APPENDIX C

Geology

This page intentionally left blank

Table of Contents

List of Figures

List of Tables

This page intentionally left blank

1. Introduction

This geologic report provides a summary of the geology of Central Idaho and the Yankee Fork of the Salmon River watershed. The Yankee Fork of the Salmon River, referred to as the Yankee Fork in this document, is part of the upper Salmon River subbasin and flows into the Salmon River near Sunbeam, Idaho, near river mile (RM) 367 (Figure 1). This document was prepared in support of the *Yankee Fork Tributary Assessment*.

Understanding the geologic setting is important for the Yankee Fork Tributary Assessment because it controls the topography, and directly influences valley- and reach-scale river characteristics such as slope, confinement, soils, and bed-forming materials (Montgomery and Bolton 2003). Indirectly, geology governs 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).

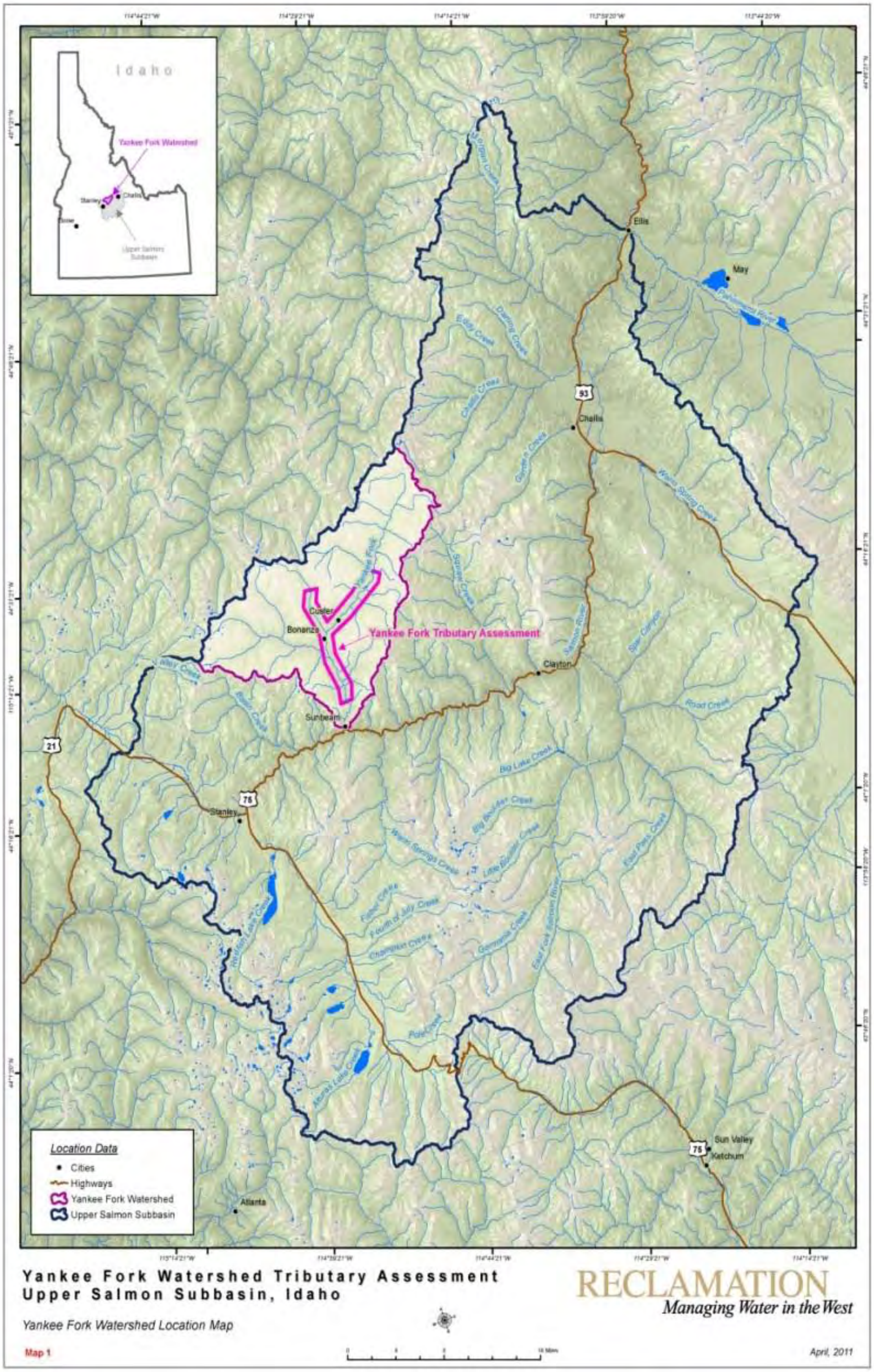

Figure 1. Yankee Fork watershed and the upper Salmon subbasin in Central Idaho.

2. Central Idaho Geology

2.1 Physiographic Setting

The Yankee Fork watershed is located in the Northern Rocky Mountains physiographic province (Fenneman 1931) with a rugged, mountainous landscape that has been dissected by fluvial and glacial erosion. The watershed has a dendritic drainage pattern, draining about 190 square miles, and has a drainage density of about 2.71 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 4,417 feet with a maximum elevation of about 10,329 feet at The General peak and a minimum elevation of about 5,912 feet at the confluence with the Salmon River.

2.2 Regional Geology

2.2.1 Bedrock Geology

Bedrock and alluvial deposits are summarized from the *Geology and Mineral Resource Assessment of the Challis 1º X 2º Quadrangle, Idaho* (USGS 1995). Glacial geology of Central Idaho is primarily summarized from *Glacial Geology of the Southeastern Sawtooth Mountains* (Borgert, Lundeen, and Thackray 1999).

The major bedrock types in the Central Idaho include Tertiary volcanic and plutonic rocks, Cretaceous intrusive rocks, and Paleozoic sedimentary and Precambrian sedimentary and metamorphic rocks. Quaternary sediments comprised primarily by alluvium from pre-Pleistocene, Pleistocene, and Holocene, and derived from fluvial and glacial processes mantle the valley bottoms and slopes.

The two primary bedrock structures in the Challis quadrangle include the Tertiary volcanic and plutonic rocks associated with the Challis Volcanics, and Cretaceous intrusive rocks of the Idaho batholiths. There are other minor formations and faulting associated with older terranes that do not appear to have significantly influenced the topography within the region.

Figure 2 shows that the southwestern section of the quadrangle is dominated by the Idaho batholith that was emplaced at depth and has since been uplifted to the surface. Nearly all the mountain ranges (i.e. Sawtooth Mountains) in the southwestern section are derived from the uplift of the batholith, and the subsequent faulting and dissection of its granitic rocks.

The northeast section of the quadrangle is dominated by the Challis Volcanics where voluminous volcanic eruptions covered much of the area with constructed landforms (vents, flows, ash-fall) and caused localized subsidence near large volcanic vents (caulderas).

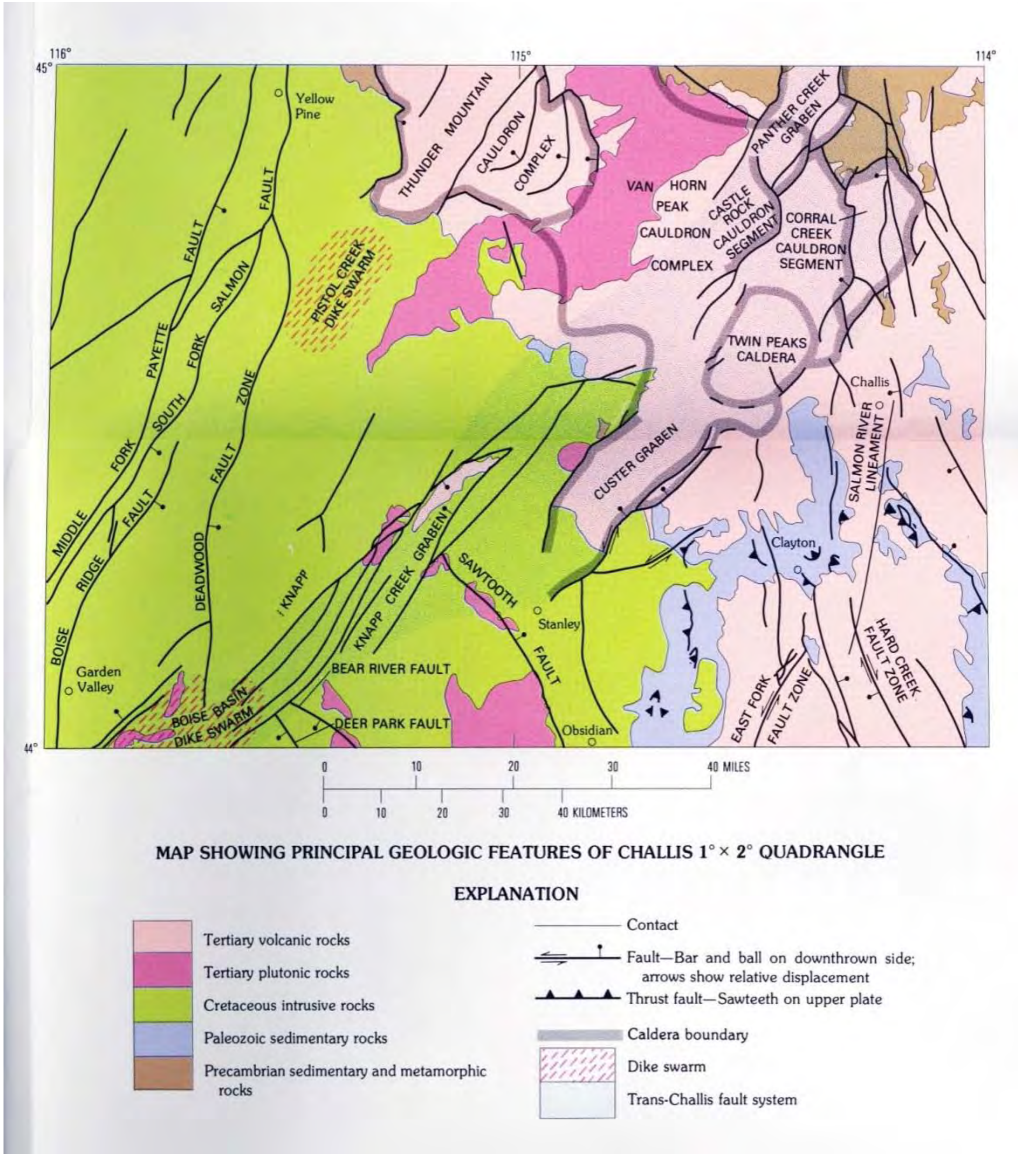

Figure 2. Geologic map of Challis 1° by 2° Quadrangle (from USGS 1995). *The Yankee Fork watershed is located along the southeast bounding fault of the Custer Graben.*

Quaternary Sediments

Quaternary sediments, referred to as the alluvial terrane, consist of unconsolidated or poorly consolidated alluvial deposits of pre-Pleistocene, Pleistocene, or Holocene age (USGS 1995). The sediments are comprised predominantly of gravel, silt, and clay. Holocene age sediments were primarily deposited by fluvial processes; whereas the Pleistocene age (and possibly pre-Pleistocene age) sediments were deposited by glacial and fluvial processes. Regionally, a majority of the sediments were deposited or reworked during the Pleistocene and are most likely associated with glacial cycles. There were at least two known alpine glaciations in the region.

Evenson et al. (1982) developed a stratigraphic glacial model to describe the glaciations that occurred in Idaho. Using relative weathering criteria, they described the landforms and sediments, and recognized two major glaciations. The older set of glacial advances was called the Copper basin glaciation and the younger advances were called the Potholes glaciation. Remnants of the Pioneer glaciaton (pre-Copper basin age) was recognized, but were not described because nearly all landforms associated with this glaciation had been obliterated by the younger glacial advances. These Idaho glaciations were interpreted to be somewhat correlative to the glaciations described in the Rocky Mountain glacial model (Table 1) developed by Blackwelder (1915) and modified by Mears (1974).

Table 1. Summary of Rocky Mountain glacial model and Idaho glacial model (Borgert, Lundeen, and Thackray 1999, and references therein).

Alpine Glacial Models			
Rocky Mountain Model[1]	Pre-Bull Lake glaciation (>140 ka)	Bull Lake glaciation (~140 ka)	Pinedale glaciation (~20 ka)
Idaho Model[2]	Pioneer glaciation	Copper basin glaciation	Potholes glaciation

[1]Blackwelder (1915)
[2]Evenson et al. (1982)

Tertiary Volcanic Rocks

Tertiary volcanic rocks referred to as the Challis Volcanics are comprised of extrusive volcanic rocks and volcaniclastic sediments both within and outside of large calderas, on the sides of stratovolcanoes, and in the vicinity of numerous small vents (USGS 1995). Volcanic rocks and sediments were deposited primarily by two types of eruptions; quiescent eruptions of lava flows forming stratovolcanoes and domes, and explosive ash-flow tuff eruptions associated with cauldron complexes.

The Van Horn Peak cauldron complex developed during Eocene time through multiple eruptive episodes. The cauldron complex is comprised of the Twin Peaks caldera, Custer graben, Corral Creek cauldron, Castle Rock cauldron, and Panther Creek graben. Significant eruptions that have contributed to the formation of this complex include the following: (a) about 47.4 m.y. ago, ash-flow tuff eruptions occurred that triggered the subsidence of the Custer graben and the Panther Creek graben; and (b) between 46.5 and 45.0 m.y. ago, the Twin Peaks caldera formed during the final events that created the cauldron complex.

During this period of volcanic activity, plutons and intrusions were emplaced predominantly along the northeast trending Trans-Challis fault system. This fault system may have also controlled the form of the Twin Peaks caldera and associated Custer graben. Associated with the faults, fracture zones, and joints related to the fault system and the formation of the Van Horn Peak cauldron complex, zones of hydrothermally altered rock formed from the circulation of hydrothermal fluids through the open fractures which resulted in areas of mineralization.

Tertiary Plutonic Rocks

Tertiary plutonic rocks were derived from the process of magma emplacement in pre-existing rocks, known as plutonism. Dike intrusions were extensive throughout Central Idaho, and their distribution and composition are thought to be equivalent to the Challis Volcanics (USGS 1995). Hydrothermal alteration in older rocks (i.e. Idaho batholith) appears to be directly related to Eocene plutonism. This process of magma intrusion was particularly prevalent along fault and shear zones, along which mineralization tended to occur.

Cretaceous Intrusive Rocks

The Idaho batholith is comprised of predominantly granitic rocks that were emplaced during Cretaceous time and have since been uplifted to the surface (USGS 1995). These granitic rocks extend westward across much of Central Idaho, and also underlie areas of the Challis Volcanics. Plutonism that probably occurred during Eocene time during the Challis Volcanics has intruded the batholith particularly along fault and shear zones.

Paleozoic Sedimentary Rocks

Paleozoic sedimentary rocks referred to as the Black Shale terrane are located predominantly in the southeastern portion of the Challis quadrangle (USGS 1995). These sedimentary rocks are of late Cambrian to Permian age and are predominantly black fine-grained sandstones, siltstones, and limestones. The sedimentary deposits occur as a mass of rock that have been moved along thrust faults and in imbricated structural plates separated by thrust faults. The rocks are stacked in the structural plates that have predominantly younger strata over older strata. In addition, these strata also progress from youngest on the west to oldest on the east.

Precambrian Sedimentary and Metamorphic Rocks

Precambrian sedimentary and metamorphic rocks referred to as the Proterozoic terrane are predominantly located in the northern and northeastern portion of the Challis quadrangle (USGS 1995). These sedimentary and metasedimentary rocks are probably of Proterozoic age and have been subdivided into seven recognizable units. From oldest to youngest these units include the following: Yellowjacket Formation, Hoodoo Quartzite, and the Big Creek, Apple Creek, Gunsight, Swauger, and Lawson Creek Formations. Only the

Yellowjacket Formation and the closely associated Hoodoo Quartzite contain economically important ore deposits that occur primarily in veins, lodes, shear zones, stockwork, and fillings. Placer and colluvial gold deposits associated with these rocks were derived from the erosion of ore bearing veins and are the only other known ore deposits of economic value.

Small to medium roof pendants comprised of metasedimentary rocks occur in the Idaho batholith. The pendants are moderately to highly metamorphosed and their correlation to known Precambrian units is considered speculative.

2.2.2 Cenozoic Tectonism

The geologic structure and deformational history of Central Idaho is complex and includes several episodes of continental plate rifting, folding, and mountain building throughout its known geologic history (Figure 3). This report focuses on the Cenozoic structural relationships and their interactions in central and eastern Idaho primarily, based on the *Geology of East-Central Idaho: Geologic Roadlogs for the Big and Little Lost River, Lemhi, and Salmon river Valleys* (Link and Janecke 1999).

Eastern and central Idaho lies within the Cordilleran fold and thrust belt, and the Basin-and-Range province. During the Mesozoic era, mountain building associated with deformation and intrusion along the Cordilleran belt produced regional thrust faults, folds, and the emplacement of the Atlanta lobe of the Idaho batholith.

In the Cenozoic, prior to the Challis Volcanics, stretching began along a series of normal faults that exhumed the Pioneer metamorphic core complex and produced numerous half-grabens in a system of north-trending basins.

Crustal thickening in the western part of the Sevier thrust belt was accompanied by the intrusion of the Idaho batholith (USGS 1995). The Atlanta lobe of the Idaho batholith was tilted eastward, exhumed and uplifted after emplacement in Late Cretaceous time, but prior to the Challis volcanism (Jordan 1994 and Rodgers et al. 1995). Extensional to transtentional deformation occurred along southwest-dipping normal-oblique faults which affected the Pioneer Mountains, and the Lemhi and Beaverhead ranges.

During the Challis Volcanics episode, extension along the northeast-trending Trans-Challis fault zone occurred (McIntyre et al. 1982; Kiilsgaard et al. 1986; Janecke 1992).

Extension along the rift zone began during the final phases of the Challis Volcanics episode. Sedimentary rocks were deposited in localized north-northwest trending half grabens (Janecke 1994). The final, and current, episode of extension north of the eastern Snake River Plain is Basin-and-Range type faulting. This episode created the Sawtooth, Lost River, Lemhi, and Beaverhead ranges (Crone and Haller 1991).

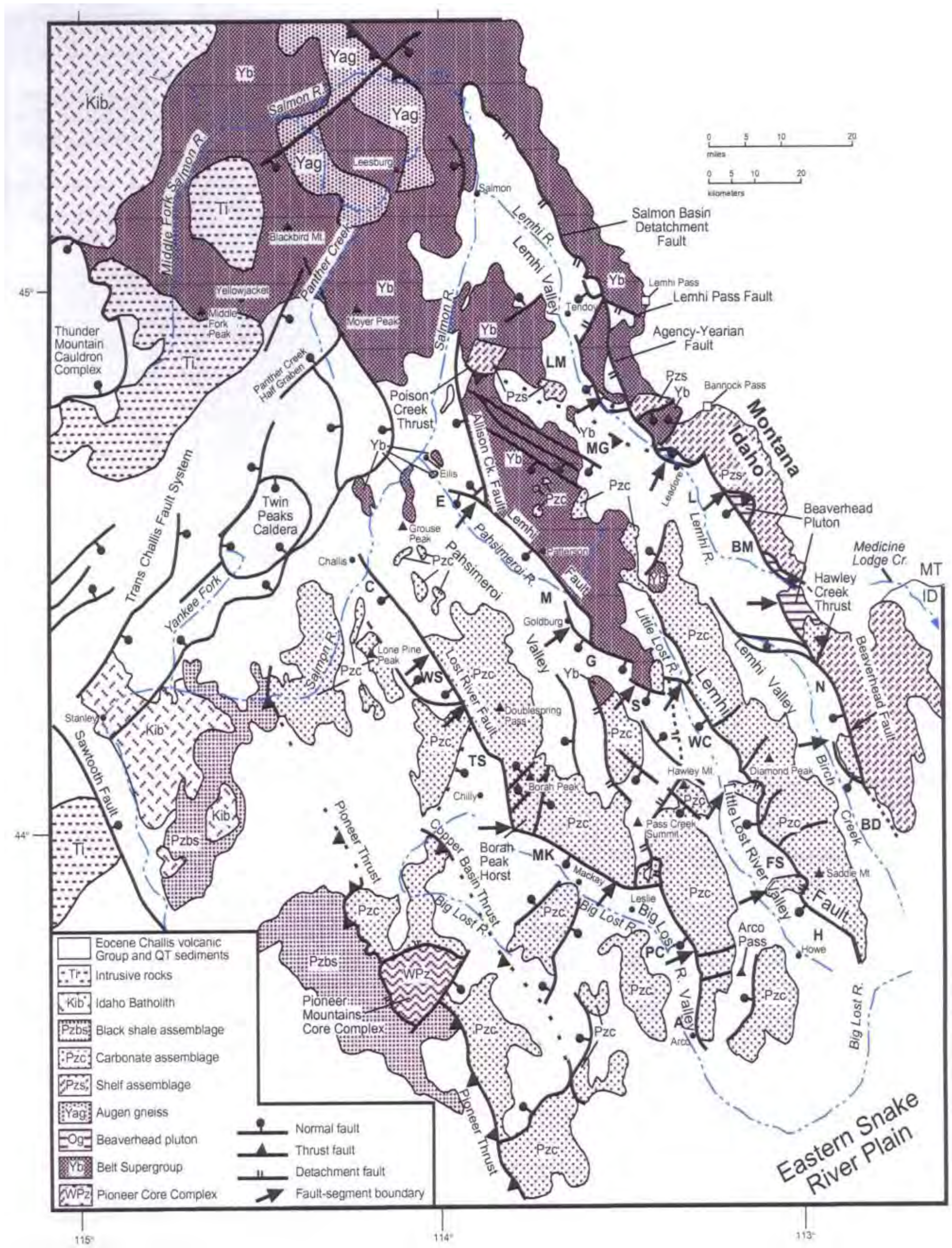

Figure 3. Regional geological map of pre-Tertiary rocks of east-central Idaho from Link and Janecke (1999). *Map compiled from Bond (1978) and modified after Wilson and Skipp (1994), Schmidt et al. (1994) and Janecke et al. (1997; 1998). Segment boundaries on normal faults are indicated by heavy arrows and are named as follows (from Janecke, 1993 and references therin): Lost River fault; A=Arco; PC=Pass Creek; MK=Mackay; TS=Thousand Springs; WS=Warm Spring; C=Challis; Lemhi Fault, H=Howe; FS=Fallert Springs; S=Sawmill Gulch; G=Goldburg; P=Patterson; M=May; Beaverhead fault, BD=Blue Dome; N=Nicholia; BM=Baldy Mountain; L=Leadore; MG=Mollie Gulch; LM=Lemhi.*

3. Geology of Yankee Fork Watershed

The Yankee Fork watershed is located in Central Idaho and covers an area about 190 square miles. This section of the report provides a cursory evaluation of the local geology of the Yankee Fork watershed in support of the Yankee Fork Tributary Assessment. The Tributary Assessment area covers the Yankee Fork between about RM 2 near Polecamp Flat Campground to RM 16 at the confluence of Eightmile Creek; and Jordan Creek, a tributary to the Yankee Fork, between its mouth and about RM 4 (Figure 4). Dominant bedrock types, geologic structures, glacial geology, and glacial landforms are briefly covered in this section. The reader is referred to the Geomorphic Appendix of the *Tributary Assessment* report for further information on surficial geology and mass wasting.

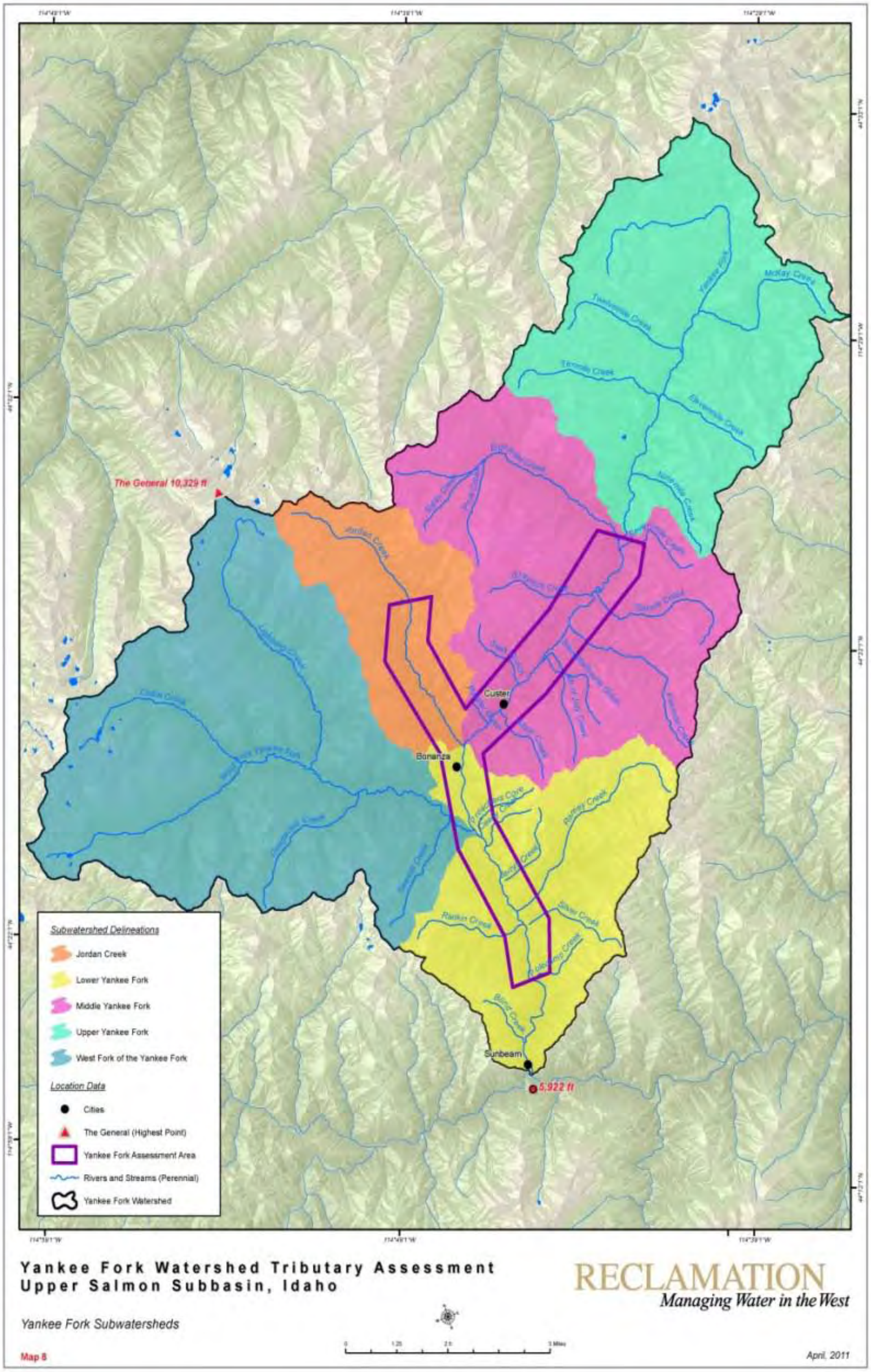

Figure 4. Yankee Fork watershed and subwatersheds, and location of the Tributary Assessment area.

Bedrock Geology

The dominant bedrock types within the watershed include the Eocene-age Challis Volcanics (about 95 percent) and Cretaceous-age Idaho batholiths (about 5 percent) (USGS 1995). Surface exposure of the Idaho batholith terrane is confined predominantly to the southern portion of the watershed; and in the western and southern portion the batholith underlies parts of the Challis Volcanics.

Rocks of the Challis Volcanics generally range in hardness and strength from hard (can be scratched by a knife) to soft (can be grooved easily by a knife). Harder rocks are associated with lava flows and welded ash-flow tuffs; whereas softer rocks are typically associated with weakly welded ash and volcanic debris, and hydrothermally altered rocks. In general, rocks of the Idaho batholith are hard except where pervasively weathered or hydrothermally altered.

Geologic Structure

Geologic structures in the watershed are related to the the Challis Volcanics, Idaho batholith, and Trans-Challis fault zone. The Yankee Fork originates in the area of the Twin Peaks caldera within the Van Horn Peak cauldron complex. About 47 m.y. ago, during the Eocene, the Twin Peaks caldera violently erupted in an ash-flow type eruption that produced copious amounts of volcanic and volcaniclastic debris that covered most of the watershed. The eruption of the caldera triggered the subsidence of the Custer graben to the southwest (USGS 1995). The Yankee Fork flows through this graben for most of its length.

Following the emplacement of the Idaho batholith during Cretaceous time, the batholith has been uplifted by tectonic processes. The granitic rocks of the batholith crop out in the lower section of the Yankee Fork between its mouth and Polecamp Creek. Through time, the Yankee Fork has been able to “keep-up” with the uplift as it incises through the rocks forming a narrow, deep canyon.

The northeast trending Trans-Challis fault zone is about 165 miles long and has been active since Precambrian time. This fault system provides a controlling affect on the location of volcanic vents, dikes, mineralization, and normal faulting along its length (Kiilsgaard et al. 1986). In the Yankee Fork watershed, this fault system may have controlled the location and orientation of the Twin Peaks caldera and Custer graben. Faults and broad shear zones with similar northeast orientations as the Trans-Challis fault system occur in the Yankee Fork valley and are associated with hydrothermal alterations and mineralization of precious metals. There are two zones of hydrothermally altered rock that are thousands of feet long and hundreds of feet wide in the Custer graben that are known to have been subjected to mineral replacement processes that have economically important ore deposits (McIntyre and Johnson 1985).

Glacial Geology

The Yankee Fork watershed has experienced two known Pleistocene alpine glaciations (Mackin and Schmidt 1956 and Williams 1961). Glacial terraces that are present along the valley walls, are hundreds of feet above the valley floor in some locations. Most of the placer gold produced in the Yankee Fork watershed was from Pleistocene deposits most likely associated with ground moraines and glacial outwash. There has been some placer gold found in the Holocene deposits where the Pleistocene gravels have been reworked by fluvial processes. Placer gold deposits found along the Yankee Fork River and Jordan Creek are believed to be close to the ore deposits that produced the gold (USGS 1995).

4. Selenium and Mercury Origins and Potential Locations

Past studies and activities in the Yankee Fork drainage have identified selenium and mercury as potential concerns for any future river and habitat rehabilitation actions. Selenium (Se) is a nonmetal, chemical element that rarely occurs in its elemental state in nature. Selenium commonly occurs in a number of inorganic forms, including selenide (Se^{2-}), selenate (SeO_4^-), and selenite (SeO_3^{2-}). These inorganic forms are soluble and easily transported by runoff.

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.

Mercury (Hg) is a metallic, chemical element that rarely occurs in its elemental state in nature. 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). However, elemental mercury was used in some areas where the extraction and processing of gold from ore and placer deposits occurred. Varying concentrations of elemental mercury could be anticipated wherever placer mining, hardrock mining, and ore processing have occurred throughout the watershed. Of particular concern are areas where placer mining and gold processing were conducted along waterways. Mercury contaminated sediments may be unearthed. Under the proper environmental conditions, mercury contaminated sediments will provide the available mercury required in the biochemical processes that create methylmercury, a highly toxic form.

Nearly all potential habitat rehabilitation projects in the Tributary Assessment area will involve some level of excavations or manipulations of mine tailings (i.e., dredge tailings, spoil piles, etc.). Disturbances to contaminated alluvium or soils could potentially expose or mobilize elemental mercury. Remedial measures should be considered during the alternatives analysis phase of each potential habitat project in the event that mercury is unearthed.

5. List of Preparers

Name	Organization	Contribution
Edward W. Lyon, Jr., L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Principal Author River Systems Analysis Group Geomorphologist
Terril Stevenson, L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Peer Reviewer River Systems Analysis Group Manager
Al Simpson	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Reviewer Upper Salmon Subbasin Liaison
Kelly Vick	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Natural Resources Natural Resources Writer

6. Literature Cited

Parenthetical Reference	Bibliographic Citation
Blackwelder 1915	Blackwelder, E. 1915. “Post-Cretaceous history of the mountains of central western Wyoming, Part 3.” *Journal of Geology*, v. 23, p. 307-340.
Bond 1978	Bond, J. 1978. *Geologic map of Idaho.* Idaho Bureau of Mines and Geology, scale 1:500,000.
Borgert, Lundeen andThackray 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.

Parenthetical Reference	Bibliographic Citation
Crone and Haller 1991	Crone, A., and Haller, K., 1991. "Sedimentation and coseismic behavior of Basin-and-Range normal faults." Examples from east-central Idaho and southwestern Montana, U.S.A.: *Journal of Structural Geology*, v. 13, p.151-164.
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.
Janecke1992	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.
Janecke 1993	Janecke, S., 1993. "Structures in segment boundary zones of the Lost River and Lemhi faults, east-central Idaho." *Journal of Geophysical Research*, v. 98, p. 16,223-16,238.
Janecke 1994	Janecke, S., 1994. "Sedimentation and paleogeography of an Eocene to Oligocene rift zone, Idaho and Montana." *Geological Society of America Bulletin*, v. 106, p. 1083-1095.
Janecke et al. 1997	Janecke, S., Hamman, B., Snee, L., and Geissman, J., 1997. "Rapid extension in an Eocene volcanic arc: Structure and paleogeography of an intra-arc half graben in central Idaho." *Geological Society of America Bulletin*, v. 109, p. 253-267.
Janecke et al. 1998	Janecke, S., Vandenburg, C., and Blankenau, J., 1998. "Geometry, mechanisms and significance of extensional folds from examples in the Rocky Mountain Basin-and-Range province, U.S.A." *Journal of Structural Geology*, v. 20, no. 7, p. 841-856.
Jordan 1994	Jordan B, 1994. *Emplacement and exhumation of the southeastern Atlanta lobe of the Idaho batholith and outlying stocks, south-central Idaho* (M.S. Thesis). Pocatello, Idaho State University, 110 p.
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
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.
McIntyre and Johnson 1985	McIntyre, D., and Johnson, K., 1985. "Epithermal gold-silver mineralization related to volcanic subsidence in the Custer graben, Custer County, Idaho, in McIntyre, D., ed., Symposium on the geology and mineral deposits of the Challis 1º x 2º quadrangle, Idaho." U.S. Geological Survey Bulletin 1658, p. 109-115.
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.
Mears 1974	Mears, B., Jr. 1974. *The evolution of the Rocky Mountain Glacial Model, in Coates, D.r., ed., Glacial Geomorphology*. New York state University Press, New York, p. 11-40.
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.
Rodgers et al. 1995	Rodgers, D., Link, P., and Huerta, A., 1995. "Structural framework of mineral deposits hosted by Paleozoic rocks in the northeastern part of the Hailey 1º x 2º quadrangle, south-central Idaho." U.S. Geological Survey Bulletin 2064-B, p. B1-B18.
Schmidt et al. 1994	Schmidt, K., Lewis, R., Burmester, R., and Lang, R. 1994. "Reconnaissance geologic map of the Shoup and Horse Creek area, Lemhi and Idaho Counties, Idaho." Idaho Geological Survey Technical Report, 94-3.

Parenthetical Reference	Bibliographic Citation
USFS 2006	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.
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.
Williams 1961	Williams, P.L. 1961. "Glacial geology of the Stanley Basin." Idaho Bureau of Mines and Geology Pamphlet, no. 123, 29 p.
Wilson and Skipp 1994	Wilson, A., and Skipp. 1994. "Geologic map of the eastern part of the Challis National forest, and vicinity, Idaho." U.S. Geological Survey Miscellaneous Investigations Series, Map I-2395, scale 1:250,000.

7. Glossary

Some terms in the glossary appear in this geologic appendix.

TERM	DEFINITION
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 valley 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 clay 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.
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.
control	A natural or human feature that restrains a streams ability to move laterally and/or vertically.

TERM	DEFINITION
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.
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.
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
river mile (RM)	Miles measured in the upstream direction beginning from the mouth of a river or its confluence with the next downstream river.
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. An example would be the Middle Fork John Day River subbasin.
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).
tributary	Any stream that contributes water to another stream.
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.

This page intentionally left blank