Beaver Creek Watershed Assessment
Shoshone County, Idaho

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Prepared for:

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North Fork Coeur d'Alene River Watershed Advisory Group

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Preface

This watershed assessment was conducted by partners from Idaho Department of Environmental Quality (DEQ), the US Forest Service (USFS) and University of Idaho Extension (UI Extension) to provide a foundation and framework for improving conditions in the Beaver Creek Watershed. The assessment was requested by the North Fork Coeur d'Alene River Watershed Advisory Group (WAG), is supported by Shoshone County, and was funded by a grant from the Idaho Panhandle National Forests (IPNF) Resource Advisory Committee (RAC). Furthermore, concerns regarding watershed conditions have been brought forward from multiple landowners in the watershed.

The goal of this project was to provide an informed and well documented strategic framework for resource management decisions to set restoration priorities in the Beaver Creek Watershed. This effort was designed to improve water quality and watershed function by gathering the needed information for a watershed assessment, producing complementary summary reports and facilitating implementation of projects. The collaboration and production of strategic recommendations will help leverage funding and other resources for the completion of watershed improvement projects.

This document outlines the goals, methodologies and results of the multi-part assessment conducted in the Beaver Creek Watershed. Issues and priorities existing in the watershed were summarized through a pre-assessment by the project partners (Appendix A). Assessment methods were employed to determine conditions, and results were analyzed to provide and prioritize recommendations for potential restoration projects within the Beaver Creek Watershed.

This document is intended to inform agencies, landowners, and any interested stakeholders on the current state of the Beaver Creek Watershed and to discuss recommended practices to restore properly functioning conditions. Findings may also guide resource management within the watershed in order to sustain forest condition, wildlife habitat, recreational use and transportation and public access needs.

Acknowledgements

Project partners would like to thank their respective agencies: Idaho Department of Environmental Quality, US Forest Service and University of Idaho Extension for supporting their work on this project. We also appreciate the Idaho Panhandle National Forests Resource Advisory Committee for funding this project and the North Fork Coeur d'Alene River Watershed Advisory Group and Shoshone County for their support. Finally, we would like to recognize the diligent work of the USFS field crew: Attila Folnagy, Michelle Morrow, Tom Burke, Lisa Dosch and Cody Settles.

Report Summary

Beaver Creek is a 44-square-mile tributary watershed to the North Fork Coeur d'Alene River in northern Idaho. The watershed contains rural areas of forests, recreational lots, rangeland, and habitat for fish and wildlife, and has a long history of timber harvest, mining and road construction on public and private lands. In 2010, Idaho Department of Environmental Quality (DEQ), the US Forest Service (USFS) and University of Idaho Extension (UI Extension) undertook this watershed assessment of water quality conditions in the Beaver Creek Watershed utilizing a local seasonal USFS field crew.

Water quality in Beaver Creek does not fully support beneficial uses as outlined in the Clean Water Act and Idaho water quality standards due to excess sediment, temperatures, cadmium, lead and zinc (Appendix B). Beaver Creek is subject to Total Maximum Daily Load (TMDL) requirements for sediment, and TMDLs are in development for temperature, cadmium, lead and zinc. Until water quality conditions improve, water quality impairments make natural resource development projects increasingly challenging and prevent Beaver Creek from fully supporting its fisheries potential. Landowners, land managers and watershed visitors are also concerned about erosion, flooding, road and culvert washouts and deposition of sediments along streamside properties. Beaver Creek also contributes excessive sediment downstream to the North Fork Coeur d'Alene River.

DEQ, USFS and UI Extension assessed conditions throughout the watershed including water quality, fisheries habitat, stream channels, flood risks, stream crossings and the transportation network. Methods included the following techniques and protocols:

- Analysis of forest roads using the USFS Geomorphic Road Analysis and Inventory Package (GRAIP) model to estimate erosion and sediment loading from the road network and to assess fish passage and habitat fragmentation.
- A historical survey and stream channel analysis was used to evaluate land use and stream channel change over time and to identify pollution sources in the watershed.
- A wadeable streams rapid bioassessment utilizing the DEQ Beneficial Use Reconnaissance Program (BURP) was performed to analyze water quality and cold water aquatic life.
- Stream channels were assessed utilizing the Rapid Assessment of Stream Conditions Along Length (RASCAL) protocol.
- Stream temperature conditions were evaluated using available historic data, and year-round temperature data loggers were deployed. Stream shade was evaluated using DEQ's Potential Natural Vegetation (PNV) methods employed in temperature TMDLs.
- Water samples were tested for the presence of *Escherichia coli* bacteria as an indicator of animal or human waste contamination and potentially hazardous human health concentrations.
- Fish health was evaluated by testing for the whirling disease parasite in sampled trout.

An inventory of pollution sources was completed using a literature review, interviews, historical photographs and visual observations in the watershed. The primary focus of the assessment was to identify sources of sediment and factors contributing to erosion, flooding, road and culvert washouts and exaggerated sediment deposition. Water quality impacts from historical activities are still significant. Present day sources of pollution include the effects of residential and recreational

development, agriculture and grazing, ongoing placer mining and roads and stream crossings. These sources are particularly associated with sediment and temperature.

Historical land uses have caused long-lasting, significant changes to the watershed that continue to have large effects on water quality and stream channel conditions. Historical land uses that continue to affect water quality include the effects of fires, construction of a railroad, mining, timber harvest and road construction. Historic mining in this part of the Coeur d'Alene Mining District was significant including more than 14 hard rock mining sites, 3 mills, and extensive placer mining that included hydraulic mining, floating dredge mining and other dredge operations in Beaver Creek and many tributaries. Historic sources of pollution contribute to sediment, temperature and metals water quality impairments as well as degraded watershed function.

Using the GRAIP model, more than 146 miles of forested roads were evaluated in the watershed, including nearly 3,000 drainage features and 85 culverts. Culverts were further evaluated for failure risk and potential to block fish migration. An estimated 219 tons of sediment is delivered annually to streams from surveyed forest roads. Nearly all of surveyed roads showed signs of erosion and the vast majority was delivered to the surrounding forest rather than to the stream network. Only 10% of the surveyed roads delivered sediment to streams, and just 2 miles of surveyed road produced half of the sediment load delivered to streams.

The drainage features evaluated during GRAIP analysis showed that greater than 90% of sediment delivered to streams was routed through just 3% of the drainage features. Non-engineered features linked roads and streams in all subwatersheds and delivered 54% of the sediment to streams though only 10% of non-engineered features delivered sediment. Stream crossing culverts consistently delivered all of the sediment routed to them into streams, though sediment was routed to only 18% of the culverts. Stream crossing culverts also presented the greatest risk of introducing large volumes of sediment to the stream network, as 21 of the 85 culverts could send up to 4,200 tons of sediment to streams if they fail and erode road-fill material surrounding them. It is unlikely that all 21 high-risk culverts could fail simultaneously, but given a large enough storm event, it is likely that at least a few could fail and introduce a large amount of sediment into streams. Nineteen of the surveyed culverts also presented migratory barriers to nearly 24 miles of habitat for fish and other aquatic organisms, though other culverts along unsurveyed roads (such as Road 456) are likely also barriers.

When evaluating sediment loading from forest roads among subwatersheds using GRAIP, Trail Creek contributed more than half of the sediment to Beaver Creek, though other smaller subwatersheds contributed larger amounts of sediment per area. Trail Creek had the most high-delivery road segments, the highest density of improperly functioning drainage features, and the most high-risk culverts.

A review of historical aerial photographs (1937-2009) was used to evaluate the effects of historical activities on the stream channel and to assess channel morphology and function over time. Particular attention was paid to the Beaver Creek mainstem which has been highly altered from natural background as riparian vegetation was removed, roads and railroads were constructed, beaver activity was constrained and portions of the floodplain were affected by mining and contributions of sediment from tributaries. Undersized bridges have also had significant effects to Beaver Creek evident over time in aerial photographs. In general, normal channel migration has been highly restricted by roads, bridges and the old railroad bed. The channel has also been highly aggraded and overwidened. This condition, combined with removal of riparian vegetation has contributed to system-wide floodplain instability. Based on historical surveys, interviews and data collected during the assessment, we suspect an ongoing declining trend in watershed functional condition.

Wadeable streams bioassessments using DEQ's BURP protocols were completed at two sites, upper Beaver Creek and lower Beaver Creek, to evaluate fish, macroinvertebrates and physical habitat. This information was used to calculate index scores to assess water quality status and support of cold water aquatic life in the stream. Stream Habitat Index scores at both sites were rated below the 10^{th} percentile of reference condition. Stream Macroinvertebrate Index scores were below the 25^{th} percentile of reference conditions for upper Beaver Creek and below the 10^{th} percentile of reference conditions in lower Beaver Creek. Westslope cutthroat trout, sculpin, brook trout and rainbow trout were collected at both sites. The Stream Fisheries Index for upper Beaver Creek site received a condition rating above the median of reference condition, while the lower Beaver Creek site was rated between the 25^{th} percentile and median of reference condition. Following DEQ's Small Stream Ecological Assessment Framework (DEQ 2002) and the Water Body Assessment Framework (Grafe et al. 2002), an average of the three index score ratings can be used to indicate water quality conditions and support of cold water aquatic life. An average condition rating less than 2 usually indicates cold water aquatic life is not fully supported, while an average condition rating of 2 or greater usually indicates cold water aquatic life is fully supported. The average condition ratings for both Beaver Creek sites were 1.7, indicating impaired water quality.

In addition to fish, habitat and macroinvertebrate index scores, pool counts, residual pool volume estimates, width/depth ratios and residual pool volumes were also evaluated. Pool measures and channel dimensions illustrated Beaver Creek's overwidened and simplified channel associated with instability of the bed and banks and excessive sediment loading.

The RASCAL stream condition survey was conducted in five sub-drainages within the Beaver Creek Watershed: Carpenter Gulch, Dudley Creek, Pony Gulch, Potosi Gulch and White Creek. A total of 11.38 miles were surveyed and results included stream habitat, canopy cover, streambank stability and streambank erosion. An evaluation of the four assessment parameters across all watersheds showed that Dudley Creek was surveyed to have the most favorable channel conditions. It had the highest incidence of excellent stream habitat and a high level of streambank stability. Pony Gulch's channel also had high favorable conditions, while White Creek was assessed to have average channel conditions. Finally, Carpenter Creek and Potosi Gulch were surveyed to have the most unfavorable channel conditions. The Potosi Gulch survey showed low percentages of canopy cover, had the highest incidence of streambank erosion and only had 1% of the channel surveyed with excellent habitat conditions.

Beaver Creek and its tributaries are listed as impaired due to elevated water temperatures and are included in draft temperature TMDLs. Stream shade and solar loading in the Beaver Creek watershed are very important for stream temperature moderation. The temperature TMDL analysis applied

Potential Natural Vegetation (PNV) techniques to estimate target shade at natural background conditions, existing shade and identified shade deficits. These were combined with channel width information to develop solar loading estimates at natural background and existing conditions. Channel dimensions are very important to stream shading and solar loading. Many reaches of Beaver Creek are much wider and shallower than natural conditions. This reduces the effect of shading and increases solar loading and stream temperatures.

Target shade in the watershed ranged from 40% near the mouth of Beaver Creek to 70% in the middle reaches of Beaver Creek and lower Trail Creek. Target shade in most of the smaller tributaries was estimated at 90-99%. Existing shade estimates ranged from 0-70% in mainstem Beaver Creek and were 70-90% in most of the tributaries. Shade deficits ranged from 10-49% in most of mainstem Beaver Creek and 0-9% in most of the tributaries. The largest shade deficits were more than 50% in stretches of Beaver Creek between the Dobson Pass Road and Carbon Center Creek, and extended into the lower reaches of Carbon Center Creek.

During the watershed assessment, field crews used Solar Pathfinder equipment and digital photography to field verify existing shade estimates at the two Beaver Creek BURP sites and in portions of Dudley Creek. Shade in sampled reaches of Dudley Creek was 80% and the same as estimated existing shade from the draft TMDL; however increased shade is needed to reach TMDL goals. Solar Pathfinder shade estimates for the lower Beaver Creek site exceeded estimated existing shade from the draft TMDL, but the measured shade did not quite reach the TMDL goal. Solar Pathfinder shade estimates from the upper Beaver Creek site exceeded both the estimated existing shade and shade target from the draft TMDL. These results show that the TMDL targets are likely met in this 1190-m segment of the assessment unit.

Escherichia coli concentrations were very low in both samples and well below Idaho water quality standards. Tests of three cutthroat trout collected during 2010 electrofishing did not detect the whirling disease parasite. Both *E. coli* and fish health evaluations had low sample sizes and are not likely enough to draw broad conclusions about the watershed.

Many watershed improvement projects have already been completed and have contributed towards implementation of TMDLs and progress towards attaining water quality goals (described in Appendix C). The largest projects have included road decommissioning and culvert removals by the USFS, and mine and mill site remediation by DEQ, USFS, and BLM. Bank stabilization and riparian restoration projects on private lands have also been led by DEQ, the Natural Resources Conservation Service (NRCS), local Conservation Districts and individual landowners. These projects have helped incrementally improve watershed conditions, but some have failed and much more work is needed to reverse the watershed's declining trend in functional condition and to reach water quality goals.

Results from these assessments have and will help project partners form and prioritize recommended actions to return the Beaver Creek Watershed to a functioning condition and attainment of water quality goals. With an improved understanding of watershed condition, strategic restoration activities will be more effective, economically viable and easier to implement. This could lead to the eventual restoration of watershed function and beneficial uses. Improved watershed function will translate into improved conditions for fish and wildlife, decreased controversial issues for local landowners, improved opportunities for recreational visitors and more streamlined and environmentally sound opportunities for natural resource development.

The following seven recommendations outline the main themes this assessment team feels needs to be addressed in order to restore properly functioning conditions to the Beaver Creek Watershed. No one solution will be able to address the degradation in the watershed. A multi-faceted strategy is recommended and specific recommendations have been included at the end of this report to assist with setting restoration priorities.

1. Share the information—WAG members should learn as much as possible about watershed ecology, BMPs and restoration techniques and share this information with neighbors, colleagues and anyone else with an interest.
2. Work together—Cooperative and coordinated efforts will be most effective to improve the Beaver Creek Watershed.
3. Protect special areas—Protect functional portions of the watershed and unique natural areas.
4. Don't make things worse—Avoid activities that would increase sediment, temperature or metals loads to streams.
5. Address urgent needs— Address sites at high risk of damage to infrastructure, property and natural resources.
6. Shut off the source—Implement watershed improvements with a strategic approach as much as possible to reduce pollutant loads in tributaries.
7. Remove limiting factors—Removing or replacing features that limit watershed function, such as undersized crossing structures, can be a powerful approach to restoration with high cost-benefit ratios.
8. Take a top-down watershed approach—Implement watershed improvements with a strategic approach as much as possible to address watershed conditions from the headwaters downstream to the North Fork Coeur d'Alene River confluence.

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Chapter 1: Watershed Background

Introduction

Beaver Creek, a tributary to the North Fork Coeur d'Alene River, contains rural areas of forests, recreational lots, rangeland and habitat for fish and wildlife. The 44-square-mile watershed has a long history of timber harvest, mining and road construction on public and private lands. Water quality in Beaver Creek does not fully support beneficial uses as outlined in the Clean Water Act due to sediment, temperature, cadmium, lead and zinc.

Beaver Creek is subject to Total Maximum Daily Load (TMDL) requirements for sediment, and TMDLs are in development for temperature, cadmium, lead and zinc. Until water quality conditions improve, water quality impairments make it challenging to proceed with natural resource development projects such as mining exploration or timber harvest. In addition, water quality in the watershed prevents Beaver Creek from fully supporting its fisheries potential. At the same time, landowners are concerned about erosion, flooding and deposition of sediments along their streamside properties. The transportation network and mining operations also produce ongoing water quality challenges.

The goal of this study was to conduct a watershed scale assessment of conditions throughout the watershed, including water quality, fisheries habitat, stream channels, flood risks, stream crossings and the transportation network. In 2010, Idaho Department of Environmental Quality (DEQ), the US Forest Service (USFS) and University of Idaho Extension (UI Extension) undertook this watershed assessment in the Beaver Creek Watershed utilizing a local, seasonal USFS field crew. Results from these assessments were used to develop recommended actions to return the Beaver Creek Watershed to a functioning condition. Recommendations will be given for each subwatershed (Figure 2) within the watershed so that work can be prioritized efficiently.

The following assessment methods were employed in order to meet our goals and objectives:

- Analysis of forest roads using the USFS Geomorphic Road Analysis and Inventory Package (GRAIP) model to estimate erosion and sediment loading from the road network and to assess fish passage and habitat fragmentation.
- A historical survey and stream channel analysis was used to evaluate land use and stream channel change over time and to identify pollution sources in the watershed.
- A wadeable streams rapid bioassessment utilizing the DEQ Beneficial Use Reconnaissance Program (BURP) was performed to analyze water quality and cold water aquatic life.
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- Fish health was evaluated by testing for the whirling disease parasite in sampled trout.

With an improved understanding of watershed condition, strategic restoration activities will be more effective, economically viable and easier to implement. This could lead to the eventual restoration of watershed function and beneficial uses. Improved watershed function will translate into improved conditions for fish and wildlife, decreased controversial issues for local landowners, improved opportunities for recreational visitors and more streamlined and environmentally sound opportunities for forest industries like mining and timber harvest.

Watershed Description

The Beaver Creek Watershed is 44 square miles (28,193 acres) and is located in northern Shoshone County. The towns of Kellogg, Osburn, Wallace, Murray and Prichard surround its boundaries. Elevation ranges from 2,358 feet at the confluence of Beaver Creek and the North Fork Coeur d'Alene River to 6,393 feet at the headwaters of Beaver Creek in the southeast corner of the watershed.

There are over 102 miles of stream channels in the watershed—12.7 miles of which are the mainstem of Beaver Creek (Figure 3). At the confluence with the North Fork Coeur d'Alene River, Beaver Creek is a 4^{th} order stream (Strahler method).

Land use and ownership varies across the watershed. A majority of land is federally managed by the Forest Service. The Bureau of Land Management (BLM) administers some land in the headwaters where there is also privately-owned forest managed for timber production. The mainstem Beaver Creek corridor downstream of Moore Gulch is predominately private land with a mix of permanent residential and recreational lots and some pastures (Figure 4). There are privately-owned mine sites at Carbon Creek and along Trail Creek.

Figure 1. Aerial view of the Beaver Creek watershed and surrounding area (1933)

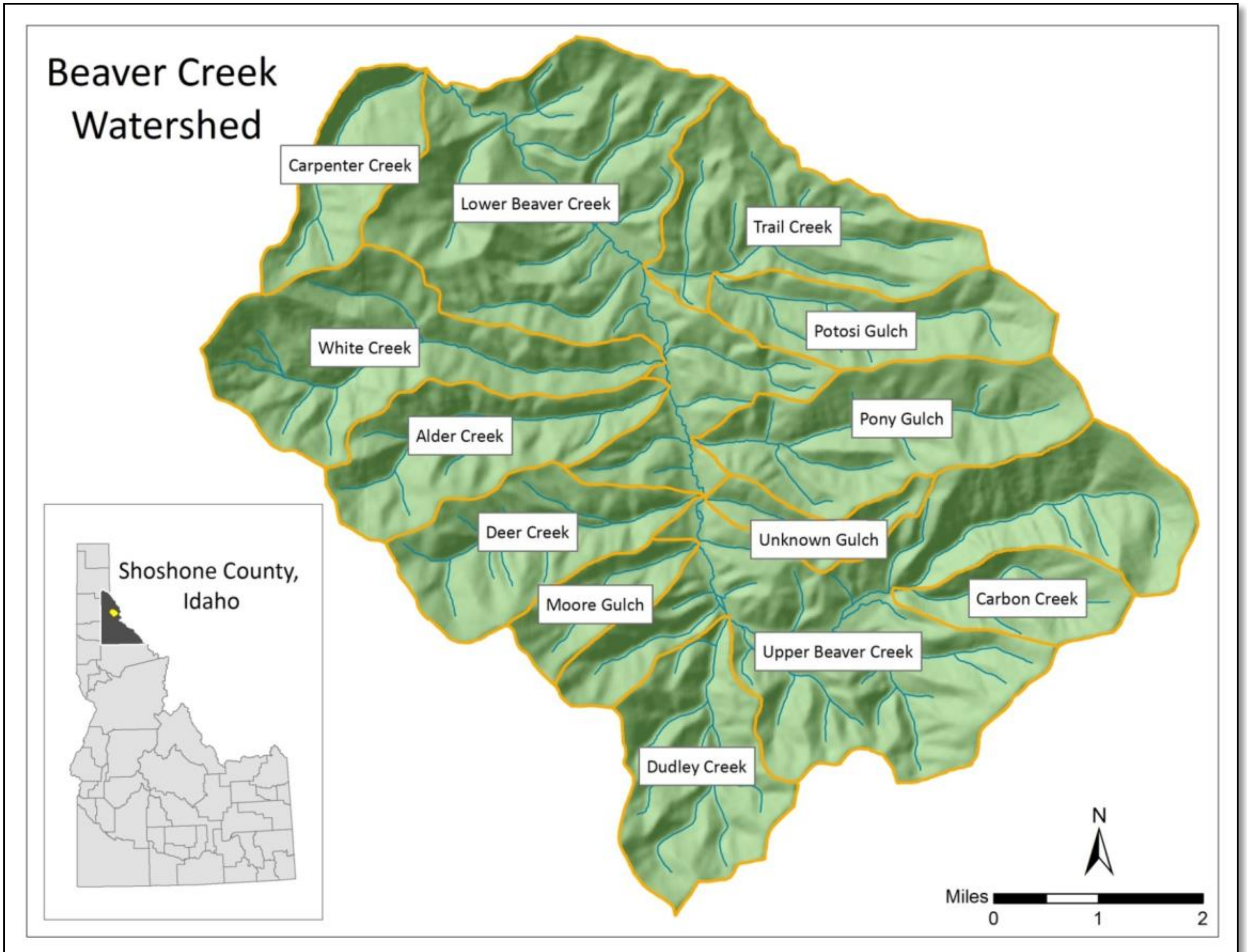


Figure 2. Subwatersheds delineated in the Beaver Creek Watershed

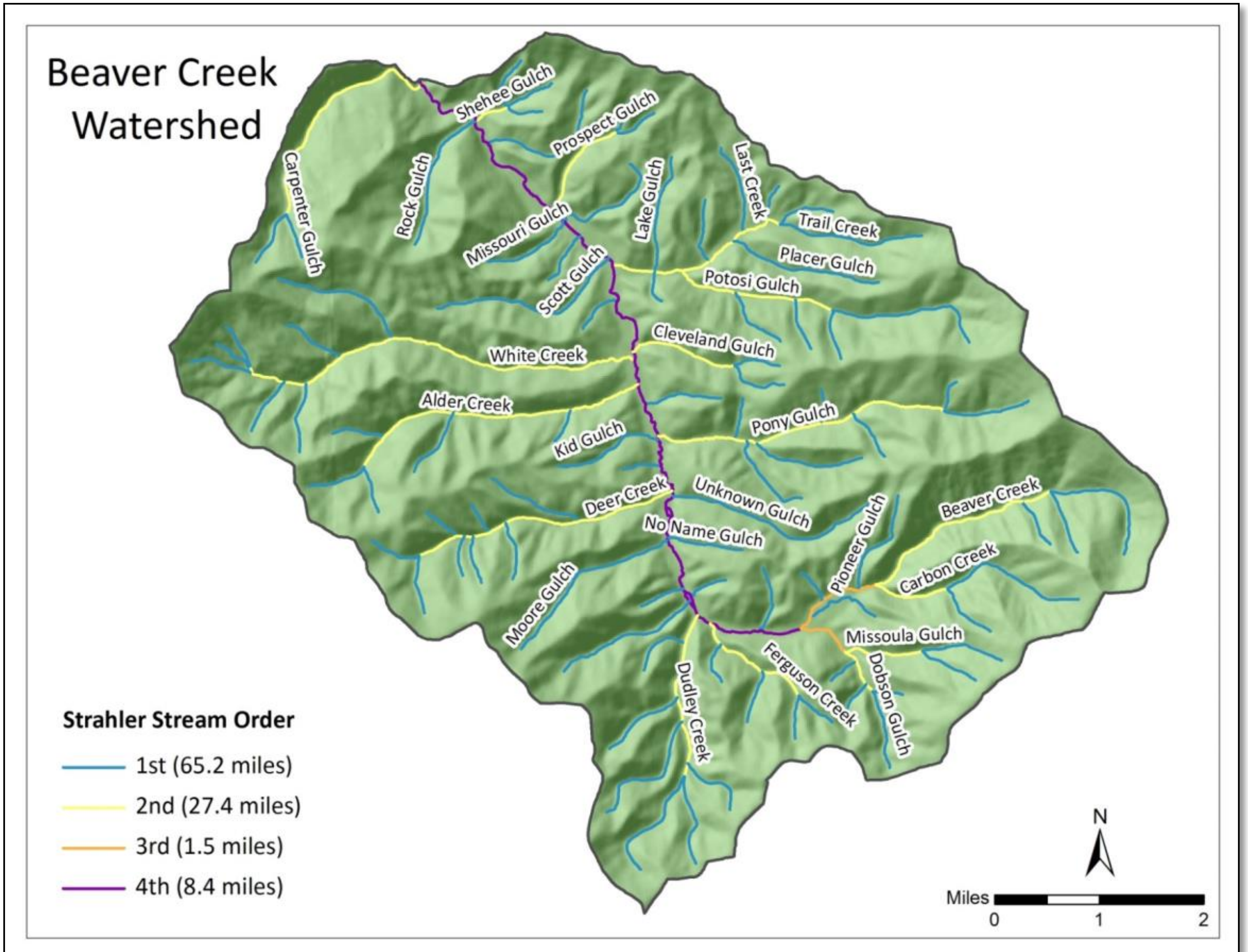
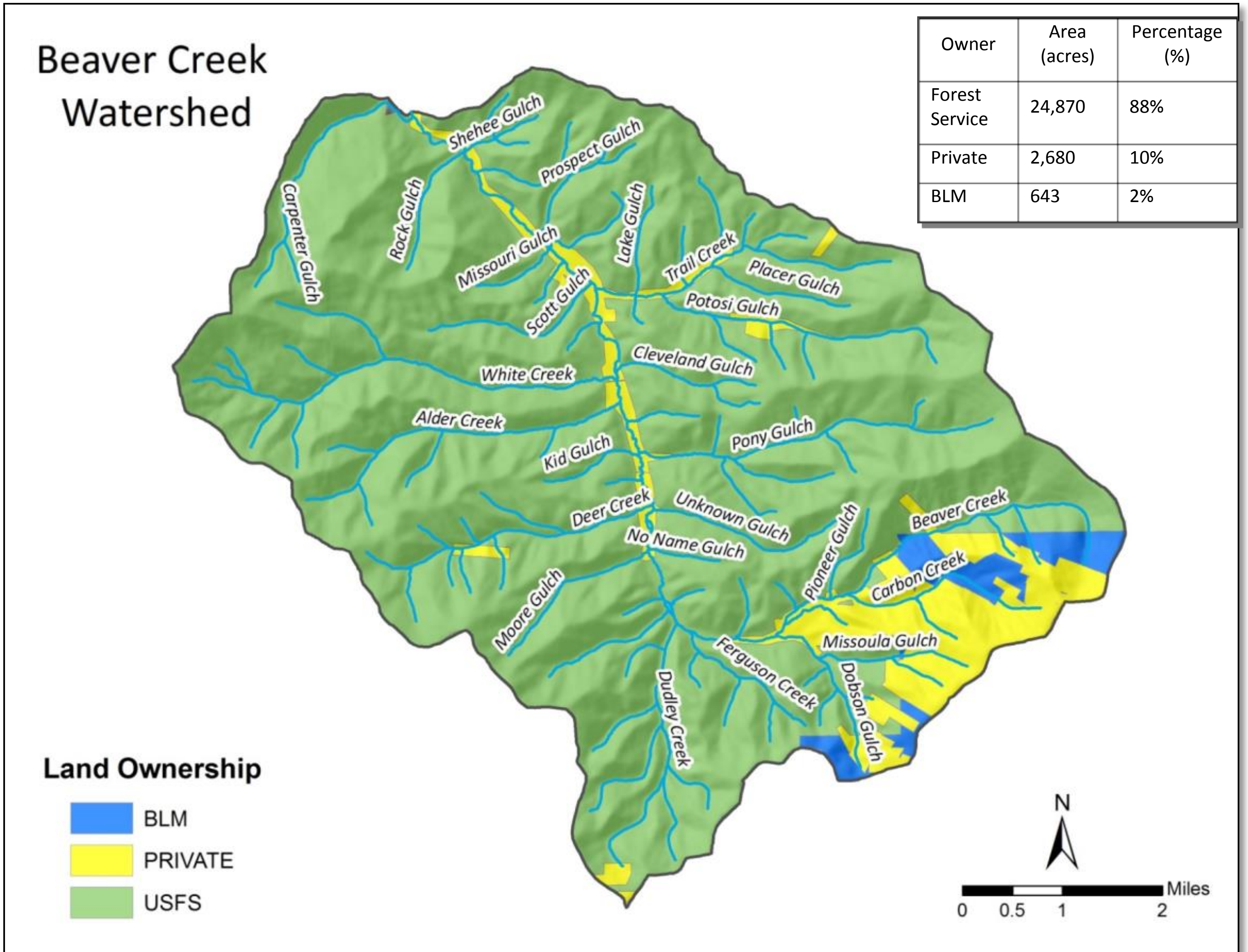


Figure 3. Beaver Creek stream network summarized according to stream order (Strahler Method)



Owner	Area (acres)	Percentage (%)
Forest Service	24,870	88%
Private	2,680	10%
BLM	643	2%

Figure 4. Land ownership in the Beaver Creek Watershed

Water Quality Status History

Water quality concerns in Beaver Creek were first identified by DEQ in 1992. An evaluation by DEQ determined that cold water biota and salmonid spawning were partially supported beneficial uses in Beaver Creek and that primary and secondary contact recreation were supported but threatened beneficial uses. Pollutants listed at that time were nutrients, pH, siltation/sedimentation, thermal modifications, other habitat alterations, unknown toxicity and metals. Sources of pollutants identified included forest practices (harvesting, reforestation, residue management and road construction/maintenance), urban runoff (storm sewers and surface runoff), resource extraction/exploration/development (surface mining, subsurface mining, placer mining, dredge mining, mill tailing and mine tailings), land disposal (landfills), hydrologic/habitat modification (channelization and removal of riparian vegetation) and other (waste storage/storage tank leaks, highway maintenance and runoff and in-place contaminants) (DEQ 1992).

The 2001 Subbasin Assessment and TMDLs of the North Fork Coeur d'Alene River reviewed available data at that time. The assessment concluded that Beaver Creek was not impaired by sediment and that the impairment to cold water aquatic life was instead caused by metals (DEQ 2001). By 2002, the Beaver Creek stream network was split into two assessment units. One unit consisted of upper Beaver Creek and tributaries while the other included just the mainstem Beaver Creek below White Creek. In 2002, the upper Beaver Creek and tributaries unit was listed on the 303(d) list as impaired by cadmium, metals and zinc, and lower Beaver Creek was listed on the 303(d) list as impaired due to temperature and sediment (DEQ 2002c).

In 2008, both segments of Beaver Creek were listed in category 4a as impaired by sediment, but covered by the 2001 sediment TMDLs. Upper Beaver Creek and tributaries was further identified as impaired due to temperature, cadmium and zinc while lower Beaver Creek was identified as impaired due to temperature, cadmium, lead and zinc (DEQ 2008).

The most recent water quality status report, Idaho's 2010 Integrated Report, listed upper Beaver Creek and tributaries (AU 17010301PN003_02) as impaired due to sediment, temperature, cadmium and zinc (DEQ 2010). Lower Beaver Creek (AU 17010301PN003_03) is listed as impaired due to sediment, temperature, cadmium, lead and zinc. See Appendix B for detailed descriptions of water quality status and history.

Potential Sources of Water Quality Pollution

Roads

The transportation network in the Beaver Creek Watershed is extensive and affects many of the stream channels. The two main issues associated with roads that threaten water quality in Beaver Creek are (1) the encroachment of roads, primarily on the mainstem, but also on smaller headwater tributaries, and (2) failing or insufficient road crossings and improper drainage. Both problems have led to flood damage on infrastructure, loss of property and degradation to channel conditions.

Flood events in recent decades have demonstrated the impacts of road encroachment in the watershed. Several roads have been consistently damaged through flooding which has resulted in road closures and costly maintenance. Sections of the main Beaver Creek road (road 456) are frequently covered by flood waters that can block access for residents to reach I-90 and the town of Wallace. Established roadbeds constrict stream channels from fully utilizing the floodplain. High water is concentrated onto adjoining properties which often causes significant erosion, loss of riparian trees and property damage. Excessive sedimentation often occurs, creating sections of dewatered channel, which reduces the quality and diversity of aquatic habitat and can lead to habitat fragmentation. In addition, these deposits lead to further channel instability.

Figure 5. Culvert failures are a major threat to water quality in the watershed

Many stream crossings throughout the watershed have also failed during flood events in recent years. Improperly placed and/or undersized culverts and bridges have greatly affected road access and fish passage. In many instances, stream channels have been altered to utilize the available road crossing, or have otherwise washed out entire sections of road.

Historic Mining and Abandoned Mine Lands

Mining has a long history in the North Fork Coeur d'Alene River Subbasin and was the initial driver for settlement and development of this area once gold was discovered in the nearby Prichard Creek drainage. This discovery was quickly followed by rapid development by European-American settlers in the 1880s (Magnuson 1968 *in* Box et al. 2004). Communities sprang up, roads and railroads were developed, timber was cleared and mines went into production. Historic mining was through surface mining of placer deposits and hard rock mining underground. The Beaver Creek Watershed is located within the Coeur d'Alene Mining District, which was both a world leader in silver production and a national leader in lead and zinc production for nearly 100 years (Ott and Clark 2003). In the North Fork Coeur d'Alene River Subbasin, the largest mine production occurred in the upper Beaver Creek drainage (1.4 million tons of ore), but only a fraction was milled there (Box et al. 2004).

Early surface mining of placer deposits included hydraulic mining (Figure 6), which caused significant damage to stream channels and floodplains. Underground mines and associated mills were also developed in the watershed. Underground mine operations in the Beaver Creek watershed were for lead, silver, and zinc while gold was mined through placer surface mining. Precisely how many historic mining operations there were in this watershed is unknown. A 1998 inventory of abandoned mine lands identified 14 abandoned hardrock mines or prospects and 3 mills in the Beaver Creek Watershed (IGS 1998). The largest underground mines in the Beaver Creek Watershed were the Idora (Figure 7) and the Ray Jefferson/Carlisle and each had an associated mill (Ott and Clark 2003, Box et al. 2004). There were also small mines and prospects of varying size including the Red Monarch, Pony Gulch (where there was also a mill), Blue Sky, and Rooster Goose. Prior to 1925, ore was milled using a gravity or "jig" process. This process produced large quantities of coarse-grained, metals-rich jig tailings. Later, flotation milling was used and produced even larger quantities of fine-grained flotation tailings that generally contained fewer metals.

Figure 6. Hydraulic placer mining near Delta in the Beaver Creek Watershed (date unknown)

Most of the underground mines and prospects began in the early 1900s and were closed, reopened, changed names and changed ownerships multiple times before finally being closed or abandoned (IGS 1998). These patterns were largely driven by metals prices. Today there are no operating hard rock mines or mills in this watershed. Production at some of the larger mines increased during World War II, but by the 1950s production from hardrock mines in the watershed had stopped. Mines frequently changed hands and, once closed, were often abandoned. Mining has long been an important and beneficial industry for local economies, and historic mining activities in this watershed have legacy environmental impacts from which the watershed is still recovering. Restoration potential is high and extensive mine reclamation is ongoing.

Figure 7. The Idora Mine and Mill site in upper Beaver Creek (now remediated) is an example of the effects of abandoned hardrock mines and mills in the watershed

Abandoned mine lands have been a significant source of water quality pollution in the Beaver Creek Watershed with numerous piles of tailings and waste rock, particularly in Upper Beaver Creek and

Carbon Creek. Investigations have revealed patterns of contamination with concentrations of these pollutants in headwater areas near the large mill sites. Concentrations of metals in stream sediments generally decrease downstream (Figure 8). Mine wastes from the Idora and Ray Carlisle mine and mill sites have been the primary sources of metals contamination in the watershed. These waste products contribute cadmium, lead and zinc at potentially damaging concentrations and have also led to aggradation of sediment in stream channels. Treating or removing sources of metals contamination is vital for restoring full support of cold water aquatic life in Beaver Creek and tributaries. Remediation of these sites is ongoing by DEQ, USFS, BLM, EPA and partners, with work on the Idora Mine and Mill Site completed in 2012. Remediation projects include removal of tailings and contaminated sediments. For example, interagency cleanup of the Idora site in 2010-2012 has addressed the major sources of metals contamination from that site. There were 24,793 tons of sediment removed or stabilized from erosion, 341 tons of lead removed to repository, and 131 tons zinc removed to repository. The Ray Carlisle site is the last remaining major source of metals contamination in the Beaver Creek Watershed.

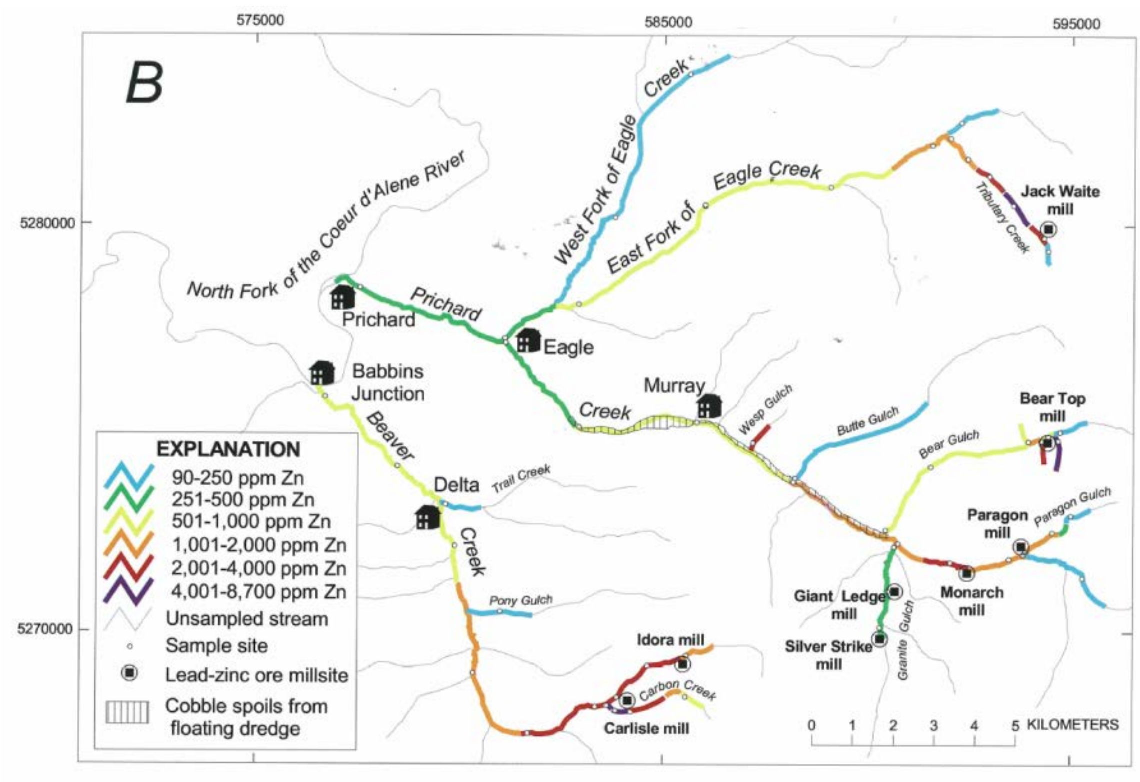


Figure 8. U.S. Geological Survey investigations of metals concentrations in stream sediment found patterns of concentration near mill sites (Box et al 2004)

<u>Placer and Dredge Mining</u>

The historical extent of placer mining in the watershed is unknown and it is difficult to determine the amount of present-day placer mining activity. There were extensive early placer operations reported in the Trail Creek drainage (Box et al. 2004) and placer mining has continued at various scales with activity largely varying with gold prices. The legacy effects of historic placer mining, especially the alteration of stream channels and increased instability, continue to affect streams in the Beaver Creek Watershed.

With record gold prices in recent years, placer mining appears to have increased and many present-day operations are co-located with historical placer dredging operations. Placer and dredge mining may generate sediment, increase stream temperature and affect the structure and function of stream channels and floodplains. By adhering to regulations and applying best management practices, these effects can be minimized and mitigated. Idaho Department of Lands (IDL) administers permits for placer and dredge mining, the Army Corps of Engineers (ACOE) administers permits for dredge and fill in many waterbodies, and Idaho Department of Water Resources (IDWR) administers permits for stream channel alterations and recreational dredge mining. Some placer and dredge mining activities may qualify as point sources of pollution and fall within National Pollution Discharge Elimination System (NPDES) permitting administered by the Environmental Protection Agency (EPA). These are issued by EPA and certified by IDEQ and must be in compliance with TMDL allocations. Currently, there are no NPDES permits issued for point source discharges in the Beaver Creek Watershed.

Recent IDL records included 5 permitted mechanical placer dredge mining operations in the Beaver Creek Watershed (Table 1). Two operations are considered active and 3 are reported as reclaimed and completed. One active operation is mechanical placer dredge mining and a wash plant located on private land in Potosi Gulch with a total project area of 4.3 acres. The other active operation is placer dredge mining of 10 acres along Trail Creek.

Table 1. Mining operations with IDL permits in the Beaver Creek Watershed (1989-2012)

Location	Type	Size	Status
Trail Creek	Placer dredge mining	10 ac.	Active
Potosi Gulch	Placer dredge mining + wash plant	4.3 ac.	Active
Trail Creek	Placer dredge mining	2 ac.	Cancelled 6/3/1998, reclaimed
Trail Creek	Placer dredge mining	3 ac.	Cancelled 2/10/1998, reclaimed
Pony Gulch	Placer dredge mining	4 ac.	Cancelled 6/2/1997, reclaimed

Mechanical placer dredge mining operations have also been permitted by the US Forest Service in recent years and there have been multiple applications for new mining activities. Mine operations on USFS-managed lands since 2000 include a small wash plant now closed and reclaimed in Potosi Gulch. A small mechanical dredge mining operation took place in upper Trail Creek and has been reclaimed. Another slightly larger mechanical dredge mining operation is ongoing in Thiard Gulch, and a third operation was permitted in Potosi but has not yet begun. Two additional plans of operation for tributaries to Trail Creek are currently being evaluated for permitting by USFS.

There are additional placer mining operations including trenching and small wash plants located on private land along Trail Creek from Potosi Gulch to the main Beaver Creek Road. These operations are visible from the Kings Pass Road and the Beaver Creek Road. Based on visual assessments from the road, these operations seem to be sources of sediment loading, temperature loading and habitat alteration detrimental to cold water aquatic life. Sediment from these operations is likely exported downstream during high flow events into Beaver Creek. Improved application of mining best management practices and adherence to TMDL allocations could improve water quality in these areas.

Figure 9. There are several wash plants on private land in the Trail Creek watershed for sorting and washing gravels

Figure 10. Mechanical dredging removes gravels to be washed and sorted for recovery of gold

Figure 11. U.S. Geological Survey investigations of metals concentrations in stream sediment found patterns of concentration near mill sites (Box et al 2004)

In addition to the larger-scale mechanical dredge mining of placer deposits described above, smaller-scale recreational dredge mining also occurs in the watershed. Recreational dredging by small suction dredges and power sluice (also known as high-banker) is permitted through the Idaho Department of Water Resources (IDWR). This permitting program does not always track the amount and specific locations of the activity, and it is difficult to know the extent of permitted and unpermitted recreational dredging and the degree of compliance with rules for the activity. When properly operated, small suction dredge operations can have minimal water quality impacts. However, even a small improperly operated dredge operation can be highly damaging to stream environments and water quality (Figures 12 and 13). Due to the remote nature of parts of the Beaver Creek Watershed, it's difficult to monitor, track and enforce the requirements for this activity and it is difficult to address and remedy problems observed.

Figure 12. Bank excavation and channel alteration associated with improper small dredge mining operation in Potosi Gulch during 2010

Figure 13. Removal of streambank vegetation, channel alteration and discharge of gravels upland associated with an improper small suction dredge mining operation in Pony Gulch during 2010

Figure 14. If mechanical placer mining applies adequate BMPs specified in state and federal permit programs, increased sediment discharge, temperature loading and channel degradation can be prevented

Figure 15. Reclaimed mechanical dredge mining sites can be resloped and revegetated, but reclamation remains challenging in this watershed due to soil conditions and expense

Figure 16. One of the difficulties in reclaiming placer dredge mining operations includes subterranean stream channels due to channel alteration and changes in alluvial soils composition

Railroad

In the early 1900s, the Idaho Northern Railroad constructed a railway that reached Murray in 1907 (Carl Ritchie, former USFS archeologist, personal communication). Construction of a branch line up Beaver Creek began in 1916, largely for the transportation of ore and metals concentrates from the Ray Jefferson/Carlisle Mine (Wood 1983, IGS 1998). The branch opened in 1917, but its use was short-lived due to lack of production at the mines. The railway was eventually abandoned after flooding in 1933. Portions of the railroad grade still exist, but much has been washed away and transported by the shifting stream channel. The old railroad grade has had significant impacts on Beaver Creek and its floodplain. In many areas, the stream channel has been constrained by the railroad grade and accumulated sediments within an artificially narrow band. The constraint and aggradation have exacerbated each other and led to channel instability. At locations where the stream has eventually broken through the berm created by the railroad grade, the stream can then be captured by the lower elevation floodplain on the other side and a new channel is then created and constrained.

Forest Management

Figure 17. Timber harvest in Beaver Creek Watershed

Timber harvest in the watershed began with minerals development in the late 1800s. This was also the approximate time of the last large fire that covered most of the watershed (1889). Another fire in 1908 burned most of the Deer Creek drainage. Historic fire patterns were mixed in severity. Stand replacement, high severity fires occurred rarely, about every 200 years (USFS 1998). The most recent large fire in the Beaver Creek Watershed was between 1850-1899 for most of the watershed, and 1900-1949 for other portions (USFS 1998). Low and moderate severity fires have been suppressed, and most of the forest in this watershed has not experienced a major burn in more than 100 years.

Early harvest techniques included clearing wide areas along valleys and hillslopes and logs were often transported by flumes and splash dams. Flumes have been found in the Beaver Creek headwaters, but the location of any splash dams in the watershed has not been clearly documented. Before development, riparian zones of Beaver Creek likely included a combination of large conifers and deciduous trees including willows interspersed with beaver dams and ponds. The tributaries were likely forested with conifers and associated undergrowth.

There was a Civilian Conservation Corps (CCC) camp on Beaver Creek, Camp F-133, which was started in June 1935. CCC crews in northern Idaho concentrated on transportation improvements, structural improvements, forest disease control, forest fire protection and forest culture. White pine blister rust control efforts were a very common activity that involved removal of currant and gooseberry (*Ribes spp.*). This was done by crews with hand tools and sometimes accomplished by bulldozing stream bottoms to remove plants and then channelizing streams. The extent of blister rust control efforts in the Beaver Creek Watershed is unknown.

The result of these activities include large portions of the watershed that are highly susceptible to forest fire, interspersed with widespread and relatively large patches of homogeneous young forest. In many of these harvested areas, riparian buffers were not administratively prescribed and so the riparian areas of many headwater streams are removed. At the same time, relatively large patches of forest were harvested in a relatively short period of time, likely altering water yields in some subwatersheds of Beaver Creek. The effects of those changes combined with the effects of widespread road construction on streams are largely unknown.

<u>Agriculture and Grazing</u>

There are agricultural land uses on private land along the middle reaches of the Beaver Creek mainstem between Dudley Creek and Trail Creek. There are several pastures and hayfields and grazing cattle. There are no grazing allotments from the Forest Service in this watershed, but cattle have accessed USFS land. On private land, cattle typically have access to the stream.

<u>Residential and Recreational Development</u>

Patterns of land use in the Beaver Creek Watershed include mainly forested USFS land in the uplands, private industrial forest and mine lands in the upper Beaver Creek headwaters and along Trail Creek, private forest and agricultural lands in the mid-reaches of Beaver Creek and then smaller recreational and residential properties in the lower reaches of Beaver Creek. There are many properties used as seasonal residences with cabins or recreational vehicles. Recreational use of properties has increased in recent years.

<u>Utilities</u>

There are telecommunications lines both buried and overhead that run primarily along the Beaver Creek Road and are often adjacent to the stream. There have been instances with erosion putting poles and lines at risk. Telecommunications lines are visible on the ground along the Carbon Center Road and are at risk from road washouts during flooding.

In addition, the Bonneville Power Administration electrical transmission line crosses this watershed. Constructed in 1986 and 1987, the Taft-Bell 500 kV line enters the Dudley Creek headwaters from the east and travels northwest crossing all of the western tributary subwatersheds to Beaver Creek. Extensive vegetation and road management occurs to allow for maintenance on this utility line.

Figure 18. Utility pole along Beaver Creek

Projects to address these sources

Many projects already completed in the watershed (described in Appendix C) by private landowners and agencies have had mixed success. They may have made improvements at individual sites, but many have failed and some may even contribute to problems upstream or downstream. This assessment was undertaken to increase success and efficiency of projects through a watershed approach to restoration.

Chapter 2: Assessments

Geomorphic Road Analysis and Inventory Package (GRAIP)

<u>Methods</u>

The Geomorphic Road Analysis and Inventory Package (GRAIP; Black et al. in prep, and Cissel et al. in prep) survey evaluates drainage conditions of roads and provides detailed information on specific locations where water flows to several types of engineered drainage features. Drainage features include water bars and culverts as well as other features that are not engineered, and each drainage feature type is defined in Appendix D. In the field, potential drainage paths are identified on roads and the extent of erosion is evaluated by determining such features as the amount of eroded material, the surface conditions and potential vehicular usage of the road and whether the drainage has directly reached a stream, using relatively accurate GPS technology. The GRAIP model then incorporates other GIS-based landscape models to evaluate how much sediment is routed to drainage features as well as how much is then routed to the stream network. The model also routes delivered sediment downstream, allowing the user to estimate the amount of road-derived sediment potentially exported from the watershed.

For this assessment, roads were chosen for surveying by evaluating the location and proximity of roads near streams from a recent US Forest Service GIS roads layer. Roads in closer proximity to valley bottoms or in a mid-slope location that potentially crossed headwater streams were generally chosen to be surveyed over those along ridges or otherwise thought to be less influential to streams. In some cases, roads that were initially chosen were ultimately not surveyed because of difficulty locating the actual road surface in the field or because they were difficult to access. In other cases, roads on the GIS layer did not actually exist in the field, while other roads were discovered during the survey that were not in the GIS data.

Road Erosion and Sediment Delivery

Data on sediment generated from roads and sediment delivered to stream channels were collected and analyzed according to the GRAIP field and office protocols (GRAIP; Black et al. in prep, and Cissel et al. in prep). If flow paths were observed on roads, they were physically followed by field crews until each flow path left the road surface. Flow paths were also followed if they showed signs of continuing through forest vegetation, and their end point was then noted. The type of drainage feature where each flow path left the road was determined, and further evaluated for its integrity or effects to the road structure according to GRAIP methods.

Channel Network Extension

Watershed drainage networks can be extended by roads as they intercept shallow subsurface water from hillslopes and redirect it toward, or away from, nearby channels (Wemple et al. 1996). The extension of the drainage network in Beaver Creek and its subwatersheds was determined by using the effective length data determined by the GRAIP model for each drainage feature.

Evaluation of Drainage Features

Drainage features were evaluated for their ability to transfer sediment from roads directly into streams, as well as for their potential to transfer sediment from roads into the surrounding forest. The condition of each drain feature was evaluated in the field and a recommended level of maintenance was then developed based on the extent of maintenance. Regular maintenance included such actions as unplugging culverts or ditches, blading roads or other actions that would typically require machinery such as a small back hoe. Significant maintenance, however, would likely mean full replacement of a structure, adding drainage features or other actions that might require heavier machinery such as excavators or bull dozers. Drain feature problems and their associated definitions are described in Appendix D.

Delivery of Sediment to Beaver Creek

As noted above, the delivery of sediment from roads into streams was field verified using the GRAIP survey methods. The GRAIP model was then used to estimate the amount of sediment reaching streams based on the length and slope of each flowpath, the condition of the road, and the base erosion rate. The GRAIP model was also used to route road-derived sediment into the stream network at those observed locations, and accumulate it into downstream stream segments.

Culvert Risks to Roads

Stream crossing culverts were evaluated using the Stream Blockage Index (SBI) methods in the GRAIP model. The model compared the width of the culvert to the bankfull width of the stream, and included a factor for the angle of the culvert to the direction of flow in the stream. The index is a unitless value from 1 to 4, with 4 representing those culverts that are both small compared to the stream and having an angle of greater than 45 degrees to the stream flow and is generally considered the highest risk culverts for blockage and failure. Scores of 3 or higher represent those culverts that have a culvert-to-stream width ratio of 0.5 or less, or those culverts that are 50% or less as wide as the bankfull width of the stream. This varies slightly from the procedures in the GRAIP model, where culverts with an SBI score of at least 3 have a culvert to stream width ratio of less than 0.5, and do not include those that are 0.5. In this case, there were 19 culverts with culvert to stream width ratios of 0.5, and we classified culverts that are 50% as wide as their stream as presenting as great of a risk to stream channels as those that were less than 50% as wide.

<u>Results</u>

The Beaver Creek watershed was divided into 12 subwatersheds to determine how much sediment was being contributed by similarly sized tributaries (Figure 19 and Table 2). Watersheds ranged in size from nearly 1 mi^2 to slightly over 5 mi^2, but also included 2 larger subwatershed areas that combined many of the smaller drainages into the upper and lower sections of the Beaver Creek mainstem.

The amount of the road network surveyed in each subwatershed varied for many reasons, including accessibility, roads having a low likelihood of contributing sediment (e.g., those at high elevations), or an inability to locate mapped roads in the field. Over half the roads were surveyed in all but three subwatersheds, and Moore Gulch was the only subwatershed with all of the roads surveyed (Table 2).

The GRAIP model estimated that of the 146 miles of roads surveyed (63% of the road network); 2,663 tons of sediment was eroded from road surfaces, 219 tons of which were delivered into the Beaver Creek stream network. Over 99% of the surveyed roads in the watershed generated some sediment, (Figure 20), though less than 10% of the roads delivered sediment to streams (Figure 21). Half of the sediment generated from roads was produced from just 22% of the road network, or only 33 miles of road. Nearly 10% of the delivered sediment was generated by a single 0.2 mile segment of road on NFR 6328A in the headwaters of Trail Creek.

Table 2. General characteristics of subwatersheds within the Beaver Creek Watershed

Watershed	Area (mi^2)	Forest GIS road length (miles)	Forest GIS road density (mi/mi^2)	Surveyed road length (mi)	% of roads surveyed
Alder Creek	2.7	14.2	5.3	8.9	63%
Carbon Gulch	1.4	11.0	7.9	4.4	40%
Carpenter Creek	1.8	17.3	9.6	5.7	33%
Deer Creek	2.6	20.7	8.0	16.9	82%
Dudley Creek	2.9	19.0	6.6	13.4	71%
Moore Gulch	1.0	7.8	7.8	7.3	94%
Pony Gulch	3.6	11.0	3.1	10.1	92%
Trail Creek w/ Potosi	5.7	28.8	5.1	19.7	68%
Unknown Gulch	0.9	5.2	8.9	3.9	53%
White Creek	4.2	22.4	5.8	14.7	75%
Upper Beaver Creek	8.9	44.2	5.0	20.1	45%
Lower Beaver Creek	8.4	30.1	3.6	19.5	65%
Beaver Creek Total	**44**	**231.7**	**5.3**	**144.6**	**63%**

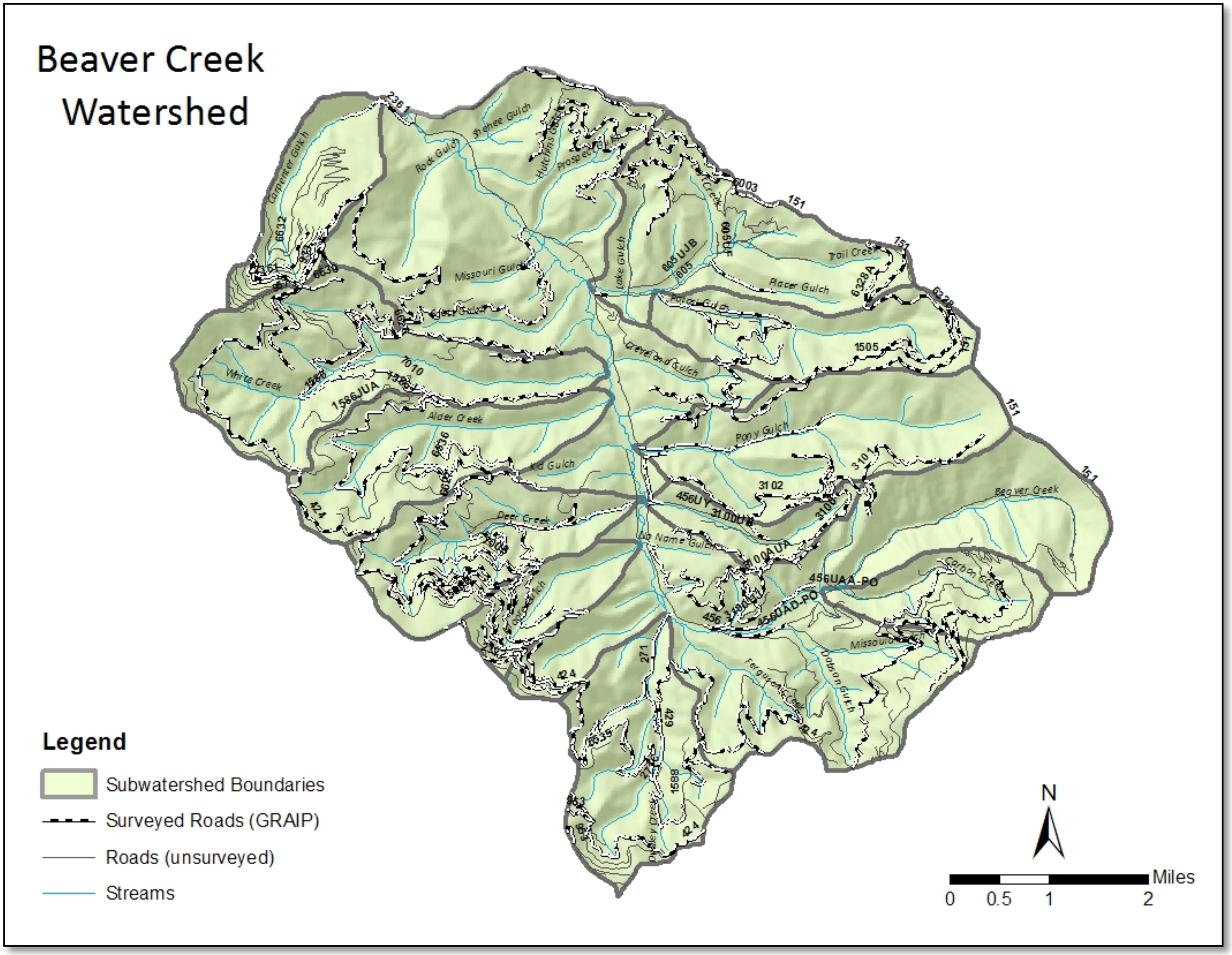


Figure 19. Roads surveyed using GRAIP methods within Beaver Creek subwatersheds

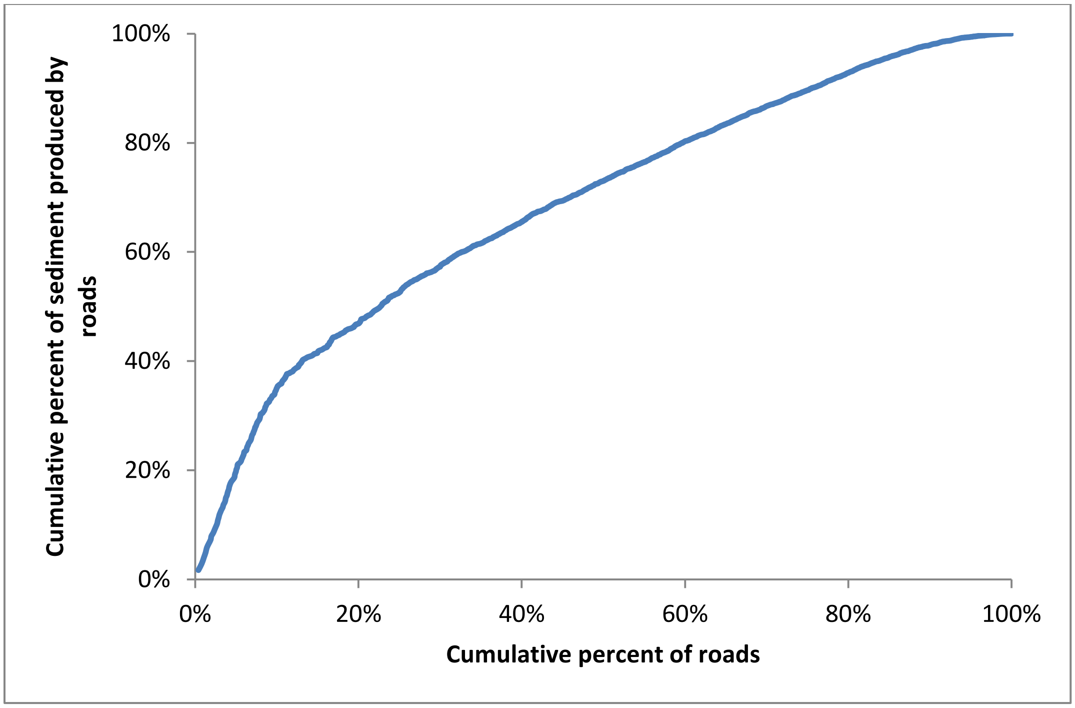


Figure 20. Cumulative percent of sediment produced annually by the surveyed road network in the Beaver Creek Watershed

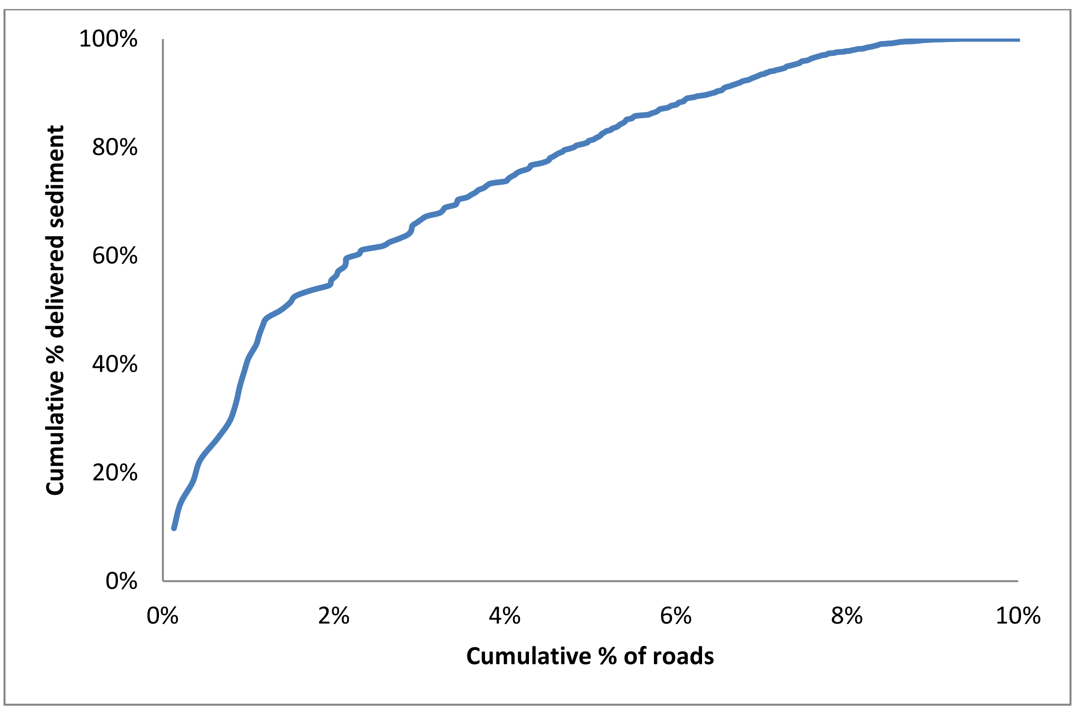


Figure 21. Relative amount of sediment delivered annually by the surveyed road network in the Beaver Creek Watershed

Road Erosion and Sediment Delivery

The Trail Creek subwatershed delivered nearly 6 times as much sediment as any other unique subwatershed, Dudley Creek, and over three times as much sediment as the next subwatershed group, lower Beaver Creek (Table 3). Trail Creek also delivered nearly twice as much sediment of any subwatershed by area. However, several smaller watersheds, including Carbon Creek and Dudley Creek, also deliver relatively large amounts of sediment per watershed area.

Table 3. Amount of sediment delivered annually to Beaver Creek from surveyed roads by subwatersheds of the Beaver Creek Watershed

Watershed	Total accumulated sediment to stream (tons/yr)	Relative amount of sediment contributed to Beaver Creek	Specific accumulated sediment rate to stream (tons/mi^2/yr)	Relative amount of sediment contributed to Beaver Creek by watershed area
Alder Creek	2	1%	1	1%
Unknown Gulch	1	0%	1	2%
White Creek	8	4%	2	3%
Moore Gulch	2	1%	2	4%
Carpenter Creek	6	3%	3	6%
Deer Creek	10	5%	4	7%
Pony Gulch	18	8%	5	9%
Dudley Creek	17	8%	6	11%
Carbon Gulch	13	6%	9	17%
Trail Creek w/ Potosi	98	45%	17	31%
Upper Beaver Creek	14	6%	2	3%
Lower Beaver Creek	30	14%	4	6%
Beaver Creek Total	**219**	**100%**	**55**	**100%**

Only two miles of road were responsible for delivering half of the sediment to Beaver Creek, all of which came from only four subwatersheds (Table 4). Fourteen percent of the road-derived sediment originated from just one-half mile of road in Trail Creek, and only 9 segments from 6 different roads in Trail Creek contributed 34% of the sediment. Only 2 segments of a single road delivered sediment into Pony Creek, while 3 segments of 2 different roads delivered sediment to the Lower Beaver subwatershed—one in Cleveland Gulch and two in Prospect Gulch (Figure 22). A list of all roads that delivered sediment, and the amount of sediment delivered to each subwatershed, can be found in Appendix E.

Table 4. Individual surveyed road segments, their respective subwatersheds, and the drainage feature that connects them to streams, responsible for delivering 50% of the sediment annually to Beaver Creek

Watershed	Road Number	Road Segment Length (mi)	Cumulative Length of Road (mi)	Sediment Delivered to Stream (tons/year)	Cumulative Sediment Delivered to Streams (tons/year)	Drainage Feature
Trail	6328A	0.19	0.19	21.34	21.3	Non engineered
Trail	1505ui	0.11	0.30	10.01	31.4	Non engineered
Pony	456UZ	0.13	0.43	8.71	40.1	Stream crossing- natural ford on washed out road.
Lower Beaver	1505B	0.21	0.64	8.71	48.8	Non engineered at 18” culvert
Trail	6541	0.29	0.93	8.49	57.3	Broad-based dip
Trail	1505	0.22	1.14	7.18	64.4	Non engineered
Trail	6328A	0.11	1.25	7.18	71.6	Non engineered
Trail	1505UIA	0.07	1.32	6.97	78.6	Waterbar
Trail	605UH	0.08	1.40	5.66	84.3	Diffuse drain
Pony	456UZ	0.07	1.47	5.66	89.9	Stream crossing- natural ford, and non-engineered
Lower Beaver	6541	0.13	1.60	5.46	95.4	Diffuse drain
Trail	605UH	0.05	1.65	3.92	99.3	Non engineered
Trail	1505UI	0.06	1.71	3.48	102.8	Non engineered
Lower Beaver	6541	0.07	1.78	3.23	106.0	Diffuse drain
Carbon	State Road 262	0.24	2.01	3.22	109.2	Diffuse drain

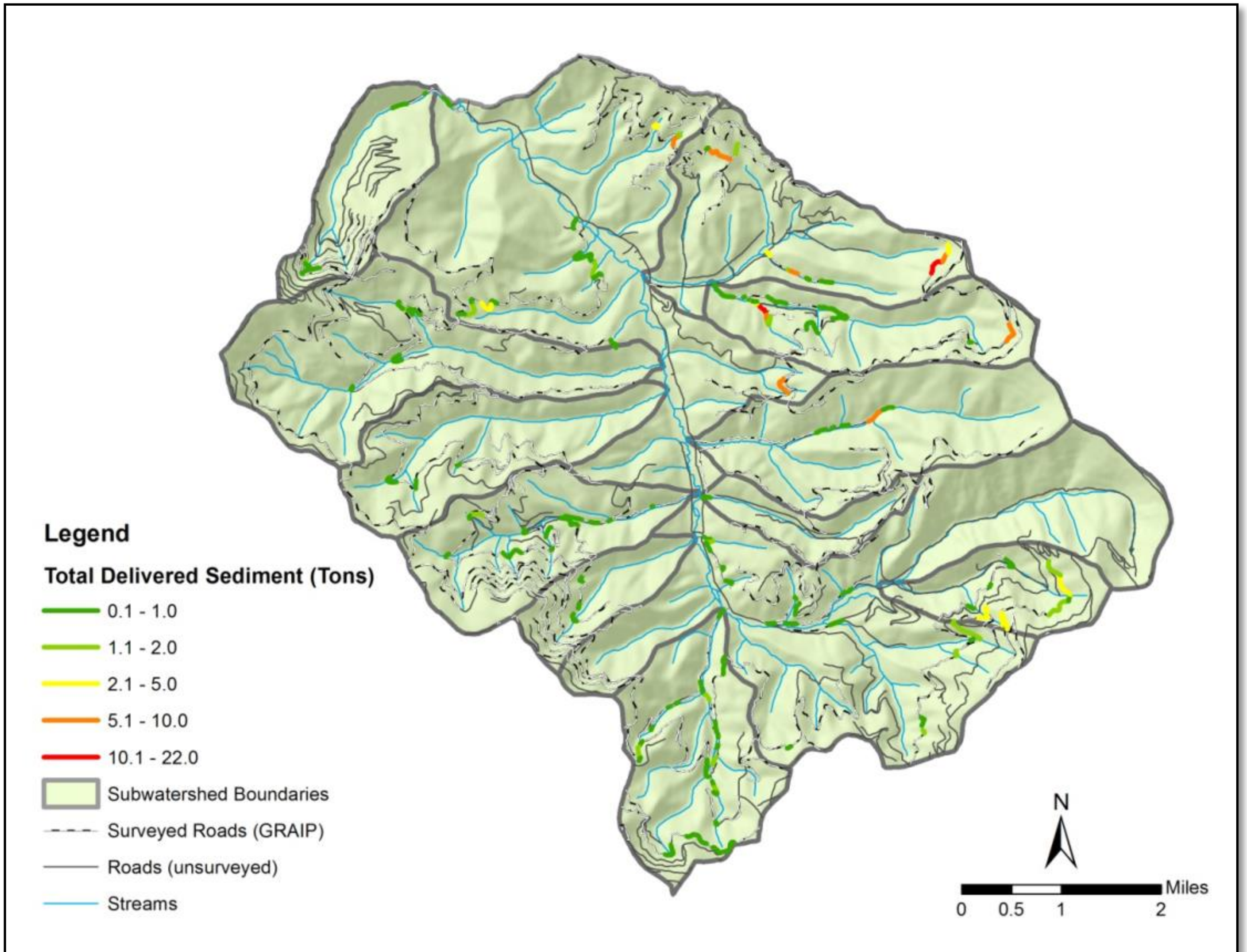


Figure 22. Surveyed road segments responsible for delivering 100% of the sediment from roads to the Beaver Creek stream network, and the relative amount delivered

Channel Network Extension

The GRAIP model recognized over 90 miles of stream in the Beaver Creek Watershed. However, roads increased the channel network by another 11% through a variety of drainage features, though non-engineered features, followed by stream crossings and diffuse drains appeared to lengthen the stream network the greatest amounts (Table 5). Most notably, roads nearly doubled the channel network in Carbon Gulch, and roads in Carpenter, Deer, Dudley and Trail Creeks also increased the channel networks each by more than 10%.

Table 5. Length of road by drainage feature connected to streams

		Length of road by drainage feature connected to streams (mi)									
	Length of Stream (GRAIP) (mi)	**Broad Based Dip**	**Diffuse Drain**	**Ditch Relief**	**Lead Off Ditch**	**Non-Engineered**	**Stream Crossing**	**Water Bar**	**Excavated stream crossing**	**Total (mi)**	**Relative channel extension**
Alder	4.8	0.09	0.13	---	---	0.03	---	---	---	0.25	5%
Carbon	2.4	---	0.12	---	---	0.38	0.38	0.12	---	1.00	42%
Carpenter	2.7	---	0.13	---	---	0.15	0.00	0.03	---	0.30	11%
Deer	4.8	0.17	0.34	---	---	0.24	0.08	---	0.10	0.92	19%
Dudley	6.1	0.38	0.12	0.14	0.03	0.58	0.13	0.01	0.05	1.45	24%
Lower Beaver	23.2	0.01	0.34	0.06	---	0.80	0.29	---	---	1.50	6%
Moore	1.7	---	0.03	---	---	0.00	0.00	---	0.10	0.13	8%
Pony	6.1	0.11	0.03	---	---	0.04	0.29	0.02	---	0.49	8%
Trail	11.6	0.15	0.22	0.16	---	1.08	0.31	0.05	0.01	1.99	17%
Unknown	2.2	---	0.01	---	---	0.01	0.04	---	---	0.05	2%
Upper Beaver	18.0	---	0.12	---	---	0.58	0.30	---	---	1.00	6%
White	7.2	---	0.22	---	---	0.25	0.02	---	0.07	0.56	8%
Total	90.7	0.91	1.80	0.35	0.03	4.12	1.85	0.23	0.32	9.63	11%

Evaluation of Drainage Features

There were nearly 3,000 individual drainage features found in Beaver Creek. The majority of those features were regarded as "engineered" and were designed to drain water from roads in a relatively controlled manner, such as through stream crossing culverts, waterbars, broad based dips, lead-off ditches, ditch relief culverts and sumps. However, two types are not regarded as "engineered", and included diffuse drains and non-engineered features. In most cases, diffuse drains are an intentional design features to allow water to naturally drain from road surfaces, such as through outsloping roads and generally have few erosive effects. Non-engineered features, however, are usually the result of a failure of an engineered structure upstream of the drainage feature and can include blocked ditches or other diversions oftentimes resulting in relatively severe erosion of the road surface or its fill structure. Non-engineered drain features may indicate needed improvements in road design, construction or maintenance. All of the drainage features were evaluated for both their immediate failure to adequately drain water and for their potential risk of diverting water and initiating erosion in the future (see Appendix D for a description of the how risk was determined). Drainage features were also evaluated for their ability to transfer sediment from the road to streams, as well as their general condition.

In Beaver Creek, 90% of the sediment delivered to streams was transferred through just 3% of the drainage features (Figure 23). Of the nine types of drainage features, stream crossings (generally culverts, but also log culverts, drivable fords, and bridges) and excavated stream crossings transferred 100% of the sediment routed to them into streams (Table 6). Sediment transferred via stream crossings represented 18% of the sediment generated by roads and delivered to streams, whereas excavated stream crossings only delivered 2% of the sediment into streams. Also, only a third of the 112 stream crossings surveyed delivered sediment to the streams, while 75% of the 20 excavated stream crossings did so.

Broad based dips, diffuse drains and water bars all transferred between 3 and 4% of their sediment from the road directly into streams, and only 3-4% of each type of feature was found to deliver sediment directly to streams. Ditch relief culverts, however, delivered 3% of the sediment to streams, but 14% of ditch relief structures actually delivered some sediment. Lead-off ditches delivered 39% of the sediment routed to them, though less than half of a ton of sediment was actually transferred through those features, and only 0.1 ton was actually delivered to streams. Non-engineered features were the drainage features that delivered the most sediment to streams, and transferred 17% of the sediment that reached those features into streams. Non-engineered features were also responsible for transferring more than half of all the delivered sediment to the stream network, yet only 10% of the non-engineered features were actually responsible for delivering sediment to streams (Table 6).

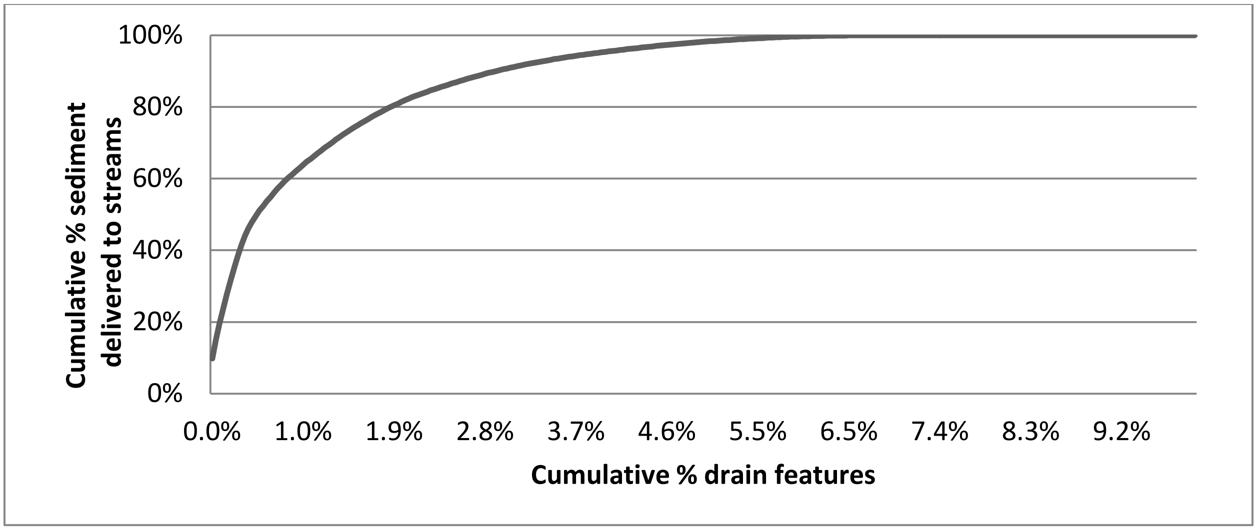


Figure 23. Relative amount of sediment delivered annually through drain features from surveyed roads in the Beaver Creek Watershed

Table 6. Sediment produced by roads surveyed in the Beaver Creek Watershed and routed to drain feature types, as well as sediment delivered to streams through each drain feature type, and the fractional delivery of each

Drain Type	Number of features	Features receiving sediment from roads	Features delivering sediment to stream	Proportion of all delivered sediment
Broad Based Dip	347	3%	4%	7%
Diffuse Drain	1286	3%	3%	15%
Ditch Relief	64	14%	3%	0%
Lead Off Ditch	4	25%	39%	0%
Non-Engineered	695	10%	17%	54%
Stream Crossing	106	34%	100%	18%
Sump	3	0%	0%	0%
Water Bar	198	4%	4%	3%
Excavated Stream Crossing	20	75%	100%	2%

Several drainage features were also responsible for delivering large amounts of sediment in several of the subwatersheds as well. For instance, non-engineered features transferred the greatest amounts of sediment to streams in all but four subwatersheds, and they were responsible for delivering over half of the sediment in five of the subwatersheds (Table 7).

Stream crossing features were responsible for transferring the second greatest amount of sediment to the stream network, followed closely by diffuse drains. Stream crossings delivered 93% of the sediment to Unknown Creek, though very little sediment was actually delivered to the stream (Table 7). Stream crossings also delivered nearly 74% of the sediment from roads to Pony Creek, though most of the actual crossings were fords and not culverts (Table 7). Diffuse drains, meanwhile, were responsible for transferring 50% of the sediment to Alder Creek, nearly 40% of the sediment to the lower Beaver Creek subwatersheds, and 36% of the sediment in Deer Creek.

Finally, excavated stream crossings transferred a little over 2% of the sediment to streams in Beaver Creek, and in particular were responsible for delivering 71% of the sediment from roads to streams in the Moore Creek subwatershed. This was particularly interesting because these are typically on roads that should no longer be coupled to the stream network.

Table 7. Sediment delivered in tons/year through each type of drainage feature surveyed in each subwatershed of Beaver Creek. No value represents absence of drainage feature in that subwatershed

Watershed	Broad Based Dip	Diffuse Drain	Ditch Relief Culvert	Lead Off Ditch	Non-Engineered Feature	Stream Crossing	Sump	Water Bar	Excavated Stream Crossing	Total
Alder	0.6	0.9	0.0	--	0.3	0.0	--	--	--	**1.8**
Carbon	0.0	1.6	--	--	5.4	4.4	--	1.6	--	**13.0**
Carpenter	--	1.3	0.0	--	2.5	0.0	--	0.6	--	**4.5**
Deer	1.7	3.6	0.0	--	3.4	0.5	--	0.0	0.9	**10.0**
Dudley	3.4	2.5	0.5	0.1	8.9	0.6	--	0.4	0.9	**17.3**
Lower Beaver	0.3	12.6	0.1	--	17.8	1.2	0.0	0.0	--	**31.9**
Moore	0.0	0.5	0.0	--	0.0	0.0	--	0.0	1.2	**1.7**
Pony	1.0	0.2	0.0	--	2.8	12.9	--	0.4	--	**17.5**
Trail	8.6	6.7	0.3	0.0	64.2	14.5	0.0	3.7	0.2	**98.2**
Unknown	0.0	0.0	--	--	0.0	0.3	--	0.0	--	**0.4**
Upper Beaver	0.0	0.4	0.0	0.0	9.5	4.4	--	0.0	--	**14.3**
White	0.0	2.8	0.0	--	3.2	0.0	--	0.0	2.1	**8.1**
Total	**15.5**	**33.1**	**0.9**	**0.1**	**117.9**	**39.0**	**0.0**	**6.8**	**5.3**	**218.7**

The condition of each drainage feature was also evaluated. Several appeared to require some level of maintenance due to issues associated with being partially or completely occluded, showing signs of erosion due to improper design or construction, excessive age particularly in metal culverts or lack of adequate drainage or function. Of the nearly 3,000 individual drainage features surveyed in Beaver Creek, an estimated 25% (719) appeared to need some basic level of maintenance. Of those needing maintenance, 83% (597) appeared to need higher levels of maintenance or actual replacement (Table 8). Only 183 features transferred sediment from the road system to the stream network and 50 of those drain features were responsible for delivering 80% of the sediment to streams (Figure 24). The greatest contributors were also located in the upper Trail Creek/Potosi Creek area, as well as Pony Gulch.

Of the two types of non-engineered drainage features found in Beaver Creek, diffuse drains comprised 47% of the nearly 3,000 drain features, but less than 3% of them appeared to need some level of maintenance, and none required significant maintenance (Table 8). Another 26% of the drain features were categorized as 'non-engineered', yet 68% of those appeared to need some level of maintenance. In every case, non-engineered features needed both regular and substantial maintenance due to the fact that their ineffectiveness was usually a result of a larger and more complicated drainage failure elsewhere along the road (see Appendix D for definitions of regular and substantial maintenance).

Of the engineered drainage features, broad based dips and water bars made up a combined 20% of the drain types, while only 15% of broad based dips and 23% of water bars required maintenance. Broad based dips needed maintenance if they did not drain well or were otherwise saturated, while water bars needed maintenance if they were inadequately sized for the amount of water they were expected to pass, or were damaged or showed other signs of erosion. Again, both drainage features delivered very little sediment to the stream network (Table 8).

Finally, nearly 45% of ditch relief culverts also needed maintenance and over 10% required replacement because they were plugged, buried or partially crushed. Only one lead-off ditch and 2 sumps needed maintenance, and perhaps more importantly, one-third of the 20 excavated stream crossings appeared to need maintenance. Finally, over a third of the stream crossing culverts needed maintenance or replacement, though some of those recommended for replacement are also recommended for basic maintenance. Several of these culverts are also potential blockages to fisheries migration, and those are discussed in greater detail below.

Table 8. Condition of each surveyed drain feature type and potential maintenance needs in the Beaver Creek Watershed

Drain Type	Total	Maintenance Needed	Significant Maintenance or Replacement Needed
Broad Based Dip	352	15.6% (54)	7.7% (27)
Diffuse Drain	1326	2.9% (38)	0.0% (0)
Ditch Relief	67	44.8% (30)	10.4% (7)
Excavated Stream Crossing	20	30.0% (6)	0.0% (0)
Lead Off Ditch	4	25.0% (1)	0.0% (0)
Non-Engineered	731	68.0% (497)	68.0% (497)
Stream Crossing	112	34.8% (39)	36.6% (41)
Sump	3	66.7%(2)	66.7% (2)
Water Bar	211	23.2% (50)	10.9% (23)
Total	**2826**	**719**	**597**

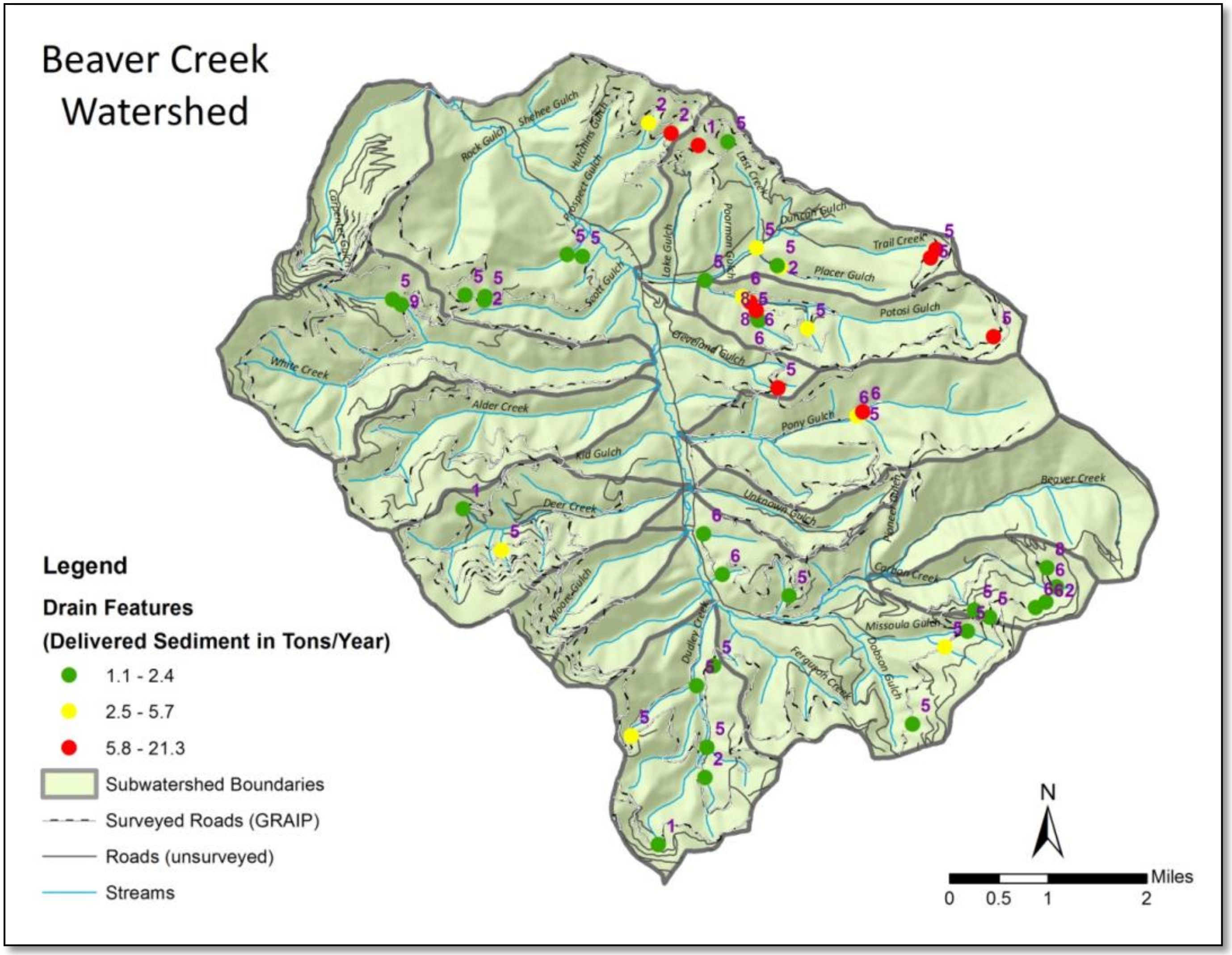


Figure 24. The 50 highest surveyed sediment delivering drain features in Beaver Creek and the relative amount of sediment they deliver to streams. Numbers associated with each point represent the type of drain feature (1=Broad based dip, 2=Diffuse Drain, 3=Ditch relief culvert, 4=Lead off ditch, 5=Non-engineered feature, 6=Stream crossing culvert, 7=Sump, 8=Water bar, 9=Excavated stream crossing)

Delivery of Sediment to Beaver Creek

Tributaries delivered a wide range of sediment from surveyed forest roads to Beaver Creek (Table 9). Unknown Creek contributed the least, with less than 1% coming from its roads, while Trail Creek contributed more than half of the total sediment, more than any other subwatershed. The Pony and Dudley Creek subwatersheds each contributed about 10% of the sediment from surveyed forest roads to Beaver Creek, and the seven other tributaries each contributed less than 10% of the total sediment to Beaver Creek.

Trail Creek again contributed the greatest amount of sediment per subwatershed area from surveyed forest roads; however Carbon Creek contributed the second most sediment per area despite it contributing the fourth greatest amount of sediment of all the subwatersheds (Table 9). Again, the other eight subwatersheds each contributed between about 1 and 6 tons of sediment/yr/mi^2.

Only 25 stream segments within 8 subwatersheds accumulated an estimated 97% of the road-generated sediment in Beaver Creek (Table 10, Figure 25). Of those, 8 stream segments in the Trail Creek subwatershed received over half of the sediment delivered to Beaver Creek. The Trail Creek subwatershed also contained the single greatest sediment-accumulating stream segment, which accumulated 14% of the road-derived sediment to Beaver Creek (Figure 25).

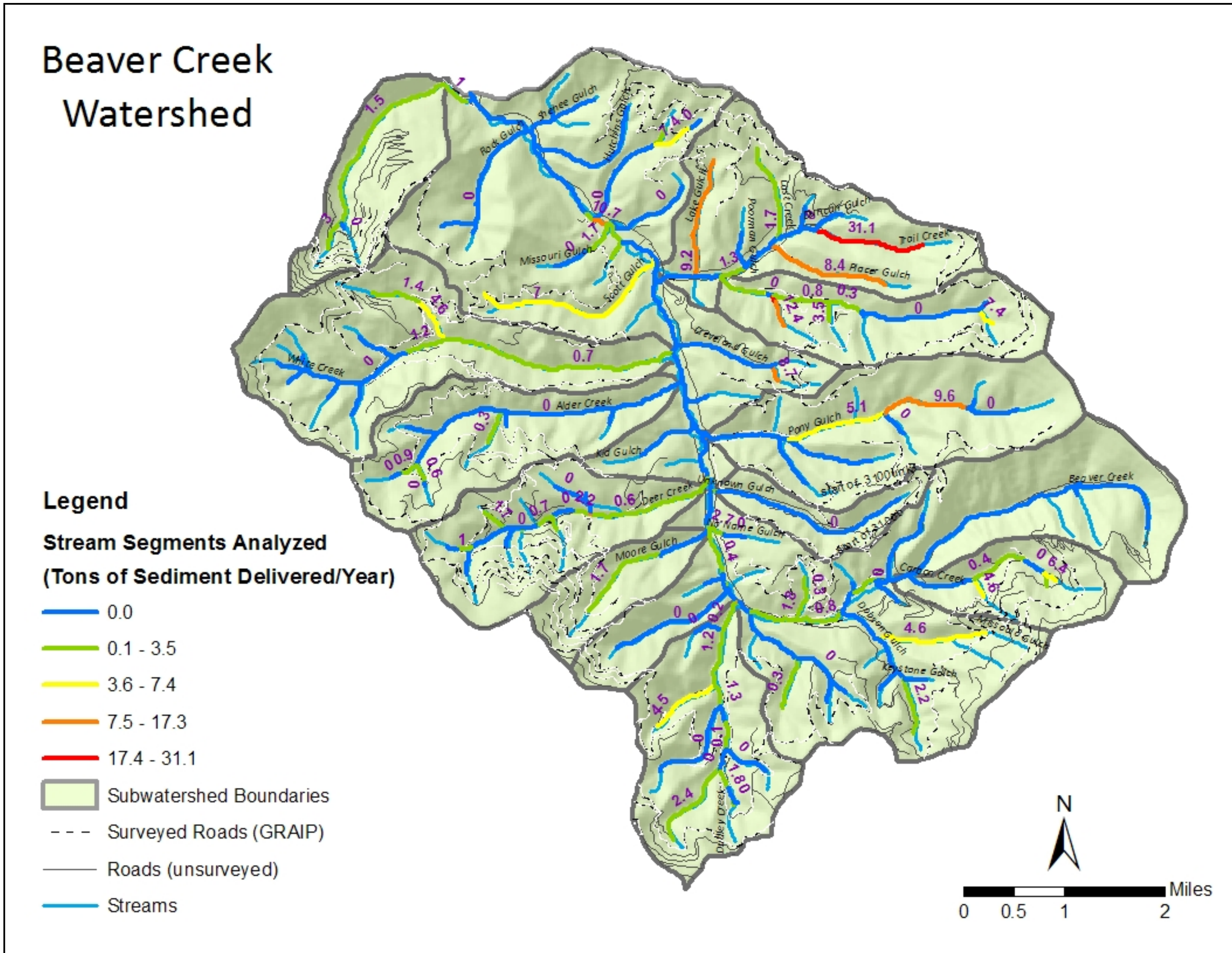
The GRAIP model also routes sediment downstream and accumulates it in downstream receiving segments. Cumulatively, the upper Beaver Creek subwatersheds, along with Carbon and Dudley Creeks, contribute 18% of the total sediment. Beaver Creek accumulates 26% of its road-derived sediment when it joins Pony Gulch, and by the time Beaver Creek joins Trail Creek, it has accumulated 42% of its road-generated sediment. The Trail Creek drainage contributes another 44% of the road-generated sediment to Beaver Creek, and the remaining 14% is accumulated from the combined lower Beaver Creek subwatersheds (Figure 26).

Table 9. Sediment contributed by selected tributaries from surveyed roads to Beaver Creek, not including those tributaries in the upper and lower Beaver Creek subwatersheds

Subwatershed	Sediment contribution to Beaver Creek (tons/yr)	Relative amount of sediment per subwatershed	Tons sediment/yr/mi^2
Alder	1.8	1.1%	0.7
Carbon	13.0	7.5%	9.3
Carpenter	5.5	3.2%	3.1
Deer	10.0	5.8%	3.9
Dudley	17.3	10.0%	6.0
Moore	1.7	1.0%	1.7
Pony	17.5	10.1%	4.9
Trail	98.2	56.6%	17.2
Unknown	0.4	0.2%	0.4
White	8.1	4.7%	1.9
Total	**173.5**	**100.0%**	**6.5**

Table 10. Amount of sediment directly input to Beaver Creek from surveyed roads by the 25 highest producing stream segments

Subwatershed	Stream Segments	Sediment (tons/yr)
Trail	8	100.74
Lower Beaver	5	37.01
Upper Beaver	3	24.65
Pony	2	14.66
Carbon	2	11.07
Deer	1	9.13
Dudley	2	7.79
White	1	4.59
Carpenter	1	2.96
Total	**25**	**212.60**


Beaver Creek Watershed
Legend
Stream Segments Analyzed
(Tons of Sediment Delivered/Year)
0.0
0.1 - 3.5
3.6 - 7.4
7.5 - 17.3
17.4 - 31.1
Subwatershed Boundaries
Surveyed Roads (GRAIP)
Roads (unsurveyed)
Streams
N
Miles
0
0.5
1
2
White Creek
Alder Creek
Kid Gulch
Deer Creek
Moore Gulch
Missouri Gulch
Rock Gulch
Placer Gulch
Trail Creek
Pony Gulch
Beaver Creek
31.1
8.4
9.6
9.2
4.6
4.5
2.4
2.2
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1.7
1.4
1.5
0.7

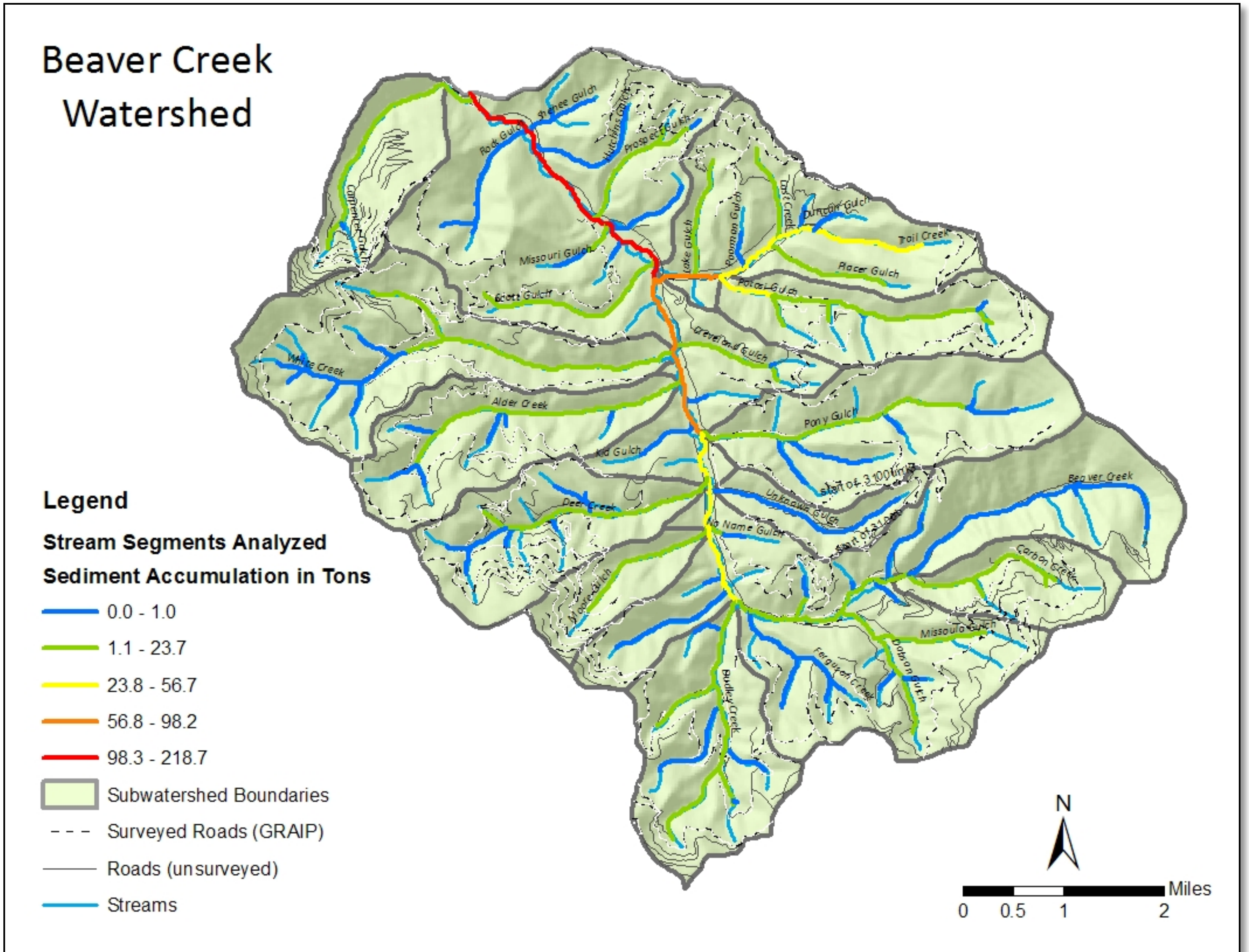


Figure 26. Tons of sediment accumulated in each stream segment per year from surveyed roads

Culvert Risk to Roads

There were 85 culverts surveyed in the Beaver Creek drainage, comprised of metal, plastic and wood. The Upper Beaver Creek subwatersheds had 9 undersized culverts, followed by Trail and Dudley Creeks each with 8. Dudley Creek also had the only culvert with an SBI of 4. In addition, 32 of the surveyed culverts also showed excessive signs of occlusion, damage, bypassing, or rust.

Table 11. Culverts evaluated using the Stream Blockage Index (SBI) methods in subwatersheds of Beaver Creek, and their SBI scores

	SBI Score				
Subwatershed	**1**	**2**	**3**	**4**	**Total**
Alder	4	3	--	--	7
Carbon	--	3	4	--	7
Carpenter	--	1	3	--	4
Deer	2	4	2	--	8
Dudley	1	6	8	1	16
Lower Beaver	1	5	5	--	11
Moore	--	1	--	--	1
Trail	1	2	8	--	11
Unknown	--	--	1	--	1
Upper Beaver	--	4	9	--	13
White	2	4	--	--	6
Total	**11**	**33**	**40**	**1**	**85**

Culverts were also evaluated for their potential risk of introducing sediment into streams due to failure. Of the 85 culverts surveyed, 41 were considered undersized and 21 of those showed signs of damage or occlusion. In addition, the GRAIP survey measured the height of fill material above each culvert and this height, multiplied by the width of the stream channel and the length and slope of the culvert, was used to estimate the potential volume of material that could be introduced to the stream. Trail Creek had the greatest number of high risk culverts and greatest amount of potential fill material (Table 12). Lower Beaver subwatershed had the culvert with the greatest potential amount of fill material (809 tons).

Table 12. Potential volume and weight of fill material above the 21 highest risk culverts in the subwatersheds

Subwatershed	**Number of high risk culverts**	**Volume of fill material (ft^3)**	**Estimated weight of fill material (tons)**
Carbon	3	2,960	150
Carpenter	1	9,750	493
Dudley	3	15,170	767
Lower Beaver	2	17,134	866
Trail	7	26,540	1,342
Upper Beaver	5	12,740	644
Total	**21**	**84,294**	**4,262**

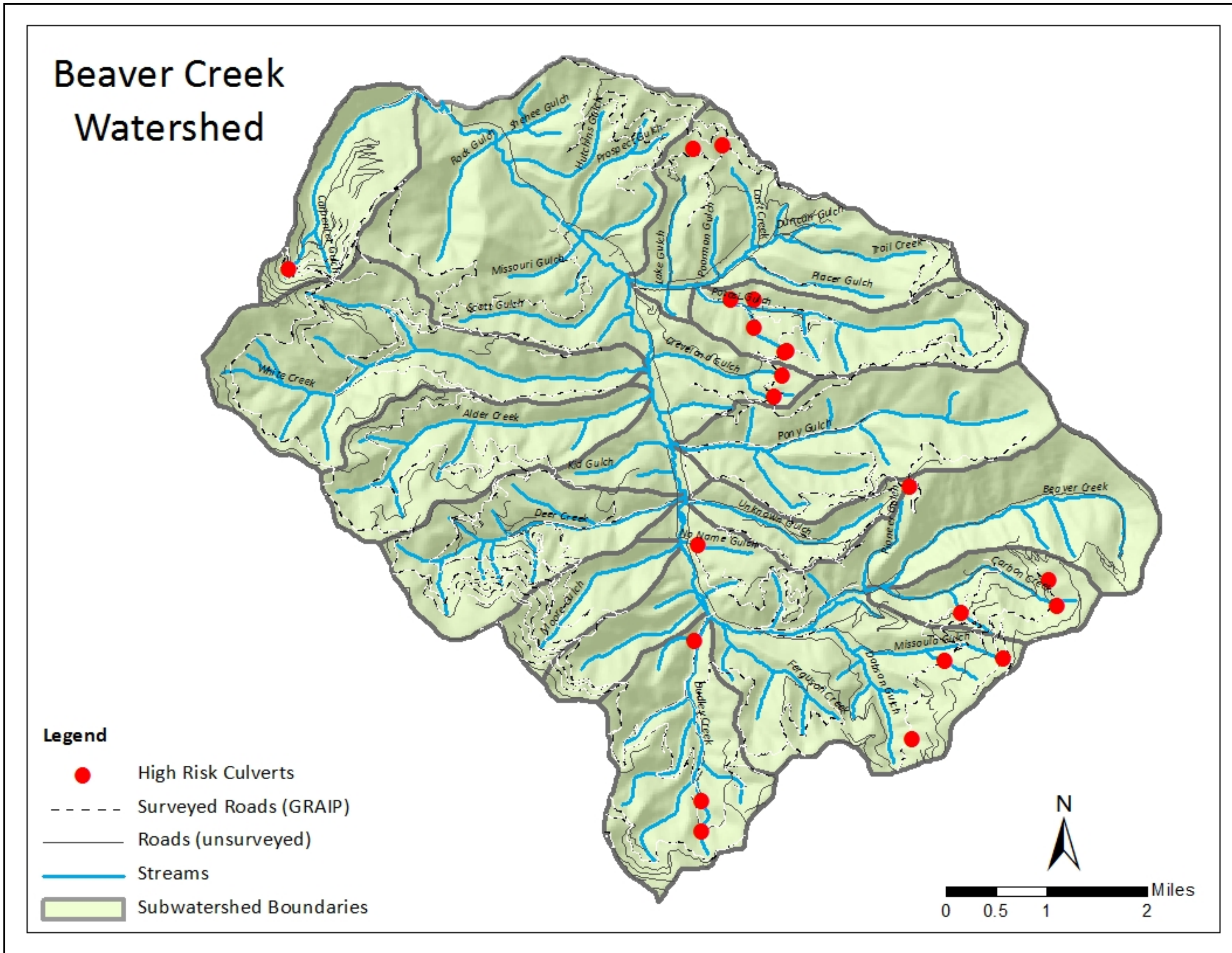


Figure 27. High risk culverts in the Beaver Creek Watershed that are at risk of failing

Discussion

Road Erosion and Sediment Delivery

The GRAIP model showed that relatively few roads are actually directly connected to streams in Beaver Creek, and was similar to results from a variety of recent road-erosion GRAIP studies (Fly et al. 2010, Nelson et al. 2010). Virtually every road in Beaver Creek showed some sign of erosion, though much of the sediment was delivered to the adjacent forest and not to streams. The fact that most roads showed signs of surface erosion from water, implies that road maintenance, such as surface blading to remove wheel tracks, may be needed more frequently than is currently occurring, or that additional drainage features or partial reconstruction is needed in order to conserve road surface material and reduce both maintenance needs and sediment production.

Roads contributing sediment to streams were generally scattered across the watershed, though the higher contributing roads tended to be located in the eastern subwatersheds. Subwatersheds on the western side of Beaver Creek had several low-sediment contributing segments throughout White, Deer, and Dudley Creeks, and suggest that those stream channels may be subjected to less road-induced erosion or artificial extensions in the channel network.

The amount of sediment contributed by roads was highest in Trail Creek, both in terms of total amount of sediment, and by sediment per watershed area. Dudley Creek contributed the second greatest amount of sediment, though Carbon Creek contributed the second greatest amount by watershed area, and suggests that smaller watersheds are not necessarily less influential to streams. Regardless, Trail Creek, followed by the Lower Beaver subwatersheds, Carbon and Dudley Creeks appeared to contribute the most road-derived sediment of the 12 subwatersheds.

Finally, because only 10% of the surveyed roads in Beaver Creek were found to deliver sediment to the stream network, eliminating the sediment delivered from the highest producing 1.4 miles of road, or about 1% of the road network, could result in a potential reduction of up to 38% of the road-derived sediment, nearly all of which could occur in Trail Creek. Furthermore, reducing the sediment delivery by 50% would require some level of road maintenance or reconstruction on only 2 miles of road. Undoubtedly this would likely require reconstruction of many very specific locations along roads, rather than on a single stretch of road (e.g., near grade reversals and stream crossing culverts), and it shows that large stretches of roads connected to streams with potentially large influence to hydrologic processes may not exist. Rather, roads connected to streams tended to be short in length and were scattered across the larger watershed, and the extent of influence they have on stream channels may be one area of further study.

Channel Network Extension

Roads are also widely believed to be at least partially responsible for changes in stream channel erosion rates, but studies to quantify exactly how roads intercept hillslope water and redirect it to or away from adjacent channels have been rare (Wemple 1996), and the exact relationships between roads and hydrology continues to be debated. Regardless, it is generally agreed that roads can intercept water from surrounding forests and redistribute it across the hillside. Wemple and others (1996) reported that stream channels in the coastal mountains of Oregon could be increased by up to 50% by forest roads and have implications on channel scour and flow volume and timing. Roads can also concentrate flow into the surrounding forest initiating gullies through highly erodible soils that may connect to established channels, increasing sediment and potentially altering both the timing and magnitude of flows in smaller headwater channels (Trombulak et al. 2000, and see Luce and Wemple 2001).

Stream channel erosion resulting from diverted hillslope flows was not evaluated here; however, surveyed roads extended the stream channel network in Beaver Creek by an estimated 11%, and ranged from 2% to 42% among subwatersheds. In Carbon Gulch, surveyed roads connected to streams nearly doubled the channel network, and only one-third of the roads were actually surveyed. Channel networks were extended by at least 10% in five other subwatersheds, and roads increased channel networks by over 1 mile in five subwatersheds. By comparison, roads extended channels in Trail Creek by 2 miles but only increased the channel network by 17%, and suggest that inadequate drainage was not as widespread or as frequently observed in Trail Creek opposed to subwatersheds like Carbon Gulch, but may have had more intense consequences to channel networks.

Evaluation of Drainage Features

Very few of the drainage features were actually responsible for delivering sediment into streams, yet some features delivered relatively more sediment than others. Several types of drainage features also appeared to be more effective at draining roads and disconnecting the road network from the stream network, while others appear to act as direct conduits of sediment into streams, or generate sediment themselves through lack of maintenance, ineffective design or improper placement.

Broad based dips and waterbars, for example, appeared to be relatively effective drainage structures and transferred only 3-4% of the sediment that reached them into streams. Other GRAIP surveys found similar effects of those drainage features in Idaho (Fly et al. 2010), suggesting that roads with those features were well drained and largely disconnected from streams.

A relatively large number of ditch relief culverts transferred sediment to streams, though very little sediment was actually transferred and suggests that these culverts may not actually be placed in the correct locations or on roads that are not otherwise well drained. It also suggests that the less erodible geology and wetter climate of northern Idaho may be important factors contributing to the low amounts of sediment transferred through ditches and into streams (T. Black, personal communication). Nearly half of the ditch relief culverts also needed some maintenance, such as cleaning the inlet, and 10% needed significant maintenance, such as complete replacement due to excessive damage or complete occlusion. In many cases, these culverts should likely be replaced with different drainage features because their maintenance is likely a result of improper placement, incorrect location or an initially inappropriate choice of drainage feature.

Stream crossing structures, such as culverts, were a direct conduit of sediment from road surfaces because many of these structures tended to be located in topographic depressions (sometimes called grade reversals) where long, gradual sloping approaches bisected hillsides and intercepted hillslope water. Oftentimes, these roads also contained inside ditches or evidence of water running down wheel tracks of the road surface and entered the stream nearly directly over the culvert. This was also not necessarily unexpected because stream crossing culverts are not meant to drain the road, and effective sediment or drainage control structures were rarely found on approaches to stream crossings. Field observations also suggested that where approaches to or from stream crossings did contain drainage features to divert water into the surrounding forest, sediment was rarely introduced at the culvert location and road surfaces were generally in better condition.

This is also interesting because it suggests that a relatively large amount of sediment (18%) is being transferred through these grade reversals, which are easily identifiable features on roads, and it is doubtful that any other drainage feature that contributes so much sediment is so closely associated with any other unique topographic feature. The GRAIP model did not identify grade reversals per se, though in the future these may be important areas to identify allowing road managers to easily disconnect roads from the stream network at relatively low economic costs. In other words, repairing the drainage in these areas may be one of the most cost effective means to lowering sediment contributions to streams.

Excavated stream crossings were also found to be relatively ineffective at controlling sediment contributions to streams, especially in Moore and Deer Creeks, though their contributions were generally more related to the erosion from the feature themselves rather than from the road surface. Excavated crossings were most often found on roads that are relatively well drained and generally not connected to streams because those roads were largely and intentionally decoupled from streams. Excavated stream crossings still transferred 2% of the sediment to their respective streams, suggesting that excavated stream crossings and the associated work of removing other drainage problems, likely reduces the potential for sedimentation but does not entirely remove the influence of the road from streams; a result that has been documented in several other studies (see Madej et al 1999, for a brief review). Also, several excavated stream crossings continued to show signs of erosion and suggest that simply removing those structures improperly and without adequate design, may result in effects to the stream; a result that has also been shown in other locations (see Cook and Dresser 2004). However, field studies in other parts of the North Fork Coeur d'Alene River Subbasin found that most excavated stream crossings effectively reduced erosion (Stromberg and James in prep).

Diffuse drains appeared to be a relatively effective non-engineered structure, transferring only 3% of the sediment delivered to them into streams, though in many cases, diffuse drains may be an artifact of an engineered road feature such as an outsloped road. These types of drainage features also appear to be relatively stable and do not require maintenance, in part because the roads in which they are found are more likely to be designed for long-term stability under the influence of traffic and water.

Non-engineered drainage features, however, are usually the result of unintended drainage from roads and were the most dominant drainage feature in Beaver Creek. These were much less effective at controlling drainage and sediment and transferred 57% of the sediment that reached them into streams. Non-engineered drainage features are undeniably responsible for transferring most of the sediment to the stream network, though their ineffectiveness at controlling flow and sediment is probably more a result of a failure or inadequate placement of a nearby structure. These features are also the most likely to require significant maintenance since they cannot necessarily be reconstructed or replaced and would probably require substantial construction, as well as some level of maintenance to other existing structures causing the uncontrolled drainage.

Another interesting result of this study is that nearly all of the roads generated some sediment, and that most of it was transferred to the surrounding forest. This may be most important to road managers who oversee maintenance of forest roads because the loss of fine sediments from road surfaces could jeopardize the surface integrity and safety of roads and increase maintenance costs. In this case, nearly half of the sediment generated by roads comes from only 14% of the road network, so relatively few roads appear to need the most attention. However, while drainage may be relatively effective on most roads at preventing sediment from entering streams, other roads may be losing an unprecedented amount of fine surface material resulting in the need for more frequent and costly maintenance.

One other implication from these results is that while many roads were found to be losing large amounts of fine surface material, inadequate construction may actually be the cause for fine material to be lost from the road surface and not necessarily the lack of maintenance. Many of these roads were constructed using techniques that cause water to be sloped toward the hillside and routed through a ditch rather than across the road. Many of these drainage features or even ditches can easily become occluded by vegetation or soil from nearby cut-slopes, causing water to be diverted onto the road surface where it may travel for long distances in wheel depressions. In fact, we observed many instances where permitted activities previously thought to have minimal effects to roads or hydrology, such as firewood cutting operations that included yarding of small logs from the hillside, had generated enough soil erosion, or even created small gullies above the road, so as to occlude ditches and divert water onto the road surface. In these cases, nearly every road would need to be maintained virtually every year; a substantial effort in terms of time and cost, and one that may have a low likelihood of success without changes to certain permitted activities.

Delivery of Sediment to Beaver Creek

Understanding how sediment is accumulated downstream is important for understanding which subwatersheds contribute the greatest amounts of sediment to the larger stream, as well as for determining how much of the tributaries and greater mainstem may be affected by road-derived sediment. Beaver Creek received a large amount of its overall sediment budget by the time it reaches Trail Creek, but Trail Creek more than doubled the amount of sediment delivered from surveyed forest roads to Beaver Creek; a relatively large amount considering the Trail Creek subwatershed comprises only 13% of the greater Beaver Creek watershed.

Trail Creek also contributes the greatest amount of sediment in part because it has many road segments and drainage features that route sediment from roads into streams, but also because those road segments and their inadequate drainage may be having a greater effect on surrounding soils than in other subwatersheds. In other words, drainage problems are not any more widespread in Trail Creek than in other subwatersheds; but they seem to be having disproportionate and more intense effects on roads and sediment contributions than in other areas. Pony and Carbon creeks both presented relatively large amounts of sediment to Beaver Creek, especially considering their relative size, and restoring adequate drainage in those subwatersheds may return large benefits at lower costs than in others drainages.

Culvert Risk to Roads

Nearly one-quarter of the culverts surveyed were also found to present a relatively high risk of contributing sediment to streams through catastrophic failures of their structures. Several studies have found that high risk culverts can introduce large amounts of sediment into streams in single events, yet few studies have evaluated the actual mass of material that could be introduced in those events. One such study in northern California by Madej (2001) evaluated the volume of material above culverts that could be introduced to streams in single events and suggested that compacted soil above culverts could weigh up to 1.62 g/cm^3. Using the figures in Madej's study, along with those found in several standard road construction engineering tables, we found that over 4,200 tons of material could be introduced to streams from those 21 highest-risk culverts or at least 19 times as much sediment than is currently being introduced from roads. Most of these are located within Trail Creek, and three are located on a single tributary to Potosi Gulch that together could contribute at least 700 tons of material. Two other culverts along Potosi Gulch could add another 100 tons, and another two culverts in the headwaters of Lake Gulch and Last Creek could contribute over 500 more tons, though these are far upstream of most perennially flowing streams.

Dudley Creek had the second greatest volume of material above high risk culverts of all the subwatersheds. Two of the culverts in Dudley Creek were on the same stream and could contribute about 570 tons of sediment. Carbon Creek also had 2 culverts on the same stream that, combined, could contribute nearly 90 tons of sediment.

It is unlikely that all 21 high-risk culverts could fail simultaneously, but given a large enough storm event, it is likely that at least a few could fail and introduce a large amount of sediment into streams. The type or size of storm required to increase that likelihood was not determined. However, were such a storm to occur, it is also likely that many roads would also become compromised in places where inadequate drainage occurs and further contribute a large amount of sediment to streams. With that in mind, it may again be as or more important to correct drainage problems first, or at least concurrently to potentially reduce any effect that surrounding roads may be having on stream culverts.

Synthesized Discussion

Several subwatersheds were responsible for sediment contributions to Beaver Creek, but the Trail Creek subwatershed generated the most sediment from roads, contained more drainage problems and had more roads connected to streams than any other subwatershed. Roads in the Trail Creek subwatershed contributed three times more sediment to Beaver Creek than the next highest contributing subwatershed and delivered twice the amount of sediment per watershed area than the next highest contributing subwatershed, Carbon Gulch. Trail Creek also had one of the highest densities of improperly functioning drainage features, along with White Creek and Dudley Creek. Five of the 14 drainage features that transferred 50% of the sediment to streams were in Trail Creek. Trail Creek also contained the most fill material above high-risk culverts. Finally, while other subwatersheds appeared to contain more fisheries barriers than Trail Creek, there is some evidence that the barriers in Trail Creek are actually isolating native westslope cutthroat trout populations from non-native salmonids (C. James, personal communication). Further analysis of the implications of this isolation to the greater population of the Coeur d'Alene River is recommended before it can be determined whether or not to replace culverts with migration-friendly structures. Trail Creek has been identified as a high priority subwatershed within Beaver Creek where substantial reductions in sediment delivery could be attained through identified cost-effective maintenance projects.

An analysis of drainage features throughout the entire watershed showed that several types of drainage features appear to be functioning as they were intended, and few actually delivered substantial sediment to streams. Stream crossing culverts and non-engineered features, including diffuse drains, presented both the greatest risk and contributed the greatest amount of sediment to streams. More road mileage was connected to streams through these types of drainage features than any others.

Stream crossing culverts are distinct because of their capacity to transfer water and their ability to concentrate flow captured from adjacent roads. Culverts are typically the costliest road crossing structure behind bridges. They are, however, the least likely to be replaced unless a strong link with fisheries conservation can be established, or unless vehicle travel is compromised. Culverts are often replaced as a reaction to failure and rarely proactively to improve capacity or function. Land managers are presented with the dilemma as to whether to replace them before they fail, which could potentially draw funds away from other structural repairs needed to meet travel needs. Culverts can directly influence biological structure within streams and cause substantial damage to stream ecosystems if they fail. The amount of sediment that could be contributed by the failure of one of the high risk culverts is in many cases greater than the amount contributed by the combined road system in any single year is why stream crossing culverts deserve much attention in the Beaver Creek Watershed.

A majority of the roads surveyed were owned or managed by the US Forest Service. Few roads on private and BLM lands in the upper watershed were surveyed, particularly in upper Missoula Gulch and Carbon Creek. On those non-surveyed roads, field crews identified a high level of connectivity to streams and likely locations of sediment loading. A complete survey of both US Forest Service and non-US Forest Service roads would be beneficial to determine the full extent of sediment delivery from roads to Beaver Creek.

Disconnecting roads from streams and improving drainage along specific road segments would reduce sediment contributions to streams and potentially restore hydrologic processes by reducing the interconnectedness of stream channels. The 11% increase in channel networks realized in Beaver Creek may have implications to fisheries survival or migration in some subwatersheds. Drainage networks in Beaver Creek have been altered across many spatial scales, from smaller headwater streams to the mainstem itself. The effects of diverting water and connecting roads to streams across the watershed may have an effect on flows throughout the entire stream network. By addressing drainage issues in identified locations across the watershed, managers can minimize the effects of roads on hydrologic processes in Beaver Creek and its subwatersheds.

Fish Passage and Habitat Fragmentation

Methods

Stream crossing culverts were screened for their potential to limit upstream migration of fisheries following the methods outlined in Prassad (2007) and Flanagan et al (1998), and was generally followed by a series of evaluations based on location in the watershed, proximity to fish-bearing waters, potential for upstream habitat availability, and finally, a survey-level evaluation and screening.

Those culverts that were determined to be potential migration barriers by the GRAIP model were then evaluated for their potential to actually be fish-bearing streams using USFS stream maps and other fisheries distribution data. Culverts that were located near headwater areas or on mapped streams with relatively short upstream areas were not considered barriers since they had a low probability of containing either fish or much usable upstream habitat.

Culverts that then had a high likelihood of precluding upstream fisheries migration in streams that likely had fish or upstream habitats were surveyed in the field to determine if they met the criteria for migration barriers according to Clarkin et al. (2005). As a result, culverts were determined to be impassable to all fish at all life stages, impassable to some fish at some life stages or passable by all fish species at all life stages.

Results

Those culverts with an SBI of 3 or 4, or found to be occluded or damaged and likely to be located in fish-bearing streams, showed that 21 culverts could potentially be barriers to fisheries migration. Of those, 17 were then surveyed following the standard culvert survey, as were an additional 2 culverts located on county roads that were not initially surveyed via the GRAIP process. Of those 19 culverts, 16 were determined to be barriers to the migration of all fish species at all life stages and impede the upstream migration of fish (Table 13, Figure 28). An estimated 24 miles of stream channel was measured in GIS above these barriers.

Table 13. Surveyed potential migration barriers to fish, by subwatersheds of Beaver Creek

Watershed	Number of culverts	Passable at all stages	Passable to some	Impassable to all
Alder	1			1
Deer	2	1		1
Dudley	5		1	4
Lower Beaver	2			2
Trail w/ Potosi	3			3
Unknown	1			1
Upper Beaver	2	1		1
White	3			3
Total	**19**	**2**	**1**	**16**

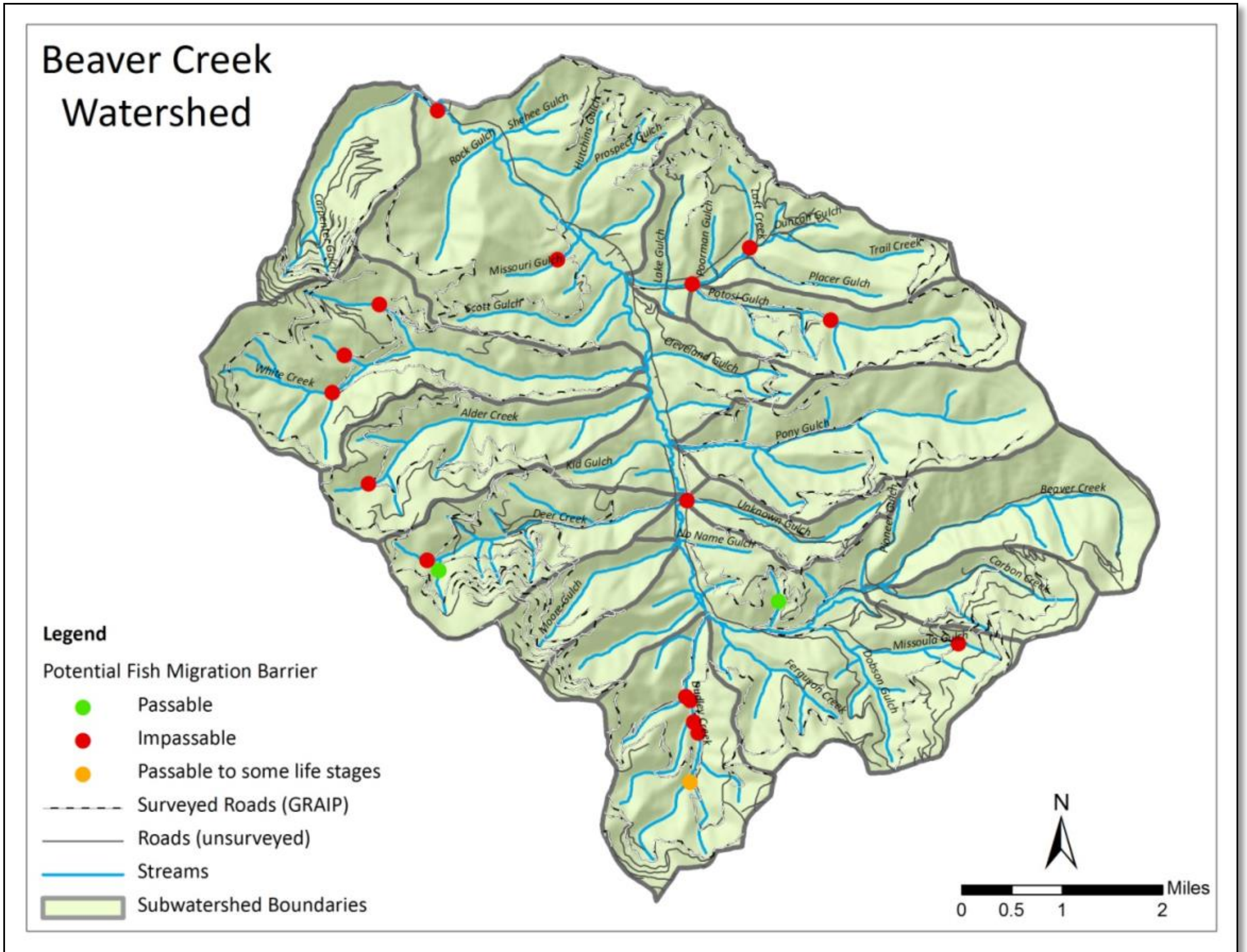


Figure 28. Surveyed culverts that are potential migration barriers to fish in the Beaver Creek Watershed

Discussion

The 21 culverts found to be potential barriers to fisheries migration currently limit access to an estimated 24 miles of stream channel. Several additional culverts that are also likely to be barriers are known to exist along Forest Road 456, the main road along Beaver Creek, but were not surveyed as part of this study. Of the culverts that were surveyed for this study, the Carpenter Creek culvert on Road 2361, two culverts on Road 605 at Potosi Gulch and Placer Gulch, one culvert on Road 1586 on the upper mainstem of White Creek and three culverts on Dudley Creek, likely have the greatest potential to inhibit fisheries migration to the longest and most productive habitats.

Furthermore, these culverts are also the most likely to influence westslope cutthroat migration, and may reduce the chances of native species, including non-salmonids, to reach habitats that do not contain non-native salmonids such as brook trout or rainbow trout, both of which are known to occur in Beaver Creek. At the same time, these culverts may offer native salmonids some refuge from non-native invasion by blocking the migration of non-native species into these areas, protecting native species genetic variability and offering a source of genetic material to downstream populations. However, while isolation may offer some protection for native species to exist without competition or hybridization with non-native species, it may also put these populations at increased risk of eventual extinction due to insufficient habitat, or make them especially vulnerable to chronic and catastrophic disturbances such as increased sedimentation by roads or large scale wildfire that significantly alter riparian and instream conditions (see Fausch et al 2006). Additional population and genetic level surveys above and below these culverts are likely necessary to fully understand the extent to which native species may be affected by these barriers and exactly how these barriers affect larger downstream populations of native species.

Land Use and Stream Geomorphic Evaluation

Methods

Field observations, historical records and aerial photographs were used to perform an evaluation of land use and stream geomorphology. Aerial photos from 1937 to 2009 and other historical photos were compiled from USFS, DEQ, Museum of North Idaho and university collections (Table 14). The photos were at different, and often unknown scales, so quantitative measurements for comparisons were not attempted in this analysis. Also, aerial photos were not available for the entire watershed in all years. Instead, sequential sets of aerial photos were compiled whenever possible and evaluated qualitatively modeled after the approach used in Pine Creek evaluations (Kondolf and Matthews 1996). Sequential sets of aerial photos were evaluated in detail at priority areas such as the reach of Beaver Creek near its confluence with the North Fork Coeur d'Alene River, lower Trail Creek and Beaver Creek near Trail Creek, Beaver Creek near Carbon Creek and middle reaches of Beaver Creek near White Creek. The evaluation looked at changes in channel location, active channel width, development and riparian vegetation. The aerial photo evaluation was supplemented by historical research, photos, and field observations.

Table 14. Historical aerial photographs analyzed for Beaver Creek

Year	Scope
1937	Beaver Creek and tributaries from the North Fork Coeur d'Alene River confluence upstream to near Pony Gulch, including Trail Creek and tributaries
1956	Beaver Creek and tributaries from near Prospect Creek to Pony Creek, including Trail Creek and tributaries.
1958	Beaver Creek and tributaries from near Hutchins Gulch to near Pony Gulch, including lower Trail Creek.
1967	Beaver Creek confluence area with North Fork Coeur d'Alene River
1968	Beaver Creek confluence area with North Fork Coeur d'Alene River
1971	Beaver Creek and tributaries from Prospect Creek to Trail Creek, including Trail Creek and tributaries
1975	Beaver Creek and tributaries from the North Fork Coeur d'Alene River confluence upstream to Carbon Creek. Photos include most of watershed.
1980	Beaver Creek and tributaries from the North Fork Coeur d'Alene River confluence upstream to White Creek
1992	Entire watershed
1996	Entire watershed
1998	Entire watershed
2003	Entire watershed
2004	Entire watershed
2006	Entire watershed
2009	Entire watershed

Results

1937

The earliest aerial photographs reviewed for this assessment were from 1937. The photographs covered most of the lower Beaver Creek Watershed from the North Fork Coeur d'Alene River confluence up to Pony Gulch. By this time, major watershed land use changes, floodplain alterations and sediment loading had already occurred and significant channel responses were obvious. Roads up Beaver Creek (now Forest Highway 456) and Trail Creek (now the Kings Pass Road) were already well developed. In 1937, there were no bridges near the confluence where the Carpenter Creek Bridge is now. There was also no bridge where the Forest Road 933 Bridge is now.

The railroad constructed around 1916 was partially washed out in 1917 and not reopened. Additional sections likely washed out during high flows in 1933-1934. Still, the railroad bed was highly visible in 1937 photographs and clearly functioning largely like a dike and constraining the stream's access to its floodplain. Both the main Beaver Creek road and the railroad constrained the stream's floodplain access and lateral movement. This effect was likely greater from the railroad in the stream reaches visible in 1937 photographs.

There had already been extensive placer dredge mining and hydraulic mining in the watershed by 1937 and the effects were observable in Trail Creek and tributaries and in Beaver Creek and some tributaries downstream of Trail Creek. The active channel of Beaver Creek in these areas was very wide and there was a lack of vegetation atop the disturbed soils. There were likely effects in other streams as well that were not covered by this set of photographs.

A Civilian Conservation Corps (CCC) camp was started in Beaver Creek in 1935 and was reportedly located near the mouth of White Creek. A cleared area is visible in the 1937 photographs at the site where local residents say the camp was located. There also appears to be a road up to Missouri Gulch which crosses Beaver Creek at the location of the present day FR 933 bridge. In these photos, there does not appear to be a defined channel carrying surface flow at this area. The combined effects of upstream changes and disturbance of the area with a floating dredge may have caused the flow to become subsurface.

In the 1937 photographs, the manifestations of multiple significant stressors occurring in the early 1900s were visible in Beaver Creek and its tributaries. This included timber harvest, at least one large flood in 1933-34, wildfires, construction of roads and railroad, conversion of floodplain areas from forests and beaver complexes to agricultural uses and development of placer and hard rock mines. The resulting constraints to the floodplain, increased sediment loading and changes to the hydrology and physical characteristics of streams led to instability and overwidened channels visible in 1937.

Figure 29. Aerial photographs from 1937 reveal evidence of roads, railroad and mining development

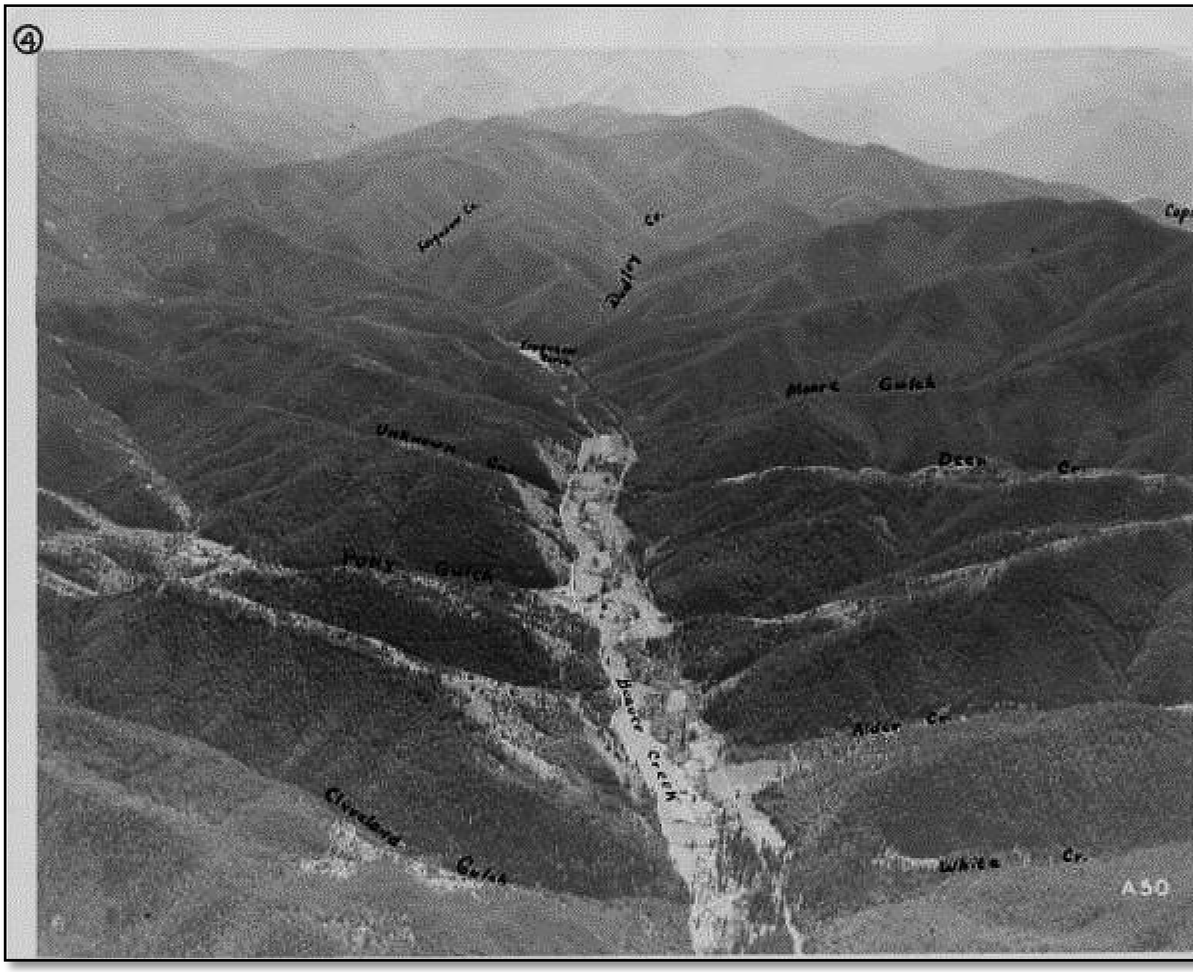


Figure 30. Aerial view of the Beaver Creek drainage (1933 photo)

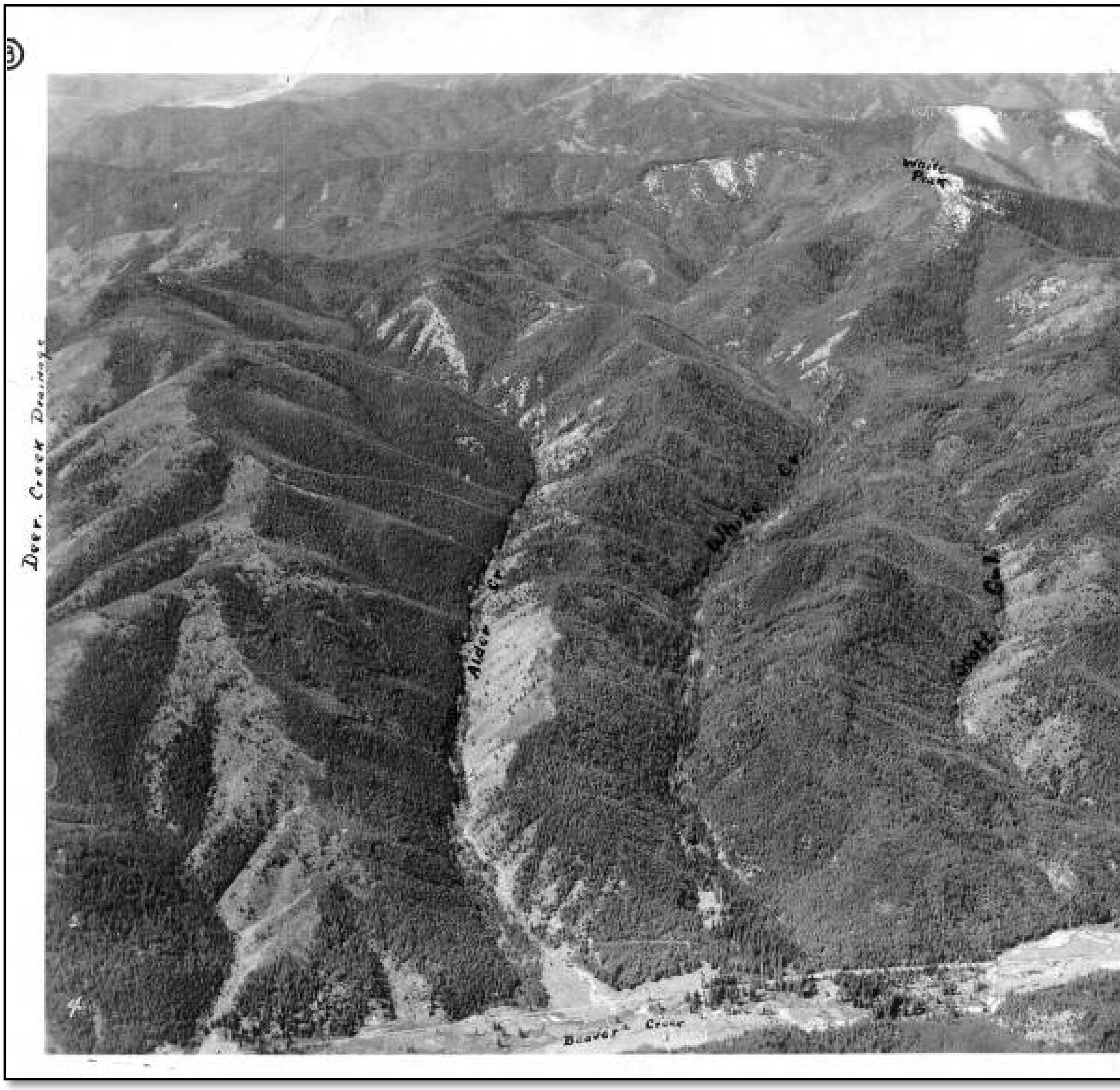


Figure 31. Alder, White and Scott Creek drainages in the Beaver Creek Watershed (1933 photo)

1956 and 1958

The aerial photos available from 1956 and 1958 show sections of Beaver Creek and tributaries from Prospect Creek upstream to Pony Gulch, including Trail Creek and tributaries. The most obvious changes from 1937 photographs are extensive placer mining in Trail Creek and tributaries and in Pony Gulch. Placer mining likely increased during the time of World War II with high metals demand and prices.

The railroad bed appears less distinct in these photos than in 1937, but is still a prominent feature in the floodplain. Areas where the railroad bed washed out are visible between Deer Creek and Alder Creek, just upstream of Trail Creek, and downstream from Prospect Gulch. Pastures and/or hay fields are visible between Prospect Gulch and Trail Creek (similar to 1937) and between White Creek and Pony Gulch along with several barns and other buildings. Photos from 1956 to 1958 show very little change.

The road up to Missouri Gulch which crosses Beaver Creek at the location of the present day FR 933 bridge is visible in these years. In these photos, a defined channel carrying surface flow at this area has been established since 1937 and there is a reduction in the amount of unvegetated area.

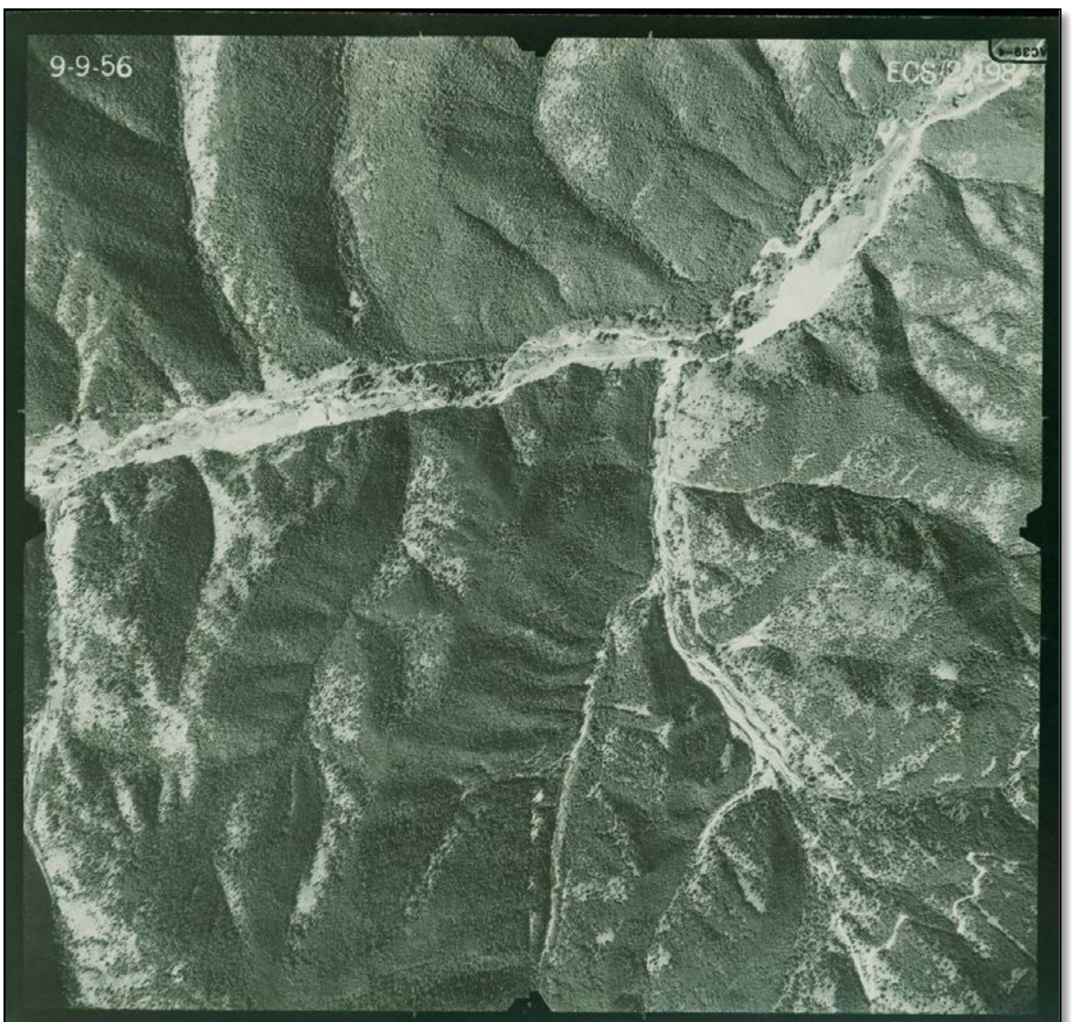


Figure 32. Aerial photos from 1956 show extensive placer mining in the Trail Creek subwatershed.

1967 and 1968

The photographs from 1967 and 1968 show the confluence area where Beaver Creek reaches the North Fork Coeur d'Alene, also visible in 1937, but not in 1956 or 1958. In 1967 and 1968, there are several roads and stream crossings of Beaver Creek at the confluence area. There appear to be two bridges near the present day location of the Carpenter Creek Bridge and there is a road up Carpenter Creek with an area of timber harvest including a relatively small, densely roaded clearcut.

Figure 33. Aerial photos in 1967 of the area near Beaver Creek's confluence with the North Fork Coeur d'Alene River show development of roads and bridges in the confluence area and timber harvest in the Carpenter Creek subwatershed

1971

Photographs from 1971 show Beaver Creek and tributaries from Prospect Gulch to Trail Creek, including Trail Creek and tributaries. Roads are visible along the mainstem of Beaver Creek and in many tributary drainages. The railroad bed is still significant, but less visible over time. By this time, there is a very visible bridge across Beaver Creek where the FR 933 bridge is now. There is also a road up Prospect Gulch, and the drainage appears mined and disturbed in the headwaters. Compared to photographs from the 1950s, there appears to be some vegetative recovery in the Trail Creek riparian zone, but evidence of placer mining remains very evident and particularly significant in lower Placer Creek and lower Lake Gulch (Figure 34).

Figure 34. Placer mining in Lake Creek 1972 (Photo: Museum of North Idaho)

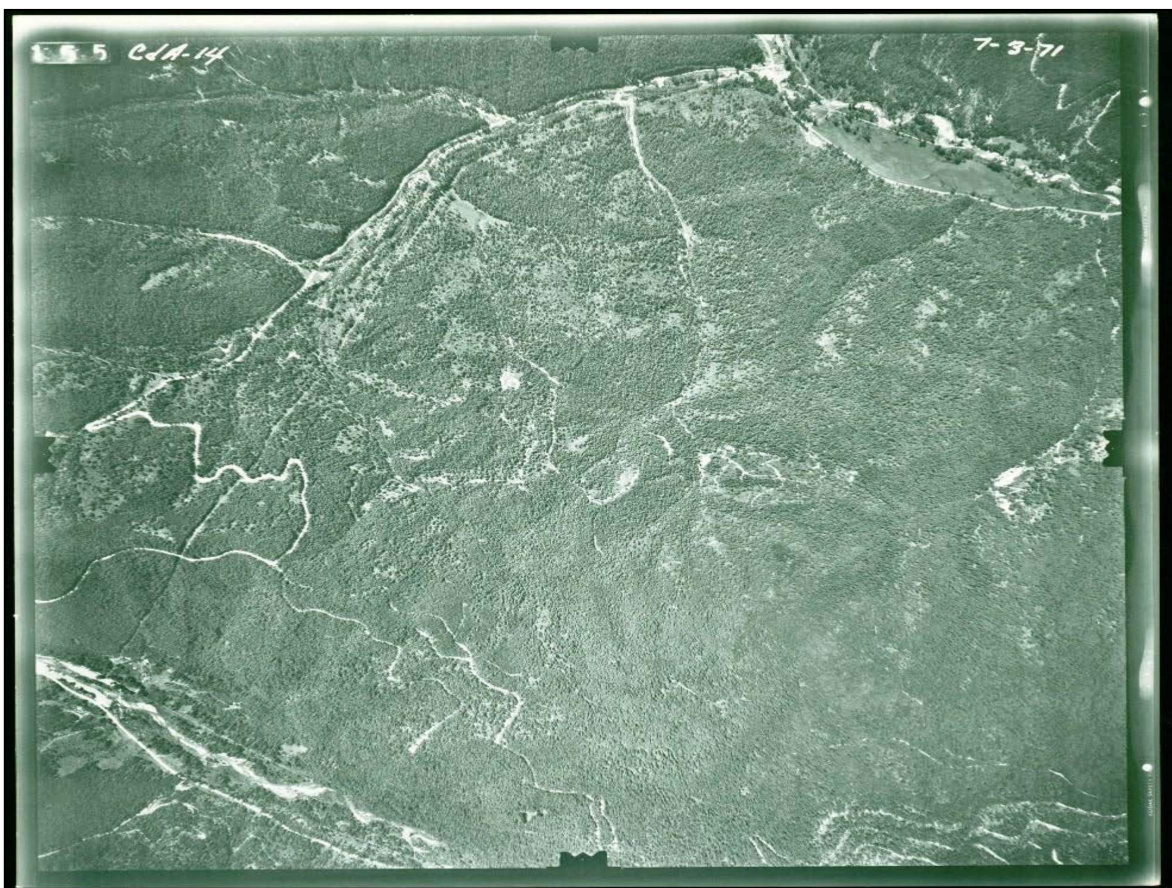


Figure 35. Aerial photos in 1971 illustrate vegetative recovery in portions of the Trail Creek subwatershed compared to photos from the 1950s

1975

Photographs from 1975 show most of the Beaver Creek Watershed from the North Fork Coeur d'Alene River confluence up to Carbon Creek. These photos follow a very large flood in 1974. At the confluence, there are fewer roads compared to photos from the 1960s and only one bridge remains in this area. The railroad bed remains highly visible in the watershed and stretches appear to have been converted to drivable roads while other stretches have been washed away. There are roads visible up the Dudley Creek Watershed and Dobson Pass with bridges over Beaver Creek for each road. There are also roads up Deer Creek and Pony Gulch. In the headwaters near Carbon Creek, the mining waste disposal areas are highly visible and the channel is overwidened and appears overloaded with sediment.

There are pastures and agricultural fields from Dudley downstream in the Beaver Creek floodplain. In many of these low gradient areas, there is a sinuous channel that looks braided with mixed vegetation. There appears to be vegetation recovery in the Pony Gulch riparian zone after dredge mining. The active channel width begins to widen below Pony Gulch and there are side channels and remnant channels visible and vegetated in the floodplain pastures and fields. Timber harvest areas are visible in Carpenter Gulch, White Creek and Deer Creek.

Farther downstream, the bridge where Forest Road 933 is today appears much less distinct than in 1971 and may have been washed out during flooding. Downstream of this bridge site, where a historic floating dredge operated and the channel is constrained by the railroad bed, there is significant instability and overwidening of the channel including a channel avulsion that likely occurred during 1974 flooding.

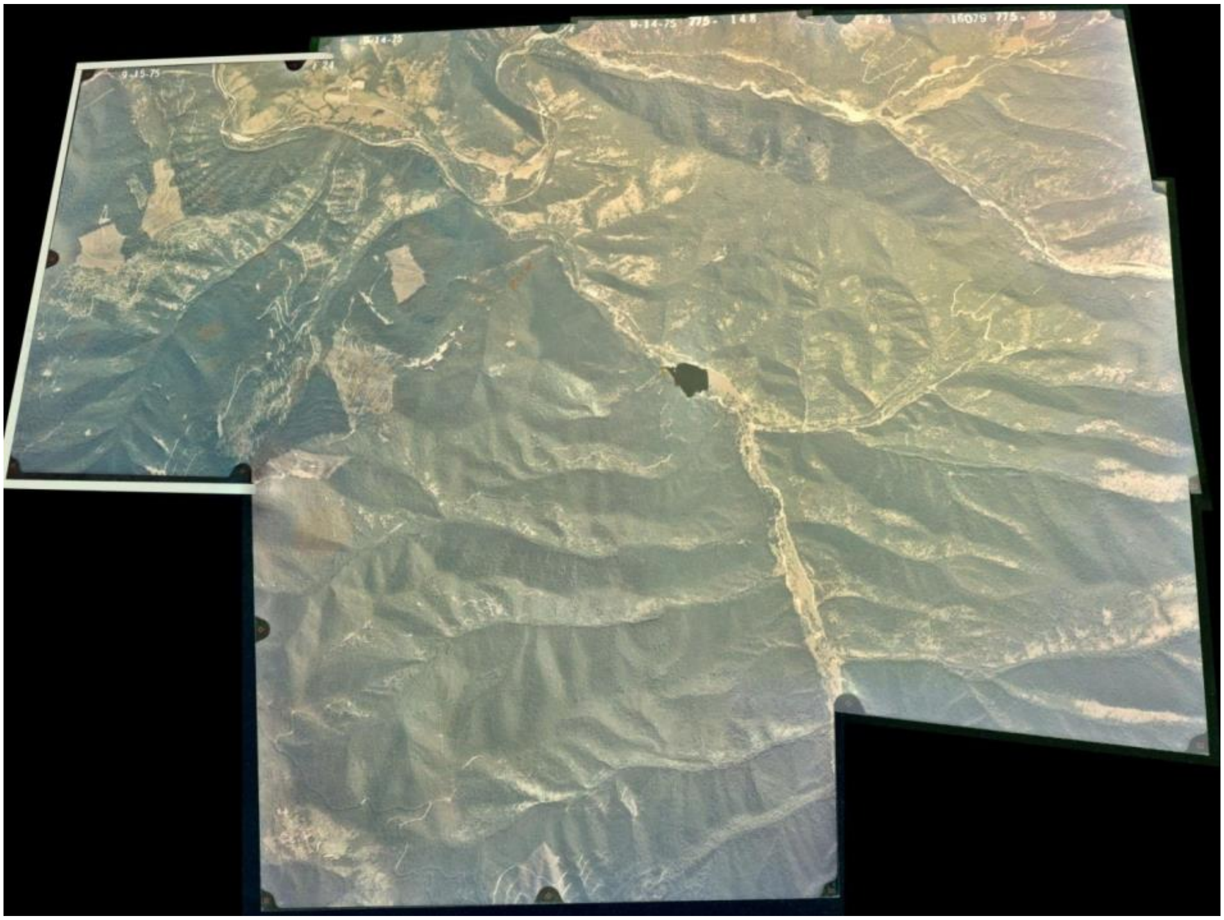


Figure 36. 1975 aerial photos cover most of the Beaver Creek watershed and reveal patterns of development and channel instability

1980

Photographs in 1980 show Beaver Creek and tributaries from the North Fork Coeur d'Alene River confluence upstream to White Creek. The railroad bed remains highly visible, but washed out or is less visible in photos over time in many stretches. Some stretches of the railroad bed appear converted to roads, especially between Trail Creek and Moore Gulch. The active channel width narrowed since 1975 in most reaches. It's unclear from these photos if there is a bridge where Forest Road 933 is now.

Mine wastes remain highly visible near Carbon Creek and the channel is very wide downstream. Between Dudley Creek and Moore Gulch, the riparian zone is forested and the channel appears sinuous and even braided near Pony Gulch. Downstream of Pony Gulch, the channel becomes more channelized along pastures.

Figure 37. Aerial photos from 1980 show roads, the railroad grade, small timber harvest areas and mine waste storage areas

1992

There was a large increase in the amount of forest roads visible in aerial photographs between 1980 and 1992. An electrical power line was constructed for Bonneville Power Administration (BPA), and the clearings for the line are visible in the 1992 photographs crossing the tributaries that enter Beaver Creek from the west. The railroad grade continues to fade from view but is still influencing channel dynamics in many reaches of Beaver Creek. Timber harvest is also visible in the watersheds of Scott, White, Deer, Potosi, Pony, Hutchins and Prospect creeks.

At the confluence of Beaver Creek and the North Fork Coeur d'Alene River, the area below the bridge near Carpenter Creek is very wide, and appears much wider than in 1975 or 1980. Approximately 900 feet of the Beaver Creek channel above the bridge looks straightened since 1980 and perhaps dredged.

In these photographs, the bridge on FR 933 reappears and is the same bridge that exists today. The current structure was constructed in 1985. The Beaver Creek channel is very wide from approximately 1,500 feet below the bridge upstream to Trail Creek. The area just downstream of Trail Creek, reported to have been historically dredge mined, appears much wider in the 1992 photographs than in 1975 or 1980. There was a new road into that area and vegetation missing. A cleared area in Scott Gulch just upstream may have been placer mined, and there is timber harvest in the drainage just upslope from there. Placer mining effects are still visible in Trail Creek and tributaries, but recovering in some areas. These factors together may explain the overwidened active channel in the Beaver Creek mainstem between Trail Creek and Prospect Gulch.

The Beaver Creek channel between Trail Creek and Pony Gulch appears wide and unstable. The meanders appear constrained from lateral migrations in the floodplain and sections may have been channelized. The channel between Pony Gulch and Deer Creek appears narrower, meandering and vegetated though there is some evidence of instability and deposition downstream of an undersized bridge upstream of Deer Creek. Between Unknown Gulch and Dudley Creek, the channel is narrower and well vegetated, and then it becomes increasingly wide between Dudley Creek and headwater mining and mill sites.

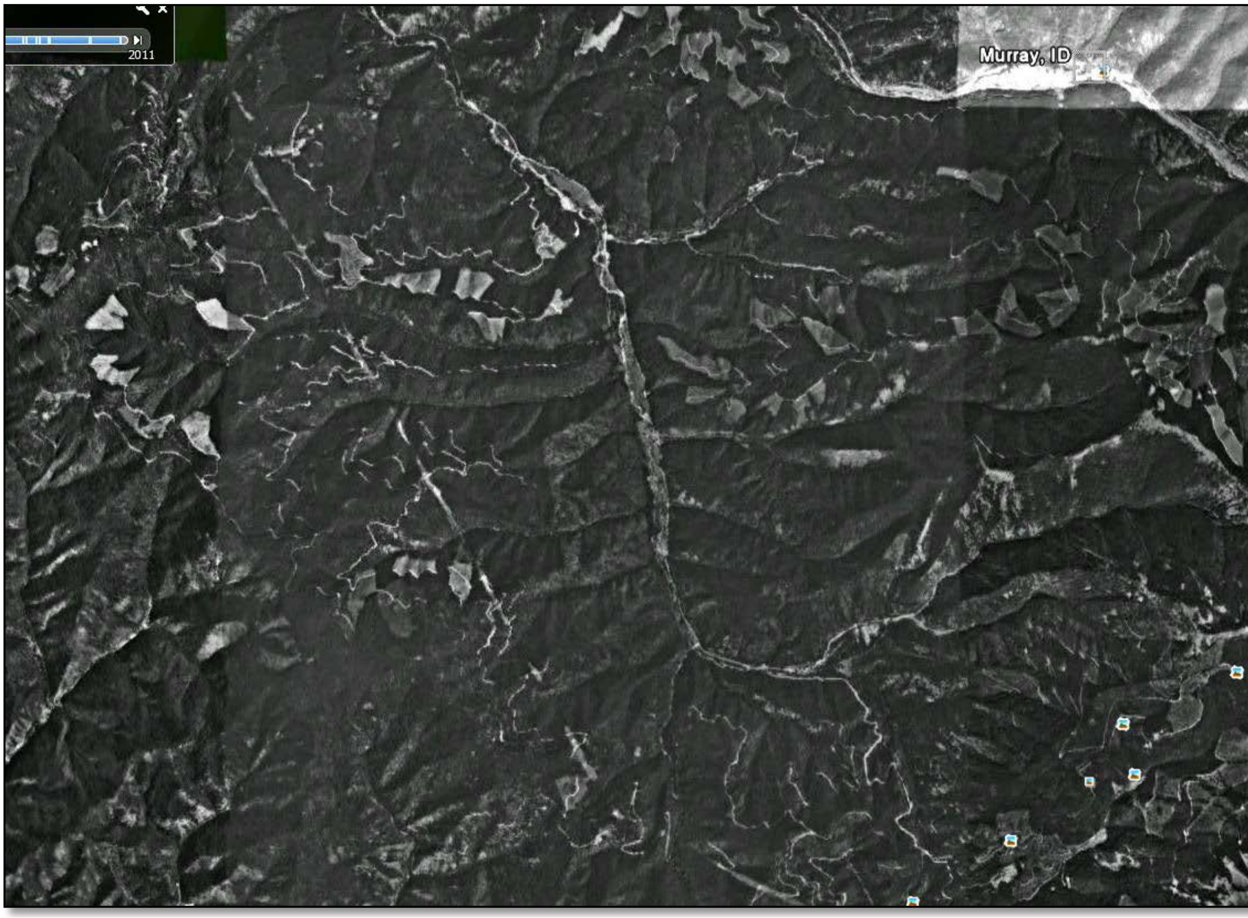


Figure 38. Aerial photos in 1995 show the development of utility lines across the watershed as well as increased areas of timber harvest

1996 and 1998

The 1996 aerial photographs occurred after a very large flood event in February 1996. The most obvious changes in the watershed between 1992 and 1996 were substantial timber harvest in nearly every Beaver Creek subwatershed. Sections of the Beaver Creek mainstem appeared to have widened in 1996, especially in the area downstream of the FR 933 bridge. In 1996 and 1998, there were similar general patterns in channel form to photographs since 1975. The channel between White and Alder widen in 1992 and become even wider in the 1998 photographs. The area upstream of the FR 933 bridge, historically dredge mined, looks dewatered in the 1998 photographs. In Potosi Gulch, dredge mining at the site of today's placer mining wash plant was cleared and active.

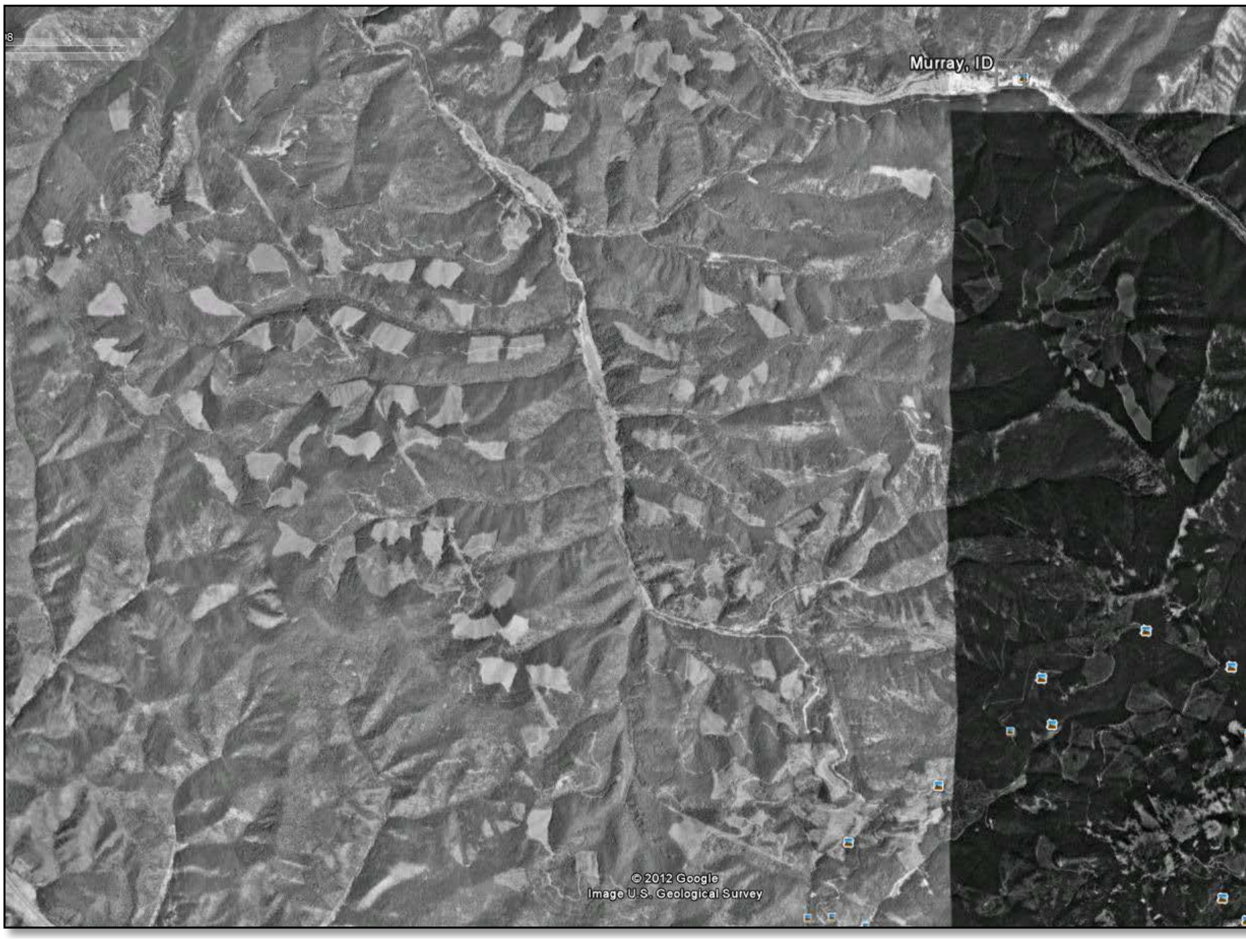


Figure 39. In 1998, aerial photos show increased areas of timber harvest, particularly around the area of utility line development

2003 and 2004

In 2003, more homes and recreational sites are visible along Beaver Creek's lower reaches. In many areas, there seems to be some vegetative recovery and narrowing channels. However, some reaches appear increasingly wide and unstable. Beaver Creek between White and Alder creeks increasingly widened from 1992-2003 and was very wide in 2003. Sections of Beaver Creek downstream of Deer Creek also exhibited instability from 1992 to 2003 and there were big changes in the Beaver Creek channel upstream of Deer Creek. There seems to have been a shift from a straightened single thread channel to a braided complex with beaver ponds, with Beaver Creek abandoning the straightened channel in the center of the floodplain. Very few changes were seen between 2003 and 2004.

2006 and 2009

Between 2004 and 2006, there were few changes. The Beaver Creek mainstem between Pony Gulch and White Creek exhibited high instability and overwidened channels. Between Unknown Gulch and Dudley Creek, the stream is much narrower and vegetated. Then, the channel becomes increasingly wide upstream of Dudley Creek. This pattern is very similar to previous years. In May 2008, there was a 25-30-year flood event. Aerial photographs from 2009 show increased channel instability, particularly in the middle reaches between FR 933 and Unknown Gulch.

Discussion

The evaluation of land use changes and stream geomorphic conditions over time using aerial imagery revealed the impacts of multiple significant stressors in large portions of the watershed. The effects of early development were already visible in 1937 with the impacts of the railroad, roads, and mines. Over time, many of these impacts appeared to fade as sections of the railroad were washed out and mining activities slowed. However, between 1980 and 1992, there was a large increase in the amount of forest roads visible in photos. Then, between 1992 and 1996, the amount of timber harvest in nearly every subwatershed increased distinctly. More recently, increased development of recreational properties along the mainstem was more evident. Many reaches of Beaver Creek seemed to narrow and revegetate by 2009, but many reaches became increasingly wide and unstable. The effects of undersized bridges were especially dramatic. Removal of riparian vegetation, stream channel dredging, and effects of channel constraints were also linked to the degraded channel conditions observed.

Figure 40. 2009 aerial photos depict smaller scale changes over the watershed scale than the 1990s with some areas becoming more stable and revegetated while others became less stable. Impacts from past timber harvest, road building, mining and other development remained evident.

Beneficial Use Reconnaissance Program

Methods

Rapid bioassessments are commonly used to assess the water quality of streams, and DEQ's Beneficial Use Reconnaissance Program (BURP) is the agency's primary mechanism for assessing wadeable streams. Past BURP sampling events in the Beaver Creek watershed occurred at two sites in 1996. Those crews visited one site in lower Beaver Creek (approximately 150 m below the Forest Road 933 bridge) and one site in upper Beaver Creek (approximately 125 m below the Forest Road 271 bridge) (Figure 41). In 1998 and 2007, DEQ crews visited two additional sites in Beaver Creek and found them either dry or inaccessible. Further rapid bioassessment sampling was needed for this watershed assessment to reflect current conditions.

For this study, the DEQ BURP rapid bioassessment protocols were followed to collect information on biological and physical conditions related to water quality. BURP program protocol descriptions and guidance for assessments can be found in the *Idaho Small Stream Ecological Assessment Framework* (DEQ 2002a), *Idaho Waterbody Assessment Guidance* (DEQ 2002b) and the *Beneficial Use Reconnaissance Program (BURP) Field Manual for Streams* (DEQ 2007). A team of DEQ and USFS personnel conducted sampling at two Beaver Creek sites in 2010. In upper Beaver Creek, a site (2010SCDAB001) was chosen just upstream of the Forest Road 217 bridge to represent the Beaver Creek headwaters and tributaries (assessment unit number 17010301PN003_02) (Figure 42). In lower Beaver Creek, a site (2010SCDAB002) was chosen just upstream of the Forest Road 2361 bridge to represent the mainstem Beaver Creek below White Creek (assessment unit number 17010301PN003_03) (Figure 43).

Crews sampled fish and macroinvertebrates at each site and measured physical habitat variables. These data are integrated into three indices: the Stream Habitat Index (SHI), the Stream Macroinvertebrate Index (SMI), and the Stream Fish Index (SFI). The SHI is made up of 10 individual habitat measures (or metrics) whereby the data were converted to a metric score and then integrated into a multimetric index that was compared to reference conditions for an overall condition rating. The SMI is comprised of 9 individual metrics, and the SFI is made up of 6 metrics. Following the DEQ Water Body Assessment Guidance, 2nd edition (DEQ 2002), the three index scores were then compared to reference conditions to obtain condition ratings for habitat, macroinvertebrates and fish. These are used to assess the condition of water bodies related to Idaho water quality standards and Clean Water Act status. The full assessment also used other available data to support or modify these assessment interpretations. This assessment utilized SHI, SMI and SFI ratings, component metrics and additional data.

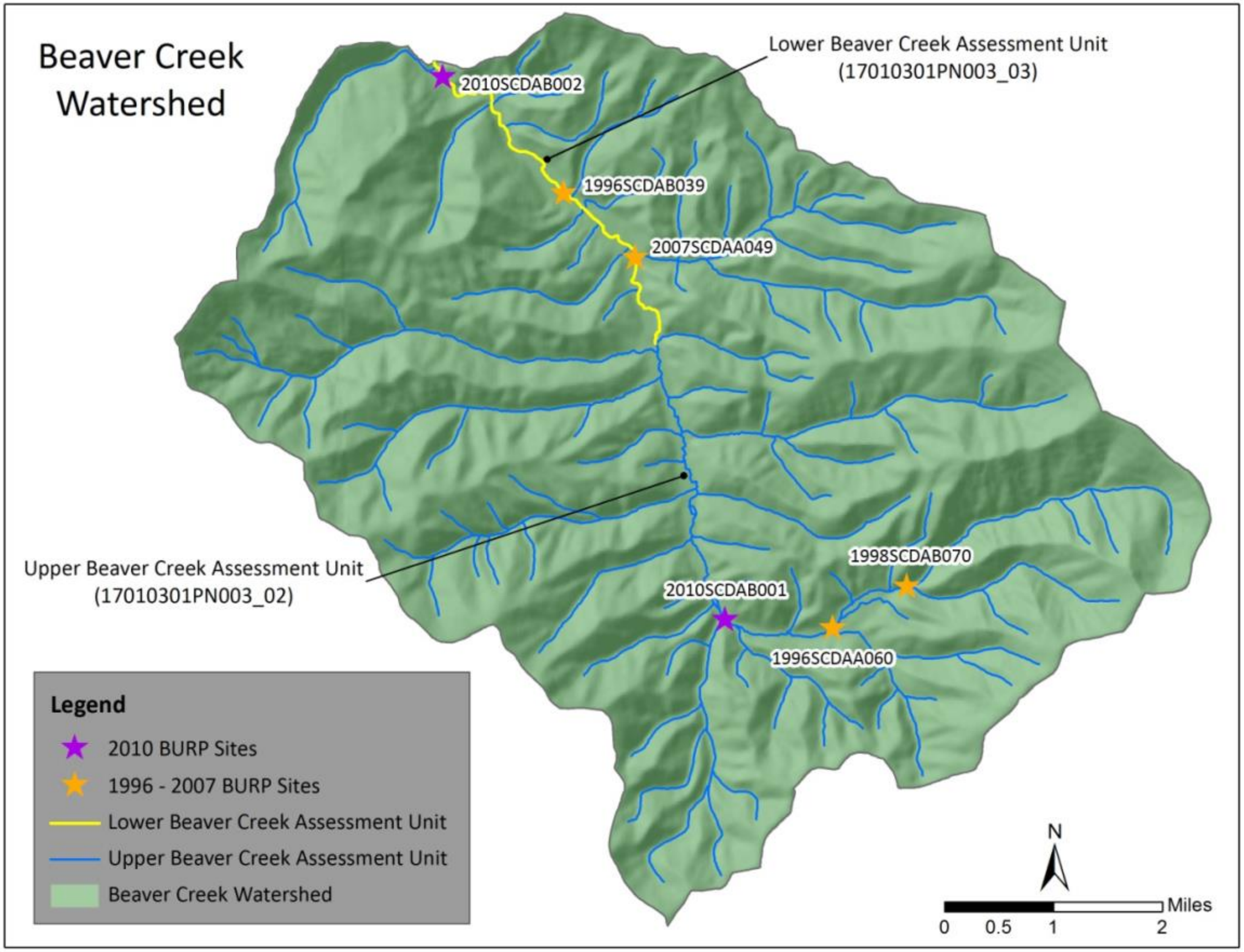


Figure 41. BURP sampling sites in the Beaver Creek Watershed (1996-2010)

Figure 42. Upper Beaver Creek Site (2010SCDAB001), bottom of site looking upstream (left), top of site looking downstream (right)

Figure 43. Upper Beaver Creek Site (2010SCDAB002), bottom of site looking upstream (left), top of site looking downstream (right)

<u>Results</u>

Stream Habitat Index

The Stream Habitat Index is made up of 10 individual habitat measures (or metrics):

- Instream cover
- Large organic debris
- Percent fine sediment
- Riffle embeddedness
- Wolman size classes
- Channel shape
- Percent bank cover

- Percent canopy cover
- Disruptive pressures
- Zone of influence

Field data are converted to metric scores ranging from 0 to 10, with 10 being most favorable, and then integrated into a multimetric index that can be compared to reference conditions for an overall condition rating. Condition ratings are determined by a comparison of sample data to ecoregional reference conditions, and range from 1 to 3.

Instream Cover

The instream cover habitat measure is a numeric rating of instream cover for fish. Instream cover consists of areas with structure in a stream channel that provides aquatic organisms with shelter or protection from predators, competitors, sunlight and high water velocities. Instream cover may include living vegetation, clumps of organic material, logs, boulders, surface turbulence and root wads. Instream cover for the entire stream reach is rated from 0 to 20 according to the estimated percent instream cover and the mix of stable fish cover.

Instream cover at lower Beaver Creek was rated a 5 or "Less than 10% cobble, gravel or other stable fish cover. Lack of cover is obvious." Instream cover at upper Beaver Creek was rated an 8 or "10-30% mix of cobble, gravel or other stable fish cover. Cover availability is less than desirable." The instream cover metric score for lower Beaver Creek was 3 and the instream cover metric score for upper Beaver Creek was 4.

Large Organic Debris

The large organic debris habitat measure is a quantitative count of large organic debris (LOD) within the BURP sampling reach. Large organic debris is defined as organic debris with a diameter greater than 10 centimeters (4 inches) and a length greater than one meter (39 inches), typically made up of fallen trees. The term LOD is synonymous with large woody debris (LWD) described in other literature. These structures add important complexity to stream habitats, provide instream cover, retain sediment and increase stream stability. Crews count each piece of naturally recruited LOD within the bankfull channel of the stream reach. The LOD count at lower Beaver Creek was 49. At upper Beaver Creek, the LOD count was 43. The LOD metric score for lower Beaver Creek was 8 and the LOD metric score for upper Beaver Creek was 7.

Percent Fine Sediment

The percent fine sediment habitat measure is a quantitative estimate of percent fine sediment within the wetted width of a stream based on Wolman pebble count data from three riffle sites. Surface fine sediments are defined as material less than 2.5 mm in diameter. These include the silt and sand size classes of the Wolman pebble count. Excessive fine sediment can be detrimental to salmonid spawning success since it may limit the quality and quantity of intergravel spaces needed for egg incubation. Crews measured and recorded substrate sizes as a pebble count at three riffles. The percent fine sediment metric used in the Stream Habitat Index uses the number of fine particles (0-2.5 mm) within the wetted width divided by the total number of particles within the wetted width multiplied by 100. At the lower Beaver Creek site, percent fine sediment was estimated at 6%. At the upper Beaver Creek site, percent fine sediment was estimated at 16%. The percent fine sediment metric score for lower Beaver Creek was 8 and the instream cover metric score for upper Beaver Creek was 5.

Riffle Embeddedness

The riffle embeddedness habitat measure is a numeric rating of the degree to which larger substrate particles (cobbles and boulders) in riffles are surrounded or covered by fine sediment. Embeddedness in riffles is visually estimated and rated from 0 to 20 in the Habitat Assessment Summary for the stream reach. Riffle embeddedness at the lower Beaver Creek site was rated 18 or "gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment." Riffle embeddedness at the upper Beaver Creek site was rated 15 or "gravel, cobble, or boulder particles are 25-50% surrounded by fine sediment." The riffle embeddedness metric score for lower Beaver Creek was 9 and the riffle embeddedness metric score for upper Beaver Creek was 8.

Wolman Size Classes

The Wolman size classes habitat measure is the number of Wolman pebble count size categories in which particles were recorded for that site. This measure illustrates the range of particle sizes observed within the three riffle sites. The BURP program uses a modified Wolman pebble count. Particles are measured in transects across the bankfull width, and observers record the particle size class and whether the particle was selected from within or outside of the wetted stream width. A minimum of 50 particles are recorded at each of three riffles. Substrate particles are measured at three riffle sites and recorded as one of 11 size classes ranging from silt/clay to large boulder. The number of Wolman particle size classes observed at lower Beaver Creek was 10. The number of Wolman particle size classes observed at upper Beaver Creek was 7. The Wolman size classes metric score for lower Beaver Creek was 10 and the Wolman size classes metric score for upper Beaver Creek was 7.

Channel Shape

The channel shape habitat measure is a numeric rating of overall bank angle and predominant channel shape. Bank angles are measured at a minimum of four representative locations using a clinometer. The channel shape is then rated from 1 to 15 in the Habitat Assessment Summary for the stream reach. The average bank angle for the lower Beaver Creek site was 21% and the stream channel was generally considered an inverse trapezoidal shape. The average bank angle at the upper Beaver Creek site was 62% and overall stream channel shape was considered rectangular. The channel shape metric score for lower Beaver Creek was 1 and the instream cover metric score for upper Beaver Creek was 5.

Percent Bank Cover

The percent bank cover habitat measure is a numeric estimate of the overall percent of streambank cover and stability as visually estimated for the entire stream reach. Bank cover refers to the percent surface protection when the following are true:

- Perennial vegetation ground cover is greater than 50%.
- Roots of vegetation cover greater than 50% of the bank.
- At least 50% of the bank surfaces are protected by rocks of cobble size (150 mm) or larger.

- At least 50% of the bank surfaces are protected by logs with 10 centimeter (4 inch) or larger diameter.
- At least 50% of the bank surfaces are protected by a combination of the above.

The percent bank cover at the lower Beaver Creek site was 56%. Percent bank cover at upper Beaver Creek was 52%. The percent bank cover metric score for lower Beaver Creek was 3 and the percent bank cover metric score for upper Beaver Creek was 3.

Percent Canopy Cover

The percent canopy cover habitat measure is a quantitative estimate of the amount of stream shaded by nearby vegetation. A spherical densiometer is used that has been modified to show only 17 grid intersections. Densiometer readings are obtained from the center of the stream at each of the three riffle transects and at each of the three width-depth transects. Readings are recorded facing upstream and downstream and towards each bank. The percent canopy cover habitat measure used in the Stream Habitat Index uses the sum of densiometer readings for the three riffle sites divided by the total possible densiometer readings (204) and multiplied by 100. Densiometer readings at the width-depth sites are not used for this metric. Percent canopy cover at lower Beaver Creek was 11%. Percent canopy cover at upper Beaver Creek was 55%. The percent canopy cover metric score for lower Beaver Creek was 1 and the percent canopy cover metric score for upper Beaver Creek was 6.

Disruptive Pressures

The disruptive pressures habitat measure is a numeric rating of the anthropogenic impacts to the riparian zone. Disruptive pressure is rated from 0 to 10 in the Habitat Assessment Summary for the stream reach. The rating is based on a visual estimate of riparian plant community vigor and the observation of anthropogenic disturbance to riparian vegetation. Disruptive pressures at the lower Beaver Creek site was rated 7 or “disruption evident but not affecting community vigor. Vegetative use is moderate, 60-90% of the potential plant biomass remains.” Disruptive pressures at the upper Beaver Creek site was rated 5 or “disruption obvious; some patches of bare soil or closely cropped vegetation present. 30-60% of potential plant biomass remains.” The disruptive pressures metric score for lower Beaver Creek was 7 and the disruptive pressures metric score for upper Beaver Creek was 5.

Zone of Influence

The zone of influence habitat measure is a numeric rating of riparian zone width. The presence and condition of riparian vegetation is important to the overall ecological health of the stream and floodplain. This habitat measure also reflects the impact of human activities on the riparian zone. Visual observation of human disturbance is included and the width of riparian vegetation is estimated. Zone of influence is rated from 0 to 10 in the Habitat Assessment Summary for the stream reach. Zone of influence at the lower Beaver Creek site was rated 5 or “width of riparian vegetative zone (each side) is at least as wide as the stream. Human activities have caused a great deal of impact.” Zone of influence at the upper Beaver Creek site was rated 4 or “width of riparian vegetative zone (each side) is at least as wide as the stream. Human activities have caused a great deal of impact.” The zone of influence metric score for lower Beaver Creek was 5 and the zone of influence metric score for upper Beaver Creek was 4.

Stream Habitat Index Score and Condition Rating

SHI metric scores range from 1 to 10 with 10 representing the best water quality, and the multimetric Stream Habitat Index (SHI) score is generated from the sum of individual metric scores for each site. The SHI score for lower Beaver Creek was 55 and the SHI score for upper Beaver Creek was 54 (Table 15). These scores are compared to reference condition values to obtain a condition rating. Both sites were rated a value of 1 or below the 10th percentile of reference condition.

Table 15. Stream habitat data values, metric scores and Stream Habitat Index (SHI) ratings for Beaver Creek sites in 2010 (pink = 1 – 3 = low metric score, green = 4 – 7 = medium metric score, blue = 8 – 10 = high metric score)

Habitat Measure	Value	
	Lower Beaver Creek Site	Upper Beaver Creek Site
Instream Cover (rating)	5	8
Large Organic Debris (count)	49	43
Percent Fine Sediment (%)	6	16
Riffle Embeddedness (rating)	18	15
Wolman Size Classes (#)	10	7
Channel Shape (rating)	3	7
Percent Bank Cover (%)	56	52
Percent Canopy Cover (%)	11	55
Disruptive Pressures (rating)	7	5
Zone of Influence (rating)	5	4
Habitat Measure	**Score**	
	Lower Beaver Creek Site	**Upper Beaver Creek Site**
Instream Cover (rating)	3	4
Large Organic Debris (count)	8	7
Percent Fine Sediment (%)	8	5
Riffle Embeddedness (rating)	9	8
Wolman Size Classes (#)	10	7
Channel Shape (rating)	1	5
Percent Bank Cover (%)	3	3
Percent Canopy Cover (%)	1	6
Disruptive Pressures (rating)	7	5
Zone of Influence (rating)	5	4
Stream Habitat Index (SHI) Score	55	54
SHI Condition Rating	1	1
	Below 10th percentile of reference condition	

The SHI condition rating of 1 at both sites below the 10th percentile of reference condition likely indicates poor habitat conditions and impairment of beneficial uses. Metric scores below 5 indicate possible evidence of physical habitat degradation. The lower Beaver Creek site had low metric scores for instream cover, channel shape, percent bank cover and percent canopy cover. The upper Beaver Creek site had low metric scores for instream cover, percent bank cover and zone of influence. These scores correspond to conditions observed at the sites and at other locations in the watershed. There are many locations along stream reaches throughout the watershed with low instream cover, uncovered banks, overwidened channel shape, low canopy cover and encroachment of human activities into the riparian zone. These physical habitat changes are often associated with sediment and temperature impairments of cold water aquatic life and seem to be pronounced in both assessment units in the Beaver Creek Watershed.

Stream Macroinvertebrates Index

Stream macroinvertebrates were sampled at each Beaver Creek site following BURP protocols, using a Hess sampler at 3 riffles for each site. The samples were sorted, identified and counted by EcoAnalysts, Inc. according to BURP protocols. Results were analyzed using the DEQ Biological Assessment Tool (BAT) to calculate metrics and the overall Stream Macroinvertebrates Index (SMI) score for each site. The SMI is calculated from 9 metrics and then compared to reference condition values to obtain a condition rating. Metric scores for each macroinvertebrate metric range from 0 to 100, with 100 representing the most favorable conditions. Individual metric scores were not reported by BAT and were estimated using Small Stream Ecological Assessment Framework formulas. The SMI calculated from these estimated metric scores did not perfectly match the SMI reported by BAT, which cannot be independently calculated. Condition ratings are determined by a comparison of sample data to ecoregional reference conditions, and range from 0 to 3.

The SMI reported by BAT for lower Beaver Creek was 62 with a condition rating of 2, and the SMI reported for upper Beaver Creek was 55 with a condition rating of 1 (Table 16). The SMI condition ratings for both sites were below the 25th percentile of reference conditions, and the SMI condition rating for upper Beaver Creek was even below the 10th percentile of reference conditions.

Estimated individual metric scores for the lower Beaver Creek site were low for the number of plecoptera taxa, the percent plecoptera taxa, ephemeroptera taxa and the Hilsenhoff Biotic Index (HBI). Estimated individual metric scores for the upper Beaver Creek site were low for the number of ephemeroptera taxa, plecoptera taxa, trichoptera taxa and the percent 5 dominant taxa. The lower macroinvertebrates index score in upper Beaver Creek may reflect the higher concentration of metals contamination in the substrate higher in Beaver Creek Watershed.

Samples from both sites were relatively low in diversity compared to reference condition and upper Beaver Creek in particular indicated water quality impairment. The upper Beaver Creek sample was dominated (32%) by Cinygmula, a genus of mayfly (Ephemeroptera). In fact, almost 50% of the sample was made up of Ephemeroptera individuals. This type of insect is generally associated with good water quality, but the lack of species diversity in the sample from this site may be considered an indication of cold water aquatic life beneficial use impairment.

Table 16. Stream macroinvertebrates data values, metric scores, and Stream Macroinvertebrates Index (SMI) ratings for Beaver Creek sites in 2010 (pink = 10 – 39 = low metric score, green = 40 – 79 = medium metric score, blue = 80 – 100 = high metric score)

Metrics and Stream Macroinvertebrates Index (SMI)	Value	
	Lower Beaver Creek Site	Upper Beaver Creek Site
Total taxa	36	24
Ephemeroptera taxa	7	6
Plecoptera taxa	4	5
Trichoptera taxa	8	5
Percent plecoptera	15	17
Hilsenhoff Biotic Index (HBI)	5.49	5.23
Percent 5 dominant taxa	58	82
Scraper taxa	5	7
Clinger taxa	16	18
Metrics and Stream Macroinvertebrates Index (SMI)	**Approximate Score[1]**	
	Lower Beaver Creek Site	**Upper Beaver Creek Site**
Total taxa	92	62
Ephemeroptera taxa	54	46
Plecoptera taxa	40	50
Trichoptera taxa	80	50
Percent plecoptera	38	42
Hilsenhoff Biotic Index (HBI)	54	57
Percent 5 dominant taxa	88	37
Scraper taxa	63	88
Clinger taxa	70	78
Stream Macroinvertebrates Index (SMI)	**62**	**55**
SMI Condition Rating	**2, 10 – 25th percentile of reference condition**	**1, Below 10th percentile of reference condition**

[1] Individual metric scores were not reported by BAT and were estimated using Small Stream Ecological Assessment Framework formulas. The SMI calculated from these estimated metric scores did not perfectly match the SMI reported by BAT (reported here), which cannot be independently calculated.

Stream Fisheries Index

Fisheries data were collected at both Beaver Creek sites in 2010 according to BURP protocols. This sampling included 100-m single-pass backpack electrofishing with no block nets. Fish were collected, measured and identified, then released back into the stream. From this information, the Stream Fisheries Index (SFI) was calculated based on six component metrics:

- Number of coldwater native species
- Percent coldwater individuals
- Percent sensitive native individuals
- Number of coldwater individuals per minute electrofishing

- Number of sculpin age classes
- Number of salmonid age classes

The SFI is calculated differently for forest or rangeland stream types based on bioregion, elevation and stream order. Fisheries data are converted to metrics scores ranging from 0 to 100, with 100 representing the most favorable conditions. Condition ratings are determined by a comparison of sample data to ecoregional reference conditions and range from 0 to 3. The Beaver Creek sites were both forest stream types in the Northern Rockies bioregion. The upper Beaver Creek site was on a 2nd order stream at approximately 2,600 ft elevation. The lower Beaver Creek site was on a 3rd order stream at approximately 2,400 ft elevation. Westslope cutthroat trout, sculpin, brook trout and rainbow trout were collected at both sites (Table 17). Crews also noted the presence of tailed frogs and other native amphibians.

The SFI for the Upper Beaver Creek site received a condition rating of 3 or above the median of reference condition, while the Lower Beaver Creek site was rated 2 or between the 25th percentile and median of reference condition (Table 18). Westslope cutthroat trout and several species of sculpin are native to the North Fork Coeur d'Alene River Subbasin, but sculpin in this sample were not identified to species. Brook trout and rainbow trout are introduced in this watershed. Brook trout are known to compete with and prey upon westslope cutthroat trout, and they are considered a conservation threat to the native cutthroat trout. Brook trout may especially have an advantage over the more sensitive cutthroat trout in waters with excessive sediment and temperature. The abundance and distribution of brook trout is thought to be expanding in the North Fork Coeur d'Alene River Subbasin and they are noted as especially abundant in the Beaver Creek drainage. Introduced rainbow trout are also noted as conservation threats to native cutthroat trout due to competition, predation and hybridization. We were unable to determine the genetic purity of westslope cutthroat trout sampled or the presence of any rainbow-cutthroat hybrids. Sculpin have been noted as especially sensitive to metals contamination. The higher concentration of metals in upper watershed substrates may account for the low number of sculpin in the sample. Sculpin were very abundant at the lower site. It's also likely that fish density during sampling at upper Beaver Creek was artificially increased due to seasonal dewatering observed upstream.

Table 17. Fish collected during 2010 Beaver Creek electrofishing

Fish	Lower Beaver Creek Site 2010SCDAB002		Upper Beaver Creek Site 2010SCDAB001	
	#	#/100m^2	#	#/100m^2
Westslope cutthroat trout	21	1.7	71	11.8
Sculpin	214	18	6	1
Brook trout	3	0.3	21	3.5
Rainbow trout	2	0.2	2	0.3

Table 18. Stream fisheries data values, metric scores, and Stream Fisheries Index (SFI) ratings for Beaver Creek sites in 2010 (pink = 10 – 39 = low metric score, green = 40 – 79 = medium metric score, blue = 80 – 100 = high metric score)

Metrics and Stream Fisheries Index (SFI)	Value	
	Lower Beaver Creek Site	Upper Beaver Creek Site
Number of coldwater native species	2	2
Percent coldwater individuals	100	100
Percent sensitive native individuals	8.8	71
Number of coldwater individuals per minute	8.3	8.5
Number of sculpin age classes	5	4
Number of salmonid age classes	2	3
Presence of tailed frog or native amphibians	Native amphibians present	Tailed frogs present
Metrics and Stream Fisheries Index (SFI)	**Approximate Score[1]**	
	Lower Beaver Creek Site	**Upper Beaver Creek Site**
Number of coldwater native species	100	100
Percent coldwater individuals	100	100
Percent sensitive native individuals	32	96
Number of coldwater individuals per minute	100	100
Number of sculpin age classes	98	93
Number of salmonid age classes	50	75
Stream Fisheries Index (SFI) Score	**80**	**94**
SFI Condition Rating	**2, between the 25th percentile and median of reference condition**	**3, above the median of reference condition**
[1] Individual metric scores were not reported by BAT and were estimated using Small Stream Ecological Assessment Framework formulas. The SFI calculated from these estimated metric scores did not perfectly match the SFI reported by BAT (reported here), which cannot be independently calculated.		

Additional Physical Habitat Data

Data collection according to BURP protocols also includes pool counts and measurements of channel dimensions that are not used in the Stream Habitat Index but can be important indicators of physical habitat integrity. These include pool counts, residual pool volume estimates, and width/depth ratios. This information can be evaluated compared to Interim Riparian Management Objectives from the Inland Native Fish Strategy (USFS 1995) and other reference information.

In streams like Beaver Creek that provide habitat for westslope cutthroat trout, pools are a very important habitat feature. The upper Beaver Creek site had 16 pools recorded over the 180-m reach, while the lower Beaver Creek site had 10 pools recorded over the 360-m reach (Table 19). The pool frequency at upper Beaver Creek was 8.8 pools per 100 m (143 pools/mi) and at lower Beaver Creek pool frequency was 2.8 pools per 100 m (45 pools/mi). Interim Riparian Management Objectives (RMOs) from the Inland Native Fish Strategy (INFS) (USFS 1995) contain minimum targets for pool frequency based on wetted width.

Width to depth ratios are also an important measure of a stream's physical habitat integrity. High width to depth ratios are associated with overwidened streams associated with instability of the bed and banks and excessive sediment loading. Interim RMOs from the Inland Native Fish Strategy (USFS 1995) contain a minimum target for wetted width to depth ratio. The wetted width to depth ratios at both Beaver Creek sites exceeded the minimum INFS RMO targets. The wetted width to depth ratios was 91 at the lower Beaver Creek site at 23 at the Upper Beaver Creek site (Table 19). These ratios are 2 to 9 times higher than the target and indicate an overwidened channel.

Table 19. Summary of additional stream physical habitat information from Beaver Creek sites in 2010 with INFS RMO targets

	Lower Beaver Creek	**Upper Beaver Creek**
Stable banks (%)	64	32
Wetted width (ft)	18	10
Wetted depth (ft)	0.2	0.4
Actual wetted width/depth	91	23
RMO Target wetted width/depth	<10	<10
Actual pool frequency (#/mi)	45	143
RMO Target pool frequency (#/mi)	56	96
Pool frequency % of target	80	149
Bankfull width (ft)	39.7	19.7
Residual pool volume (ft^3/mi)	329	2,565

Four representative pools were selected for further measurements of width, length, depth, substrate and cover characteristics. From these data, residual pool volume can be estimated. Residual pool volume is the volume of water held in pools if the stream were to reach zero discharge conditions. This can make a useful comparison to other streams and reference conditions as an indicator of habitat quality. Residual pool volume at upper Beaver Creek was 2,565 ft^3/ mi and at lower Beaver Creek was 329 ft^3/ mi. Compared to data contained in the 2001 Subbasin Assessment and Total Maximum Daily Loads of the North Fork Coeur d'Alene River Subbasin, these values are far below the reported residual pool volumes for Beaver Creek and similar stream widths (Table 20).

Table 20. Estimated residual pool volume from North Fork Coeur d'Alene River Subbasin (DEQ 2001) for comparison to 2010 Beaver Creek sample data

2001 Pool Volume	**NF Coeur d'Alene River** ^{R}	**Independence** ^{R}	**Buckskin** ^{R}	**Beaver**
Bankfull width (ft)	23.9	20.4	12.6	14.8
Residual pool volume (ft^3/mi)	41,099	79,701	24,345	15,528

^{R} *Reference site*

Incorporating data on pool frequency, residual pool volumes and wetted width/depth ratios provides additional information relevant to assessment of beneficial use support. At upper Beaver Creek, pool frequency exceeded the minimum INFS targets, but the residual pool volume was considerably less than comparable stream data from the original sediment TMDL, and the wetted width/depth ratio was also approximately twice the INFS target value. This indicates that while pool frequency may be adequate, the pools are small in volume and of lower fisheries habitat value. This also indicates an overwidened stream channel typical of unstable beds and banks and excessive sediment loading. At lower Beaver Creek, pool frequency was lower than INFS targets, residual pool volume was much lower than comparable stream data from the original sediment TMDL and the wetted width/depth ratio was also approximately nine times the INFS target value. This indicates that pool frequency and volume are reduced and that the channel is severely overwidened. These physical habitat changes are often associated with unstable beds and banks and excessive sediment loading, and the effects are particularly evident in the aggrading lower reaches of Beaver Creek.

Discussion

According to the DEQ Water Body Assessment Guidance, 2nd edition (DEQ 2002), rapid bioassessment data collected following BURP protocols can be integrated and used during water quality status assessments of beneficial use support. If at least two index scores are available, the average of the SHI, SMI, and SFI condition ratings can be used to indicate water quality support of cold water aquatic life. The full assessment can also use other available data to support or modify these assessment interpretations. Results from sampling two Beaver Creek sites during 2010 provided SHI, SMI and SFI condition ratings (Table 21).

Table 21. Summary and average index condition ratings from Beaver Creek Watershed sites in 2010

	Lower Beaver Creek Site	**Upper Beaver Creek Site**
SHI	1	1
SMI	2	1
SFI	2	3
Average	**1.7**	**1.7**

The average condition rating for both the lower Beaver Creek site and the upper Beaver Creek site was 1.7. An average condition rating less than 2 usually indicates cold water aquatic life is not fully supported, while an average condition rating of 2 or greater usually indicates cold water aquatic life is fully supported. In this case, results of rapid bioassessment index scores from both Beaver Creek sites sampled in 2010 indicate impairment of cold water aquatic life. Evaluation of physical habitat data further affirms this impairment.

Rapid Assessment of Stream Conditions Along Length (RASCAL)

Methods

To assess stream channel conditions, the Rapid Assessment of Stream Conditions Along Length (RASCAL) protocol was employed to provide a rapid snapshot of stream conditions in order to prioritize areas for targeted restoration projects (Iowa DNR). RASCAL is a modified version of the USDA Natural Resource

Conservation Service Stream Visual Assessment Protocol (SVAP). It was developed by Iowa Department of Natural Resources and was slightly modified for use in Idaho.

Data collection was accomplished with a GPS installed with the RASCAL program. As the crew walked the stream channel, assessments were conducted at pre-determined segment lengths, or wherever there were significant changes in channel characteristics. Parameters assessed included flow, channel condition, in-stream habitat diversity, substrate, riparian and bank conditions. Points of interest, such as log jams or stream crossings, were also noted. Assessment parameters are outlined in Table 22.

Table 22. Parameters and points of interest assessed with the RASCAL protocol

Stream Assessment Items		
Flow	Left bank:	Percent bare bank
Stream habitat type	Riparian zone width	Average bank height
Dominant substrate	Riparian zone cover	Bank stability
Channel condition	Adjacent land use	Bank material
Pool frequency	Livestock access (yes or no)	Comments
Canopy cover	Right bank:	
Embeddedness	Riparian zone width	
In-stream habitat	Riparian zone cover	
Losing flow (yes or no)	Adjacent land use	
	Livestock access (yes or no)	
Points of Interest		
Bank erosion	Drainage ditch	Storm sewer
Beaver dam	Drums/barrels	Stream sink
Boating access	Fence across stream	Stream crossing (animal)
Bridge	Gully minor	Stream crossing (machinery)
Concrete/rock waste	Gully severe	Suspicious activity
Confluence	Manure	Tile outlet
Construction activity	Metal/cars	Trash--other
Culvert	Nick point	Unknown
Dam/barrier	Seep	Wastewater
Dead animal	Sink hole	Other--please describe
Dead fish	Spring	Comments

The RASCAL survey was conducted in the Beaver Creek Watershed by a USFS field crew in late summer through early fall 2010. The stream network was prioritized to provide for a representative sample that had the necessary access for the crew to be most efficient with their time. Over 11 miles were surveyed, which included portions of Carpenter Gulch, Potosi Gulch, White Creek, Pony Gulch and Dudley Creek.

In order to analyze results from the RASCAL survey, the assessed stream segments—or stream management units (SMUs)—were analyzed in GIS. Priority parameters for this analysis included stream habitat condition, canopy cover, stream bank stability and stream bank erosion. These parameters were selected because of their importance to aquatic habitat.

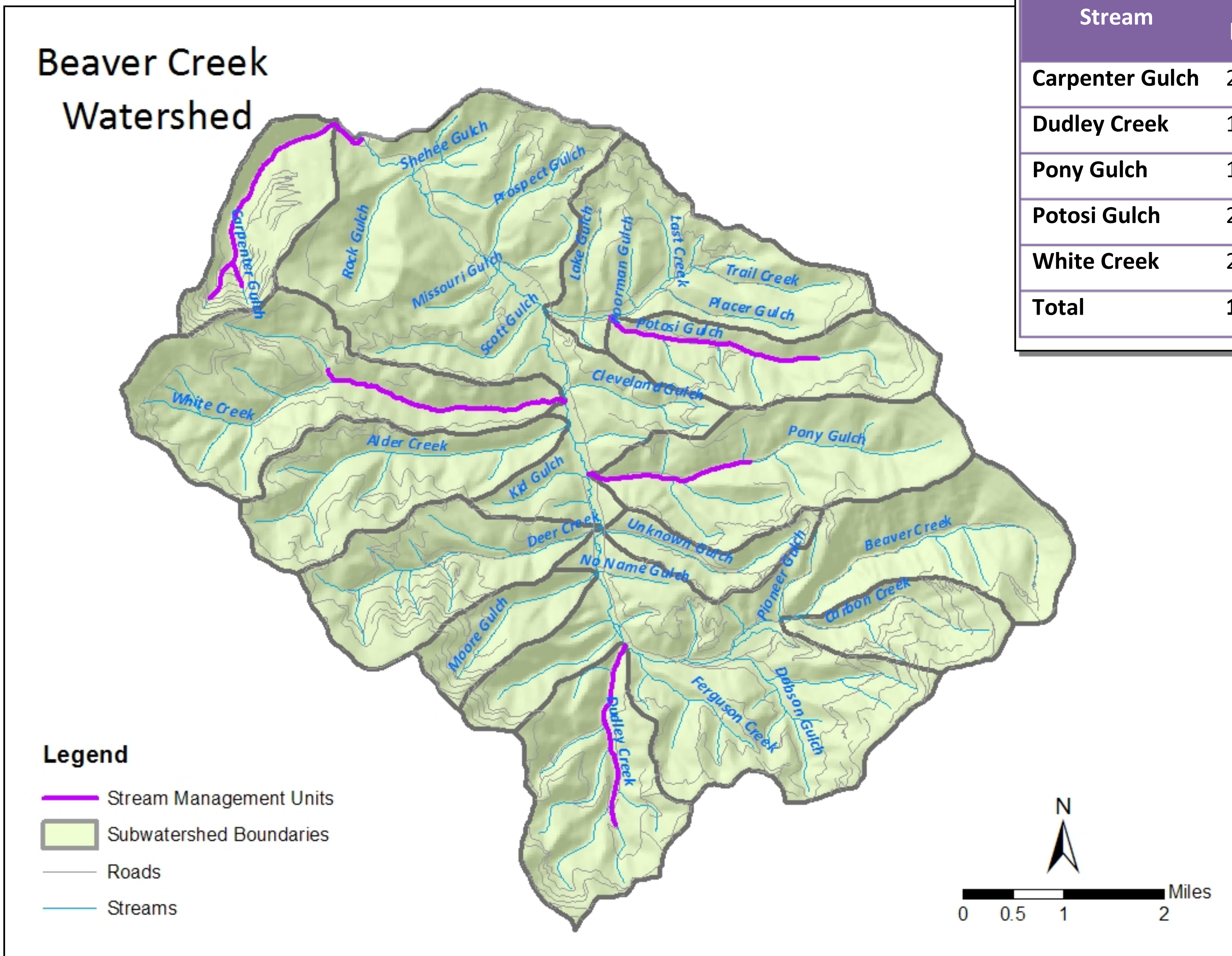
Results

Five sub-drainages within the Beaver Creek Watershed were analyzed with the Rapid Assessment of Stream Conditions Along Length or RASCAL. A total of 11.38 miles were surveyed. Preferably, the entire stream network would be surveyed, but due to a lack of time and in some cases, access, a complete RASCAL survey throughout the entire watershed could not be accomplished. Project partners would like to see this carried out in the future, however. A summary of the streams surveyed can be found in Figure 44.

For purposes of the Beaver Creek Watershed RASCAL survey, only four assessment parameters were analyzed. These were; stream habitat, canopy cover, streambank stability and streambank erosion, as they best represent conditions of concern within the Beaver Creek Watershed. A summary of these four parameters within the entire survey area is provided in Table 23. Results are also summarized for each subdrainage surveyed.

Table 23. Rapid Assessment of Stream Conditions Along Length (RASCAL) summaries for each parameter analyzed in the Beaver Creek Watershed

Survey Parameter	Categories				
Stream Habitat	*Excellent*	*Average*	*Poor*		
stream miles	2.86	7.50	1.02		
	25%	66%	9%		
Streambank Stability	*Stable*	*Minor Erosion*	*Moderate Erosion*	*Severe Erosion*	
stream miles	2.22	5.16	3.52	0.50	
	19%	45%	31%	4%	
Streambank Erosion	*None*	*Random*	*Alternate Banks*	*Both Banks*	
stream miles	1.44	5.85	2.18	1.91	
	13%	51%	19%	17%	
Canopy Cover	*0 – 10%*	*10 – 25%*	*25 – 50%*	*50 – 75%*	*75 – 100%*
stream miles	0.02	0.35	2.98	6.57	1.46
	0%	3%	26%	58%	13%



Stream	Survey length (mi.)
Carpenter Gulch	2.99
Dudley Creek	1.88
Pony Gulch	1.71
Potosi Gulch	2.20
White Creek	2.60
Total	**11.38**

Figure 44. Streams analyzed with the RASCAL protocol

Carpenter Creek

The 3.29 mile Carpenter Creek channel was almost entirely surveyed. The 1.8 mi^2 drainage is completely within National Forest land. Carpenter is a second order stream and is the last tributary that flows into Beaver Creek before draining into the North Fork Coeur d'Alene River. The RASCAL assessment determined Carpenter Creek to have the highest incidence of poor stream habitat of all the channels surveyed. Furthermore, nearly half of the channel had either moderate (40%) or severe erosion (7%) issues.

Table 24. Rapid Assessment of Stream Conditions Along Length (RASCAL) summaries for Carpenter Creek

Survey Parameter	Categories				
Stream Habitat	*Excellent*	*Average*	*Poor*		
stream miles	0.62	1.60	0.77		
	21%	54%	26%		
Streambank Stability	*Stable*	*Minor Erosion*	*Moderate Erosion*	*Severe Erosion*	
stream miles	0.43	1.15	1.20	0.22	
	14%	38%	40%	7%	
Streambank Erosion	*None*	*Random*	*Alternate Banks*	*Both Banks*	
stream miles	0.41	1.08	1.15	0.36	
	14%	36%	38%	12%	
Canopy Cover	*0 – 10%*	*10 – 25%*	*25 – 50%*	*50 – 75%*	*75 – 100%*
stream miles	0.02	0	0.90	1.89	0.18
	1%	0%	30%	63%	6%

Dudley Creek

The mainstem of Dudley Creek was surveyed from the mouth up 1.88 miles. Multiple tributary streams do exist within the 2.9 mi^2 drainage, but were not surveyed. Land ownership is predominately National Forest, but there are some private ownership parcels in the headwaters. Dudley Creek is the southernmost tributary flowing into Beaver Creek. Fifty percent of the stream surveyed showed evidence of excellent stream habitat and over seventy-five percent of the channel had either stable banks (43%) or only minor erosion (34%).

Table 25. Rapid Assessment of Stream Conditions Along Length (RASCAL) summaries for Dudley Creek

Survey Parameter	Categories				
Stream Habitat	*Excellent*	*Average*	*Poor*		
stream miles	0.93	0.83	0.12		
	50%	44%	6%		
Streambank Stability	*Stable*	*Minor Erosion*	*Moderate Erosion*	*Severe Erosion*	
stream miles	0.81	0.64	0.39	0.05	
	43%	34%	21%	3%	
Streambank Erosion	*None*	*Random*	*Alternate Banks*	*Both Banks*	
stream miles	0.37	0.88	0.24	0.40	
	19%	47%	13%	21%	
Canopy Cover	*0 – 10%*	*10 – 25%*	*25 – 50%*	*50 – 75%*	*75 – 100%*
stream miles	0	0.08	0.39	0.80	0.62
	0%	4%	21%	42%	33%

Pony Gulch

The Pony Gulch drainage is 3.6 mi^2 and flows into Beaver Creek as a first order stream. The Pony Gulch stream network has a total of 7.31 miles of channel, although only 1.71 miles were surveyed, beginning at the mouth. Ownership in this drainage is exclusively National Forest land. Eighty-nine percent of the channel surveyed had greater than 50% canopy cover. Furthermore, surveys in Pony Gulch highlighted the highest level of stream bank stability and lowest incidence of stream bank erosion.

Table 26. Rapid Assessment of Stream Conditions Along Length (RASCAL) summaries for Pony Gulch

Survey Parameter	Categories			
Stream Habitat	*Excellent*	*Average*	*Poor*	
stream miles	0.44	1.28	0	
	26%	74%	0%	
Streambank Stability	*Stable*	*Minor Erosion*	*Moderate Erosion*	*Severe Erosion*
stream miles	0.74	0.58	0.32	0.08
	43%	34%	18%	5%
Streambank Erosion	*None*	*Random*	*Alternate Banks*	*Both Banks*
stream miles	0.55	0.74	0.23	0.20

	32%	43%	13%	12%	
Canopy Cover	*0 – 10%*	*10 – 25%*	*25 – 50%*	*50 – 75%*	*75 – 100%*
stream miles	0	0	0.18	1.34	0.20
	0%	0%	10%	78%	11%

Potosi Gulch

Potosi Gulch is a tributary to Trail Creek, which is a major drainage to Beaver Creek. The Potosi Gulch drainage is 2.26 mi^2 and has mixed ownership with both National Forest and private land. The RASCAL survey was completed on 2.20 miles of Potosi Gulch beginning at the confluence with Trail Creek. The assessment highlighted Potosi Gulch having less than a third of the surveyed channel with over 50% canopy cover and 60% with either erosion on alternate banks (19%) or both banks (41%).

Table 27. Rapid Assessment of Stream Conditions Along Length (RASCAL) summaries for Potosi Gulch

Survey Parameter	Categories				
Stream Habitat	*Excellent*	*Average*	*Poor*		
stream miles	0.03	2.04	0.14		
	1%	92%	6%		
Streambank Stability	*Stable*	*Minor Erosion*	*Moderate Erosion*	*Severe Erosion*	
stream miles	0.24	1.04	0.77	0.15	
	11%	47%	35%	7%	
Streambank Erosion	*None*	*Random*	*Alternate Banks*	*Both Banks*	
stream miles	0.11	0.76	0.43	0.91	
	5%	34%	19%	41%	
Canopy Cover	*0 – 10%*	*10 – 25%*	*25 – 50%*	*50 – 75%*	*75 – 100%*
stream miles	0	0.13	0.73	1.06	0.26
	0%	6%	33%	48%	13%

White Creek

White Creek is a large drainage that flows into the lower half of Beaver Creek. It is 4.2 mi^2 and has 8.75 miles of channel within the stream network. The mainstem was surveyed from the confluence with Beaver Creek up 2.60 miles before reaching additional tributaries that flowed into White Creek. The drainage falls almost entirely within National Forest land with the most downstream reaches in private land. White Creek did not display any extreme variations within the RASCAL survey.

Table 28. Rapid Assessment of Stream Conditions Along Length (RASCAL) summaries for White Creek

Survey Parameter	Categories				
Stream Habitat	*Excellent*	*Average*	*Poor*		
stream miles	0.84	1.76	0.00		
	32%	68%	0%		
Streambank Stability	*Stable*	*Minor Erosion*	*Moderate Erosion*	*Severe Erosion*	
stream miles	0	1.76	0.84	0	
	0%	68%	32%	0%	
Streambank Erosion	*None*	*Random*	*Alternate Banks*	*Both Banks*	
stream miles	0	2.40	0.15	0.05	
	0%	92%	6%	2%	
Canopy Cover	*0 – 10%*	*10 – 25%*	*25 – 50%*	*50 – 75%*	*75 – 100%*
stream miles	0	0.15	0.79	1.48	0.18
	0%	6%	30%	57%	7%

Discussion

The RASCAL protocol is an efficient means to collect significant channel condition data in a relatively short amount of time. Through this assessment, parameters that dealt specifically with streambanks and riparian vegetation were analyzed in order to highlight areas that would most benefit from restoration efforts. These included; streambank stability, streambank erosion, canopy cover and habitat condition. Five tributaries of Beaver Creek were assessed, however further data collection is needed to provide a comprehensive analysis of the watershed as a whole.

The most beneficial means of interpreting RASCAL data is to build maps within a GIS to display channel conditions. Often times, channel degradation can be linked to multiple assessment parameters, such as streambank stability and canopy cover. Breaking down the channel into stream management units is an efficient way to prioritize restoration. This process can be seen in the following maps of Dudley Creek.

The Dudley Creek maps in Figure 45 represent channel conditions changing significantly downstream from the white line that intersects the channel. These GIS maps can assist management decisions, whether identifying further assessment needs or allocating resources for restoration work.

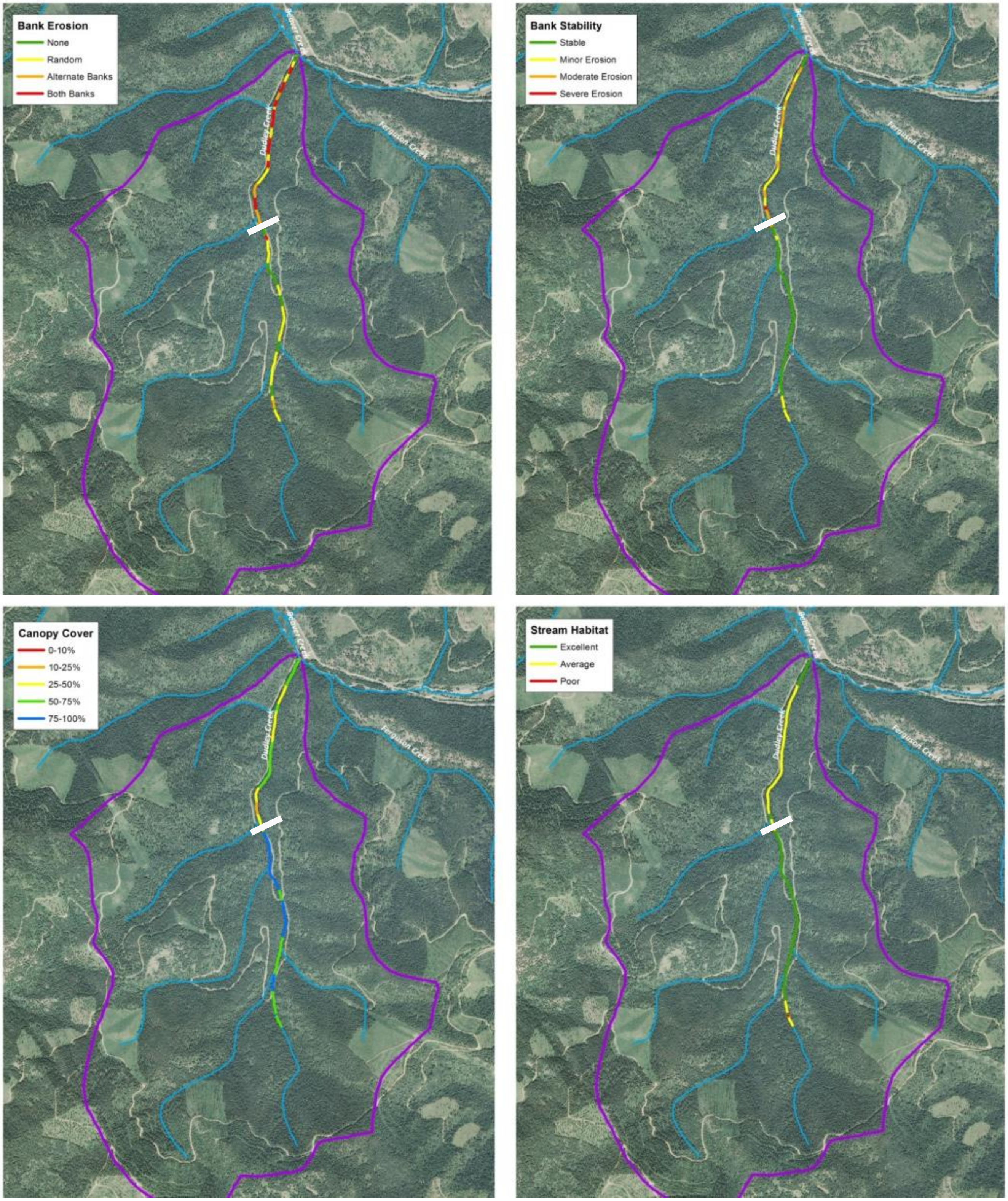


Figure 45. Bank erosion (top left) stability assessments (top right), canopy cover (bottom left) and habitat conditions (bottom right) for Dudley Creek

The RASCAL assessment can also be used to further prioritize assessment needs in a watershed. Utilizing this 'rapid' methodology quickly highlights areas that need further inspection. Data can also be analyzed from a land use perspective by overlaying other data collected (ex. Land use) to aid in determining why channel conditions, such as erosion and stability, are degraded. Maps that include the four assessment parameters; bank erosion and stability, canopy cover and stream habitat for the other watersheds assessed; Carpenter and White Creek, Pony and Potosi Gulch can be found in Appendix G.

An evaluation of the four assessment parameters across all watersheds showed that Dudley Creek was surveyed to have the most favorable channel conditions. It had the highest incidence of excellent stream habitat and was similar to Pony Gulch in terms of a high level of streambank stability. Dudley Creek had 75% of the surveyed channel with at least 50% canopy cover and nearly 20% of the channel showed no streambank erosion. Pony Gulch's channel also had high favorable conditions, with 90% of the channel surveyed with greater than 50% canopy over. No poor stream habitat was surveyed and only 25% of the channel surveyed had erosion on alternating or both banks. White Creek was assessed to have average channel conditions across the board. Finally, Carpenter Creek and Potosi Gulch were surveyed to have the most unfavorable channel conditions. Carpenter Creek had over 25% of the channel surveyed as poor stream habitat and had nearly 50% of the channel with moderate or severe erosion. The Potosi Gulch survey showed low percentages of canopy cover, had the highest incidence of streambank erosion and only had 1% of the channel surveyed with excellent habitat conditions.

Stream Shade and Solar Loading

Methods

Stream temperatures in Beaver Creek and its tributaries are considered too warm to fully support cold water aquatic life during certain times of the year. As such, the streams in the watershed have been listed on the 2010 Idaho 303d/305b Integrated Report as impaired due to temperature. They also flow into the North Fork Coeur d'Alene River, which is listed as impaired due to temperature. For this assessment, available stream temperature data were compiled and evaluated. USFS stream temperature data were collected from data loggers deployed in 2005 and 2007 following Dunham et al. 2005 (Table 29). The data were evaluated and compared to Idaho water quality standards with an emphasis on protection of cutthroat trout.

Table 29. USFS stream temperature monitoring, 2005 and 2007

Year	Streams
2005	Alder, Beaver (lower), Beaver (upper), Deer, Dudley, Pony, Trail, White,
2007	Alder, Beaver (lower), Beaver (upper), Carpenter, Deer, Dudley, Pony (x3), Trail, Unknown Gulch, White

Since the streams in the Beaver Creek Watershed are listed as impaired due to temperature, DEQ must prepare a temperature TMDL to provide a framework and targets for water temperature reduction and attainment of water quality standards. This assessment utilized draft temperature TMDLs and associated analyses to assess riparian shade, channel width and solar loading to streams. Using this information, actions were identified and prioritized to improve riparian shade where needed, reduce solar loading and reduce stream temperatures. The ultimate goal is to meet water quality standards and to fully support thriving fisheries populations.

DEQ prepared draft temperature TMDLs for the North Fork Coeur d'Alene River Subbasin to address stream temperature using an approach called potential natural vegetation (PNV) as described by Shumar and de Varona (2009). This method assumes that excess temperature loads to streams are due to solar radiation as a nonpoint source of pollution, that solar radiation loads have been increased as a result of riparian shade loss from human activities and that maximum shading under potential natural vegetation results in natural background stream temperatures. Estimates are calculated for shade and solar loading under existing and potential conditions in order to establish the temperature TMDL load allocations. Existing shade was estimated from visual evaluation of aerial photographs that were field-verified with Solar Pathfinder data. Potential shade was estimated using USFS vegetation information, bankfull width estimates, and shade curves for various vegetation types, aspects and channel widths. This method evaluates existing effective shade to the streams, potential effective shade and the amount of shade needed to reach potential effective shade and thus, natural background water temperatures. Based on natural background provisions of the Idaho water quality standards (IDAPA 58.01.02.200.09), the shade and solar loading observed at potential natural vegetation provide natural background stream temperature and are the TMDLs' target rather than numeric temperature criteria.

Existing shade conditions can be measured using a Solar Pathfinder, digital photography and Solar Pathfinder Assistant software (Shumar and De Varona 2009). During 2010 BURP sampling on two Beaver Creek sites, ten photographs were taken using the Solar Pathfinder to estimate stream shade over the six months April to September (Figure 46). These can be compared to TMDL estimates for model verification and monitoring changes. Solar Pathfinder shade estimates were also developed from 6 readings in Dudley Creek. 2010 Solar Pathfinder shade estimates were compared to draft TMDL shade estimates and targets.

Figure 46. Solar Pathfinder digital photography from Beaver Creek used to estimate stream shading for a 6-month average from April to September

Canopy closure estimates were also obtained from 6 transects during BURP habitat sampling using a concave spherical densiometer following BURP protocols (DEQ 2007). Canopy closure measures the amount of overhanging vegetation directly over the stream that is visible in the spherical densiometer. An average canopy closure (%) was calculated over the entire site and compared to shade estimates. Canopy closure is related to shade but is not a true shade estimate.

Results

Stream temperature results from 2005 and 2007 USFS monitoring revealed exceedances of Idaho water quality criteria for protection of salmonid spawning. Stream shade conditions were estimated from aerial photographs and compared to models of the vegetation community at natural conditions in the draft temperature TMDLs. Historical forest vegetation composition for IPNF Coeur d'Alene National Forest data were used including white pine, Douglas fir, western larch, western redcedar and other trees. Abundance of white pine has been greatly reduced from historic conditions due to white pine blister rust and present-day forest communities are likely to demonstrate an altered species composition.

The entire mainstem lower Beaver Creek below White Creek was modeled as nonforest group 1 with a desired shade of 41-48% during April through September (Figure 47). Estimated existing shade in lower Beaver Creek below White Creek was 0-60% during April through September (Figure 48). The greatest shade deficit in lower Beaver Creek is found in the 2 miles of stream channel between 1.5 and 3.5 miles upstream from the North Fork Coeur d'Alene River confluence (Figure 49). Vegetation in nonforest group 1 includes a diverse plant community including late successional cedar-hemlock, black cottonwood, mixed conifers and shrubs.

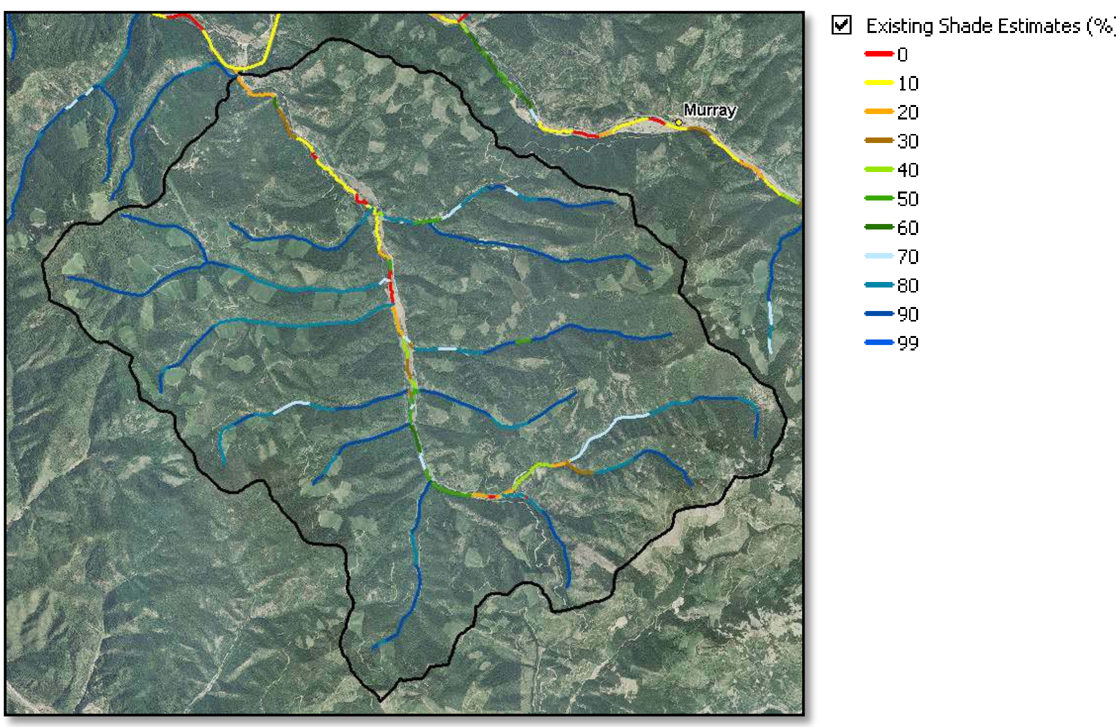


Figure 47. Beaver Creek Watershed Existing Shade Estimates (%)

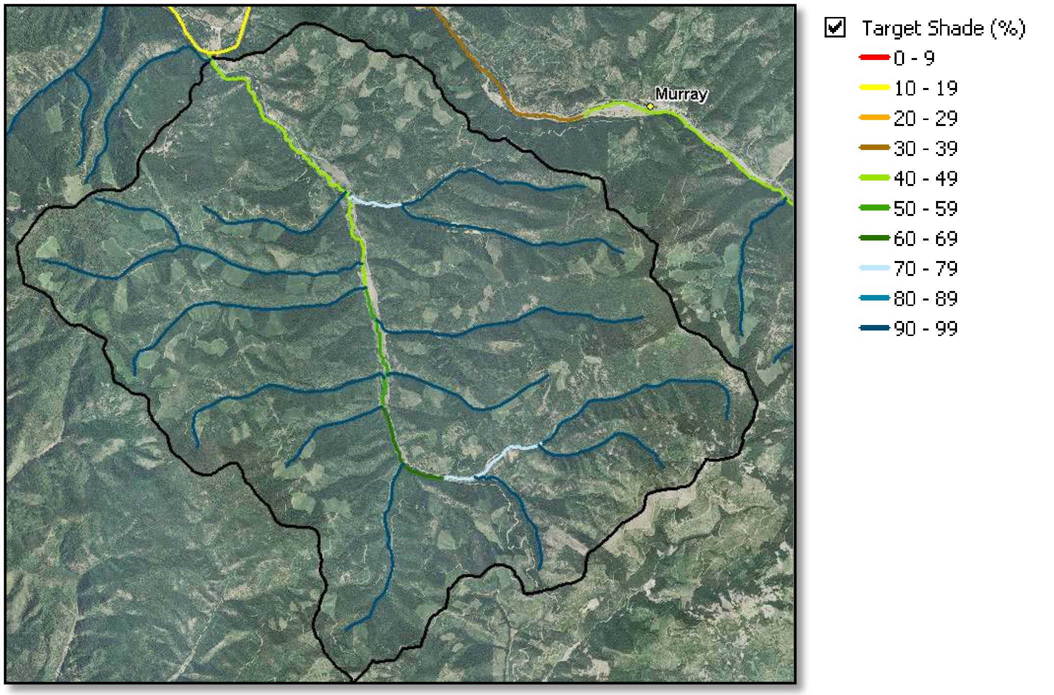


Figure 48. Beaver Creek Watershed TMDL Target Shade Estimates (%)

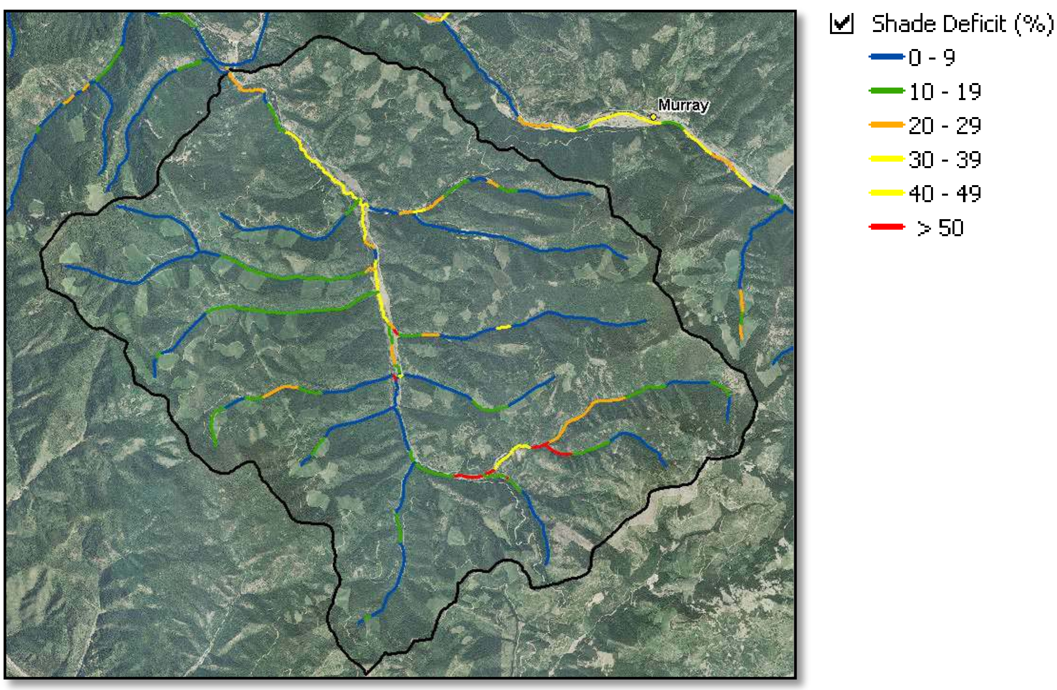


Figure 49. Beaver Creek Watershed TMDL Estimated Shade Deficits (%)

Upper Beaver Creek headwaters and tributaries were modeled as nonforest group 1, forest group B and forest group C and shade conditions were estimated from aerial photographs. The 5 miles of Beaver Creek above White Creek were modeled as nonforest group 1 just like the lower reaches of Beaver

Creek. The lower reaches of Trail Creek were also modeled as nonforest group 1. Desired shade at these channel dimensions was 48-78% during April through September. Existing shade was estimated as 0-80% during April through September and was lowest in sections of the mainstem Beaver Creek. The Beaver Creek headwaters and smaller tributaries were predominantly modeled as forest group B, moist forest sites, usually low to mid elevation, in stream bottoms and adjacent benches and toe slopes. The highest headwater reaches were modeled as forest group C, a group dominated by subalpine fir with white pine, lodgepole pine and other trees. The headwater reaches were much closer to attaining natural shade conditions with deficits of only 8-18%. Shade deficits in middle reaches of Beaver Creek and tributaries were highest in upper Beaver Creek near Dobson Creek and Carbon Creek and in sections of Trail Creek. Estimated shade deficits were up to 98%.

The estimated existing solar loads to Beaver Creek exceeded the target solar loads estimated at potential natural vegetation and natural channel widths (Table 30). Upper Beaver Creek headwaters and tributaries existing solar load is nearly 3 times the estimated target load at natural conditions while lower Beaver Creek below White Creek has an existing solar load nearly twice the estimated target load. Riparian vegetation removal and associated reductions in shade are major factors in excess solar loading. In the Beaver Creek mainstem, channel widening compared to natural conditions has further contributed to excess solar loading and elevated water temperature. Wider, shallower streams with little shade tend to be much warmer than a narrower, deeper channel that is well shaded by vegetation. Temperature TMDL implementation to reduce stream temperatures should focus on activities that narrow the channel and promote shade.

Table 30. Solar load estimates from draft temperature TMDLs

Stream Name	Assessment Unit #	Existing Load (kWh/d)	Target Load at Natural Conditions (kWh/d)	Load Reduction Needed
Beaver Creek headwaters and tributaries	17010301PN003_02	436,783	147,154	66%
Beaver Creek below White Creek	17010301PN003_03	419,095	213,717	49%

Solar Pathfinder shade estimates and canopy closure estimates obtained during 2010 BURP habitat sampling were used to calculate an average over the entire site and compared to shade estimates in the draft TMDLs (Table 31). Though not always the case, in this small example the canopy closure estimates were very close to the existing shade estimates from the draft TMDL. Solar Pathfinder shade estimates from 2010 indicate that the reach of Dudley Creek is currently at 80% and the same as estimated existing shade from the draft TMDL. The Solar Pathfinder shade estimates for the lower Beaver Creek site indicate that measured shade exceeds the estimated existing shade from the draft TMDL, but that the measured shade does not quite reach the TMDL goal. The Solar Pathfinder shade estimates from the upper Beaver Creek site indicate that measured shade exceeds both the estimated existing shade from the draft TMDL and the TMDL shade target. Solar Pathfinder shade estimates matched existing shade estimates from the draft TMDL, confirming the accuracy of those estimates. However, some increased shade would still be needed in this reach of Dudley Creek to attain TMDL goals.

Table 31. Beaver Creek shade estimates from draft TMDLs loading analysis and 2010 Solar Pathfinder measurements for April through September

	Estimated Existing Shade Draft TMDL (%)	2010 Solar Pathfinder Shade Estimate (%)	Shade Target Draft TMDL (%)	2010 Overall Canopy Closure Estimate (%)
Lower Beaver Creek Site	20	36	41	17
Upper Beaver Creek Site	50	71	65	48
Dudley Creek	80	80	97	ND

<u>Discussion</u>

The Solar Pathfinder shade estimates for the lower Beaver Creek site indicate that measured shade exceeds the estimated existing shade from the draft TMDL, but that the measured shade does not quite reach the TMDL goal. Channel width at the lower Beaver Creek site is another important consideration for stream temperature. The estimated natural stream width at the site in the draft TMDL was approximately 12 m while the estimated existing width was estimated at 16 m. During BURP sampling, the average bankfull channel width was 12 m at the site. Further assessment in this 1200 m stream segment is recommended to monitor temperature TMDL implementation progress.

The Solar Pathfinder shade estimates from the upper Beaver Creek site indicate that measured shade exceeds both the estimated existing shade from the draft TMDL and the TMDL shade target. These results indicate that the TMDL targets may have been met in this 1190-m segment of the assessment unit. Further monitoring is recommended to monitor temperature TMDL implementation progress in the assessment unit overall since other segments continue to have more dramatic shade deficits.

Bacteria Analysis

<u>Methods</u>

To protect human health during recreation, there are water quality criteria to limit exposure to human pathogens. A bacterium called *Escherichia coli* (*E. coli*) is used as an “indicator” organism. Its presence in water samples is used to indicate the presence of other harmful human pathogens. *E. coli* naturally occurs in the digestive system of warmblooded animals, and *E. coli* can enter streams from animals or human sources. It can also be present without causing illness.

Water samples are often collected for bacterial analysis during the IDEQ Beneficial Use Reconnaissance Program (BURP) monitoring events. In the North Fork Coeur d'Alene River Subbasin there were 32 samples collected for *E. coli* analysis through the BURP program during 2000 to 2006. Sample results ranged from 0 to 30 *E. coli* per 100 ml water. An additional sampling effort took place during 4th of July weekend in 2000 on the lower mainstem North Fork Coeur d'Alene River. Five samples were collected and all samples contained less than 5 *E. coli* per 100 ml. Altogether, 37 water samples have been collected in the North Fork Coeur d'Alene River Subbasin during 2000 to 2006. Results have ranged from 0 to 30 *E. coli* per 100 ml water, and are well below levels that would threaten human health during recreational exposure. However, none of these samples were taken from the Beaver Creek Watershed.

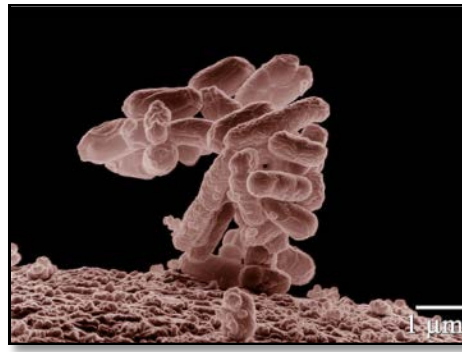


Figure 50. A cluster of E. coli bacteria magnified 10,000 times (Photo: USDA-ARS)

During 2010 BURP sampling events at two sites in Beaver Creek, a water sample from each site was tested by a contract laboratory for total coliform and *E. coli* concentrations.

Results

Escherichia coli concentrations were very low in both samples collected from Beaver Creek in 2010 and were well below Idaho water quality standards (Table 32). Beaver Creek and tributaries are designated for secondary contact recreation like wading and fishing. The applicable water quality standards include a single sample maximum criterion of 576 *E. coli* organisms/100 mL. A water sample exceeding the *E. coli* single sample maxima is not alone a violation of water quality standards. If a single sample exceeds that maximum value, additional samples must be collected. A minimum of five samples must be collected every three to seven days over a 30-day period to calculate a geometric mean which cannot exceed 126 *E. coli* organisms per 100 mL. Results from 2010 Beaver Creek sampling were well below any Idaho water quality standards for protection of human health.

Table 32. 2010 Beaver Creek E. coli concentration

Site	***E. coli*** **(Most Probable Number/100mL)**
Lower Beaver Creek	2
Upper Beaver Creek	< 1

Discussion

Although results from the 2010 Beaver Creek samples had concentrations well below Idaho water quality standards, this analysis was not enough to characterize the entire watershed at all times throughout the year, every year. Further analysis would be required to conclude the level of bacteria impairment in the watershed. However, this assessment found no reason to suspect a bacteria impairment of water quality.

Whirling Disease Evaluation

Methods

The parasite *Myxobolus cerebralis* that causes whirling disease in trout has historically been detected in the North Fork Coeur d'Alene River Subbasin and trout with black tails, a possible indication of whirling disease, have been observed. The true cause of the black tissues is unknown and may be caused by disease or environmental contamination.

Figure 51. Westslope cutthroat trout analyzed for whirling disease (Stromberg)

During electrofishing for 2010 BURP sampling events, three westslope cutthroat trout approximately 65 mm in total length were collected from the lower Beaver Creek BURP site (2010SCDAB002). The fish were tested for the presence of parasite spores using a pepsin-trypsin digestion method by the Idaho Department of Fish and Game (IDFG) Fish Health Laboratory.

Results

Three westslope cutthroat trout approximately 65 mm in total length were collected from the lower Beaver Creek BURP site (2010SCDAB002) during 2010 electrofishing. The fish were tested for the presence of parasite spores using a pepsin-trypsin digestion method by the (IDFG) Fish Health Laboratory. No *M. cerebralis* spores were observed in any of the samples.

Discussion

Due to the small sample size, the results cannot conclude that *M. cerebralis* is not present in the watershed but it is helpful to know these fish did not contain spores. Long-term monitoring of fish health in this watershed is encouraged, and a more sensitive test such as polymerase chain reaction to detect such spores could be used. In addition to evaluating pathogens, fish tissue sampling and metals analysis could help assess the impacts of metals on fish in the watershed, determine the cause of black tissues and assess the safety of ingesting fish from the area.

Chapter 3: Conclusions and Recommendations

Conclusions

Results from the Beaver Creek Watershed Assessment support the need for continued restoration work throughout the watershed in order to improve aquatic resources and to reduce problems for residents and visitors. Issues identified in this study include excessive sedimentation, channel instability and threats to the transportation network due to failing road crossings and flooding. Landowners in this watershed are experiencing loss of land and loss of access because of these problems. Like all watersheds, these issues are as interconnected as are the solutions.

One of the most significant problems in the Beaver Creek Watershed is the management of sediment as it moves throughout the landscape. Historical and current landuse affects the sediment budget in the watershed. Sediment sources include roads, natural resource development and stream channel instability. Deposition of this sediment contributes to flooding concerns through the loss of potential channel volume in aggrading systems. Furthermore, sediment that cannot be processed through the system puts a great deal of stress on encroaching road features such as bridges and culverts.

Although roads are affected by sedimentation in this watershed, they too are contributing to the cause. This assessment estimated nearly 220 tons of sediment entering Beaver Creek each year from those roads surveyed. In addition, potential failures from undersized culverts or misplaced bridges could release over 4,000 tons of sediment into stream channels in catastrophic events.

Additional issues in the watershed include legacy effects from a historic railroad grade that constricts floodplain development and channel movement, leading to instability and sediment deposition. Sections of this railroad grade have been naturally obliterated as Beaver Creek has moved laterally, introducing sediment into the channel, while other sections have continued to restrict lateral migration and likely contributed to downstream bank erosion and scour.

Additionally, habitats for many aquatic species have become compromised from a lack of in-channel woody debris and overall shading from streamside forests. Much of the stream and riparian corridor has been modified to accommodate private land uses, much of which may collectively be contributing to erosion issues, and resulting in poor aquatic habitats as was found in the DEQ BURP surveys.

Finally, the presence of metals in potentially toxic quantities may be further contributing to depressed populations of aquatic invertebrates and fish. The combined effects of all these factors are likely to contribute to long-term instability and depressed biological conditions in Beaver Creek as well as negatively affect human uses throughout the watershed.

Projects already completed in the watershed (described in Appendix C) by private landowners and agencies have had mixed success. They may have made improvements at individual sites, but many have failed and some may even contribute to problems upstream or downstream. To increase success and efficiency of projects, a watershed approach to restoration based on the findings of this assessment is recommended.

The following section outlines recommendations based on the observations made throughout the Beaver Creek Watershed Assessment. These recommendations specifically address riparian areas and stream channels, mining and roads. In addition, outreach and planning recommendations have also been developed in order to build on the work proposed in the watershed.

Recommendations

The following seven recommendations outline the main themes this assessment team feels needs to be addressed in order to restore properly functioning conditions to the Beaver Creek Watershed. No one solution will be able to address the degradation in the watershed. A multi-faceted strategy is recommended and specific recommendations have been included at the end of this report to assist with setting restoration priorities.

1. Share the information—WAG members should learn as much as possible about watershed ecology, BMPs and restoration techniques and share this information with neighbors, colleagues and anyone else with an interest.
2. Work together—Cooperative and coordinated efforts will be most effective to improve the Beaver Creek Watershed.
3. Protect special areas—Protect functional portions of the watershed and unique natural areas.
4. Don't make things worse—Avoid activities that would increase sediment, temperature or metals loads to streams.
5. Address urgent needs— Address sites at high risk of damage to infrastructure, property and natural resources.
6. Shut off the source—Implement watershed improvements with a strategic approach as much as possible to reduce pollutant loads in tributaries.
7. Remove limiting factors—Removing or replacing features that limit watershed function, such as undersized crossing structures, can be a powerful approach to restoration with high cost-benefit ratios.
8. Take a top-down watershed approach—Implement watershed improvements with a strategic approach as much as possible to address watershed conditions from the headwaters downstream to the North Fork Coeur d'Alene River confluence.

Specific recommendations

Social, Education and Planning

- Consider preservation of watershed history and special places when carrying out projects including educational outreach.
- Share informational guides and hold training workshops for topics like riparian vegetation management, permits for instream work, bank and floodplain stabilization techniques, conservation easements, mining BMPs and aquatic organism passage.
- Seek grants and other funding sources to carry out the recommendations of this watershed assessment and conduct cooperative projects with agencies, organizations and landowners.
- Use cost-share agreements when possible to assist willing landowners.

Riparian Buffers and Stream Channels

- Manage riparian buffers to restore and preserve stream and floodplain functions.
    - Maintain minimum vegetated riparian buffers of 25 feet from streambanks (Shoshone County Ordinance #126).

- Maintain state and federally mandated buffers, per the Inland Native Fish Strategy (1995) and Idaho Forest Practices Act. Whenever possible, ideal buffers would include the active and historic floodplain.
  - Development within riparian buffers should use care to minimize water quality impacts and alterations to riparian zones. Encroachments should be removed when possible and a vegetated buffer reestablished.
- Maintain and enhance riparian vegetation.
  - Use native plants when possible and control invasive weeds to promote healthy riparian vegetation that will provide long-term supplies of LWD, shade and habitat values.
  - Use temperature TMDL report to identify locations needing improved shade.
- Manage stormwater and use appropriate BMPs to prevent excessive erosion and sediment loads to streams and to minimize impacts to hydrology and stream function.
- Increase large woody debris (LWD) in mainstem and tributary stream channels where possible and in appropriate frequencies and sizes approximating reference conditions. Increasing LWD should be a key component of watershed restoration in the Beaver Creek Watershed.
- Refrain from removing wood from Beaver Creek and tributaries, unless it poses a substantial risk to human health, infrastructure, property or natural resources. Stabilize key banks and floodplain features to reestablish more natural patterns of stream profile, dimensions and associated stream functions such as sediment transport.
  - Stabilizing banks should generally occur on the outside edges of meander patterns and should consider larger stream patterns and lateral channel migrations. This is likely to be more effective than stabilizing existing banks based on a single site evaluation.
  - Riprap rock installations should carefully follow industry standard BMPs and be completed by trained installers. Riprap stabilization projects seem to fail in the watershed when not properly stabilized at the toe, installed at overly steep angles, lacking a filter layer or using under-sized material.
- Reconstruct stream channels at severely degraded sites. Consider watershed scale and integrated channel reconstruction to improve the likelihood of successful channel and floodplain stabilization. This would aid in at least a partial return to more natural and highly functioning stream conditions that would be less likely to threaten private land and homes and be more likely to result in persistent and viable populations of fish and other organisms. Emphasis for this work should be placed on the lower portion of the Beaver Creek main stem, but work should also be focused on tributaries such as Potosi Gulch and Trail Creek.
- Avoid dredging stream channels as a way of protecting streambanks or infrastructure for the following reasons:
  - The volume of material needed to be removed from upstream areas would likely require annual or near annual dredging throughout the stream. The amount of unstable and easily mobilized material within Beaver Creek would also require wide-spread and likely expensive dredging operations. At the same time, dredging without concurrent channel reconstruction would likely result in lower densities of fisheries and other organisms because it would likely need to be widespread and be done for many years. .

    - Dredging may disturb streambed materials contaminated with harmful concentrations of metals such as lead and zinc and could result in a potentially hazardous release of these substances, causing a human health risk. In addition, material removed from the stream will likely require special transport and containment to ensure these materials do not come into contact with its surrounding environment.
- Restore stream connectivity to improve cold water aquatic life.
    - Due to aggradation of excess sediment in streams, sections of Beaver Creek and tributaries are dry from mid-summer to early fall, reducing habitat available for fish and other organisms and restricting migration. Reducing aggradation, stabilizing floodplains, narrowing and deepening channels through the placement of LWD and other structures designed to mimic natural stream channels (rather than by dredging) would help restore a more natural sediment transport regime, surface water flow and connectivity in streams.
    - Remove or replace stream crossings that are barriers for aquatic organism passage. Brook trout are widely distributed throughout the watershed and can be detrimental to cutthroat trout populations through competition or predation. Fish passage projects should consider effects of brook trout on cutthroat trout with input from USFS and IDFG biologists.
- Allow natural flooding when and wherever possible, discourage channel manipulation related to flood mitigation.
    - Encourage *proactive* floodplain management rather than *reactive* flood fighting. Encourage flooding where possible and design appropriate flooding locations to avoid critical infrastructure while still allowing an appropriate amount of access to floodplain. Allowing Beaver Creek to expand over its banks allows the deposition of critical nutrients into grazing pastures and agricultural areas, and if designed correctly, may actually protect homes and roads rather than threaten them during high flows.
    - Provide information to landowners about the benefits of flooding, as well as reasonable expectations and natural erosion.
- Fully evaluate and address erosion, aggradation and channel movement caused by undersized bridges along the Beaver Creek mainstem. Determine the hydraulic capacity of those bridges and determine if their size and location is influencing Beaver Creek. Develop a long-term plan for maintenance, replacement or removal.
- Evaluate the feasibility of railroad bed removal to reduce effects on stream channels and hydrology.

Mining

- Remediation and restoration of the Ray Carlisle mine and mill site is recommended to reduce metals, sediment and temperature loading along with restoration of stream function. The Ray Carlisle site is an inactive mine located near the confluence of Carbon Creek and Beaver Creek and is privately owned. Following the cleanup of the Idora mine and mill site, it is the only large historic mine and mill site remaining in the watershed and the last remaining large source of metals pollution in the watershed. Sections of the stream in the area are highly aggraded with sediment and dewater seasonally. Reductions in sediment and temperature loading along with channel restoration would be beneficial.

- Stabilize the floodplain of Beaver Creek downstream of Trail Creek in areas historically mined by floating dredge. To be most effective, this stabilization should coincide with treatments to the stream channel near the FR933 Bridge and reductions in sediment loading from Trail Creek and other upstream tributaries.
- Address remaining adits with surface water discharges from historic hardrock mine sites.
- Improve tracking of placer mining activities in the watershed including mechanical and suction dredge mining within existing regulatory framework for federal and private lands.
- Update and streamline the interagency process for mine permitting to improve regulatory compliance, provide better protection for water quality and reduce the burden for mine operators.
- Improve enforcement and ensure that mine operations have required permits and comply with applicable requirements for water quality protection.
- Conduct monitoring and further evaluate the effectiveness of BMPs utilized in mechanical and suction dredge mining for water quality protection, and work with mine operators to implement improved BMPs as needed.
    - Provide updates to the Best Management Practices for Mining in Idaho manual. The current guide was published by IDL in 1992 (IDL 1992).
    - Develop and employ improved reclamation techniques to restore soil conditions in placer mined sites to improve revegetation and hydrology of sites. This could include more use of fine sediment, organic materials and compost or fertilizer during site reclamation.
- Complete a cumulative effects analysis for placer mining in the watershed including mechanical and suction dredge mining to more fully quantify and document effects to water quality in the Beaver Creek Watershed.
- Work cooperatively with willing mine operators on water quality improvement projects including providing possible cost-share.

Roads

The analysis of roads in the Beaver Creek Watershed using the GRAIP model resulted in some general recommendations that apply across the entire watershed. These recommendations include the need for additional research, further inventory and collaborative, multi-resource management strategies for application of best management practices. We suggest a watershed-scale transportation management strategy based on the results of the GRAIP model to successfully reduce the effects of roads and drainage structures on streams and water quality. The following general recommendations are proposed:

Inventory and Data Gaps

- Develop a locally-derived base erosion rate to further refine TMDL analyses, develop sediment budgets, and even more reliably highlight the positive effects of replacing culverts or reconstructing roads.

- Develop discharge estimates specifically for Beaver Creek and tributaries. Discharge estimates are critical for designing adequately sized drainage structures, such as bridges and culverts, yet they are rarely developed at the subwatershed scale and instead are developed at very localized scales, such as for specific culverts. Many bridges and culverts in the Beaver Creek Watershed are undersized for passing the recommended 100 year flow event, and several exhibit signs of erosion and damage from flows that exceed their capacity (example: Forest Road 933 bridge over Beaver Creek). Discharge curves could be developed from a long term flow data collected by the US Forest Service across northern Idaho and be extrapolated to smaller watersheds such as Beaver Creek and its tributaries. Potentially, the flow gage system and site near the mouth of Beaver Creek could be reconstructed.
- Conduct an analysis for bridges and culverts to evaluate the necessity and placement of each structure. A hydraulic analysis for bridges and culverts would determine the flow capacity that crossings are capable of passing as well as their location, design, maintenance, capacity, and flooding risk.
- Complete the travel network inventory. Many roads in the Beaver Creek Watershed were observed during field surveys, although they were not documented in USFS GIS layers.
- Develop a watershed-scale comprehensive Transportation Analysis Process (TAP) for federal forest roads, county roads and willing private landowners to identify the minimum road system needed for safe and efficient travel and for administration, utilization and protection of natural resources, including identification and decommissioning of unneeded roads.
- Examine opportunities for road crossing alternatives such as flood relief culverts, channel realignment and other options.

Management strategies

- Unauthorized use and damage to roads in the watershed should be minimized based on the current USFS Coeur d'Alene River Ranger District Motor Vehicle Use Map (MVUM) through enhanced enforcement using closure notices, gates or other closure devices. (USFS, Subpart B of 36 CFR Part 212). Several roads are managed as 'closed' to motorized vehicles, but in some cases those roads continue to be used by high clearance vehicles. In some cases, the use of roads by those vehicles are the mechanism by which drainage has been compromised, while in other cases, the presence of a 'road' bisecting a hillside, even if unused by vehicles, is capturing hillside flow and rerouting surface water and transporting sediment into streams. In those cases, storm-proofing or full decommissioning is recommended. In cases where vehicles have access (physically, not legally), then reconstruction may be needed.
- For long-term inactive roads (stored roads), ensure that access is blocked and that roads are left in a condition suitable to control erosion by outsloping, water barring and removal or maintenance of crossing structures Idaho Forest Practices Act 040.04.f).
- For decommissioned roads, ensure that access is blocked and that all drainage structures are removed and roadway sections are treated to minimize erosion and landslides. (FPA 040.04.g)
- Develop a comprehensive drainage reconstruction plan, based on the GRAIP information to reduce sediment delivery from roads, reduce the risk of additional sediment from inadequately

sized culverts and restore flow and other watershed processes to attain water quality standards. The GRAIP survey identified specific sections of road contributing sediment to streams and influencing stream flows, and a comprehensive plan, complete with cost estimates, timeframes and priorities, would allow land managers and private land owners to collectively work toward restoring water quality in Beaver Creek.

- Consider realignment of sections of Forest Road 456 that are within the floodplain of Beaver Creek, and that periodically flood or are damaged by high flows. When these sections of road are flooded, they both present an unsafe condition for residents by blocking their access and influence the stream by constricting it and causing streambank and roadside damage; both of which result in environmental and economic costs.
- Use the GRAIP survey information to inform and guide road reconstruction or decommissioning projects. Focus reconstruction on road segments that GRAIP surveys identified as delivering sediment to streams, as well as for culverts and other stream crossing structures that were found to be high-risk to streams.

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Appendices

Appendix A – Identifying Priorities

This summary report is intended to summarize "issues" related to water quality in Beaver Creek that have been raised through agency analyses and public interactions. This summary report does not represent the opinions of the USFS, DEQ or UI. This report does not present analysis on the impacts of these issues or provide conclusions about management recommendations, and it is solely intended to guide the development of analysis questions for the Beaver Creek Watershed Assessment. (9/14/10)

A major issue in the Beaver Creek Watershed is the network of roads that has been developed throughout the watershed. An inventory could determine where the roads are, their status, maintenance, and whether or not they are properly functioning. Possible concerns with these roads across jurisdictions include stream crossings (fish passage), road surfacing, drainage, and erosion impacts. Other road-related concerns may include road use as it relates to travel planning, elevation of roads and their potential risk of flooding and failure, and road constraints to floodplain development. A thorough assessment of this network would help identify and prioritize improvement opportunities.

The Beaver Creek Watershed has a long history of mining that continues today. Mines not properly managed have the potential to cause erosion and water quality degradation. An inventory of all mines would be helpful to evaluate what kind of effects this may have on water quality. For present-day mines, the permitting associated with these projects can be complicated and confusing. For historic and abandoned mines, an inventory of remediation efforts would assist in determining the stage of closure and be very helpful in determining its effect to the watershed. A review of metals contamination and updated assessment could be helpful.

Management of timber in the watershed is an ongoing process led by both private entities and governmental agencies. Multiple landowners with multi-resource objectives have created a diverse forest. Current conditions of these forests, both in upland and riparian areas, could be determined in order to protect those areas sensitive to management and to identify areas threatened by fuels and forest health hazards. Best Management Practices (BMPs) could be identified so that the best science can be applied to forest land management. Land along stream channels is critically important as a proper forest canopy is needed to provide essential shade to the stream and aquatic organisms. Analyzing shade conditions could be included in this assessment.

Many people call the Beaver Creek Watershed home, either seasonally or year-round. Residences, in the form of homes, cabins and recreational vehicles have sprouted along the main channel. With these residences may come issues of water rights and wastewater management. Some properties withdraw from the stream, and this may affect stream flow. Adequate water quality for their water use must also be ensured. Furthermore, poorly managed septic systems and port-a-potties all have the possibility of emitting sewage into the water. In addition, many property owners are concerned about flooding, erosion, and the environmental quality of their properties. Some have taken it upon themselves to stabilize riparian areas. While some of these projects have benefited water quality, others may be failing or causing problems downstream. Good communication with these landowners and a thorough assessment of their properties could build relationships that can be leveraged for cooperative work along Beaver Creek.

Management of utilities is also a concern within the watershed—both for power and telecommunication. With expanding populations and development, further expansion of these services may occur. Cooperation with companies, such as Avista, Verizon and Bonneville Power Administration is crucial. Utility corridors and lines along the stream may become threatened as stream channels meander throughout the landscape, and activities related to utilities management may have effects to water quality.

Many recreation opportunities exist within the watershed, including camping, hiking, berry collecting, hunting, fishing and ATV trail riding. Taking stock of these opportunities could ensure that they are available and managed properly to prevent water quality degradation

Although agriculture does not play a dominant role in the Beaver Creek Watershed, some agricultural land use occurs in the watershed. This includes pasture and grazing along the stream network. A survey of grazing in the watershed, including any grazing allotments, would help estimate the effects of this practice on riparian stability and water quality.

Appendix B – Water Quality Status History

Beaver Creek from its headwaters to the North Fork Coeur d'Alene River (then called the Coeur d'Alene) was listed in the 1992 Idaho Water Quality Status Report in 'Appendix D Idaho Impaired Stream Segments Requiring Further Assessment'. An evaluation by DEQ determined that cold water biota and salmonid spawning were partially supported beneficial uses in Beaver Creek and that primary and secondary contact recreation were supported but threatened beneficial uses. Pollutants listed were nutrients, pH, siltation/sedimentation, thermal modifications, other habitat alterations, unknown toxicity, and metals. Sources of pollutants identified included forest practices (harvesting, reforestation, residue management, and road construction/maintenance), urban runoff (storm sewers and surface runoff), resource extraction/exploration/development (surface mining, subsurface mining, placer mining, dredge mining, mill tailing, and mine tailings), land disposal (landfills), hydrologic/habitat modification (channelization and removal of riparian vegetation), and other (waste storage/storage tank leaks, highway maintenance and runoff, and in-place contaminants) (DEQ 1992).

At the time, the State of Idaho considered waters in 'Appendix D' separate from the 303(d) list of impaired waters. Later, the 1992 305(b) 'Appendix D' evaluations and Forest Service information were used as the basis for including Beaver Creek in the 303(d) list promulgated by the Environmental Protection Agency (EPA) in 1994 (EPA 1994). The 1994 303(d) List of Water Quality Limited Waterbodies for the State of Idaho promulgated by EPA included Beaver Creek as impaired due to sediment. Beaver Creek was also included in the 1996 303(d) list and 1998 303(d) list of impaired waterbodies due to sediment (DEQ 1996, DEQ 1998).

The 2001 Subbasin Assessment and TMDLs of the North Fork Coeur d'Alene River reviewed available data at that time. The assessment concluded that Beaver Creek was not impaired by sediment and that the impairment to cold water aquatic life was instead caused by metals (DEQ 2001). By 2002, the Beaver Creek stream network was split into two assessment units. One unit consisted of upper Beaver Creek and tributaries while the other included just the mainstem Beaver Creek below White Creek. In 2002, upper Beaver Creek and tributaries was listed on the 303(d) list as impaired by cadmium, metals, and zinc, and lower Beaver Creek was listed on the 303(d) list as impaired due to temperature and sediment (DEQ 2002c). In 2008, both segments of Beaver Creek were listed in category 4a as impaired by sediment, but covered by the 2001 sediment TMDLs. Upper Beaver Creek and tributaries was further identified as impaired due to temperature, cadmium, and zinc while lower Beaver Creek was identified as impaired due to temperature, cadmium, lead and zinc (DEQ 2008).

The 2010 Idaho Integrated Report listed upper Beaver Creek and tributaries as impaired due to sediment, temperature, cadmium, zinc (DEQ 2010). Lower Beaver Creek is listed as impaired due to sediment, temperature, cadmium, lead, zinc.

Table B.1. Water Quality Status History for Upper Beaver Creek and tributaries

Stream Name	Beaver Creek (Upper Beaver Creek and tributaries)
Assessment Unit (AU) #	ID17010301PN003_02
Listing History	1992 305(b) Report: Beaver Creek was originally listed in Appendix D, Idaho Impaired Stream Segments Requiring Further Assessment. At the time, evaluation of data by DEQ indicated partial support of CWAL and SS due to siltation/sedimentation, nutrients, pH, thermal modification, other habitat alterations, unknown toxicity, and metals. 1994 303(d) List: Beaver Creek impaired due to sediment. 1996 303(d) List: Beaver Creek impaired due to sediment. 1998 303(d) List: Beaver Creek impaired due to sediment. 2002 Integrated Report: Upper Beaver Creek and tributaries impaired due to cadmium, metals, and zinc. 2008 Integrated Report: Upper Beaver Creek and tributaries impaired due to sediment, temperature, cadmium and metals. Draft 2010 Integrated Report: Upper Beaver Creek and tributaries not fully supporting CWAL and SS due to sediment, temperature, cadmium and zinc.

Table B.2. Water Quality Status History for Lower Beaver Creek, below White Creek

Stream Name	Beaver Creek (Lower Beaver Creek, below White Creek)
Assessment Unit (AU) #	ID17010301PN003_02
Listing History	1992 305(b) Report: Beaver Creek was originally listed in Appendix D, Idaho Impaired Stream Segments Requiring Further Assessment. At the time, evaluation of data by DEQ indicated partial support of CWAL and SS due to siltation/sedimentation, nutrients, pH, thermal modification, other habitat alterations, unknown toxicity, and metals. 1994 303(d) List: Beaver Creek impaired due to sediment. 1996 303(d) List: Beaver Creek impaired due to sediment. 1998 303(d) List: Beaver Creek impaired due to sediment. 2002 Integrated Report: Lower Beaver Creek, below White Creek, impaired due to temperature and sediment. 2008 Integrated Report: Lower Beaver Creek, below White Creek, impaired due to sediment, temperature, cadmium, lead and zinc. Draft 2010 Integrated Report: Beaver Creek below White Creek not fully supporting CWAL and SS due to sediment, temperature, cadmium, lead and zinc.

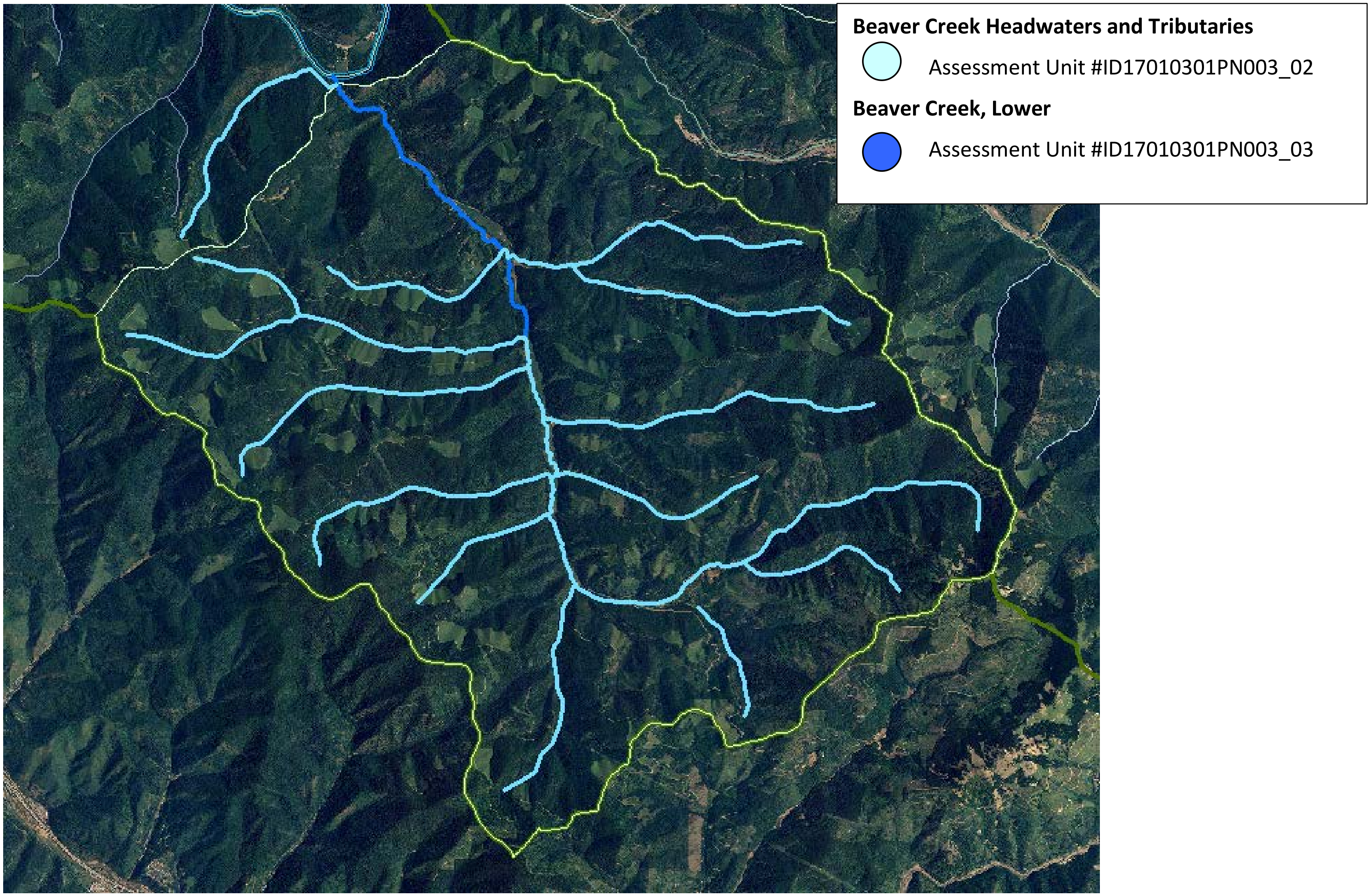


Figure B.1. History of Water Quality Listing Status for Beaver Creek Streams (1988-2010)

Appendix C – Restoration Projects Completed in the Beaver Creek Watershed

Many projects have already been carried out to address watershed conditions and the issues identified in Appendix A. Projects have been completed on public and private land by a combination of landowners, government agencies, and others. Currently, there is no complete list of projects, but a selection of known projects is included here with photographs were available.

Idora Mine and Mill Site Remediation

When: 2011-2012

Where: Beaver Creek

Who: DEQ with USFS, and BLM

The Idora Mine and Mill Site is located near the headwaters of Beaver Creek. It began operation in the early twentieth century and operated into the 1950s when many of the mines of the area ceased operations. Mill tailings were deposited in the floodplain of Beaver Creek, often behind plank dams, during the operation. Some of these tailings were subsequently eroded and deposited downstream.

Mine wastes at the mill site and those deposited downstream presented potential human health impacts to site users related to lead and caused water quality impacts to Beaver Creek related to zinc and cadmium. The remediation project in 2011-2012 was a non-time-critical removal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). DEQ, USFS, and BLM partnered to address the site across varied ownerships. The project excavated, removed and compacted approximately 8,800 cubic yards of tailings and contaminated sediment deposits to Prichard Repository. Clean soil was used to cap (create a soil barrier over) some removal areas. Capped areas were re-vegetated. Beaver Creek was stabilized as practicable through the removal area. After work was completed on the removal area, those sections of the road subject to erosion by Beaver Creek were removed.

Stream Channel Realignment Project at Scott Creek Bridge (FR 933)

When: Fall 2012

Where: Beaver Creek

Who: Shoshone County

During fall 2012, Shoshone County led a project to realign the Beaver Creek stream channel upstream of the Scott Creek Bridge (FR 933). The project included coordination with nearby private landowners, DEQ, USFS, and permitting agencies. The bridge is undersized and this contributes to excessive aggradation of bedload upstream of the bridge. As sediments were deposited upstream of the bridge, the channel began to migrate until it finally approached the bridge at a nearly 90 degree angle. During January 2011, these conditions combined with floodwaters to erode the banks and bridge footings and the bridge had to be closed for safety concerns. During this same time period, the stream flooded over FR 933, eroded portions of the road, and made passage difficult for local residents. The channel migration also eroded a large portion of private property just upstream of the bridge and there were concerns that the channel would eventually breach the road and create a new channel on the other side of the valley, which would also damage additional properties as well as cause significant environmental damage.

Figure C.1. Before—A combination of factors led to flood damage of the bridge and road closure during 2011.

Figure C.2. Before—Aggradation of sediment in the Beaver Creek stream channel just upstream of the bridge (FR 933) contributed to channel migration and a 90 angle of entry at the bridge, May 10, 2011.

Shoshone County led a project to realign the stream channel at the bridge site. They coordinated with USFS, DEQ, and permitting agencies to develop plans and obtain the necessary permits. The project involved excavation and redistribution of approximately 3,250 cubic yards of alluvial gravel upstream of the bridge. The original channel configuration and alignment was restored to the approximate condition when the bridge was installed (1985). Two rock barbs and numerous large logs (woody debris) were installed along the streambanks and within the floodplain to provide grade control, reduce floodplain erosion, prevent migration of the creek thalweg, and provide stable conditions for the propagation of woody riparian vegetation. These structures/installations are intended to help direct the water flow toward the bridge opening and to resist channel erosion and down cutting of the floodplain. Rock barb structures were installed adjacent to the proposed channel area immediately upstream from the bridge to provide streambed stabilization and prevent channel migration and erosion of the bridge approach toe of slope. Construction was completed in fall 2012.

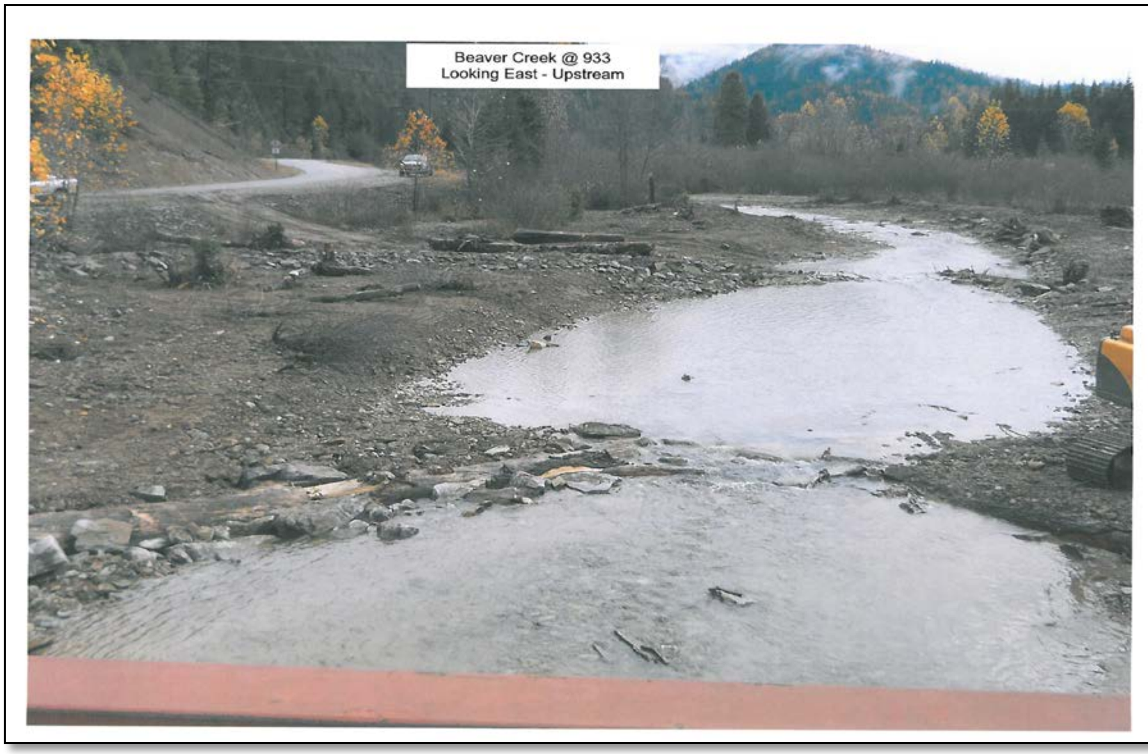


Figure C.3. After—Beaver Creek with channel realignment, Nov 2012. Photo: Shoshone County Public Works.

<u>Stream Channel Realignment Project near Unknown Gulch</u>

When: 2011-2012

Where: Beaver Creek

Who: Shoshone County with ACOE and private landowner

Aggradation and channel instability in this area has been causing concerns for natural resources, property values, and transportation on the main Beaver Creek Road (FR 456). A migrating headcut was causing additional damage to habitat and water quality as well as headaches for property owners. Most of the land nearby is privately owned. In one section of the valley, the stream channel elevation is nearly level with the flat valley and the road. Under high flow conditions, the stream could flood over the road and disrupt travel on this important road. During one of these events in 2011, Army Corps of Engineers assistance was called in to provide emergency actions and prevent flood damage. A vulnerable utility line was stabilized and berms constructed of streambed material were constructed to divert the stream channel to the other side of the valley and away from the road. This action temporarily prevented flooding of the road, but additional work was needed in 2012 to approximate the desired channel conditions. Shoshone County performed this construction in fall 2012.

Figure C.4. Before—Aggradation and channel instability across a flat valley posed flood risks to this part of the Beaver Creek Road, April 2011.

Stream Channel Management Project at Carpenter Creek Bridge (FR 2361)

When: 2011

Where: Beaver Creek

Who: Shoshone County

During 2011, Shoshone County led a project to manage the Beaver Creek stream channel upstream of the bridge over Beaver Creek at FR 2361. The project included coordination with DEQ, USFS, and permitting agencies. The bridge is undersized and this contributes to excessive aggradation of bedload upstream of the bridge. As sediments were deposited upstream of the bridge, the channel began to migrate and erode banks until large trees were undercut enough to fall into the channel just upstream of the bridge. Originally, the trees were thought to be large enough to be stable in the channel and pose no threat to the infrastructure. However, a field evaluation later found that at least one of the trees had been cut into sections that could be moved during high flows and contribute to a blockage of the undersized bridge downstream. In order to protect the bridge and access to a landowners property, Shoshone County led a project to remove some of the trees from the channel thought to pose a hazard.

The channel migration also eroded a portion of private property just upstream of the bridge and there were concerns that the channel would continue to erode this land and damage the road. To protect the outside meander from erosion and continued instability, a small rock barb was placed along with some large woody debris secured into the bank. The project had mixed success. The structures were not as stable as hoped and further plans were being developed to improve this site. During this assessment, we have also noted erosion of the bridge footings at the site and have suggested further evaluations of the bridge itself.

Stream Channel Management and Bank Stabilization on Dobson Creek

When: 2011

Where: Dobson Creek

Who: Shoshone County with private landowners

A section of Dobson Creek runs along the Carbon Center Road before turning 90 degrees and passing through a culvert and downstream across private property to Beaver Creek. Several times in recent years, this site has plugged or failed and floodwaters have eroded the channel and road surface. This causes water quality problems as well as maintenance costs. In addition to these problems, the channel between the culvert and Beaver Creek shows erosion on several bends. The landowners were concerned about this erosion and partnered with Shoshone County to install log structures to stabilize eroding banks near the culvert. Shoshone County also cleaned out the section of stream along the road which is now functioning more like a ditch. Ideally, a realignment of Dobson Creek could help solve these ongoing problems along with providing a larger structure for the stream crossing. The work was completed in 2011 and appeared stable during 2012.

Stream Channel Reconstruction and Flood Prevention at Carbon Center Bridge

When: 2007

Where: Beaver Creek downstream of Carbon Center Bridge

Who: Shoshone County

The reach of Beaver Creek just below the Carbon Center Bridge was highly aggraded and the channel was full of sediment until the channel was nearly flat and the elevation was nearly level with the adjacent floodplain and nearby road (FR 456). This contributed to flooding of the road and disruption of travel on the main road. The channel's aquatic habitat was very poor quality and often dewatered during low flow conditions. During fall 2007, Shoshone County constructed a series of rock barbs in a berm to focus the stream's flow and direct the channel away from the road. The berm and barbs performed this function during high water in 2008, the channel downcut to create a single channel that maintains more water during low flow, and fine sediments have since collected behind the barbs and support the growth of vegetation where formerly there was none.

Figure C.5. Before—Beaver Creek aggraded channel (Oct 2007).

Figure C.6. After—Beaver Creek after barbs construction (May 2008).

<u>Placer Creek Culvert Replacement Project</u>

When: 2012

Where: Placer Creek

Who: Shoshone County

An aging culvert in a log crib structure failed on Placer Creek during January 2011 under the Kings Pass Rd. Along with disrupting traffic, the failure took with it tons of sediment into the stream from fill under the road. The culvert was replaced by Shoshone County in 2012.

Figure C. 7. (Left) Before—Failure of Placer Creek culvert at Kings Pass Road, (Right) Placer Creek culvert following replacement

Potosi Creek Culvert Failure Temporary Maintenance

When: 2011

Where: Potosi Creek

Who: Shoshone County

An aging culvert failed on Potosi Creek during January 2011 under the Kings Pass Rd. Along with disrupting traffic, the failure took with it tons of sediment into the stream from fill under the road. The culvert has not yet been replaced. Instead the road bed was stabilized enough to allow one lane of traffic to pass over the crossing. The crossing remains vulnerable for further failure.

Figure C. 8. Before—Potosi Gulch culvert failure site before maintenance opened up a lane for traffic.

Unknown Gulch Culvert Removal Project

When: 2011

Where: Unknown Gulch

Who: Shoshone County with DEQ and private landowner

A failing culvert on Unknown Gulch, a tributary to Beaver Creek, was a fish passage barrier, a water quality problem, and a risk to the downstream Beaver Creek Road. The culvert was removed through partnership with the private landowner, Shoshone County, DEQ, and USFS (who manage the watershed upstream) in 2011. The County road crew removed the failing culvert, stabilized the grade, and installed a small rock ford. During spring runoff 2012, the stream channel and structures were stable, water quality is improved, aquatic organism passage is improved, and risks to the downstream infrastructure are reduced.

Figure C. 9. Before—Unknown Gulch failing culvert (April 2011).

Figure C. 10. After—Unknown Gulch after culvert removal (May 2011).

Private Lands Bank Stabilization

Sites 1 & 2 Beaver Creek, Deer Creek and White Creek

When: 2008-2012

Where: Beaver Creek, Deer Creek and White Creek

Who: Private landowners, Kootenai-Shoshone Soil and Water Conservation District, and other partners

In the middle reaches of Beaver Creek, the stream winds through pastureland, forests, and wetlands. In several areas, landowners are concerned about aggradation in the stream, instability of the channel, widening of the channel, and erosion that causes loss of property and trees. Landowners are also concerned about the impacts of these conditions to water quality and habitat for fish and wildlife. To deal with these issues, several landowners have completed bank stabilization on their own and in partnership with agencies including NRCS and Conservation Districts. Most of the projects have included a combination of riprap with willow bundles planting. Cabled tree revetments were also used. Success has been mixed and frequently depended on the construction techniques and design features. Landowners have employed a phased approach addressing problem sites one or a few at a time, and it's been recognized that a watershed approach to restoration would greatly help facilitate more success for private landowners along the mainstem.

Site 3 Phase 1 Beaver Creek

When: 2010

Where: Beaver Creek

Who: Private landowners with DEQ, Benewah SWCD, and partners

The landowners at this site were concerned about bank erosion, channel aggradation, channel instability, fish habitat and loss of trees on their property. An evaluation of the site noted the following resource concerns: surface water degraded by excessive sediment and channel instability, native plant communities inadequate to support riparian function, surface water temperature increased from channel alterations and loss of vegetative shade, and aquatic habitat lacked complexity and cover. The site is a recreational lot of 2.94 acres with approximately 320 feet of streambank, including both banks.

To improve water quality and aquatic habitat at the site, the landowner partnered with DEQ and the Benewah Soil and Water Conservation District with funding from the Idaho Governor's Office of Species Conservation. Idaho Soil and Water Conservation Commission staff provided design and technical assistance. More than 3,500 willow cuttings were planted along the streambed in 2010. A further 30 western red cedar and 10 grand fir tree seedlings along with 10 each snowberry, red osier dogwood, Douglas spirea, and woods rose shrubs were planted in the riparian area along the stream. Four large willow clumps were moved to an area that would benefit from improved vegetative protection. The disturbed area along the stream bank was seeded and mulched.

The project's success was limited. Most of the willow plantings were destroyed and many of the plantings did not survive. Channel instability and erosion continued to be a problem on the site.

Site 3 Phase 2 Beaver Creek

When: 2012

Where: Beaver Creek

Who: Private landowners with Idaho Soil and Water Conservation Commission

Due to the continued channel instability and erosion at this site, the landowners desired additional work in a phase 2. Idaho Soil and Water Conservation Commission staff provided design and technical assistance. A series of rock barbs combined with rock and willow plantings were constructed in 2012 to provide additional stabilization and improve stream conditions.

Figure C. 11. After—A series of rock barbs with willow plantings were constructed in Beaver Creek at Site 3, Phase 2 in 2012.

Site 4 Beaver Creek

The landowners at this site were concerned about erosion and loss of trees on their property. An evaluation of the site noted the following resource concerns: surface water degraded by excessive sediment and channel instability, native plant communities inadequate to support riparian function, surface water temperature increased from channel alterations and loss of vegetative shade, and aquatic habitat lacked complexity and cover. The site is a recreational lot of 5.28 acres with approximately 360 feet of streambank, including both banks.

To improve water quality and aquatic habitat at the site, the landowner partnered with DEQ and the Benewah Soil and Water Conservation District with funding from the Idaho Governor's Office of Species Conservation. Plantings were combined with the development of a single hardened access in 2010. Along Beaver Creek, 900 willow cuttings were planted, including willow bundles buried using an excavator. An additional 200 western red cedar, 50 grand fir, 50 larch and 200 western white pine tree seedlings along with 20 each chokecherry, mountain ash, elderberry, service berry and syringa shrubs were planted in the riparian area. A set of large stones were placed to provide a single, hardened stream access for the landowners and to reduce erosion caused by bank trampling.

The project's success was limited. The large stone steps were washed away, many of the willow plantings were destroyed, and many of the plantings did not survive. However, some of the willow plantings and floodplain plantings were successful and continue to grow. Additional work is needed to further improve conditions on the site.

Site 5 Beaver Creek confluence with NFCDA

Landowners were concerned about bank erosion, loss of property, and undercutting trees at the confluence of Beaver Creek and the North Fork Coeur d'Alene River. They partnered with Kootenai-Shoshone Soil and Water Conservation District to cable some logs and root wads against the existing bank and riparian trees to provide protection from erosion. The project was small in scale and appeared to be successful in slowing erosion at the site.

<u>Shoshone County Bank Stabilization for Road Maintenance</u>

When: Multiple sites and years

Where: Beaver Creek

Who: Shoshone County

Most of FR 456 is within the Beaver Creek floodplain and there are multiple locations where the road is directly adjacent to the stream channel. At some of these sites, Shoshone County has completed bank stabilization or riprap protection of the road. There are 5-10 important sites of this kind affecting stream and road including some of the examples below.

Figure C. 12. Roadside maintenance area along Beaver Creek, April 2010.

Figure C. 13. Roadside maintenance area on Beaver Creek, April 2011.

USFS Restoration Projects

There have been multiple restoration projects carried out by the USFS over the past several decades to decommission roads, treat problem crossings, and improve stream conditions. Extensive work of this kind was completed in Carpenter Creek, Deer Creek, and other tributaries.

Figure C. 14. An example of instream habitat improvements completed by USFS in Carpenter Creek.

Appendix D – Drain Feature Definitions and Maintenance or Replacement Attributes

Table D.1. Drain feature definitions

Drain Type	Definition
Broad based dip	A broad based dip is a large grade reversal in the road either designed into the road grade or that is there as a result of two hillslopes meeting.
Diffuse drain	Diffuse drainage describes a type of road which does not concentrate flow. Examples of this situation are the classic outsloped road and the crowned road with a ditch (there are two flow paths in this case—the ditch and diffuse). Water does not exit the road in a ditch or concentrated flow path, but in a series of small minor flow paths that run directly off of the road.
Ditch relief	A ditch relief culvert drains water from the inboard ditch under the road onto the hillslope. These culverts drain water from the road and cutslope, not from a continuous channel.
Excavated stream crossing	This is a stream crossing on a decommissioned road where the crossing culvert and fill have been removed. The fill is usually pulled back to create a more natural stream bank.
Lead off ditch	A ditch that moves flow from the roadside ditch and leads it onto the hillslope. This feature is also known in some areas as a daylight ditch, or a mitre drain.
Non engineered	This type of feature describes a situation where the water leaves the ditch or road in an unplanned manner. This can occur where the ditch becomes dammed by debris or where a rut diverts over the fillslope. Water flowing against a berm may erode through and escape over the hillslope to create a non-engineered drainage.
Stream crossing	A stream crossing occurs when an established stream channel that has flow for at least part of most years crosses the road. These features may drain water from the road and cutslope, but their primary purpose is to route water flowing down the hillslope in stream channels under the road.
Sump	A sump is defined as a closed depression where water is intentionally sent to infiltrate. These can occur where two roads join, or where the ground is very flat and little water accumulates. A sump is generally a designed feature in the roadway intentionally used to route water with no outlet such as a holding pond. A sump can also be any place where water enters and does not escape, such as a very flat section of road where water ponds and puddles on the surface.
Water bar	A water bar is a water diversion feature cut into the road surface with a grader blade or other equipment. They are smaller than broad based dips. Water bars are typically 5-10 feet in road length and 1 to 4 feet deep. Fabricated water bars are usually wooden or rubber flow diversions across the road used to channel water to the ditch or hillslope.

Table D.2. Attributes used for each drain feature in the GRAIP model to determine maintenance or replacement

Drain Type	Attribute Requiring Regular Maintenance	Attribute Requiring Substantial Replacement
Broad based dip	*condit* = puddles on road, wetland in ditch, saturated fill, does not drain	*obstruction*= abundant
Diffuse drain	stream_con = yes	NA
Ditch relief	*condit* = 20-80%, 80-100%, buried, flows around pipe, partially crushed	those requiring maintanence, plus *flow_diver* = yes
Excavated stream crossing	*condit* = erosion, flows under fill	NA
Lead off ditch	*condit* = excess deposition, gullied	NA
Non engineered	*condit* = blocked ditch, broken berm, diverted flowpath, gully crosses road and *fill_eros* > 0	same as those requiring maintenance
Stream crossing	*condit* = flows around pipe, partially blocked, totally blocked, rusted significantly	*SBI* = 3 or 4
Sump	*condit* = fill saturation	same as requiring maintenance
Water bar	*condit* = damage or too small, *obstruct* = abundant, fill eros > 0	NA

Appendix E – Sediment Produced and Delivered from Surveyed Roads in Beaver Creek Subwatersheds

Table E.1. Sediment produced and delivered from roads surveyed within each Beaver Creek subwatershed

Subwatershed and road number (from GRAIP)	Amount of sediment produce by each road (Tons)	Amount of sediment delivered from each road (Tons)
Alder	**101.01**	**1.83**
1586	65.31	1.52
1586 OH	3.23	0.00
1586C	0.09	0.00
1586UN	8.88	0.30
1586UN-unk	0.73	0.00
1586UO	1.89	0.00
424	10.62	0.00
6536	4.54	0.00
6537	0.37	0.00
957	3.22	0.00
BPA service ROAD	0.91	0.00
rd unknown	1.04	0.00
unknown side road	0.18	0.00
Carbon	**75.51**	**14.57**
456UAZ	19.95	0.86
CZ262UL	33.44	5.97
CZ262UNK	1.13	0.00
CZ262UNKB	20.99	7.75
Carpenter	**98.22**	**4.45**
2361	26.39	0.91
2361UA	5.49	1.49
2361UN	6.46	0.00
2361UO	4.88	0.00
3261	0.78	0.00
4x4 trial	1.95	0.00
6631	14.31	2.05
933	13.15	0.00
933G	0.87	0.00
CarpenterLoggingRd	23.95	0.00
Deer	**281.26**	**10.02**
1586	52.42	5.18
1586A	4.22	0.00
1586AUA	26.44	3.13

1586AUA _UNK	0.55	0.00
1586AUA-UNK	0.91	0.00
1586AUB	5.36	0.00
1586B	17.46	0.00
1586BUB	0.05	0.00
1586C	0.45	0.00
1586UD-UNK	2.13	0.00
1586UE	12.07	0.00
1586UH	0.67	0.67
1586UJ	23.96	0.55
1586uk	0.85	0.49
1586UN-b	0.55	0.00
2322	2.18	0.00
424	31.10	0.00
424UI	16.64	0.00
424UJ	7.74	0.00
424uk	11.16	0.00
6536	2.96	0.00
6536A	1.97	0.00
7008	58.89	0.00
BPA service rd[1586]	0.52	0.00
Dudley	**231.88**	**17.33**
1588	3.74	0.00
1588UBd	9.14	0.00
1588UC	5.14	0.00
2322	4.18	0.00
271	57.71	6.91
271C	0.74	0.00
271D	4.27	0.00
271HIR	19.26	1.68
271UA	23.53	3.11
271UA-UNK	0.30	0.00
424	43.94	3.35
424UNK	1.83	0.00
429	12.84	1.43
712	3.47	0.86
953	35.24	0.00
pioneered 4x4	6.53	0.00
Lower Beaver	**347.30**	**32.67**
1505	9.67	0.00
1505A	4.35	0.00
1505B	30.91	8.71

1505BUB	1.16	0.00
1505C	6.28	0.00
1505UC	0.43	0.00
2361	4.48	1.04
3261	0.78	0.00
456Unk	4.39	0.00
4x4 trial	0.55	0.00
605C	0.07	0.00
6536	0.09	0.00
6536A	4.83	0.00
6541	99.97	10.67
6541B	7.92	0.00
6541B UNK	13.11	0.00
6641	4.69	0.00
933	79.32	11.51
933F	7.81	0.73
933G	1.83	0.00
933H	0.35	0.00
958	28.87	0.00
958C	17.49	0.00
958UE	12.03	0.00
958UF	1.13	0.00
993	1.39	0.00
CarpenterLoggingRd	2.61	0.00
(blank)	0.78	0.00
Moore	**86.93**	**1.68**
1586	6.75	0.00
1586A	12.80	1.68
1586Acont	1.16	0.00
1586AUA	3.05	0.00
1586B	4.36	0.00
1586BUB	0.27	0.00
2322	9.48	0.00
424	13.35	0.00
424C	3.44	0.00
424D	0.33	0.00
424UI	5.24	0.00
424uk	3.54	0.00
424UL	21.09	0.00
424unk1	0.43	0.00
424unk2	1.65	0.00
Pony	**182.70**	**17.49**

1505	52.79	0.00
1505B	17.58	0.00
1505BUB	1.16	0.00
1505C	0.24	0.00
1505UD	1.65	0.00
1505UE	13.06	0.00
3100	3.99	0.00
3100UE	33.07	0.00
3100UNK2	4.08	0.00
3100unk3	4.33	0.00
3102	14.57	0.00
3102A	0.98	0.00
456Unk	1.95	0.00
456UZ	33.26	17.49
Trail	**789.26**	**98.21**
1505	185.45	14.25
1505 unka	0.49	0.00
1505A	15.87	0.00
1505D	99.26	0.00
1505UB	3.35	0.00
1505UC	0.12	0.00
1505UE	28.46	0.00
1505UG	6.52	0.18
1505ui	17.85	16.98
1505-UI	0.87	0.00
1505UIUNK	24.13	12.41
1505unka	3.05	0.00
605C	0.07	0.00
605UH	34.39	12.28
605UJ	2.26	0.00
605UJA	2.19	0.00
6328	155.44	0.00
6328A	87.52	31.14
6541	77.16	10.98
6541A	17.91	0.00
6541B	0.12	0.00
958	20.36	0.00
958C	6.40	0.00
Unknown	**84.10**	**0.36**
1300AUA	16.98	0.00
3100	21.60	0.00
3100?	0.37	0.00

3100a	2.93	0.00
3100b	12.19	0.00
3100D	12.19	0.00
3100UE	8.74	0.00
3100UNK	1.22	0.00
3100unk3	1.04	0.00
3102A	4.08	0.00
456Unk	2.07	0.00
456UY	0.69	0.36
Upper Beaver	**327.04**	**14.32**
1300AUA	3.48	0.00
1588	1.65	0.00
2322	10.80	0.00
271	0.44	0.00
3100	42.81	1.79
3100?	1.34	0.00
3100a	7.19	0.00
3100b	16.11	0.00
3100C	14.20	0.00
3100D	6.45	0.00
3100UE	16.69	0.00
3100UNK	2.44	0.00
424	10.89	0.00
424C	8.22	0.00
424UL	9.69	0.00
424UNK	0.73	0.00
424unk1	2.07	0.00
429	44.70	0.26
429B	27.82	0.00
429BUA	5.55	0.00
456uaa	7.75	0.73
456uaa-spur	0.55	0.00
456uad-po	2.87	0.35
456UAZ	33.09	5.22
456UX	20.20	4.41
CZ262 UNK A	2.05	0.00
CZ262UL	27.26	1.57
White	**223.05**	**8.09**
1586	76.79	1.42
1586 UA	8.28	0.00
1586 UB	9.78	3.38
1586H	42.53	0.00

1586UA	2.44	0.00
1586UB	8.39	2.56
2361	1.57	0.00
6537	3.78	0.00
6628	14.46	0.00
6630	1.09	0.00
933	1.12	0.00
933F	1.10	0.73
933G	3.13	0.00
933H	4.56	0.00
957	31.49	0.00
957A	12.56	0.00
Grand Total	**2828.26**	**221.02**

Appendix F – Model Limitations

GRAIP—Time and Costs

The Beaver Creek road assessment was funded by an Idaho Panhandle National Forests Resource Advisory Committee grant (RAC) in 2010 for $65,000, allowing the US Forest Service to hire four field technicians and purchase necessary equipment. Two field technicians worked exclusively on this project for nearly 4 months, while the remaining two assisted for about 1 month. About $35,000 was spent on field personnel in 2010, while an additional $6,000 was spent on equipment and training, and $3,000 on travel expenses and University of Idaho costs. As of 2011, the remaining nearly $18,000 was spent on quality control, running the GRAIP model, surveying the last few remaining roads that may have an influence on streams, field reviewing those locations found to be contributing sediment, and road maintenance planning and project development.

Nearly 150 miles of road was surveyed, resulting in identifying discreet locations where sediment is being generated by the road and entering the stream, as well as the condition of drainage structures and the potential for stream crossings to become compromised or block fisheries migration. The entire field survey and modeling cost nearly $44,000 and resulted in a cost of approximately $300 per mile of road. Each drainage structure cost about $14 to evaluate, and about $61 to evaluate only the approximately 700 drainage structures that potentially needed maintenance, if roads themselves were not evaluated. It is difficult to differentiate the cost of evaluating the roads from the drainage structures since they were combined in the survey and the time required to evaluate structures or length of roads was not recorded.

Post-processing and analysis of the data was a separate cost and was not funded by the RAC grant. Processing and analyzing the data required approximately 2 months of a professional hydrologist and cost approximately $12,000, though much of those costs were associated with learning the model and understanding how it generated results. There was also an additional cost to interpreting the results and writing this report.

Benefits of using the GRAIP Model

The GRAIP model provided several important benefits to evaluating the effects of roads in the Beaver Creek watershed. First, it provided managers with both a tangible and transparent method to evaluate the influence of roads on streams. Because it directs managers to visually inspect road surface flow paths and follow them to their termination, it allowed managers to pinpoint those exact segments of roads draining into streams, as well as the drainage feature it flows through.

The model also allows a systematic and detailed evaluation of all drainage features on roads by classifying drainage features by the type of feature, the condition of each feature, and the potential for each feature to contribute or transfer sediment from roads to streams. More importantly, it classifies those features into those that were engineered and designed to control drainage across roads, and those that were not engineered and drain water in an uncontrolled manner, and allows managers to focus limited funding resources on those drainage features and road segments that are directly responsible for linking roads to streams.

The GRAIP model also accumulates the effects of roads and drainage features across larger landscapes, whereas most road surveys simply allow interpretation at the scale of the road or drainage feature. One important value of the model is that it allows managers to view the effects of a given road segment in the context of all other road segments, and where most road surveys typically describe features similar to those in the GRAIP survey, they rarely have the ability to compare the effects of their results across broad areas or between watersheds. In other words, typical road surveys do not allow managers to rank roads or culverts in terms of their relative effects to streams- they are all, in effect, equally as influential on the stream as any other road segment or culvert. There are few, if any, scientifically-based, peer reviewed and standardized road survey methods used in the US Forest Service, especially those that combine global positioning system technology (GPS) with geographic information systems technology (GIS). Yet despite the potential drawbacks in using those systems, such as occasionally waiting for satellites to be received by GPS units in the field, or learning how to run the GRAIP model in the office, the results are far more accurate and meaningful in terms of managing the effects of roads on stream ecosystems.

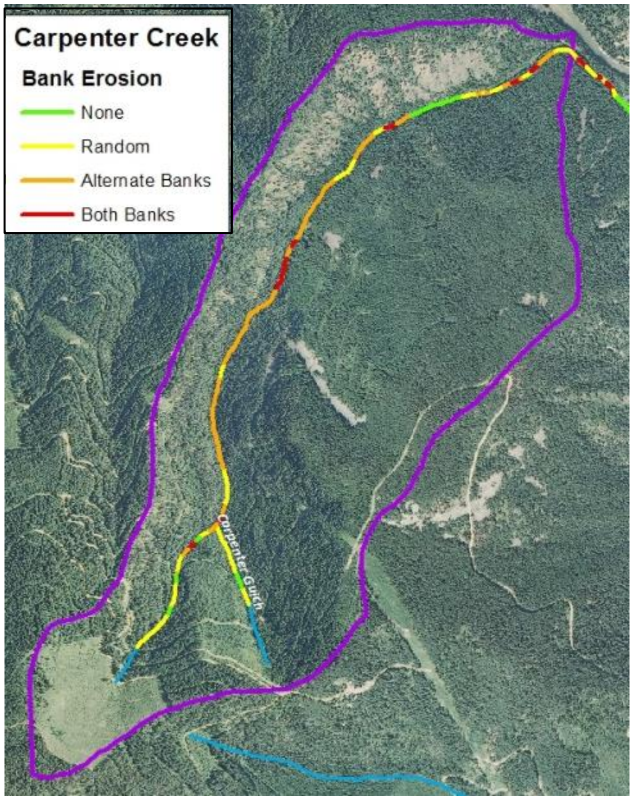
The GRAIP model also visually portrays the location and type of drainage issue on roads and may allow managers to develop maintenance, re-construction, or obliteration plans, with greater accuracy and more cost effectively. For instance, this information could be used during landscape-scale road analyses when managers are debating the necessity of individual roads, as is required by 36 CFR 212.5 and Forest Service Manual 7700, and provide information about roads that may have adverse environmental impacts. The model may also provide a scientific platform from which to make decisions for those analyses, as is also mandated by 36 CFR 212.5.

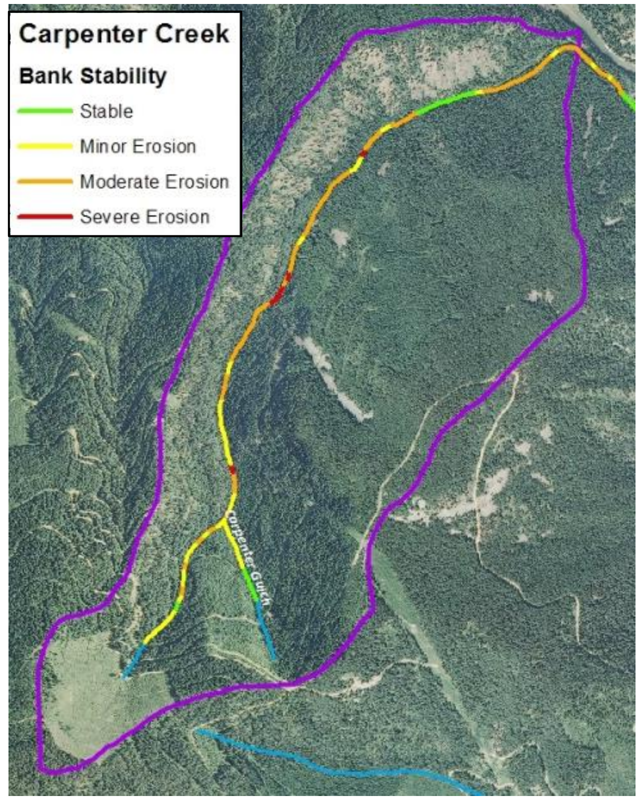
The GRAIP model did, however, require managers to learn a new and somewhat complicated process, and at times resulted in field crews waiting for GPS satellite coverage, or office technicians spending time learning how to correct data errors and run the model. While these are undoubtedly necessary steps for any new process, it is not yet understood if it was worth undertaking such a radically new method and will only be evident if the Forest Service and other regulatory agencies work in conjunction to adopt this new approach in their attempt to attain water quality standards and reduce road maintenance costs.

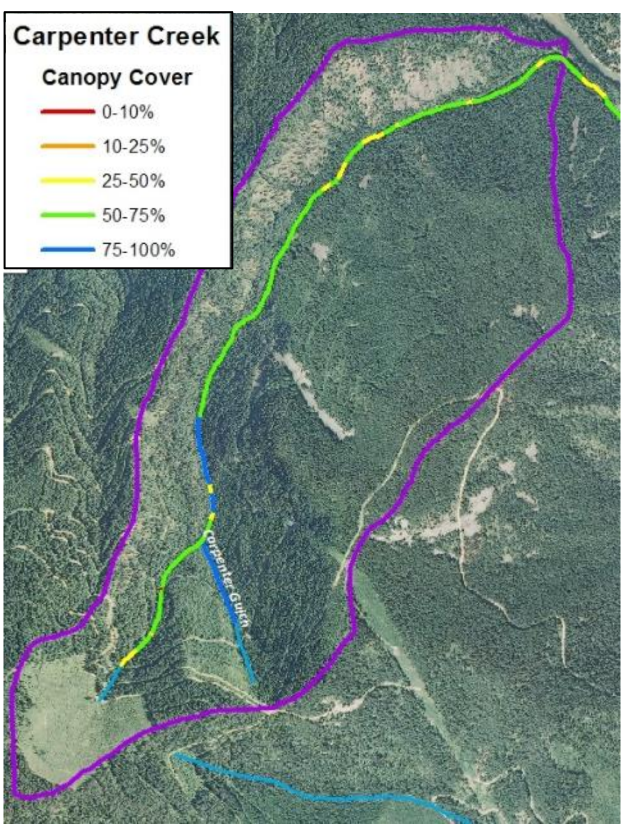
The model also may not be useful in accurately comparing the effects of roads with the state of Idaho's TMDL for Beaver Creek, which lists 1,688 tons of sediment (both fine and coarse) are exported each year, and of that, 1,042 tons/yr are generated from 221 miles of road. The sediment load for Beaver Creek exceeds its allocated amount by 80 tons per year. While agencies that have worked with the GRAIP model have shown interest in its ability to evaluate the effects of roads on streams for TMDL's, the few examples exist. One way in which managers might be able to better utilize the GRAIP model for evaluations of water quality and TMDL's in Beaver Creek and across northern Idaho, is to further our understanding of base erosion rates from roads. Currently, it would be difficult to accurately estimate the amount of sediment that could be reduced by repairing any one road segment, and though it is undoubtedly important for furthering the attainment of beneficial uses, it would also be useful to the Forest Service in describing the beneficial effects of their projects, or describing the potential negative effects of not acting on this information.

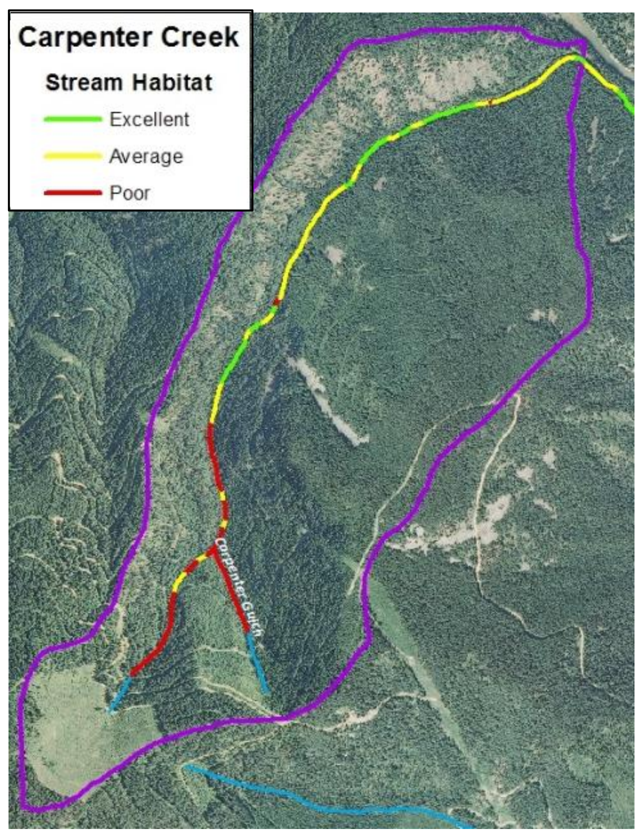
Finally, it seems that while at first glance the cost of using the GRAIP model is relatively expensive, we felt that in comparison to the other methods available, GRAIP ultimately provided a far greater understanding of road-stream interactions and can be largely cost effective. Costs could be further reduced, and additional roads could be surveyed, with better GPS coverage, well-trained and efficient crews, and with a better understanding of both how to run the model and interpret the results. Field crews received about 2 days of training and relatively few quality control reviews, while most GRAIP field crews receive about 1 to 2 weeks of intensive training and regular quality control reviews. However, if this model results in furthering attainment of water quality standards in impaired waterbodies as well as maximizing limited road maintenance funding by repairing only the roads that require it, it seems well worth the initial investment.

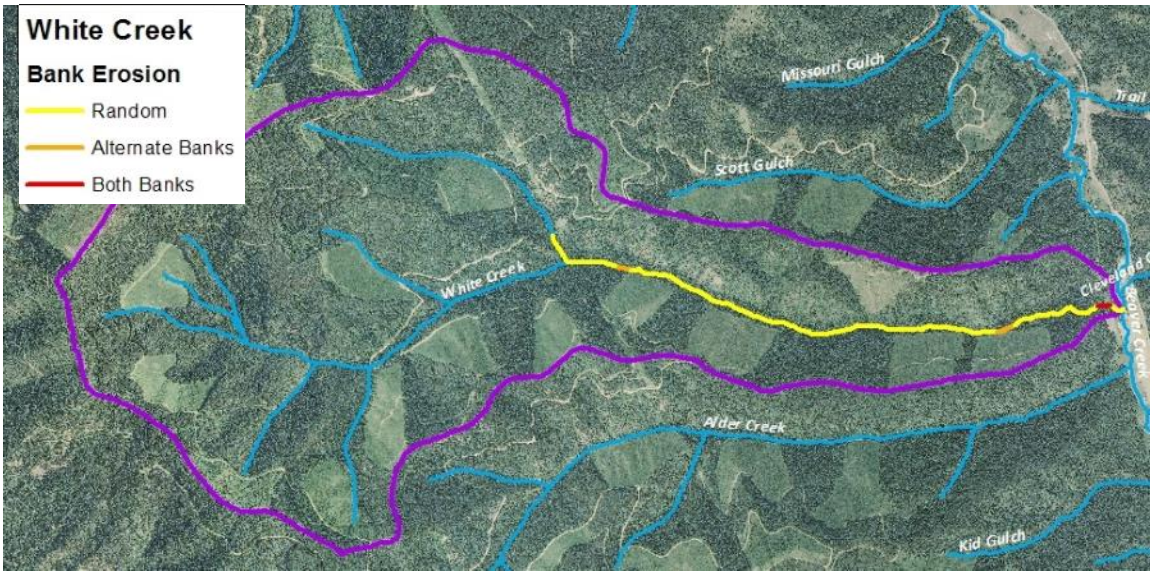
__Appendix G – RASCAL Assessment Maps__

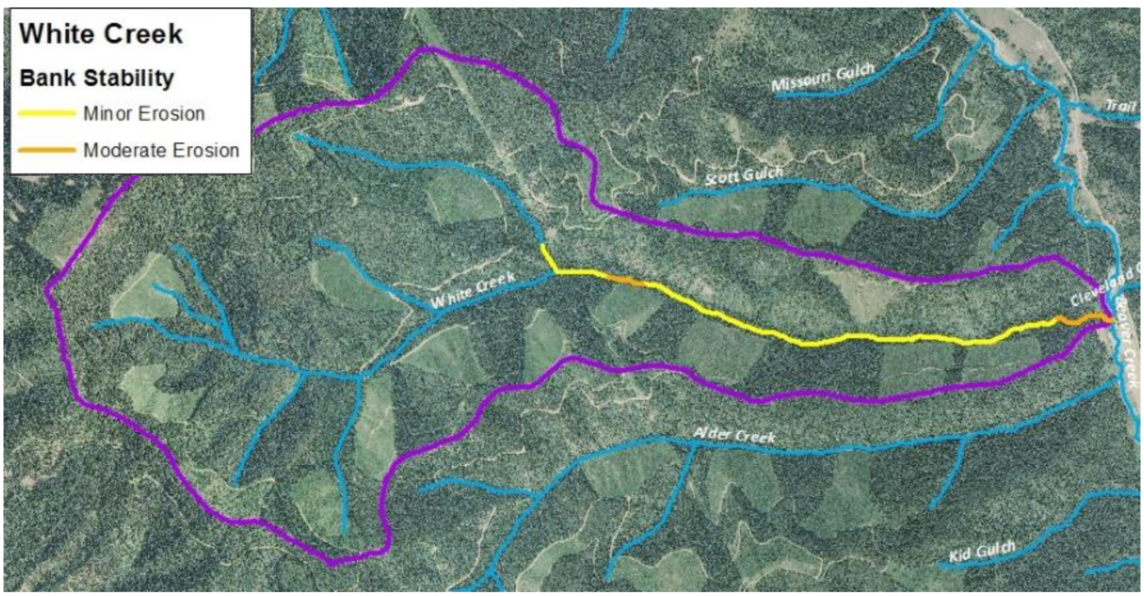


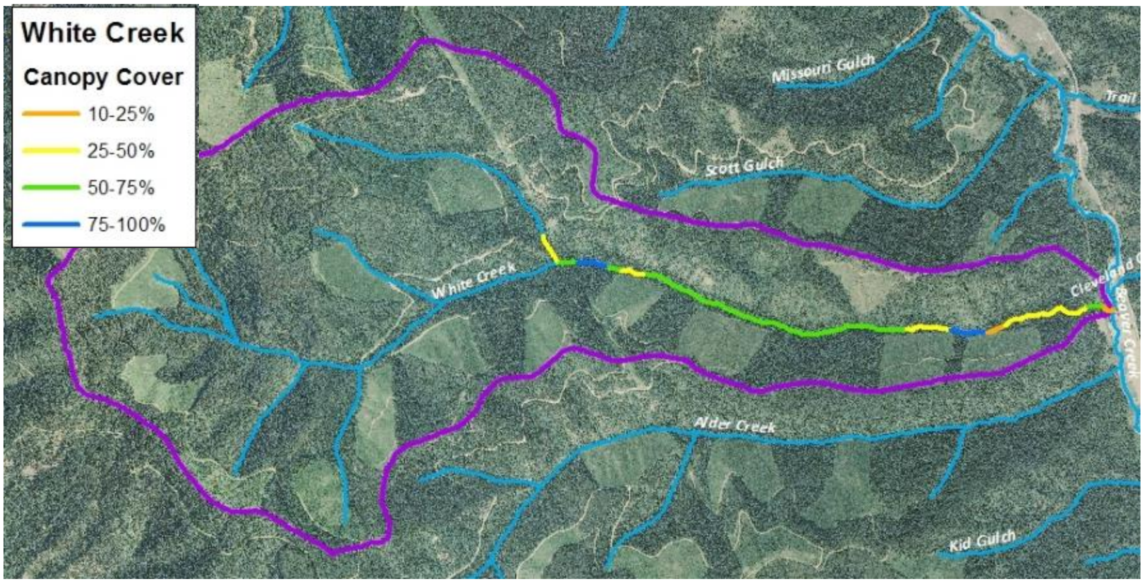


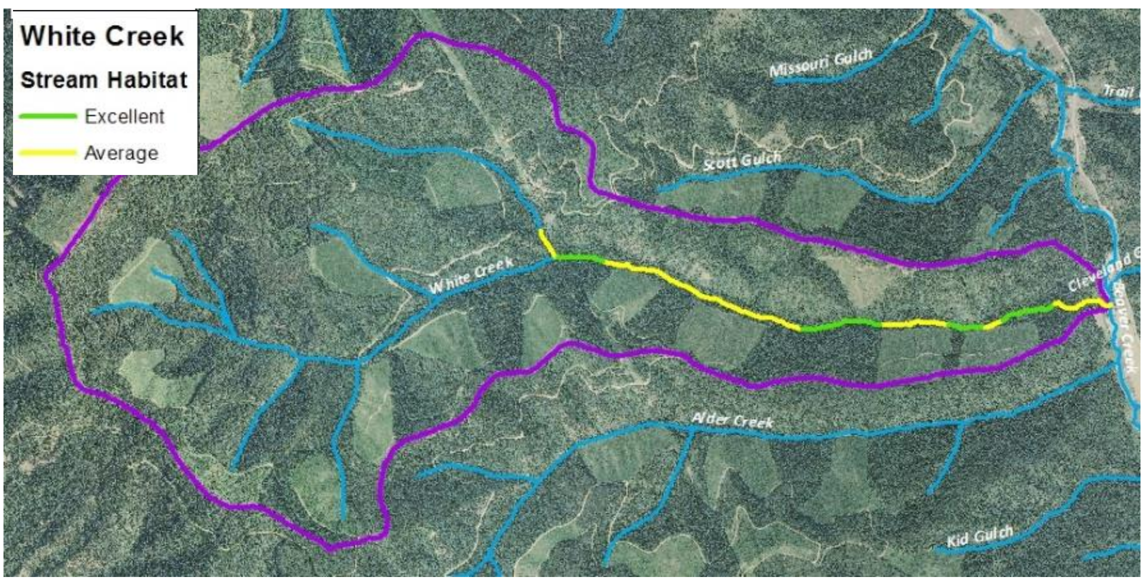


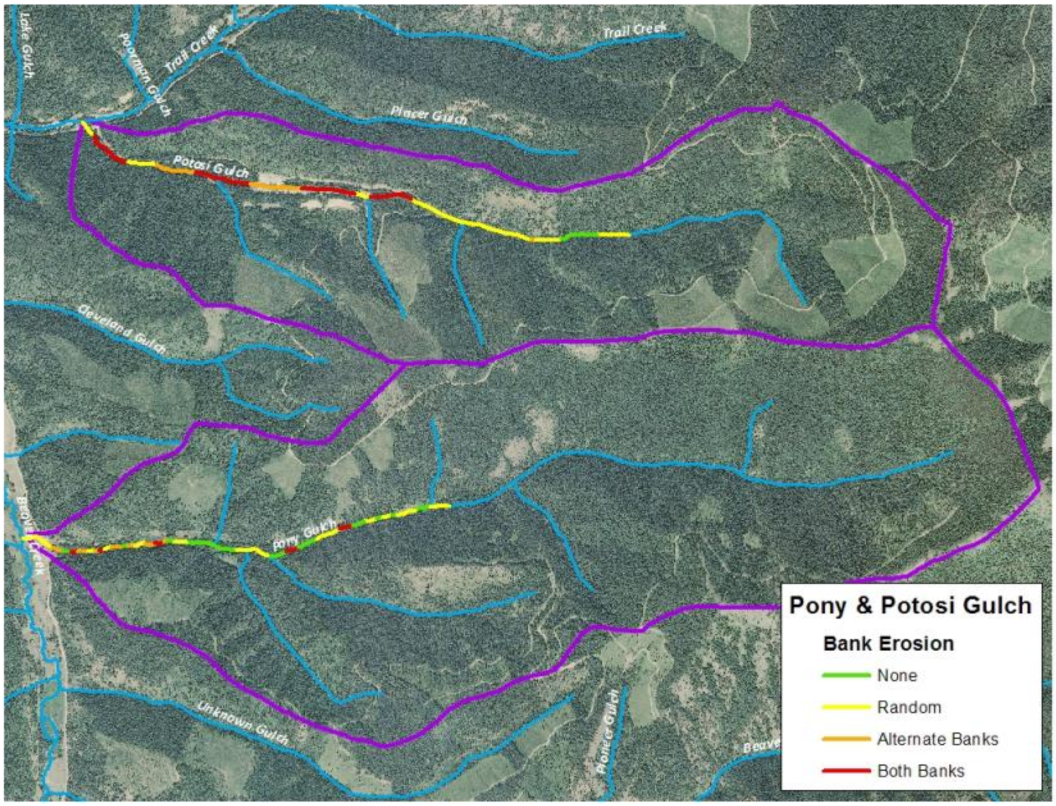


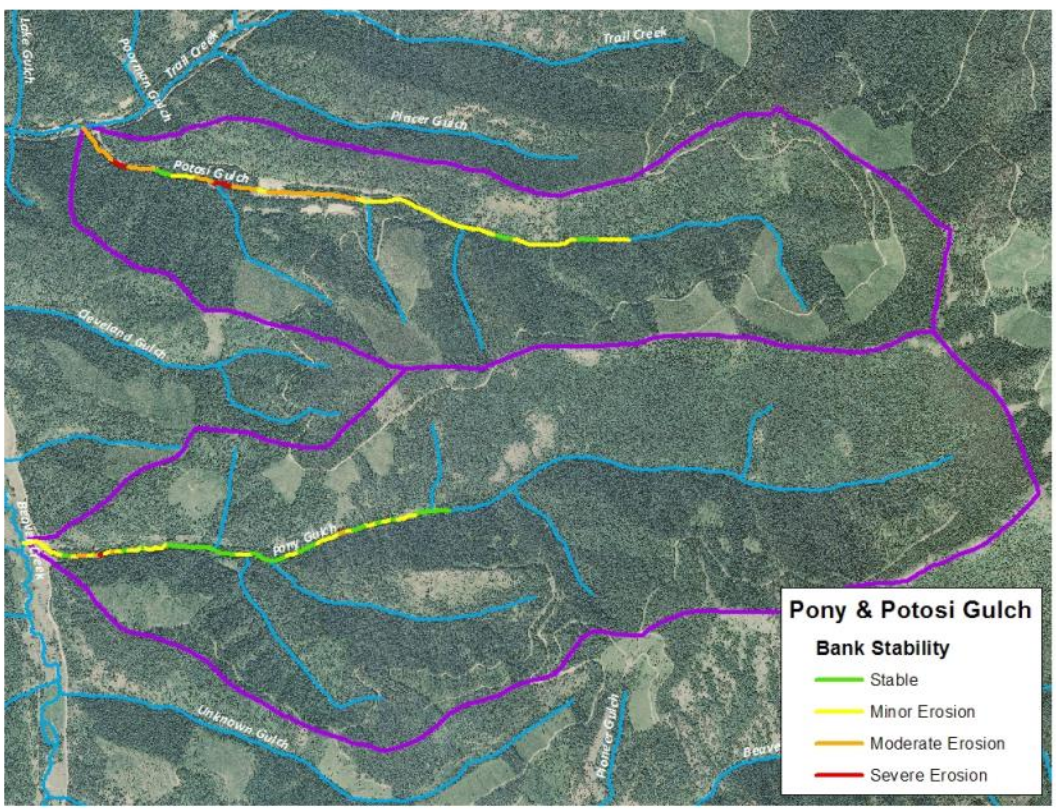

White Creek
Bank Erosion
Random
Alternate Banks
Both Banks
Missouri Gulch
Trail
Scott Gulch
White Creek
Alder Creek
Kid Gulch

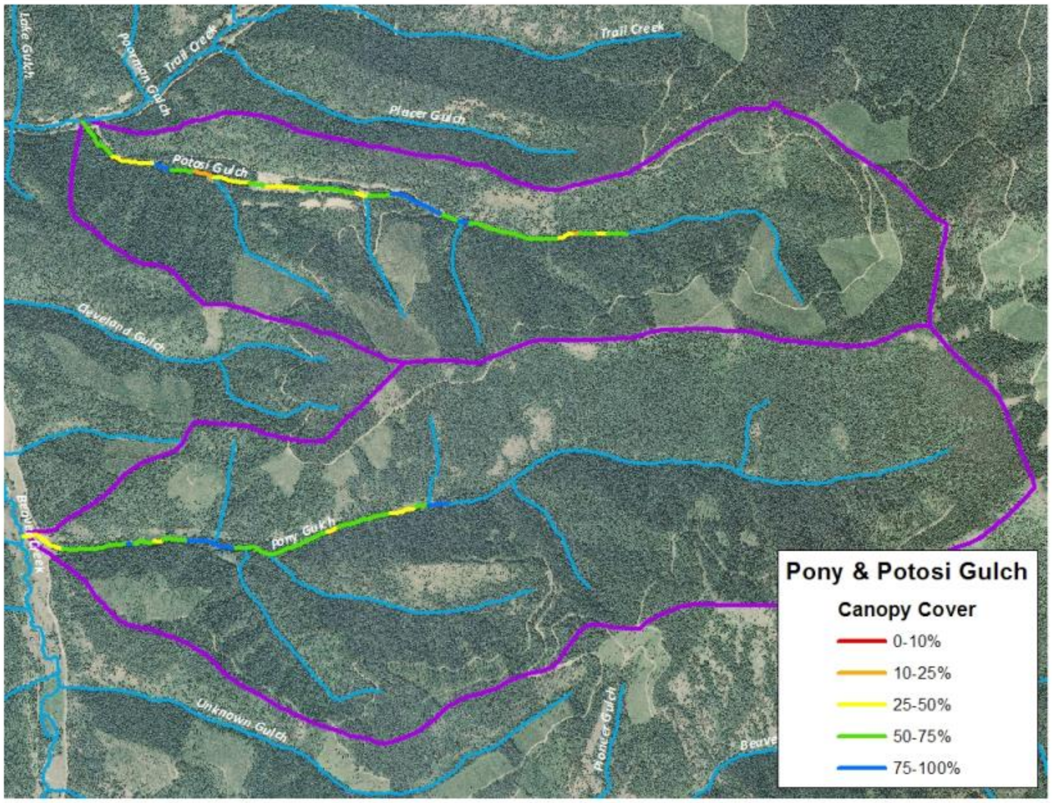

White Creek
Bank Stability
Minor Erosion
Moderate Erosion
Missouri Gulch
Trail
Scott Gulch
White Creek
Alder Creek
Kid Gulch

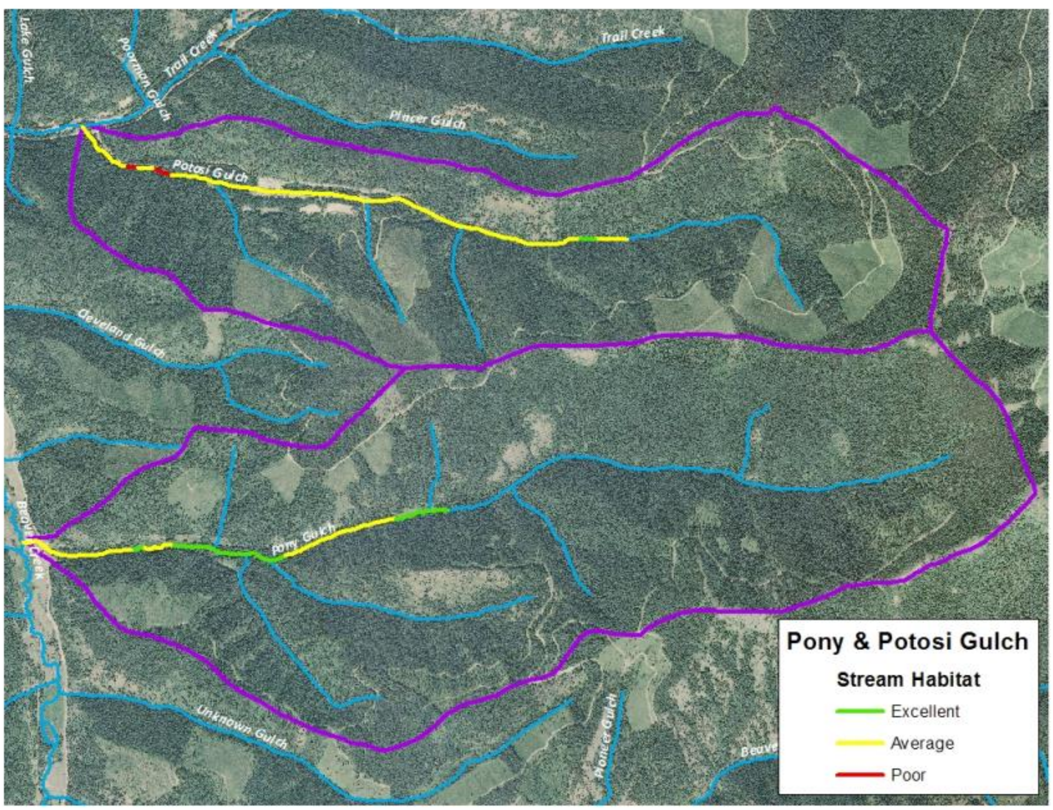

White Creek
Canopy Cover
10-25%
25-50%
50-75%
75-100%
Missouri Gulch
Scott Gulch
White Creek
Alder Creek
Kid Gulch
Trail


White Creek
Stream Habitat
Excellent
Average
Missouri Gulch
Scott Gulch
White Creek
Alder Creek
Kid Gulch
Trail


Lake Gulch
Poorman Gulch
Trail Creek
Trail Creek
Placer Gulch
Potosi Gulch
Cleveland Gulch
Pony Gulch
Unknown Gulch
Pony & Potosi Gulch
Bank Erosion
None
Random
Alternate Banks
Both Banks


Lake Gulch
Poorman Gulch
Trail Creek
Trail Creek
Placer Gulch
Potosi Gulch
Cleveland Gulch
Pony Gulch
Unknown Gulch
Pony & Potosi Gulch
Bank Stability
Stable
Minor Erosion
Moderate Erosion
Severe Erosion


Lake Gulch
Poorman Gulch
Trail Creek
Trail Creek
Placer Gulch
Potosi Gulch
Cleveland Gulch
Pony Gulch
Unknown Gulch
Pioneer Gulch
Pony & Potosi Gulch
Canopy Cover
0-10%
10-25%
25-50%
50-75%
75-100%


Lake Gulch
Poorman Gulch
Trail Creek
Trail Creek
Placer Gulch
Potosi Gulch
Cleveland Gulch
Pony Gulch
Unknown Gulch
Pioneer Gulch
Pony & Potosi Gulch
Stream Habitat
Excellent
Average
Poor

Appendix H. Beaver Creek Watershed Assessment Summary Table

	Alder	Carbon	Carpenter	Deer	Dudley	Lower Beaver	Moore	Pony	Trail w/ Potosi	Unknown	Upper Beaver	White
Road Density[1]		#4 (7.9 mi/mi^2)	#1 (9.6 mi/mi^2)	#3 (8.0 mi/mi^2)	#6 (6.6 mi/mi^2)		#5 (7.8 mi/mi^2)			#2 (8.9 mi/mi^2)		
Forest Roads Sediment Delivery[2]		#6 (13 t/y)			#4 (17 t/y)	#2 (30 t/y)		#3 (18 t/y)	#1 (98 t/y)		#5 (14 t/y)	
High Delivery Forest Road Segments[3]		#4 / 262UL-PO (Carbon) 262UNKB (Carbon)				#2 / 1505B (Cleveland) 6541 (Prospect) 933 (Scott)		#3 / 456UZ (Pony)	#1 / 6328-A-FDR (Trail) 605UH (Placer) 1505ui (Potosi) 6541 (Lake)			
High Delivery Drain Points[4]		#4 / 7 (Carbon)		#7 / 2 (Deer Cr)	#6 / 6 (Dudley)	#2 / 3 (Scott) 2 (Prospect) 2 (Missouri) 1 (Cleveland)		#3 / 3 (Pony)	#1 / 9 (Potosi) 3 (Placer) 2 (Trail) 1 (Lake) 1 (Last)		#5 / 2 (Missoula) 1 (Dobson) 3 (tributaries to Beaver Cr along 456UX)	#8 / 2 (White)
Stream Segments Receiving >3.5 t/y[5]		#6 / Trib on S side of Carbon Cr and Carbon Cr headwaters			#8 / Trib on W side of Dudley Cr	#2 / Scott Gulch, Beaver Cr just below Missouri Gul, upper Prospect Gul, trib to Cleveland Gul		#4 / Middle reaches of Pony Gulch	#1 / Trail Creek, Placer Gulch, Potosi headwaters, trib on S side of Potosi Cr, Lake Gulch		#3 / Missoula Gulch	#7 / Trib on N side of White Cr
High Risk Culverts[6]		#3 (3)	#5 (1)		#3 (3)	#4 (2)			#1 (7)		#2 (5)	
Channel Extension[7]		#1 (42%)	#5 (11%)	#3 (19%)	#2 (24%)				#4 (17%)			
Undersized Mainstem Bridges[8]						Yes: 2361 933					Yes: 456-U-PO 271 456	
Placer Mining in Riparian Areas[9]								Pony Gulch	Trail Cr and multiple tributaries			
Large Mine Sites, Metals Sources[10]		Ray-Carlisle										
BURP[11]	Cold water aquatic life impaired											
RASCAL[12]			Carpenter Gulch = low stability, high erosion, headwaters poor habitat		Dudley Creek = low stability, high erosion, >/= average habitat			Pony Gulch = some reaches of high erosion and low stability, >/= average habitat	Potosi Gulch = low stability, high erosion, </= average habitat			White Creek = reaches of high erosion near mouth, mostly good habitat
Shade Analysis[13]		High shade deficits		Shade deficits				Shade deficits	High shade deficits		Highest shade deficits	

[1]**Road density:** Road density is the miles of road per square mile of land area in the watershed. The 6 subwatersheds with the highest road density were ranked in order of #1 (highest) to #6 (lowest) to identify priority subwatersheds with road densities greater than 6 mi/mi^2. These data are based on best available information at the time of this assessment and may over- or underestimate the actual roads on the landscape. See page 20 of assessment.

[2]**Forest roads sediment delivery:** Sediment delivery from forest roads was analyzed by the GRAIP method on 146 miles of road (63% of the known road network) in the Beaver Creek Watershed. Sediment delivery estimated from these roads was ranked in order of #1 (highest) to #6 (lowest) to identify subwatersheds with sediment delivery greater than 10 tons/year. See page 22 of assessment.

[3]**High delivery forest road segments:** Most of the sediment delivered to streams from forest roads occurred from a few road segments. This table identifies road segments delivering more than 2 tons of sediment to streams per year. These segments account for more than 50% of total sediment estimated delivered to streams from forest roads. Rankings were based on total sediment delivery from the listed road segments in order of #1 (highest) to #4 (lowest). See pages 23-24 of assessment.

[4]**High delivery drain points:** Most of the sediment delivered to streams from forest roads occurred through a small fraction of drain points. The 50 drain points delivering the highest amount of sediment were identified by subwatershed to prioritize sediment-reducing opportunities. Rankings were based on total sediment delivery from the listed drain points in order of #1 (highest) to #8 (lowest). See page 30 of assessment.

[5]**Stream segments receiving >3.5 t/y:** Forest roads surveyed in this assessment delivered sediment to stream segments throughout the watershed. Stream segments receiving more than 3.5 tons per year were identified to prioritize sediment-reducing opportunities. Rankings were based on total sediment delivery from the listed stream segments in order of #1 (highest) to #8 (lowest). See page 33 of assessment.

[6]**High risk culverts:** Culverts were assessed for size, damage or blockage, and nearby characteristics including fill volume surrounding the culvert. There were 21 high risk culverts identified with a high risk of blockage and/or failure and a total estimated fill volume of more than 4,000 tons. See page 35 of assessment.

[7]**Channel extension:** Channel extension refers to the effect forest roads can have by intercepting and redirecting water on hillslope and extending the length of the drainage network. This was assessed using GRAIP and the highest 5 subwatersheds were ranked from #1 (most) to (#5) least to identify and prioritize subwatersheds with greater than 10% channel extension. See page 25 of assessment.

[8]**Undersized mainstem bridges:** This identifies locations with undersized bridges over the mainstem of Beaver Creek. Some are in better condition than others and closer to appropriate size, but several are causing significant upstream and downstream effects to the stream and floodplain. See pages 45-60 of assessment.

[9]**Placer mining in riparian areas:** Locations with placer mining observed in riparian areas during the assessment process were identified as locations for sediment reduction opportunities through improved BMP application. See pages 10-13 of assessment.

[10]**Large mine sites/metals sources:** There is one large mine and mill site in the watershed identified as a source of sediment and metals that has not yet been remediated. See pages 8-10 of assessment.

[11]**BURP:** These are summary findings from rapid bioassessment of Beaver Creek using DEQ's Beneficial Use Reconnaissance Program protocols. See pages 61-73 of assessment.

[12]**RASCAL:** These are summary findings from assessment of Beaver Creek tributaries using an adapted Rapid Assessment of Stream Condition Along Length. Findings emphasized stability, erosion and overall habitat quality. See pages 73- 80 of assessment.

[13]**Shade analysis:** These are summary findings based on potential natural vegetation predictions and shade deficits identified in draft TMDLs. See pages 83-88 of assessment.

Appendix I. Beaver Creek Watershed Assessment Summary Map