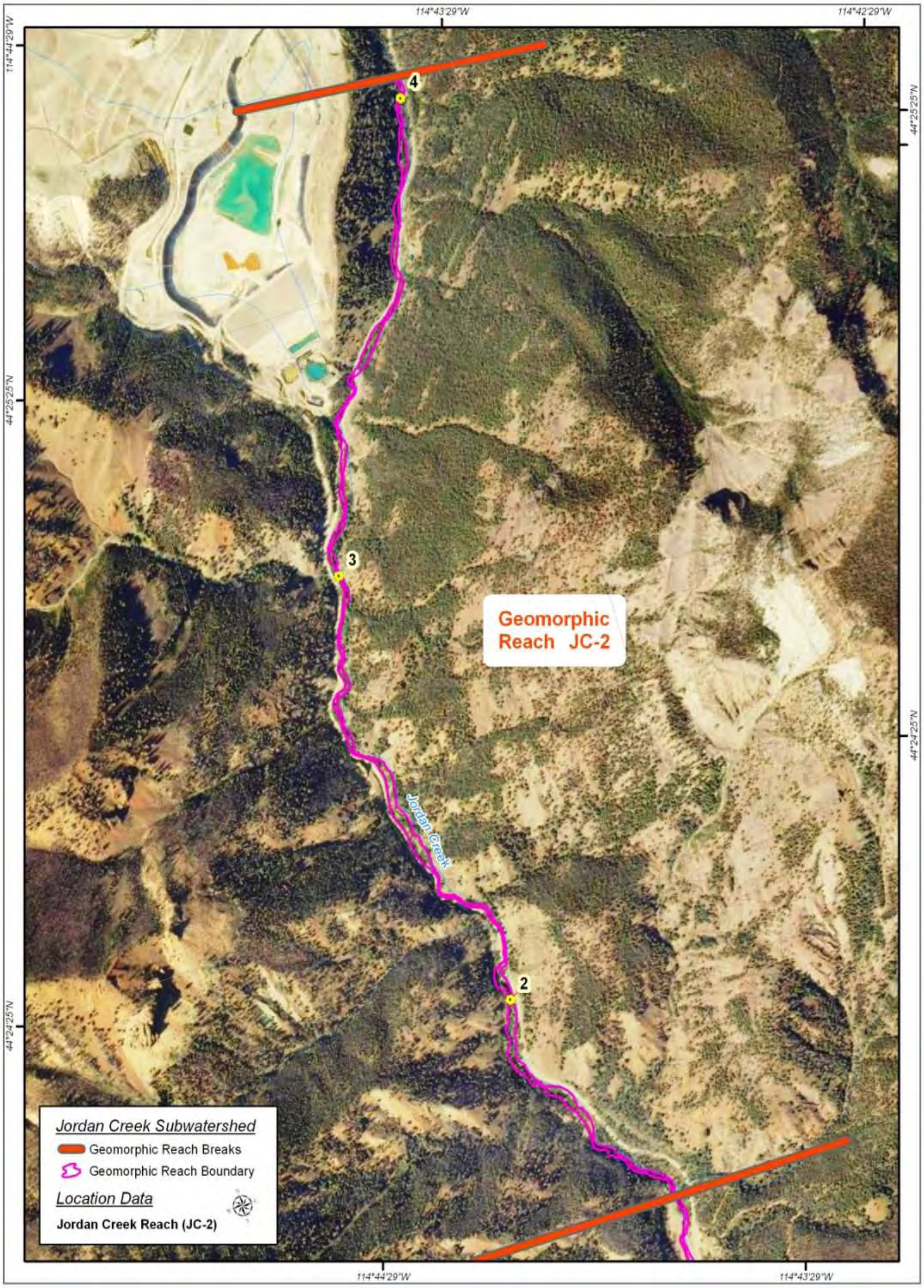

Figure 41. Jordan Creek Geomorphic Reach JC-2 in the Jordan Creek subwatershed.

Anthropogenic Disturbances

Significant impacts to geomorphic processes are road embankments and bridges that confine the channel. Bridge JC5 appears to create a backwater condition by exerting hydraulic control during the 10-year and greater recurrence flood. Bridge JC4 does not appear to exert hydraulic control at flows less than the 2-year recurrence discharge. Bridge JC3 appears to create a backwater condition by exerting hydraulic control during the 100-year recurrence flood. Bridge JC2 appears to create a backwater condition by exerting hydraulic control at the 2-year and greater recurrence discharge.

Other anthropogenic disturbances are related to mining operations. The Grouse Creek Mine is located near RM 3.4. A slope failure near the entrance of the mine near RM 3.3 provided sediment to the stream. It is unknown if the failure was the result of effluent from the mine. The mine is currently in the process of closing and reclamation.

There are active mining operations throughout the subwatershed and the mining activity along Jordan Creek has created topographic features that disconnect or impede channel/floodplain interactions. In addition, vegetation has been removed where many ongoing mining operations are occurring and along their associated access roads.

Fish Usage, Channel Condition, and Habitat Elements

Chinook salmon use this geomorphic reach for some juvenile rearing where suitable habitat patches are present. Steelhead use this reach for spawning where patches of gravel are retained and for juvenile rearing where suitable habitat patches are present. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation.

The following channel condition and habitat elements are from the 2010 stream inventory survey conducted by the USFS. The stream inventory survey identified two habitat reaches that covered most of the geomorphic reach between about RM 3.6 and 1.8 (Table 27). Stream type classification is a B-stream type (Rosgen 1996) defined as a single-threaded channel that is moderately entrenched with a moderate sinuosity. Dominate substrate was cobble and gravel with boulders common.

Table 27. Geomorphic Reach JC-2 stream inventory survey habitat reach and channel condition.

River Miles	Habitat Reach	Geographic Description	Rosgen Stream Type	Average Wetted Channel Width	Average Bankfull Width	Average Floodprone Width
RM 3.6 – 2.7	Reach 4	Unnamed tributary to where valley opens-up	B	14 feet	23 feet	44 feet
RM 2.7 – 1.8	Reach 3	Where valley opens-up to end of dredge tailings	B	12 feet	23 feet	69 feet

The number of pools per mile was about 26 with deep pools comprising about 1 percent of pool habitat (Table 28). Wood frequency for all wood measured was about 20 pieces of wood per mile.

Table 28. Geomorphic Reach JC-2 stream inventory habitat elements.

Habitat Reach	Dominant Substrate	Number of Pools Per Mile	Number of Pools > 3 Feet Deep Per Mile	Average Residual Pool Depth	Total Number of Wood Per Mile
Reach 4	Gravel (2-64 mm) /Cobble (64-256 mm)	27.5	0.9	1.5 feet	21
Reach 3	Cobble (64-256 mm)	23.7	1.2	1.4 feet	18

Discussion and Potential Habitat Actions

This geomorphic reach is in a V-shaped bedrock canyon that moderately confines the channel. The channel type is predominantly a bedrock channel with alternating plane-bed and pool-riffle bedforms and has a straight channel pattern indicating a low rate of lateral channel migration. Predominant substrate is cobble- to gravel-sized materials with boulders and bedrock common, and the channel slope is about 2.9 percent. Channel confinement, slope and lack of sinuosity suggest that an A-stream type transitioning into an F-stream type (Rosgen 1996) is more appropriate for this reach. Channel/floodplain interactions are connected where small floodplains have developed.

The number of observed pools per mile ranged from about 24 to 28 based on the 2010 stream inventory survey. Pool spacing in moderately confined, predominantly bedrock controlled channels is variable (Montgomery and Buffington 1993). In this reach the channel generally alternates between bedrock and alluvial channel segments, and about 7 percent of pools were formed by bedrock and 68 percent were formed by boulders.

Wood frequency was determined to be about 20 pieces of wood per mile. Wood is delivered to the channel primarily from toppling trees along steep valley walls, especially where the stream erodes the toe of the slope, and from episodic debris flows originating in tributaries. The wood is stored in the system as apex log jams on vegetated gravel bars and along the outside edge of meanders where it frequently interacts with the stream during channel forming flows.

Vegetation along the banks of the active channel is comprised predominantly of alder and lodgepole pine in a small tree successional stage. The vegetation is fragmented adjacent to the channel due to its removal in several locations near mining operations, along Loon Creek Road, and other access roads. A continuous riparian corridor would improve channel processes by increasing channel boundary roughness and wood recruitment, and would improve ecologic connectivity for macroinvertebrate production.

Anthropogenic features that constrict the valley bottom are primarily the Loon Creek Road embankment, mine tailings, and spoil piles. There are three bridge crossings that constrict the channel near RM 3.6, 3.2, and 2.1. However, none of these anthropogenic features have a significant impact on reach-scale channel processes.

Potential habitat actions could be implemented to improve channel processes by modifying road embankments and mine tailings that constrict the channel, and planting riparian vegetation in areas where it has been removed to improve channel boundary roughness. However, it is unlikely these actions would result in significant reach-scale changes that would increase juvenile rearing habitat. Essentially, the in-stream bedforms and structure, and resulting habitat, are within the range of variability that should be expected for the channel type and physical characteristics of this reach.

A reach assessment is not necessary to address the localized anthropogenic impacts in this geomorphic reach. Specific alternatives could be developed and evaluated to address the localized anthropogenic disturbances that constrict the channel constraints and/or affect channel boundary roughness and ecological connectivity. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

Geomorphic Reach JC-1

Geomorphic Reach JC-1 (Figure 42) is located between RM 1.4 and the Yankee Fork/Jordan Creek confluence in a moderately confined valley segment that is constrained by mine tailings, and by glacial and colluvial deposits. Channel slope is variable and is about 5.5 percent between RM 1.4 and 1.3, about 2.4 percent between RM 1.3 to 0.4, and about 1.8 percent between RM 0.4 and the mouth. Channel type is predominantly a plane-bed, free-formed alluvial channel that has a straight channel pattern indicating a low rate of lateral channel migration. Dominant substrate is cobble with gravel and boulders.

Hydraulic modeling shows that overbank areas are small and Jordan Creek is confined within its channel banks through the upper segment of Reach JC-1. The creek begins to access floodplains in the rehabilitated segment from RM 0.4 to RM 0.05 during the 1.11-year recurrence discharge. The hydraulic control upstream of Jordan Creek Bridge is the result of the habitat rehabilitation project and not the bridge itself.

The average shear stress in the main channel during the 2-year recurrence discharge is approximately 1.7 lb/ft^2 which indicates the creek is capable of transporting small cobbles up to 4.4 inches in dimension. There are two locations where shear stress is greater than 3 $lb/ft^{2.}$ At RM 1.3, the channel is constrained by dredge piles on both river right and river left, and at RM 0.4, the channel is constrained by dredge piles on river right and the Loon Creek Road on river left. The average flow velocity in the main channel during the 2-year recurrence discharge is 5.7 ft/s.

Local coarse sediment inputs are predominantly from intermittent bank erosion along mine tailings between RM 1.4 and RM 0.4 that are comprised predominantly of cobbles with gravel and boulders. These tailing piles become “self-armoring” as finer materials (i.e., sand and gravel) are eroded and transported downstream, leaving the coarser materials (i.e., cobbles and boulders) that are more resistant to erosion thereby restricting lateral channel migration. Red Rock Creek, a perennial tributary near RM 0.5 on river right, does not appear to be a significant sediment source, but does contribute flows to Jordan Creek. Almost all other ephemeral drainages are disconnected from Jordan Creek due to mine tailing piles or the Loon Creek Road embankment.

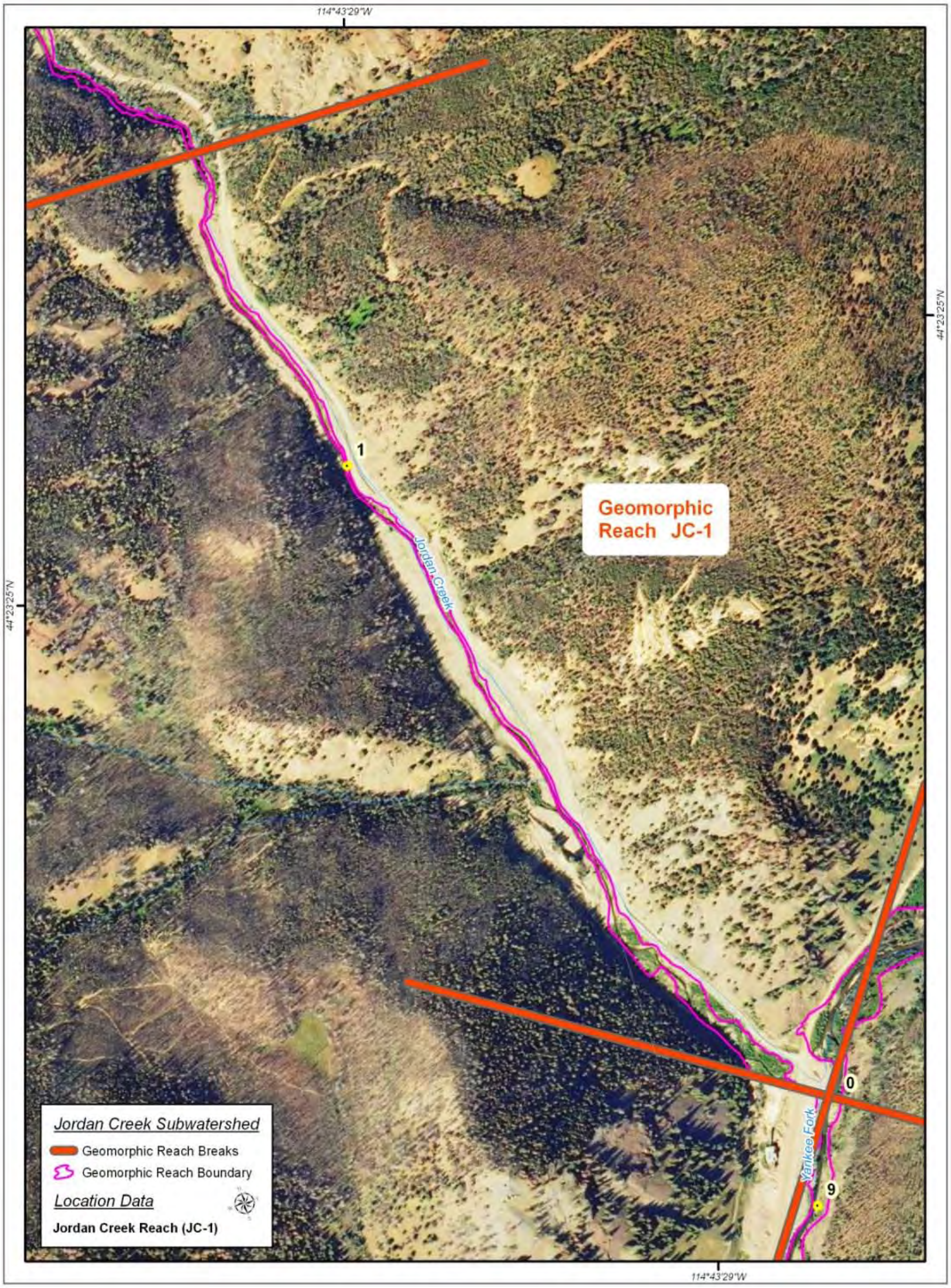

Figure 42. Jordan Creek Geomorphic Reach JC-1 in the Jordan Creek subwatershed.

Anthropogenic Disturbances

The most significant impacts to the channel processes in this geomorphic reach are from mining activities beginning in the late 1800s to the present. Alluvial deposits have been dredged and/or hydraulically mined from about RM 1.4 to the mouth. Following the dredging and hydraulic mining activities, Jordan Creek was constructed adjacent to and through the mine tailings. Presently, dredging and hydraulic mining no longer occur along Jordan Creek, but there are some active placer mines still in operation.

A thin riparian buffer zone (about 30 feet or less) exists from about RM 1.4 and 0.4 that somewhat improve bank stability and channel boundary roughness. Between RM 0.4 and 0.1 riparian vegetation density has significantly improved following the completion of the Grouse Creek Mine Wetland Mitigation Project in 1993. This project included leveling and removing dredge tailings, seeding the rehabilitation area, and adding wood to the system in order to improve channel complexity. The project was successful in re-establishing channel/floodplain interactions, improving bank stability and channel/floodplain roughness, and the added wood contributes by forcing channel adjustments (i.e., scour, avulsion, and lateral channel migration). From about RM 0.1, just above the Jordan Creek Bridge, to the Yankee Fork/Jordan Creek confluence, Jordan Creek is channelized and the riparian vegetation is sparse.

Other anthropogenic disturbances include bridge crossings and road embankments. Bridge JC1 near RM 0.9 appears to access private land and exerts some minor backwater hydraulic control at the 2-year and above recurrence flood. Jordan Creek Bridge on the Custer Motorway near RM 0.1 does not appear to exert hydraulic control. At RM 0.4, the channel is constrained by dredge tailings on river right and the Loon Creek Road embankment on river left.

Fish Usage, Channel Condition, and Habitat Elements

Chinook salmon use this geomorphic reach primarily for juvenile rearing. Steelhead use this reach for juvenile rearing and as a migratory corridor. These findings are based on a Habitat Work Session meeting conducted on April 12, 2011 in Challis, Idaho with fisheries biologists from the Tribes, USFS, IDFG, and Reclamation.

The following channel condition and habitat elements are from the 2010 stream inventory survey conducted by the USFS. The stream inventory survey identified two habitat reaches that covered all of the geomorphic reach (Table 29). Stream type classification for habitat reach 2 is a G-stream type and habitat reach 1 is a B-stream type (Rosgen 1996). Both stream types are single-threaded channels, but the stream transitions from a G-stream type to a B-stream type as the channel becomes less confined in the downstream direction. Measured substrate was predominantly cobble with gravel.

Table 29. Geomorphic Reach JC-1 stream inventory habitat reach and channel condition.

River Miles	Habitat Reach	Geographic Description	Rosgen Stream Type	Average Wetted Channel Width	Average Bankfull Width	Average Floodprone Width
RM 1.8 – 0.4	Reach 2	End of dredge tailings to about Red Rock Creek	G	14 feet	23 feet	40 feet
RM 0.4 – 0	Reach 1	About Red Rock Creek to mouth	B	15 feet	19 feet	79 feet

The number of pools per mile averaged about 19 pools per mile with deep pools comprising about 5 percent of pool habitat (Table 30). Wood frequency for all wood measured ranged from 8 to 67 pieces of wood per mile with an average of about 38 pieces per mile.

Table 30. Geomorphic Reach JC-1 stream inventory habitat elements.

Habitat Reach	Dominant Substrate	Number of Pools Per Mile	Number of Pools > 3 Feet Deep Per Mile	Average Residual Pool Depth	Total Number of Wood Per Mile
Reach 2	Cobble (64-256 mm)	25	1	1.1 feet	8
Reach 1	Cobble (64-256 mm)	13	1	2 feet	67

Discussion and Potential Habitat Actions

This geomorphic reach is in a V-shaped alluvial valley that moderately confines the channel. Channel type is predominantly a plane-bed, free-formed alluvial channel that has a straight channel pattern indicating a low rate of lateral channel migration. Dominant substrate is cobble with gravel and boulders. Channel slope is variable and is about 5.5 percent where the channel is confined by an alluvial fan between RM 1.4 and 1.3, decreases to about 2.4 percent where the channel is moderately confined by mine tailings between RM 1.4 to 0.4, and further decreases to about 1.8 percent where mine tailings have been partially removed and leveled, creating channel/floodplain interactions. The stream survey conducted in 2010 showed that the stream type is a G-stream type that graded into a B-stream type (Rosgen 1996) as channel slope and channel confinement decreased in the downstream direction.

Historically, Jordan Creek had a straight, moderately confined channel that was constrained by glacial, alluvial, and colluvial deposits upstream of RM 0.4. The creek had a plane-bed, free-formed alluvial channel with gravel to boulder substrate based on the 1934 stream survey (USDC 1934) and 1945 aerial photographs. Channel gradients were probably similar because of the grade controls provided by bedrock, boulders, and alluvial fans. About 95 percent of the channel was comprised of riffles, and the few pools observed in this reach were formed by boulders with some lateral scour pools along outside meanders (USDC 1934).

Jordan Creek has a moderately confined straight channel that has a higher gradient (5.5 percent) which transitions to a lower gradient (1.8 percent). These types of systems generally have a high sediment transport capacity and are efficient at transporting sediment, and wood, downstream that typically results in forming an armor layer that inhibits pool development in the absence of structures that force flow convergence, or bed scour (Montgomery and Buffington 1997; Bisson, Buffington, and Montgomery 2006). In general, the steeper channel segments tend to have step-pool morphology, and as the channel slope decreases to 3 percent or less transitions to a plane-bed morphology (Montgomery and Buffington 1993).

Pool spacing for step-pool channel segments is typically 1 to 4 channel widths, and for plane-bed channel segments there are no correlations associated with pool spacing (Montgomery and Buffington 1993). The number of pools per mile observed during the stream inventory survey (2010) ranged from 25 pools per mile in the higher gradient segments to 13 pools per mile in the lower gradient segments. Based on the physical characteristics of this system, the frequency of pools in this reach is within the expected range of variability for a transitional channel type (i.e., predominantly plane-bed).

The number of pieces of wood observed during the stream inventory survey (2010) ranged from 8 pieces of wood in the higher gradient segments to 67 pieces in the lower gradient segments. Wood is delivered to the channel predominantly from toppling trees along steep valley walls or is transported into this reach from upstream. The wood is stored as log jams on vegetated bars and along the outside edge of meanders where it frequently interacts with the stream during channel forming flows. The number of pieces of wood per mile retained in the system would be expected to increase as the channel decreases in gradient and becomes less confined, as is the case in this reach. However, in the lower gradient section between RM 0.4 and 0.1, the higher number of wood pieces per mile also represents wood that was added to the system as part of the Grouse Creek Mine Wetland Mitigation Project (1993).

Vegetation along the banks of the active channel is comprised predominantly of willow and lodgepole pine in a shrub/seedling to small tree successional stage. Riparian vegetation has created a thin buffer zone (about 30 feet or less) along the active channel that is fragmented due to clearing in several locations near mining operations, along the Loon Creek Road, and other access roads. A comparison between the 1945 and 2010 aerial photographs shows that the riparian corridor was more robust and most likely provided small- to medium-sized trees to the channel. There were patches of larger trees that appear to be growing above the active floodplain that may have been available to the stream through lateral channel migration. However, a majority of the larger wood in the system was probably recruited through mass wasting in tributary drainages.

The Grouse Creek Mine Wetland Mitigation Project (1993) was located between RM 0.4 to the Custer Motorway Bridge near the Yankee Fork/Jordan Creek confluence. The project included the removal and/or modifications of mine tailings to improve channel/floodplain interactions. The channel has a gradient of about 1.8 percent with a predominantly gravel and cobble substrate. Wood and sediment are mobilized during channel forming flows and their interactions create areas of flow convergence and divergence that force lateral scour pools and deposition of riffles and bars.

Anthropogenic features that constrain the channel are primarily dredge tailings, mining spoils, and road embankments. There are two bridge crossings that do not significantly impact channel processes because they were built in locations where the channel was already constricted by dredge tailings near RM 0.9 and RM 0.1. The dredge tailings impact geomorphic processes by confining the channel in many locations and providing a continuous sediment source. Along the lower section of the reach, between about RM 0.1 to the Yankee Fork/Jordan Creek confluence, the constructed channel is straight and confined between dredge tailings.

Presently, there is a thin riparian buffer zone (about 30 feet or less) from about RM 1.4 and 0.4 that provides some bank stability, channel boundary roughness, and ecological connectivity. Riparian vegetation, in conjunction with improved channel/floodplain interactions, was significantly improved between RM 0.4 and 0.1 following completion of the Grouse Creek Mine Wetland Mitigation Project in 1993.

Potential habitat actions could be implemented in localized areas to address past mining activities and the road embankments that result in channel constraints. Replanting riparian vegetation to improve channel boundary roughness and ecologic connectivity could also be considered. It is unlikely these actions would result in a reach-scale improvement that would significantly increase juvenile rearing habitat. Essentially, the in-stream bedforms and structure and resulting habitat are within the range of variability that should be expected for the channel type and physical characteristics for the reach. Also, it is unlikely that project implementation is feasible where placer mining activities continue (or are anticipated in the near future).

A reach assessment is not necessary to address the localized anthropogenic impacts in this geomorphic reach. Alternatives analysis could be conducted to address anthropogenic features affecting channel constraints and channel boundary roughness. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

9. Conclusions

The purpose of this assessment was to provide information that describes (1) the large scale geomorphic processes occurring within the watershed; (2) the basis for delineation of geomorphic reaches within the TA area; and (3) the geomorphic reaches that have the greatest potential for improving geomorphic processes, reconnecting isolated habitats, and improving habitat quantity and quality.

Valley segments and geomorphic reaches were delineated along the Yankee Fork in the middle and lower Yankee Fork subwatersheds, and along lower Jordan Creek in the Jordan Creek subwatershed. The geomorphic reaches were coincident with the valley segments and are located as follows:

- In the middle Yankee Fork subwatershed, three geomorphic reaches were identified (upstream to downstream): (1) Reach YF-6 from RM 16.5 to 13.3, (2) Reach YF-5 from RM 13.3 to 11.7, and (3) Reach YF-4 from RM 11.7 to 9.1.

- In the lower Yankee Fork subwatershed, three geomorphic reaches were identified: (1) Reach YF-3 from RM 9.1 to 6.8, (2) Reach YF-2 from RM 6.8 to 3, and (3) Reach YF-1 from RM 3 to Yankee Fork/Salmon River confluence.

- Two geomorphic reaches were identified in the Jordan Creek subwatershed: (1) Reach JC-2 from RM 4 to 1.4 and (2) Reach JC-1 from RM 1.4 to Yankee Fork/Jordan Creek confluence.

The following are summaries of each geomorphic reach:

- **Yankee Fork Reach YF-6**: Chinook salmon and steelhead use this reach for migration, spawning, and rearing. The river is unconfined and has a predominantly straight, free-formed alluvial channel with good channel/floodplain interactions. The most significant anthropogenic disturbance to physical and ecological processes have been from past timber harvests that supported mining activities in the late 1800s and from fire suppression efforts beginning in the 1900s that may have changed the species assemblage and successional stages from pre-European settlement time (Overton et al. 1999). The riverine system is on a recovering trend as the vegetation progresses through varying successional stages. Other anthropogenic impacts do not significantly affect physical or ecological processes that contribute to habitat quantity and quality at the reach-scale. Essentially, the in-stream bedforms and structure and resulting habitat are within the range of variability that should be expected for the channel type and physical characteristics for this reach.

- **Yankee Fork Reach YF-5**: Chinook salmon, steelhead, and other fish species use this reach primarily as a migratory corridor. The river is confined within a V-shaped canyon and the predominant channel type is bedrock with a straight channel planform. There are no anthropogenic impacts that negatively affect reach-scale processes, and the channel morphology and habitat structure are within the expected range of variability for a bedrock channel.

- **Yankee Fork Reach YF-4**: Chinook salmon and steelhead use this reach for migration, spawning, and juvenile rearing. The river is moderately confined with a predominantly straight, free-formed alluvial channel. Channel/floodplain interactions are occurring in the lower section from RM 10.3 to 9.1. Past timber harvests, mining, and development may have changed the species assemblage and successional stages from pre-European settlement time in this reach (Overton et al. 1999). Reach-scale processes are strongly influenced by the type of vegetation and successional stage which influences channel morphology and habitat arrangement. There are localized anthropogenic impacts that affect physical processes and habitat quantity and quality that include: (1) small floodplain areas disconnected by a levee and deflection berm and (2) a bridge crossing near RM 10.9 (General's Bridge) that slightly constricts the channel. However, the overall impact of these features on reach-scale channel processes and floodplain connectivity are minimal.

- **Yankee Fork Reach YF-3**: Chinook salmon use this reach for migration, spawning, and juvenile rearing and steelhead use it for migration and juvenile rearing. The river is presently confined by dredge tailings and has a predominantly straight, free-formed alluvial channel. Prior to dredging, much of this reach was unconfined and maintained a straight channel pattern with some meandering channel segments and connected channel/floodplain interactions. The dredging operations involved rerouting the Yankee Fork and disconnecting it from its floodplain; and on the West Fork, the lower channel segment was rerouted and artificially constrained by dredge piles. Historically, the Yankee Fork and West Fork confluence area had a broad floodplain in which the two unconfined channels dynamically interacted. The channels migrated across their floodplains which progressively changed where and how the channels converged. These dynamic interactions resulted in varying hydraulic conditions that created and maintained a mosaic of habitat patches. Presently, the new channel configurations and location of channel convergence are now static and the hydraulic conditions no longer create the mosaic of habitat patches.

- **Yankee Fork Reach YF-2**: Chinook salmon and steelhead use this reach for migration, spawning, and juvenile rearing. Presently, the river is predominantly confined by dredge tailings and maintains a straight, free-formed alluvial channel with a cobble dominated plane-bed. Prior to dredging, this reach was moderately confined by higher surfaces (comprised primarily of glacial outwash), alluvial fans, and bedrock, and maintained a straight, free-formed alluvial channel similar to the present channel. The difference between the pre-dredge channel and the present channel is the degree of channel confinement. By increasing channel confinement between dredge piles, the cross sectional area geometry of the channel and floodplain has a narrower width which must convey the same peak flows, resulting in increases to water depth, flow velocity, and sediment transport capacity.

Other significant anthropogenic impacts include: (1) tailing piles disconnecting Jerrys Creek and Silver Creek (perennial tributaries) from the Yankee Fork that most likely provided juvenile rearing habitat for both Chinook salmon and steelhead in the low gradient sections along the valley floor, and steelhead rearing and spawning habitat in the higher gradient sections along the valley wall (Bureau of Fisheries Stream Survey in 1934 that reported many fingerlings observed in the lower quarter mile section of Silver Creek); (2) removal of vegetation and reworking of topsoil within the dredged area leaving behind tailing piles of mixed unconsolidated alluvium with the coarse fraction remaining at the surface; (3) lateral channel migration into the tailing piles has been occurring at a very slow rate and is restricted because the tailings tend to be "self-armoring" as finer materials (i.e., sand and gravel) are eroded and transported downstream leaving behind coarser materials (i.e., cobbles and boulders) along the toe; and (4) the lower section of Ramey Creek has been channelized and peak flows are confined to within the channel and not dissipated across its alluvial fan resulting in increased water depth, flow velocity, and sediment transport capacity.

- **Yankee Fork Reach YF-1**: Chinook salmon, steelhead, and other species use this reach primarily as a migratory corridor. The river flows through a V-shaped canyon and the channel is confined by bedrock and talus. The river has a bedrock channel type with predominantly a step-pool bedform and high sediment transport capacity. There are some anthropogenic impacts from road embankments encroaching on the channel and floodplain, and a bridge crossing that constricts the channel. However, these anthropogenic disturbances do not significantly impact physical processes or habitat quantity and quality.

- **Jordan Creek Reach JC-2**: Steelhead use this reach for spawning and juvenile rearing, and there is very limited Chinook salmon juvenile rearing habitat. The creek flows through a moderately-confined valley segment that is constrained by bedrock with colluvial, glacial, alluvial fan, and landslide deposits. The channel type is predominantly a bedrock channel with alternating plane-bed and pool-riffle bedforms and has a straight channel pattern. Channel slope is about 2.9 percent with a cobble-dominated substrate with boulders and bedrock common. Anthropogenic features that constrict the valley bottom are primarily the Loon

Creek Road embankment, mine tailings, and spoil piles. There are three bridge crossings that constrict the channel near RM 3.6, 3.2, and 2.1. However, none of these anthropogenic features have a significant impact on reach-scale channel processes. Essentially, the bedform and in-stream structure and resulting habitat is within the range of variability that should be expected for the channel type and physical characteristics for this reach.

- **Jordan Creek Reach JC-1**: Chinook salmon and steelhead use this reach primarily for juvenile rearing. The creek flows through a V-shaped alluvial valley that moderately confines the channel. Channel type is predominantly a plane-bed, free-formed alluvial channel that has a straight channel pattern indicating a low rate of lateral channel migration. Past dredging and hydraulic mining operations have resulted in the relocation of Jordan Creek. Other anthropogenic impacts include: (1) removal of vegetation along the valley bottom from mining operations and construction of the Loon Creek Road; (2) two bridge crossings that do not significantly impact channel processes because they were built in locations where the channel was already constricted by dredge tailings near RM 0.9 and RM 0.1; (3) a wetland mitigation project that included the removal and/or modification of mine tailings to improve channel/floodplain interactions was completed in 1993 between RM 0.4 and the Custer Motorway Bridge; and (4) channelizing the creek through mine tailings between about RM 0.1 to the Yankee Fork/Jordan Creek confluence.

In conclusion, the geomorphic reaches, in order of their potential to improve geomorphic processes and habitat quantity and quality, along with their needs for further assessment are as follows:

1. **Yankee Fork Reach YF-3**: The physical and ecological processes have been significantly impacted by dredging operations in this reach. Dredge piles artificially constrain the Yankee Fork and West Fork channel, disconnect relatively large floodplain areas from the Yankee Fork, and have changed the convergence between the Yankee Fork and West Fork from a dynamic interaction that created a mosaic of habitat patches to a static condition that no longer provides the complex habitat types. A more detailed reach assessment, potentially involving a more complex hydraulic model, is needed to evaluate current physical and ecologic processes, and to evaluate the overall potential to improve these processes and their benefit and risks to the resource.

2. **Yankee Fork Reach YF-2**: The Tribes have worked with consultants and stakeholders on implementing habitat projects in this geomorphic reach. Alternatives should continue to be pursued to reconnect isolated tributaries and improve channel/floodplain interactions. In addition, the four dredge pond series have the potential to provide replacement of juvenile rearing habitat that was lost

when dredging obliterated the lower sections of some tributaries. If flows were increased into these pond series, it would also reduce peak flows in the mainstem Yankee Fork, resulting in a reduction in sediment transport capacity and lower flow velocities which would improve spawning gravel retention and juvenile fish movement. All relevant environmental parameters, such as those used in NOAA Fisheries (1996) *Matrix of Pathways and Indicators* or U.S. Fish and Wildlife Service's (1998) *Matrix of Diagnostics/Pathways and Indicators*, should be measured prior to implementation of any rehabilitation project to characterize the current environmental conditions. This information provides an environmental "baseline" that can be used to predict the effects of rehabilitation actions, and to detect changes following implementation of the actions (i.e., effectiveness monitoring).

3. **Jordan Creek Reach JC-1**: A reach assessment is not necessary to address the localized anthropogenic impacts in this geomorphic reach. Modifications to localized channel constrictions (i.e., mine tailing and road embankments) could be pursued on a case-by-case basis dependent on landowner cooperation. Replanting riparian vegetation (i.e., 30-foot buffer zone) to improve channel boundary roughness and ecologic connectivity could also be considered. It is unlikely these actions would result in a reach-scale improvement that would significantly increase juvenile rearing habitat. Essentially, the in-stream bedforms and structure and resulting habitat are within the range of variability that should be expected for the channel type and physical characteristics for the reach. Also, it is unlikely that project implementation is feasible where placer mining activities continue (or are anticipated in the near future). All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

4. **Yankee Fork Reach YF-4**: Physical and ecological processes are negatively impacted primarily from past timber harvests along the valley bottoms and margins. The riverine system appears to be on a recovering trend as vegetation progresses through varying successional stages, albeit at a slower rate due to continued recreational and private landowner usage. Maintaining and actively managing a riparian corridor (i.e., about 100-foot buffer zone) along both sides of the channel to insure proper species assemblage and improve growth rates would be an appropriate approach for long-term rehabilitation. Addressing localized constrictions along the channel (i.e., levee, deflection berm and bridge crossings) and identifying potential locations for large wood placements could be pursued on a case-by-case basis dependent on landowner cooperation. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

5. **Yankee Fork Reach YF-6**: Physical and ecological processes have been negatively impacted primarily from past timber harvest along the valley bottoms and margins. The riverine system appears to be on a recovering trend as the vegetation progresses through varying successional stages. Active management of these stands to insure proper species assemblage and improve growth rates would be an appropriate approach for long-term rehabilitation. Potential short-term rehabilitation approaches to increase availability of wood to the system could be pursued on a case-by-case basis which includes: (1) ensuring that wood and sediment inputs from tributaries are not impeded by obstructions (i.e., undersized culverts), and (2) wood placement along the channel and floodplain if the anticipated ecologic benefits outweigh the disturbances to the channel or floodplain. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

6. **Jordan Creek Reach JC-2**: A reach assessment is not necessary to address the localized anthropogenic impacts in this geomorphic reach. Specific alternatives could be pursued on a case-by-case basis to address the localized anthropogenic disturbances that constrict the channel and/or affect channel boundary roughness and ecological connectivity. Essentially, the in-stream bedforms and structure and resulting habitat are within the range of variability that should be expected for the channel type and physical characteristics for the reach. All relevant environmental parameters should be measured as part of any alternatives analysis to characterize environmental baseline conditions to predict potential effects of any action and for future effectiveness monitoring.

7. **Yankee Fork Reaches YF-5 and YF-1**: These geomorphic reaches are primarily Chinook salmon and steelhead migratory corridors. In these reaches the river flows through V-shaped canyons that have bedrock type channels with predominantly step-pool bedforms. There are no anthropogenic features that significantly impact channel processes at the reach-scale. Therefore, no further assessments are recommended.

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11. Literature Cited

Parenthetical Reference	Bibliographic Citation
57 FR 57051	Federal Register. 1992. National Marine Fisheries Service Final Rule. Designated Critical Habitat; Snake River Sockeye Salmon, Snake River Spring Chinook Salmon and Snake River Fall Chinook Salmon. December 2, 1992, Vol. 57, No. 232, pp. 57051-57056.
62 FR 43937	Federal Register. 1997. National Marine Fisheries Service Final Rule: Endangered and Threatened Species; Listing of Several Evolutionarily Significant Units (ESUs) of West Coast Steelhead. August 18, 1997, Vol. 62, No. 159, pp. 43937-43954.
63 FR 31647	Federal Register. 1998. Fish and Wildlife Service Final Rule: Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Klamath River and Columbia River Distinct Population Segments of Bull Trout. June 10, 1998, Vol. 63, No. 111, pp. 31647-31674.
70 FR 37160	Federal Register. 2005. National Oceanic and Atmospheric Administration Final Rule: Endangered and Threatened Species; Final Listing for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. June 28, 2005, Vol. 70, No. 123, pp. 37160-37204.
71 FR 834	Federal Register. 2006. National Oceanic and Atmospheric Administration Final Rule: Endangered and Threatened Species; Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. January 5, 2006, Vol. 71, No. 3, pp. 834-862.
75 FR 63898	Federal Register. 2010. Department of the Interior, Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States. October 18, 2010, Vol. 75, No. 200, pp 63898-64070.
Anderson 1949	Anderson, A. 1949. "Silver-gold deposits of the Yankee Fork district, Custer County, Idaho." Idaho Bureau of Mines and Geology Pamphlet 83, 37 p.
Beechie et al. 2006	Beechie, T., Liermann, M., Pollock, M., Baker, S., and Davies, J., 2006. Channel pattern and river-floodplain dynamics in forested mountain river systems: Geomorphology 78 (2006) p. 124-141.

Parenthetical Reference	Bibliographic Citation
Bellmore and Baxter 2009	Bellmore, J.R., and C.V. Baxter. 2009. *Yankee Fork Salmon River Dredge Tailings Restoration Project: A Plan for Monitoring and Evaluation*. Idaho State University. Pocatello, Idaho.
Berenbrock 2002	Berenbrock, C. 2002. "Estimating the magnitude of peak flows at selected recurrence intervals for streams in Idaho." U.S. Geological Survey Water-Resources Investigation Report 02-4170, 59 p.
Bisson, Buffington, and Montgomery 2006	Bisson, P., Buffington, J., and Montgomery, D. 2006. *Valley segments, stream reaches, and channel units: in Methods in Stream Ecology*. Elsevier, p. 23-49.
Bjornn and Reiser 1991	Bjornn, T., and Reiser, D., 1991. "Habitat requirements of salmonids in streams" American Fisheries Society Special Publication 19: 83-138.
Borgert, Lundeen, and Thackray 1999	Borgert, J., Lundeen, K., and Thackray, G. 1999. "Glacial geology of the southeastern Sawtooth Mountains" in hughes, S., and Thackray, C., eds., *Guidebook to the geology of Eastern Idaho*. Idaho Museum of Natural History, Pocatello, Idaho, p. 205-217.
Chapman 1986	Chapman, D. W. 1986. "Salmon and steelhead abundance in the Columbia River in the nineteenth century." Transaction of the *American Fisheries Society* 115:662-670.
Choate 1962	Choate, R. 1962. "Geology and ore deposits of the Stanley Area." Idaho Bureau of Mines and Geology, Pamphlet No. 126, Moscow, Idaho, 122 p.
CRHRP 2009a	Columbia River Hatchery Reform Project. 2009. *Hatchery Scientific Review Group. Columbia River Hatchery Reform System-Wide Report*. Salmon-Yankee Fork Spring Chinook Population and Related Hatchery Programs.
CRHRP 2009b	Columbia River Hatchery Reform Project. 2009. *Hatchery Scientific Review Group. Review and Recommendations*. Salmon River. Upper Salmon Summer Steelhead A-Run Population and Related Hatchery Programs.
Davidson 1960	Davidson, D. 1960. "Selenium in some epithermal deposits of antimony, mercury, and silver and gold." U.S. Geological Survey Bulletin 1112-A, 16 p.

Parenthetical Reference	Bibliographic Citation
Davidson and Powers 1959	Davidson, D., and Power, H. 1959. "Selenium content of some volcanic rocks from the Western United States and Hawaiin Islands." U.S. Geological Survey Bulletin 1084-C, p. 69-81.
Ecovista 2004	Ecovista. 2004. *Salmon Subbasin Management Plan*. Prepared for the Northwest Power and Conservation Council.
EPA 2004	U.S. Environmental Protection Agency. 2004. *Draft aquatic life criteria for selenium – 2004.* EPA-822-D-04-001. Office of Water, Office of Science and Technology, Washington D.C.
Evenson et al. 1982	Evenson, E.B., Cotter, J.F.P., and Clinch, J.M. 1982. "Glaciation of the Pioneer Mountains, a proposed model for Idaho" in Bonnichsen B., and Breckenridge, R.M., eds., *Cenozoic Geology of Southern Idaho*. Idaho Bureau of Mines and Geology Bulletin, v. 26, p.653-665.
Fenneman 1931	Fenneman, N. 1931. *Physiography of the Western United States*. McGraw-Hill, New York, 534 p.
Fisher and Johnson 1995	Fisher, F., and Johnson, K. 1995. Geology and Mineral Resource Assessment of the Challis 1º X 2º Quadrangle, U.S. Geological Survey Professional Paper 1525: U.S. Geological Survey, U.S. Government Printing Office, Washington, 204 p. + maps.
Frost and Box 2009	Frost, Thomas P., and S.E. Box. 2009. "Stream-sediment geochemistry in mining-impacted drainages of the Yankee Fork of the Salmon River, Custer County Idaho." U.S. Geological Survey Scientific Investigation Report 2009-5115.
Gamett and Bartel 2008	Gamett and Bartel. 2008. The Status of Fishes on the Yankee Fork Ranger District, Salmon-Challis National Forest. South Zone Fish Program. Salmon-Challis National Forest.
Hillman 2006	Hillman, T. 2006. *Monitoring strategy for the Upper Columbia Basin, second draft report, August 2006*, prepared for the Upper Columbia Salmon Recovery Board, Bonneville Power Administration, and NOAA's National Marine Fisheries Service: BioAnalysts, Inc., Boise, Idaho. 98 pp.
Hillman and Giorgi 2002	Hillman, T., and Giorgi, A. 2002. *Monitoring protocols: effectiveness monitoring of physical/environmental indicators in tributary habitats*, prepared for the Bonneville Power Administration: BioAnalysts, Inc., Boise, Idaho. 104 pp.

Parenthetical Reference	Bibliographic Citation
Hortness 2006	Hortness, J.E. 2006. "Estimating low-flow frequency statistics for unregulated streams in Idaho:" U.S. Geological Survey Scientific Investigations Report 2006-5035, 31 p.
Hyatt et al. 2006	Hyatt, M.W., C. Claire, and T. Cochnauer. 2006. *Evaluate status of Pacific Lamprey in the Clearwater River and Salmon River Drainages, Idaho*. Annual Report. BPA Report Project 2000-028-00
IBHS 2009	Idaho Bureau of Homeland Security. 2009. *Putting down roots in earthquake country, your handbook for earthquakes in Idaho*. Idaho Bureau of Homeland Security, Boise, Idaho. 38 p.
ICTRT 2010	ICTRT (Interior Columbia Technical Recovery Team). 2010. *Part 3: Current Status Review: Interior Columbia Basin Salmon ESU's and Steelhead DPSs. Part 3: Status summary-Snake River Spring/Summer Chinook Salmon ESU's*. NOAA Northwest Fisheries Science Center, Seattle, Washington.
IDEQ 2003	Idaho Department of Environmental Quality. 2003. *Upper Salmon River subbasin assessment and TMDL*: Idaho Department of Environmental Quality, Boise, Idaho, 217 p.
IDEQ 2009	Idaho Department of Environmental Quality. 2009. *Department of Environmental Quality working principles and policies for the 2008 (303[d]/305[b]) report*. State of Idaho Department of Environmental Quality, Boise, Idaho, 92 p.
ISHS 1993	Idaho State Historical Society. 1993. *Site Report, Yankee Fork-Robinson Bar*. Reference Series, Number 204. Prepared by the Publication unit, Boise, Idaho. 8 p.
ISRP 2008	Independent Scientific Review Panel. 2008. *Review of the Yankee Fork floodplain restoration project Implementation plan for 2008 – 2018: Independent Scientific Review Panel for the Northwest Power and Conservation Council*. Portland, Oregon. 15 pp.
Janecke 1992	Janecke, S. 1992. "Kinematics and timing of three superposed extensional systems, east central Idaho: Evidence for an Eocene tectonic transition." *Tectonics*, v. 11, p. 1121-1138.
Kiilsgaard et al. 1986	Kiilsgaard, T., Fisher, F., and Bennett, E. 1986. "The Trans-Challis fault system and associated precious metal deposits, Idaho." *Economic Geology*, v. 81, p. 721-724.

Parenthetical Reference	Bibliographic Citation
Link and Janecke 1999	Link, P., and Janecke, S. 1999. "Geology of East-Central Idaho: Geologic roadlogs for the Big and Little Lost River, Lemhi, and Salmon River valleys." Pages 295-334 in Hughes, S., and Thackray, G., eds., *Guidebook to the Geology of Eastern Idaho*: Idaho Museum of Natural History, Pocatello, Idaho
LOYF Historical Association 2005	Land of the Yankee Fork Historical Association. *Land of the Yankee Fork Historic Area in Words and Pictures.* Produced and Published by the Land of the Yankee Fork Interpretive Center and the Idaho Department of Parks and Recreation. 51 p.
LOYF Master Plan 2009	Idaho Department of Parks and Recreation. 2009. *Land of the Yankee Fork Master Plan.* 160 p.
Mackin and Schmidt 1956	Mackin, J., and Schmidt, D. 1956. "Uranium and thorium-bearing minerals in placer deposits in Idaho" in Page, L., Stocking, H., and Smith, H., compilers, Contributions to the geology of uranium and thorium by the United States Geological Survey and Atomic Energy Commission for the United Nations International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955: U.S. Geological Survey Professional Paper 300, p. 375-380.
McIntyre et al. 1982	McIntyre, E., Ekren, E., and Hardyman, R. 1982. "Stratigraphic and structural framework of the Challis volcanics in the eastern half of the Challis 1º x 2º quadrangle, Idaho," in Bonnichsen, B., and Breckenridge, R., eds., Cenozoic geology of Idaho. Idaho Bureau of Mines and Geology Bulletin 26, p. 3-22.
Mitchell 1997	Mitchell, V. 1997. "History of the Sunbeam Mine, Custer County, Idaho." Idaho geological Survey Staff Report 97-18, 19 p.
Montgomery and Bolton 2003	Montgomery, D., and Bolton, S. 2003. "Hydrogeomorphic variability and river restoration" in R. C. Wissmar and P.A. Bisson, editors. Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and managed system: American Fisheries Society, Bethesda, Maryland, 39-79 pp.
Montgomery and Buffington 1993	Montgomery, D., and Buffington, J. 1993. "Channel classification, prediction of channel response, and assessment of channel condition." *Washington State Timber, Fish & Wild-life*: p.84 + figures

Parenthetical Reference	Bibliographic Citation
Montgomery and Buffington 1998	Montgomery, D., and Buffington, J. 1998. *Channel processes, classification, and response: in River Ecology and Management*. Robert Naiman & Robert Bilby [editors]: Springer-Verlag New York, Inc., p. 13-39.
Naiman et al. 1992	Naiman, R.J., Lonzarich, D.G., Beechie, T.J., and Ralph, S.C. 1992. "General principles of classification and the assessment of conservation potential in rivers." Pages 93-123 in: P.J. Boon, P. Calow, and G.E. Petts, editors. River conservation and management. John Wiley and Sons, New York, NY.
NOAA Fisheries 1996	NOAA's National Marine Fisheries Service. 1996. *Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale* [Matrix of Pathways and Indicators]: NOAA's National Marine Fisheries Service, Northwest Region, Portland, Oregon.
NOAA Fisheries 2010	NOAA's National Marine Fisheries Service. 2010. *Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program*. May 20, 2010, F/NWR/2010/0209.
Nolan 1933	Nolan, T. 1933. *Epithermal precious metal deposits, in Ore Deposits of Western States.* American Institute of Mining and Metallurgical Engineers, New York, p. 623-640.
NRCS 2006	U.S. Department of Agriculture, Natural Resources Conservation Service. 2006. *Soil survey of Custer-Lemhi Area, Idaho, parts of Blaine, Custer, and Lemhi Counties.* Natural Resources Conservation Service, 1287 p.
NWAA 2002	Northwest Archaeological Associates, Inc. 2002. *Historical Context for the Yankee Fork Dredge and Its Tailings, Custer County, Idaho.* Prepared for USDA Forest Service, Salmon-Challis National Forest by Nancy F. Renk of Flume Creek Historical Services and Northwest Archaeological Associates, Inc. July 29, 2002.
NWPC 2004	Northwest Power and Conservation Council. 2004. *Salmon Subbasin Assessment and Management Plan*. Portland, Oregon.

Parenthetical Reference	Bibliographic Citation
ODFW 2010	Oregon Department of Fish and Wildlife. 2010. *Aquatic inventories project methods for stream habitat surveys*. Oregon Department of Fish and Wildlife, Aquatic Inventories Project, Conservation and Recovery Program, Corvallis, Oregon 70 p.
Overton et al. 1999	Overton, C., Radko, M., and Wollrab, S. 1999. *Watershed analysis approaches for Chinook salmon, Yankee Fork of the Salmon River, Idaho*. An example [draft]: U.S.D.A. Forest Service, Rocky Mountain Research Station, Boise, Idaho 47 p.
Packard 1983	Packard, Howard A. Jr. 1983. *Gold Dredge on the Yankee Fork.* Yankee Fork Publishing Company, Great Falls, Montana. 40 p.
Reclamation 2011	U.S. Department of the Interior, Bureau of Reclamation. 2011. *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011*. Prepared for: United States Congress. 226 p.
Reiser and Ramey 1987	Reiser, D.W., and M.P. Ramey. 1987. *Feasibility Plan For The Enhancement Of The Yankee Fork Of The Salmon River, Idaho*. Prepared for the Shoshone-Banock Tribes Fisheries Department. Fort Hall, Idaho. BPA contract No. 83-359.
Rhea et al. 2008	Rhea, Darren T., A.M. Farag, E. McConnell, and W.G. Brumbaugh. 2008. "Mercury and selenium concentrations in biofilm, macroinvertebrates, and fish collected in the Yankee Fork of the Salmon River, Idaho." U.S. Geological Survey Final Report Agreement No. 01-IA-11041303-090.
Rodeheffer 1935	Rodeheffer, I.A. 1935. *A Survey of the Waters of the Challis National Forest, Idaho*. Department of Commerce, Bureau of Fisheries. Washington.
Rosgen 1996	Rosgen, Dave. 1996. *Applied River Morphology*. Wildland Hydrology, Inc. Pagosa Springs, Colorado.
SBT 2011	Shoshone Bannock Tribes. 2011. *Crystal Springs Fish Hatchery and programs for Snake River Chinook Salmon and Yellowstone Cutthroat Trout, Master Plan*. Shoshone Bannock Tribes, Fort Hall, Idaho, 198 p.
Schoby and Curet 2007	Schoby, G.P., and T. Curet. 2007. *Seasonal Migrations of Bull Trout, Westslope Cutthroat Trout, and Rainbow Trout in the Upper Salmon River Basin, Idaho*. Idaho Department of Fish and Game. Boise, Idaho.

Parenthetical Reference	Bibliographic Citation
Smith 1911	Smith, G. 1911. "Field Notes of the Survey of the Mining Claim of Yankee Fork Placer Company, Ltd." Mineral Survey No. 2406. Recorded in Custer County, Idaho, September 1, 1911.
Stephens 1991	Stephens, George C. 1991. *A History of Gold Mining on the Yankee Fork River, Custer County, Idaho.* Idaho Geological Survey, University of Idaho, Moscow, Idaho.
Tardy 2009	Tardy, K. 2009. *Steelhead Streamside Incubation (SSI) Program. Annual Report, October 1, 2008 – September 30, 2009*. Shoshone-Bannock Tribes, Fort Hall, Idaho.
Tardy and Denny 2010	Tardy, K.A., and L.P. Denny. 2010. *2010 Yankee Fork Salmon River Chinook Salmon Run Report. Annual Report*. Shoshone-Bannock Tribes, Fish and Wildlife Department. Fort Hall, Idaho.
Tsosie et al. 2009	Tsosie, T., Bacon, K., and Wadsworth, P. 2009. Salmon River Habitat Enhancement: Shoshone-Bannock Tribes, Fort Hall, Idaho.
Umpleby 1913	Unpleby, Joseph B. 1913. *Some Ore Deposits of Northwestern Custer County, Idaho*. Bulletin 539. U.S. Geological Survey. 104 p with 8 figures.
USDA 2011	U.S. Department of Agriculture, Forest Service. 2011. Annual Operation Instructions for the Garden Creek C&H Allotments. Memorandum dated June 14, 2011.
USDC 1934	U.S. Department of Commerce. 1934. *Stream survey, Yankee Fork, from Sunbeam Dam to mouth of West Fork*. Bureau of Fisheries, Stream Survey, 7 p.
USFS 1999	U.S. Department of Agriculture, Forest Service. 1999. Watershed and Fisheries Monitoring Completion Report: Salmon-Challis National Forest, Robert Rose, Fisheries Biologist.
USFS 2001	U.S. Department of Agriculture, Forest Service. 2001. *Yankee Fork of the Salmon River Watershed Analysis*. U.S. Department of Agriculture, Salmon-Challis National Forest, Yankee Fork Ranger District, Clayton, Idaho.
USFS 2004	U.S. Department of Agriculture, Forest Service. 2004. Status of the Amended Salmon-Challis National Forest Plans Management Indicator Species Bull Trout. Salmon-Challis National Forest.

Parenthetical Reference	Bibliographic Citation
USFS 2006	U.S. Department of Agriculture, Forest Service. 2006. *Biological assessment for the potential effects of managing the Salmon-Challis National Forest in the Yankee Fork Section 7 Watershed on Snake River Basin Spring/Summer Chinook Salmon, Snake River Steelhead, and Columbia River Bull Trout [Draft]*. U.S. Department of Agriculture, Salmon-Challis National Forest, Yankee Fork Ranger District, Clayton, Idaho. 126 p.
USFS 2010	U.S. Department of Agriculture, Forest Service. 2010. *Stream Inventory Handbook, Level I & II, Version 2.10*. Pacific Northwest Region, Region 6, Portland, Oregon.
USFWS 1999	U.S. Fish and Wildlife Service. 1999. *Status review for Westslope Cutthroat Trout in the United States*. U.S. Fish and Wildlife Service, Regions 1 and 6, Portland, Oregon and Denver, Colorado, 183 p.
USFWS 2010	U.S. Fish and Wildlife Service. 2010. *Best management practices to minimize adverse effects to Pacific Lamprey (Entosphenus tridentus).*
USGS 1995	U. S. Geological Survey. 1995. “Geology and Mineral Resource Assessment of the Challis 1º X 2º Quadrangle.” *Professional Paper 1525*. U.S. Geological Survey, U.S. Government Printing Office, Washington, 204 p. + maps.
Watershed Sciences 2010	Watershed Sciences. 2010. *Airborne Thermal Infrared Remote Sensing, Yankee Fork River Basin, Idaho*. September 27, 2010.
Williams 1961	Williams, P.L. 1961. “Glacial geology of the Stanley Basin.” Idaho Bureau of Mines and Geology Pamphlet, no. 123, 29 p.
Yarber 1963	Yarber, E. 1963. *Land of the Yankee Fork, Salt Lake City*: Publishers Press, 207 p.

12. Glossary

Some terms in the glossary appear in this TA.

TERM	DEFINITION
action	Proposed protection and/or rehabilitation strategy to improve selected physical and ecological processes that may be limiting the productivity, abundance, spatial structure or diversity of the focal species. Examples include removing or modifying passage barriers to reconnect isolated habitat (i.e., tributaries), planting appropriate vegetation to reestablish or improve the riparian corridor along a stream that reconnects channel-floodplain processes, placement of large wood to improve habitat complexity, cover and increase biomass that reconnects isolated habitat units.
alluvial fan	An outspread, gently sloping mass of alluvium deposited by a stream, esp. in an arid or semiarid region where a stream issues from a narrow canyon onto a plain or valley floor. Viewed from above, it has the shape of an open fan, the apex being at the canyon mouth.
alluvium	A general term for detrital deposits made by streams on river beds, floodplains, and alluvial fans; esp. a deposit of silt or silty caly laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas and lakes.
anadromous fish	A fish, such as the Pacific salmon, that spawns and spends its early life in freshwater but moves into the ocean where it attains sexual maturity and spends most of its life span.
anthropogenic	Caused by human activities.
bank	The margins of a channel. Banks are called right or left as viewed facing in the direction of the flow.
baseflow	That part of the streamflow that is not attributable to direct runoff from precipitation or melting snow; it is usually sustained by groundwater discharge.
basin	The drainage area of a river and its tributaries.
bedrock	The solid rock that underlies gravel, soil or other superficial material and is generally resistant to fluvial erosion over a span of several decades, but may erode over longer time periods.
cfs	Cubic feet per second; a measure of water flows

TERM	DEFINITION
channel forming flow	Sometimes referred to as the effective flow or ordinary high water flow and often as the bankfull flow or discharge. For most streams, the channel forming flow is the flow that has a recurrence internal of approximately 1.5 years in the annual flood series. Most channel forming discharges range between 1.0 and 1.8. In some areas it could be lower or higher than this range. It is the flow that transports the most sediment for the least amount of energy, mobilizes and redistributes the annually transient bedload, and maintains long-term channel form.
channel morphology	The physical dimension, shape, form, pattern, profile and structure of a stream channel.
channel planform	The two-dimensional longitudinal pattern of a river channel as viewed on the ground surface, aerial photograph or map.
channelization	The straightening and/or deepening of a stream channel, typically to permit the water to move faster, to reduce flooding, or to drain marshy acreage.
control	A natural or human feature that restrains a streams ability to move laterally and/or vertically.
degradation	Transition from a higher to lower level or quality. A general lowering of the earth's surface by erosion or transportation in running waters. Also refers to the quality (or loss) of functional elements within an ecosystem.
discharge	The volume per unit of time of streamflow at a given instant or for a given area. Discharge is often used interchangeably with streamflow.
diversion	The taking of water from a stream or other body of water into a canal, pipe, or other conduit.
diversity	Genetic and phenotypic (life history traits, behavior, and morphology) variation within a population. Also refers variations in physical conditions or habitat.
dredging	The various processes by which large floating machines, or dredges, scoop up earth material at the bottom of a body of water, raise it to the surface, and discharge it back to the water body after removal of ore minerals.
ecosystem	An ecologic system, composed of organisms and their environment. It is the result of interaction between biological, geochemical, and geophysical systems.
erosion	Wearing away of the lands by running water, glaciers, winds, and waves.
ethnographic	The study and systematic recording of human cultures.
evapotranspiration	That portion of the precipitation returned to the air through evaporation and transpiration.
fine sediment	Sand, silt and organic material that have a grain size of 6.4 mm or less.
floodplain	That portion of a river valley, adjacent to the channel, which is built of sediments deposited during the present regimen of the stream and is covered with water when the river overflows its banks at flood stages.

TERM	DEFINITION
fluvial	Produced by the action of a river or stream. Also used to refer to something relating to or inhabiting a river or stream. Fish that migrate between rivers and streams are labeled “fluvial.”
fluvial geomorphology	The study of stream channel and floodplain pattern and geometry as well as the sediment, sediment sources and sediment transport regimes, and the analysis of how the stream channel and floodplain form and function interact.
fluvial process	A process related to the movement of flowing water that shape the surface of the earth through the erosion, transport, and deposition of sediment, soil particles, and organic debris.
gaging station	A particular site on a watercourse where systematic observations of stage and/or flow are measured.
geomorphic reach	An area containing the active channel and its floodplain bounded by vertical and/or lateral geologic controls, such as alluvial fans or bedrock outcrops, and frequently separated from other reaches by abrupt changes in channel slope and valley confinement. Within a geomorphic reach, similar fluvial processes govern channel planform and geometry resulting from streamflow and sediment transport.
geomorphology	The science that focuses on the general configuraion of the earth’s surface; specif. the study of the classification, description, nature, origin and development of landforms and their relationships to underlying structures, and the history of geologic changes as recorded by these surface features.
GIS	Geographical information system. An organized collection of computer hardware, software, and geographic data designed to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.
gradient	Degree of inclination of a part of the earth’s surface; steepness of slope. It may be expressed as a ratio (of vertical to horizontal), fraction, percentage, or angle.
groundwater	That part of the subsurface water that is in the saturated zone.
habitat connectivity	Aquatic and/or terrestrial conditions that are linked together and needed to provide the physical and ecological processes necessary for the transfer of energy (i.e., food web) to maintain all life stages of species that are dependent on the riverine ecosystem.
habitat unit	A segment of a stream which has a distinct set of characteristics.
headwaters	Streams at the source of a river.
hydraulics	The branch of fluid mechanics dealing with the flow of water in conduits and open channels.
hydrograph	A graph relating stage, flow, velocity, or other characteristics of water with respect to time.

TERM	DEFINITION
hydrology	The applied science concerned with the waters of the earth, their occurrences, distribution, and circulation through the unending hydrologic cycle of: precipitation, consequent runoff, infiltration, and storage; eventual evaporation; and so forth. It is concerned with the physical and chemical reaction of water with the rest of the earth, and its relation to the life of the earth.
indicator	A variable used to forecast the value or change in the value of another variable; for example, using temperature, turbidity, and chemical contaminents or nutrients to measure water quality.
limiting factor	Any factor in the environment that limits a population from achieving complete viability with respect to any Viable Salmonid Population (VSP) parameter.
mainstem	The reach of a river/stream formed by the tributaries that flow into it.
peak flow	Greatest stream discharge recorded over a specified period of time, usually a year, but often a season.
perennial stream	A stream that flows all year round. Compare intermittent stream.
reach	A section between two specific points outlining a portion of the stream, or river.
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
recurrence interval	The average amount of time between events of a given magnitude. For example, there is a 1 percent chance that a 100-year flood will occur in any given year.
redd	A nest built in gravel or small substrate materials by salmonids where eggs are deposited; the nest is excavated by the adult fish and the eggs are covered by the female after spawning.
riparian area	An area adjacent to a stream, wetland, or other body of water that is transitional between terrestrial and aquatic ecosystems. Riparian areas usually have distinctive soils and vegetation community/composition resulting from interaction with the water body and adjacent soils.
riprap	Materials (typically large angular rocks) that are placed along a river bank to prevent or slow erosion.
river mile (RM)	Miles measured in the upstream direction beginning from the mouth of a river or its confluence with the next downstream river.
runoff	That part of precipitation that flows toward the streams on the surface of the ground or within the ground. Runoff is composed of baseflow and surface runoff.
shear stress	The combination of depth and velocity of water. It is a measure of the erosive energy associated with flowing water.

TERM	DEFINITION
side channel	A distinct channel with its own defined banks that is not part of the main channel, but appears to convey water perennially or seasonally/ephemerally. May also be referred to as a secondary channel.
sinuosity	Ratio of the length of the channel or thalweg to the down-valley distance. Channels with sinuosities of 1.5 or more are called “meandering.”
smolt	A subadult salmonid that is migrating from freshwater to seawater; the physiological adaptation of a salmonid from living in freshwater to living in seawater.
SNOw TELemetry (SNOTEL)	An automated network of snowpack data collection sites. The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), has operated the Federal-State-Private Cooperative Snow Survey Program in the western United States since 1935. A standard SNOTEL site consists of a snow pillow, a storage type precipitation gage, air temperature sensor and a small shelter for housing electronics.
snow water equivalent (SWE)	The water content obtained from melting accumulated snow.
spawning and rearing habitat	Stream reaches and the associated watershed areas that provide all habitat components necessary for adult spawning and juvenile rearing for a local salmonid population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident and migratory fish, and may also support subadults and adults from local populations.
subbasin	A subbasin represents the drainage area upslope of any point along a channel network (Montgomery and Bolton 2003). Downstream boundaries of subbasins are typically defined in this assessment at the location of a confluence between a tributary and mainstem channel.
terrace	A relatively level bench or steplike surface breaking the continuity of a slope. The term is applied to both the lower or front slope (the riser) and the flat surface (the tread).
Total Maximum Daily Load (TMDL)	TMDLs are written plans and analyses established to ensure that the waterbody will attain and maintain water quality standards. The OAR definition is “The sum of the individual wasteload allocations (WLAs) for point sources and LAs for nonpoint sources and background. If a receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any nonpoint sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. If Best Management Practices (BMPs) or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TDML prcess provides for nonpoint source control tradeoffs.”
tributary	Any stream that contributes water to another stream.

TERM	DEFINITION
valley segment	An area of river within a watershed sometimes referred to as a subwatershed that is comprised of smaller geomorphic reaches. Within a valley segment, multiple floodplain types exist and may range between wide, highly complex floodplains with frequently accessed side channels to narrow and minimally complex floodplains with no side channels. Typical scales of a valley segment are on the order of a few to tens of miles in longitudinal length.
viable salmonid population	An independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame. Viability at the independent population scale is evaluated based on the parameters of abundance, productivity, spatial structure, and diversity (ICBTRT 2007).
watershed	The area of land from which rainfall and/or snow melt drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins. Ridges of higher ground form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

APPENDICES

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